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Temporal Statistical Analysis and Retrospective Assessment of Mortality Rate in the United States from 1999 to 2018

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Authors' contributions

This work was carried out in collaboration among all authors. All authors did the conceptualization, data curation, methodology, formal analysis, investigation, methodology, validation, writing – original draft, writing (review & editing). All authors read and approved the final manuscript.

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ABSTRACT

Objectives: To retrospectively examine the mortality trend in the USA from 1999 to 2018 using a basic statistical model while examining multiple variables. The inferential and descriptive statistical tools will be prioritized to elucidate the mortality of both years in simple terms.

Methods: We conducted a retrospective observational descriptive analysis of data on the 10 leading causes of death in the United States by age, race, and sex over 2 decades (1999 to 2018). The data in this report are based on information from all death certificates filed in the 50 states and the District of Columbia. The causes of death are classified by the International Classification of Diseases, 10th Revision (ICD–10), which is ranked according to the number of deaths (Cause-of-death statistics are based on the underlying cause of death). This report supplements “Deaths: Final Data for 2020,” the National Center for Health Statistics’ annual report of final mortality statistics.

SPSS (statistical package for social sciences) version 29 Software in Excel sheet was used to analyze the generated datasets. Descriptive and inferential (parametric and non-parametric) analyses were used. The statistically significant relationships and assumptions were made using the chi-square/t-test, Kruskal-Wallis, and Fischer's exact tests with the significance level set at $p \leq 0.05$. The analysis and determination of the level of agreement between the initial diagnosis and findings from the new analysis done.

Results: The proportion of age-adjusted death rates of the heart (such as coronary artery disease) account for the highest proportion of 24%, while Malignant neoplasms (cancers) represent 23%, Chronic lower respiratory diseases contribute 6%, Unintentional injuries (accidents) also play a significant role, accounting for 5% of deaths. The regression analysis reveals a strong and statistically significant relationship between the number of causes in females and males. There was a high death rate of around 60 years in 1999 and a consistent decline over the years, reaching below 40 by 2018, with a 15/100,000 death fluctuation mark.

Asian or Pacific Islander has the lowest age adjustment value of 8762.4, American Indian or Alaska Native, Hispanic, or Latino(11673.2), Black or African American, Hispanic, or Latino (12992.1), White, not Hispanic or Latino(15457.1), Black or African American (15708.2), Hispanic or Latino(19624.1), American Indian or Alaska Native, not Hispanic or Latino (16287.9).Asian or Pacific Islander, not Hispanic or Latino(8791.3), and 99.2% of the variability in the dependent variable and standard error of 6.7240.

Conclusions: Cardiovascular death remains the most common cause of death, with a significant decrease in the death rate from 1999 to 2018 due to improved health care and the provision of measures to improve health care. The regression analysis reveals a strong and statistically significant relationship between the number of causes in females and males. Therefore, based on the results, the number of causes in females strongly predicts the number of causes in males.

Keywords: Mortality; national vital statistics system; racial and ethnic differences; sex differences.

1. INTRODUCTION

Mortality analysis provides essential information about a population's well-being and life expectancy. This helps to identify significant changes over time and understand key drivers of these changes, such as technological advancements, socioeconomic conditions, and various public health changes and initiatives. Mortality rate is the number of deaths per population unit in a given period. It is a fairly good indicator of a population’s overall well-being.

Globally, there was a notable decline in mortality rates due to communicable diseases such as HIV/AIDS, tuberculosis, and malaria due to international public health interventions, which improved access to health care in low- and middle-income countries. However, similar to the U.S., the global burden of non-communicable diseases like heart disease, stroke, cancer, and diabetes increased, possibly due to massive diet changes influenced by the Western world [1,2,3]. The capacity to manage these diseases also varied widely between high-income and low-income countries.

Significant progress was also made globally in reducing maternal and child mortality rates, driven by improvements in prenatal care, vaccinations, and better healthcare services for women and children; however, low- and middle-income countries continued to face challenges related to weaker healthcare infrastructure, limited access to medical care, and higher rates of poverty-related health issues. These disparities significantly influenced global mortality rate differences in low –and middle-income countries compared to high-income countries like the USA [4,5].

While previous research has examined mortality trends in specific demographic groups, this research project intends to fill in a comprehensive temporal statistical and comparative analysis of mortality in these 20 years to provide valuable insight into public health trends to enhance better decision-making by policymakers, researchers, and health care professionals using essential statistical tools [6]. The research aims to provide a prototype for teaching early medical educators the various possibilities and assumptions using statistical analysis in the retrospective representation of mortality indices in the United States from 1999 to 2018.

2. MATERIALS AND METHODS

2.1 Research Design, Strategy, and Data Collection and Analysis

This is a quantitative research design to investigate the relationship between various factors. The research employs descriptive and inferential statistical analyses to achieve the research objectives.

Data in this report are based on information from all death certificates filed in the 50 states and the District of Columbia from 1999 to 2018 (National Center for Health Statistics, National Vital Statistics System, mortality data file). Death certificates are generally completed by funeral directors, attending physicians, medical examiners, and coroners. Cause-of-death statistics from 1999 to 2018 presented in this report are classified according to the 10th revision of ICD (ICD–10). Discussions of the cause-of-death classification and coding rule changes in data year are provided in the narration at the end of the results.

Data visualization of the statistical tool used for the analysis in Excel. Excel offers various chart types and formatting options for visually appealing graphs and charts. It makes it easy to generate histograms, scatter plots, bar charts, line graphs, and pivot tables to visualize data trends, patterns, and relationships. Descriptive statistics were computed to summarize the characteristics of the variables under study, including measures of central tendency, dispersion, and frequency distributions. The statistical tools used for the descriptive statistics are SPSS, Excel, and Python programming language (NumPy and Pandas library).

Inferential Statistics are adopted are:

i. Regression analysis using SPSS to examine the relationship between the dependent variable and independent variables. This analysis will help identify significant predictors and their impact.
ii. Parametric tests, such as t-tests or ANOVA, were employed to compare means across different groups or conditions, assuming normal distribution and homogeneity of variances.
iii. Non-parametric tests, such as the Mann-Whitney U test or the Kruskal-Wallis test, were used when data did not meet the assumptions of parametric tests.
iv. Regression analysis assumptions, including normality, linearity, homoscedasticity, and independence of residuals, were assessed using graphical methods and statistical tests.
v. A chi-square test analyzes the association between categorical variables and assesses the goodness-of-fit of observed data to expected frequencies.

This comprehensive methodology ensures that the data collected was analyzed using appropriate statistical techniques to draw meaningful conclusions in line with the research objectives. Starting with 1999 data, the rules changed for selecting Chronic lower respiratory diseases (CLRD) and Pneumonia as the underlying cause of death, increasing the number of deaths for CLRD and a decrease in the number of deaths for Pneumonia. Therefore, trend data for these two causes of death was interpreted with caution. For more information, see Sources and Definitions, Comparability ratio.

The cause-of-death title for Chronic obstructive pulmonary disease (COPD) in the International Classification of Diseases, Ninth Revision (ICD–9) was renamed Chronic lower respiratory diseases (CLRD) in ICD–10. Starting with 2011 data, the rules changed for selecting Renal failure as the underlying cause of death, affecting the number of deaths in the Nephritis, nephrotic syndrome, and nephrosis and Diabetes categories. These changes directly affect deaths with mention of Renal failure and other associated conditions, such as Diabetes mellitus with renal complications. The result is a decrease in the number of deaths for Nephritis, nephrotic syndrome, and nephrosis and an increase in the number of deaths for Diabetes mellitus. Therefore, trend data for these two causes of death should be interpreted with caution. SPSS, which stands for Statistical Package for the Social Sciences, is a powerful software tool used for statistical analysis and data management. Originally developed by IBM, SPSS provides a user-friendly interface that allows researchers and analysts to perform a wide range of statistical analyses, from basic descriptive statistics to advanced modeling techniques. After defining the variable view, the data is then inputted into the data view. The next step is to perform a descriptive statistic using our SPSS.

3. RESULTS

The exploratory data analysis from the sources dissected 18 common causes of death between 1999 and 2018 (Fig. 1). Heart-related diseases remain the common cause of death, accounting for 40% of all deaths across the board. A time plot series helps to show the trend, or the patterns observed from each disease in the time in question (1999 to 2018), with concurrent application to multiple variables (Fig. 2 to Fig. 26). Tables 1-7 depicts the results of investigation into the relationship between two numerical variables. They demonstrated Linearity assessment residual statistics, Collinearity Diagnostics, Coefficients, Tests for assumptions, and Regression analysis.

The pie chart illustrates the proportion of age-adjusted death rates for selected diseases. Here are the key findings:

I. Diseases of the heart (such as coronary artery disease) account for the highest proportion of age-adjusted death rates, contributing 24%.
II. Malignant neoplasms follow closely, representing 23% of deaths.
III. Chronic lower respiratory diseases (e.g., chronic obstructive pulmonary disease) contribute 6%.
IV. Unintentional injuries (accidents) also play a significant role, accounting for 5% of deaths.
V. Several other conditions make up the remaining percentages

In conclusion, heart-related conditions remain the leading cause of mortality, emphasizing the importance of preventive measures and healthcare interventions.

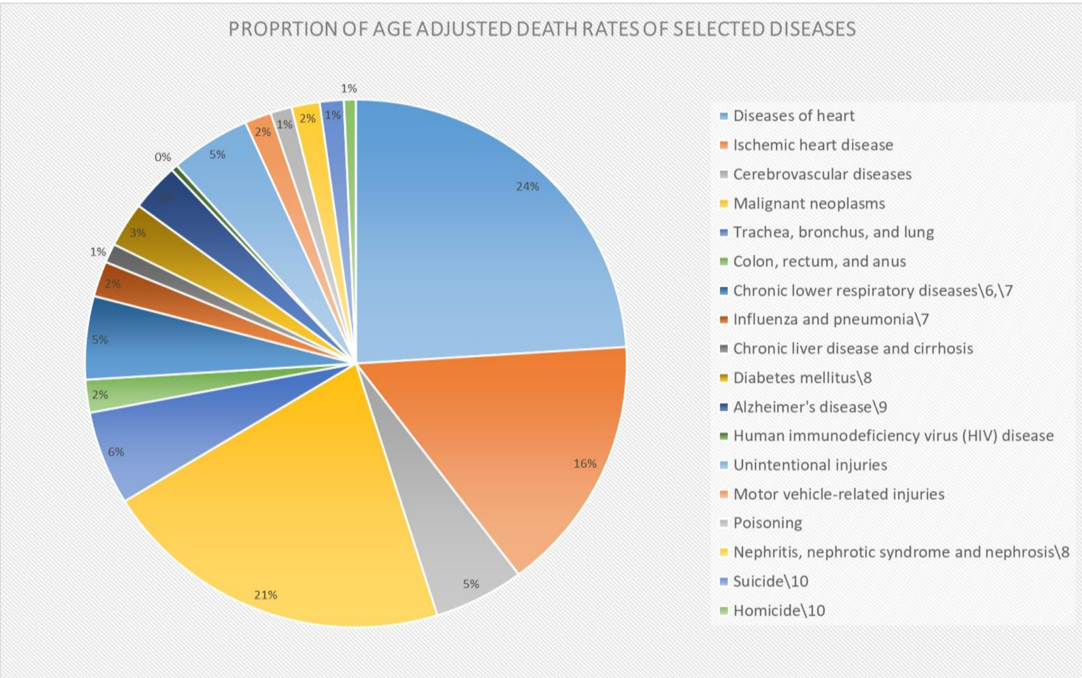

Fig. 1. Exploratory data analytics on all people

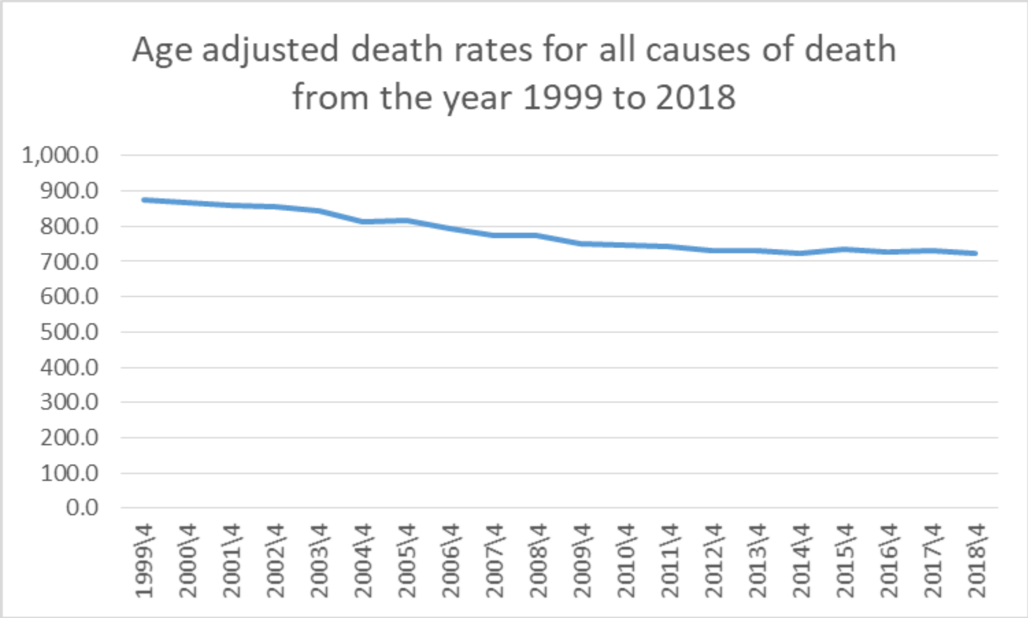

Fig. 2. Time series plot of age-adjusted death rate (All causes)

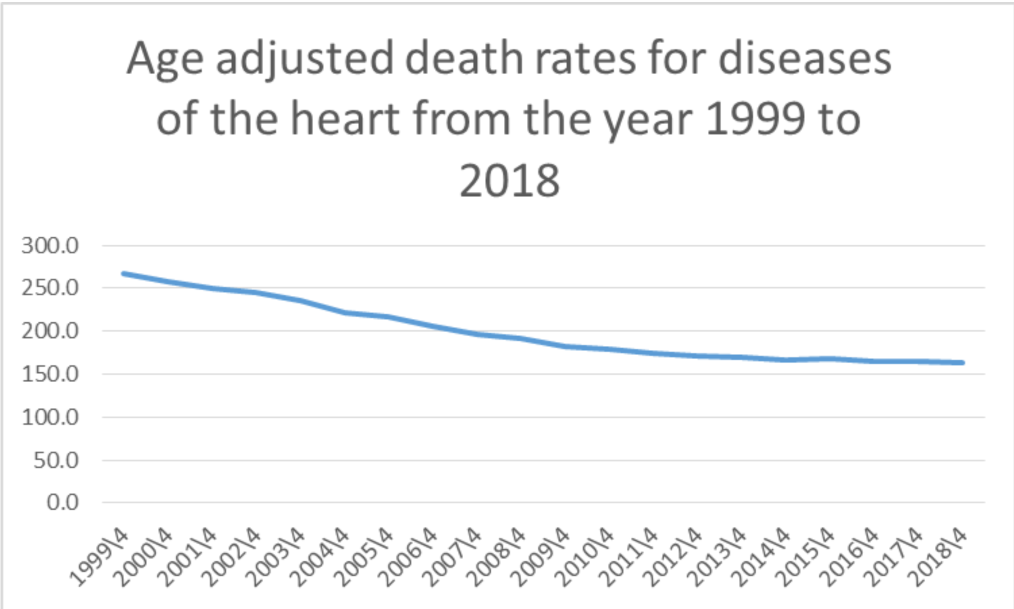

Fig. 3. Adjusted death rate from heart diseases

The graph represents age-adjusted death rates for all disease causes from 1999 to 2018. The y-axis shows the death rate, ranging from 0 to 1,000. The x-axis represents the years.

The graph displays the age-adjusted death rates for all causes of death from 1999 to 2018. The key observations are:

I. The blue trend line indicates a gradual decline in death rates over this period.
II. This decline suggests health, safety, or medical treatment improvements during these years.
III. The y-axis represents the number of deaths per specific population, ranging from 0.0 to 1,000.0.
IV. The x-axis shows years in intervals, spanning from 1999 to 2018.

Overall, health outcomes or medical interventions have improved, reducing overall age-adjusted death rates for diseases over these years.

The chart of "Age-adjusted death rates for diseases of the heart from the year 1999 to 2018". A line graph shows a consistent decrease in the age-adjusted death rates for heart diseases from 1999 to 2018. The Y-axis represents the death rates, presumably per some standard population size, ranging from 0.0 to 300.0. The X-axis represents the years, marked in year intervals from 1999 to 2018. The descending blue line indicates that the age-adjusted death rates for heart diseases have decreased over this period. This trend suggests improvements in heart disease management and prevention during these years.

The graph illustrates the age-adjusted death rates for ischemic heart disease from 1999 to 2018. The key observations on the graph are:

I. **Steady Decline:** The blue line in the graph shows a consistent downward trend in death rates over the specified period. This indicates that the mortality rates due to ischemic heart disease have been decreasing over the years.
II. **Age Adjustment:** The rates are age-adjusted, accounting for variations in age distribution across different years. This adjustment allows for a fair comparison of mortality rates over time.

The decline in death rates is a positive sign and suggests that efforts in prevention, early detection, and treatment of heart disease have been effective. However, continued public health initiatives are crucial to reduce the impact of ischemic heart disease further.

Here is the interpretation of the chart (Fig. 5):

I. Y-Axis (Death Rate): The death rate ranges from 0 to 70. It represents the age-adjusted death rates of cerebrovascular disease.
II. X-Axis (Years): The years range from 1999 to 2018, representing the time period over which the data was collected.
III. Trend Line: The blue line shows the trend of age-adjusted death rates over the years. It started at a high rate of around 60 in 1999 and consistently declined over the years, reaching below 40 by 2018.

The graph demonstrates that the age-adjusted death rates of cerebrovascular disease have significantly decreased from 1999 to 2018. This positive trend could be attributed to various factors, including advancements in medical treatments, better healthcare facilities, increased awareness about the disease, and improved lifestyle habits.

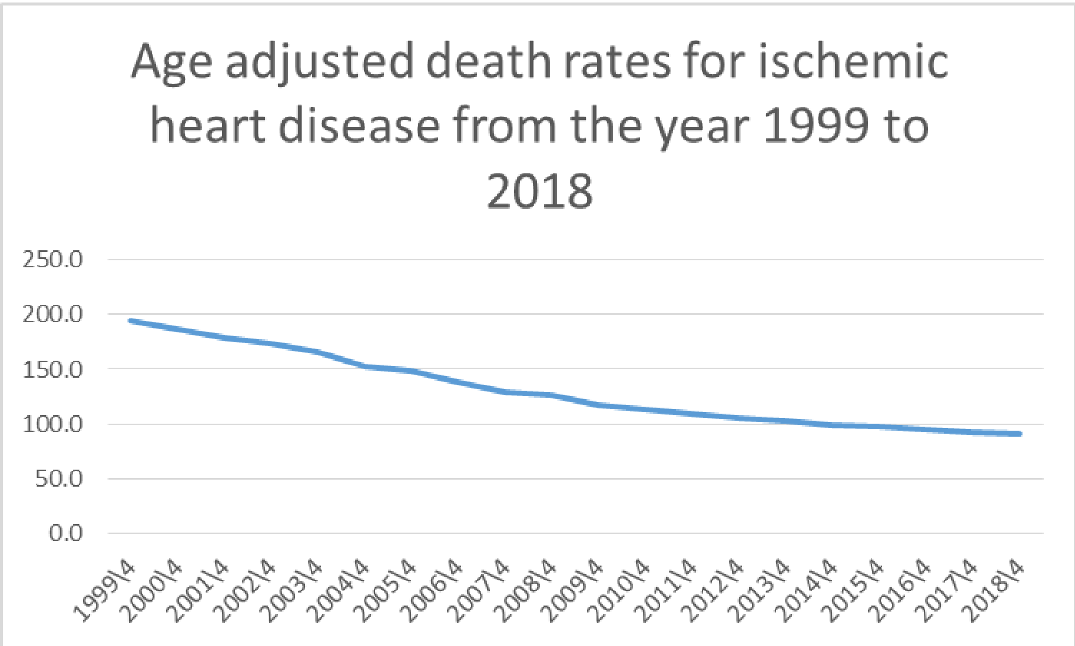

Fig. 4. Adjusted death rate from ischemic heart disease

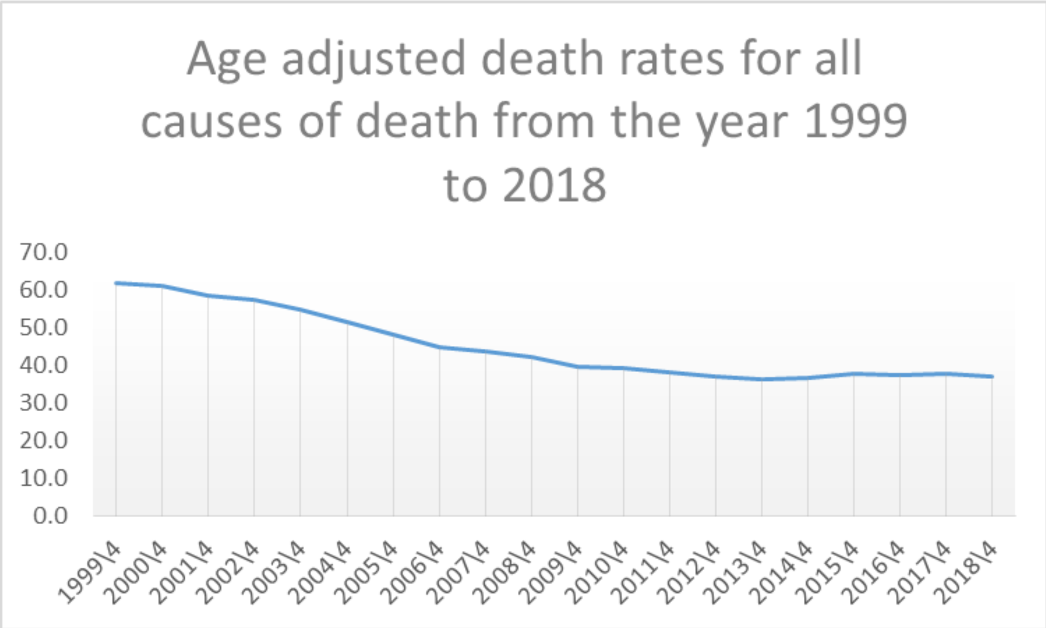

Fig. 5. Adjusted death rate from Cerebrovascular diseases

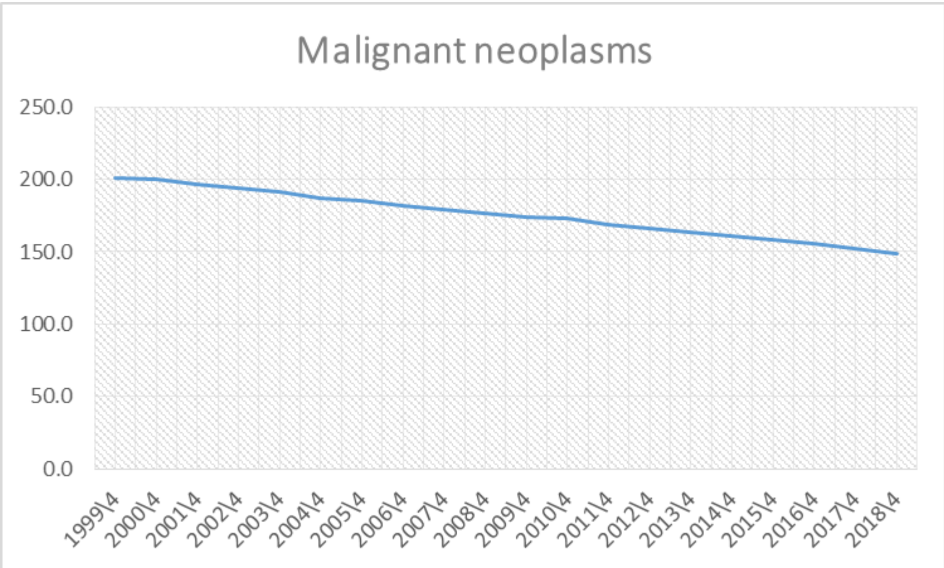

Fig. 6. Adjusted death rate from Malignant neoplasm

The time series plot of death rates caused by malignant neoplasms shows a marginal change at the outset from 1999 to 2018, and then a declining trend can be observed.

The chart is a line graph titled "Age death rates of Trachea, bronchus, and lung diseases." It shows the trend of age death rates due to these conditions from the year 1999 to 2018.

The x-axis represents the years from 1999 to 2018, while the y-axis indicates the age death rates of trachea, bronchus, and lung diseases. The blue line in the graph represents the trend of these death rates over the years. The death rates show a significant reduction over time. The chart shows a significant decrease in the age death rates due to trachea, bronchus, and lung diseases from 1999 to 2018. This suggests that there has been a substantial improvement in the prevention, diagnosis, and treatment of these conditions over the years.

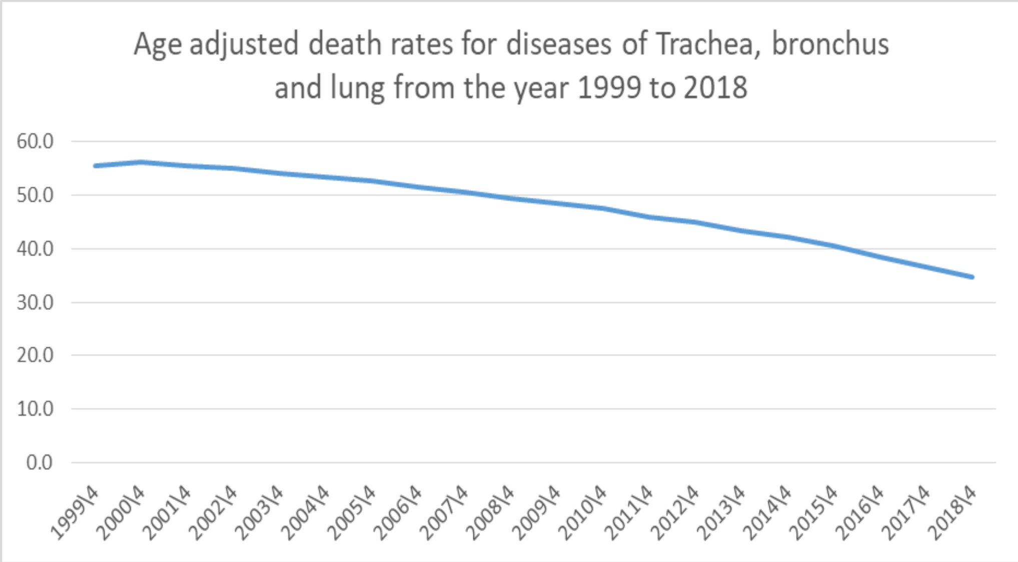

Fig. 7. Adjusted death rate from Trachea, Bronchus, and lung diseases

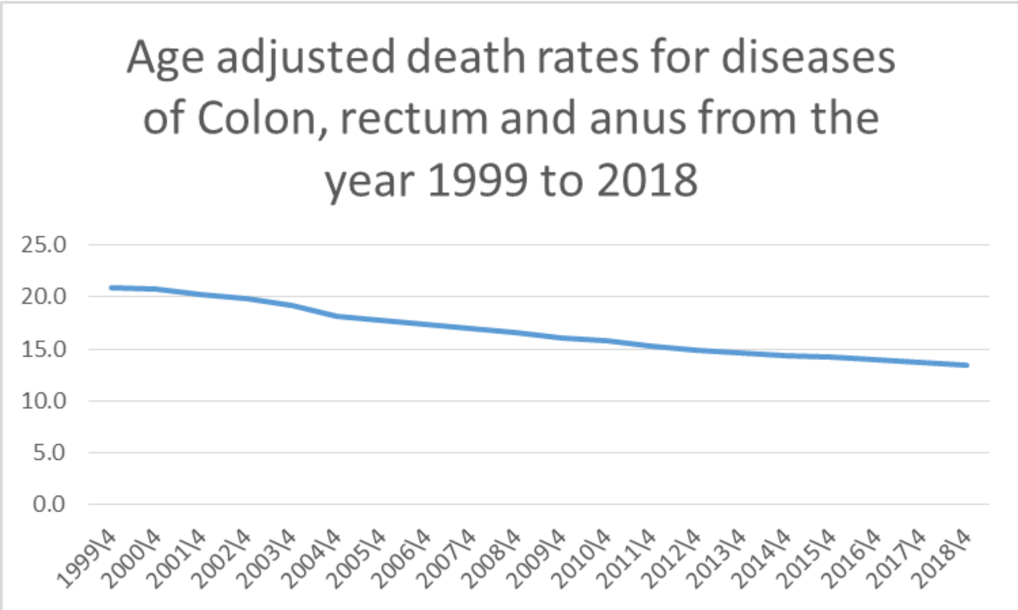

Fig. 8. Adjusted death rate from diseases of the Colon, rectum and anus

The chart shows a general gradual decreasing trend from 1999 to 2018.This progress can be attributed to the aggressive progress in the use of Colonoscopies and guaiac tests.

The graph visualization shows an overall decrease in mortality with varying inconsistencies. The summary of the graphical findings is:

I. **Y-Axis (Death Rate):** The death rate ranges from 36.0 to 46.0. It represents the age-adjusted death rates of chronic lower respiratory diseases.

II. **X-Axis (Years):** The years range from 1999 to 2018, representing the time period over which the data was collected.

III. **Trend Line:** The blue line graphically represents the data points for each year. Despite some fluctuations, the death rates have been trending downward over time.

The chart indicates that the age-adjusted death rates of chronic lower respiratory diseases have declined from 1999 to 2018.

The chart we have provided is a line graph titled "Age-adjusted death rates of Influenza and pneumonia." It shows the trend of age-adjusted death rates due to these conditions from 1999/4 to 2018/14. The key findings are:

I. **Y-Axis (Death Rate):** The death rate ranges from 0 to 25.0, representing the age-adjusted death rates of Influenza and Pneumonia.
II. **X-Axis (Years):** The x-axis spans from 1999 to 2018, covering nearly two decades.
III. **Trend Line:** The blue line graphically represents the data points.
IV. **Initial decline (1999-2009):** Death rates significantly decreased from 1999 to 2009. This period likely reflects improvements in healthcare, vaccination efforts, and public health interventions.
V. **Stabilization (2009-2018):** After 2009, the death rate stabilized and fluctuated slightly around 15 people mark. This suggests that efforts to manage or prevent these diseases have been effective.

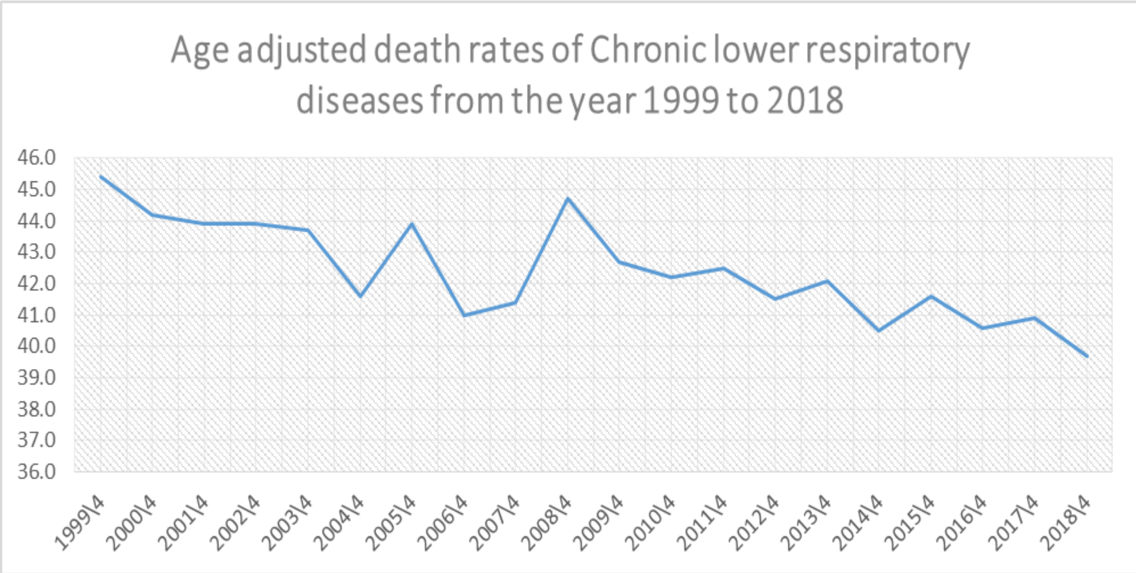

Fig. 9. Adjusted death rate from chronic lower respiratory diseases

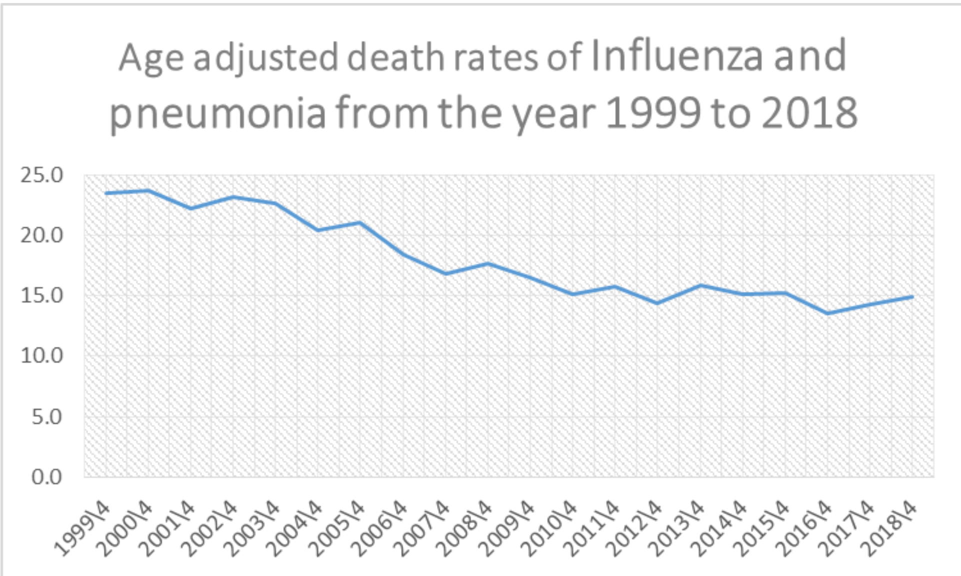

Fig. 10. Adjusted death rate from Influenza and Pneumonia

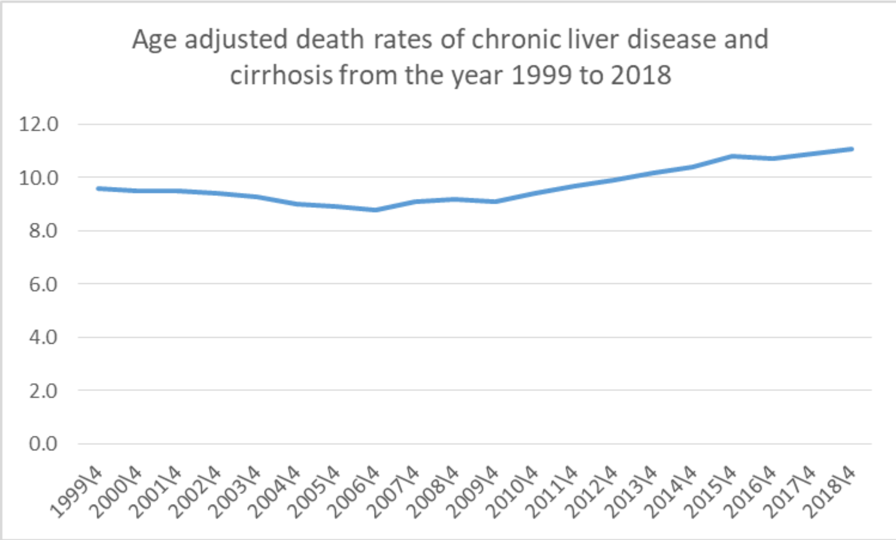

Fig. 11. Adjusted death rate from chronic liver diseases

The chart shows a significant decrease in the age-adjusted death rates due to Influenza and Pneumonia from 1999 to 2018. This suggests that there has been a substantial improvement in the prevention, diagnosis, and treatment of these conditions over the years. Although the age-adjusted death rates have reduced compared to previous years, there is a spike upward (2017-2018), indicating an increase in their adjusted.

The chart we have provided is a line graph titled "Age-adjusted death rates of chronic liver disease and cirrhosis." It shows the trend of age-adjusted death rates due to these conditions from 1999 to 2018.

The x-axis represents the years from 1999 to 2018, while the y-axis indicates the age-adjusted death rates of chronic liver disease and cirrhosis. The blue line in the graph represents the trend of these death rates over the years. The death rates fluctuate slightly but generally remain around the 10.0 mark throughout these years. We observed two year-to-year variations, which are:

I. Stability (1999-2009): From 1999 to around 2009, the death rate remained relatively stable.
II. Slight Increase (2009-2018): After 2009, death rates slightly increased, fluctuating around 15 per 100,000 people.

The chart suggests that the age-adjusted death rates of chronic liver disease and cirrhosis have not significantly changed over this period.

The graph of “Age-adjusted death rates of Diabetes mellitus from 1999 to 2018.” The x-axis represents the years. The y-axis represents the death rate, ranging from 0 to 30. A blue line graphically represents the data, showing the decline in death rates. The death rate due to diabetes appears to have decreased slightly over this period. This positive trend suggests improved management and/or prevention of diabetes-related deaths.

The graph shows the age-adjusted death rates related to Alzheimer’s disease over almost 20 years (from 1999 to 2018). The overall trend indicates a general increase in the death rate due to Alzheimer’s disease during this time frame. The other findings are:

I. The x-axis represents the years, starting from 1999 and ending in 2018, marked at intervals.
II. The y-axis represents the death rate, ranging from 0 to 35.
III. A blue line graphically represents the data points for each year.
IV. Although there was a slight dip around 2004 to 2008, the overall trend is an upward trajectory in death rates over these years.

The analysis of age-adjusted death rates related to Alzheimer's disease over 20 years (from 1999 to 2018) reveals a concerning trend. Despite a slight dip in death rates observed around 2004 to 2008, the overall trajectory shows a notable increase in death rates associated with Alzheimer's disease during this timeframe. This upward trend suggests a growing burden of Alzheimer's disease on public health over the years studied.

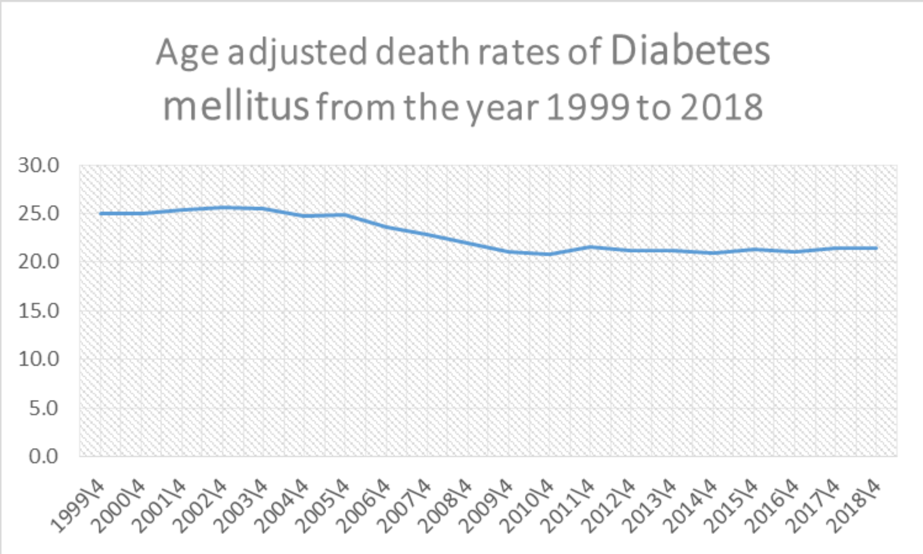

Fig. 12. Adjusted death rate from diabetes mellitus

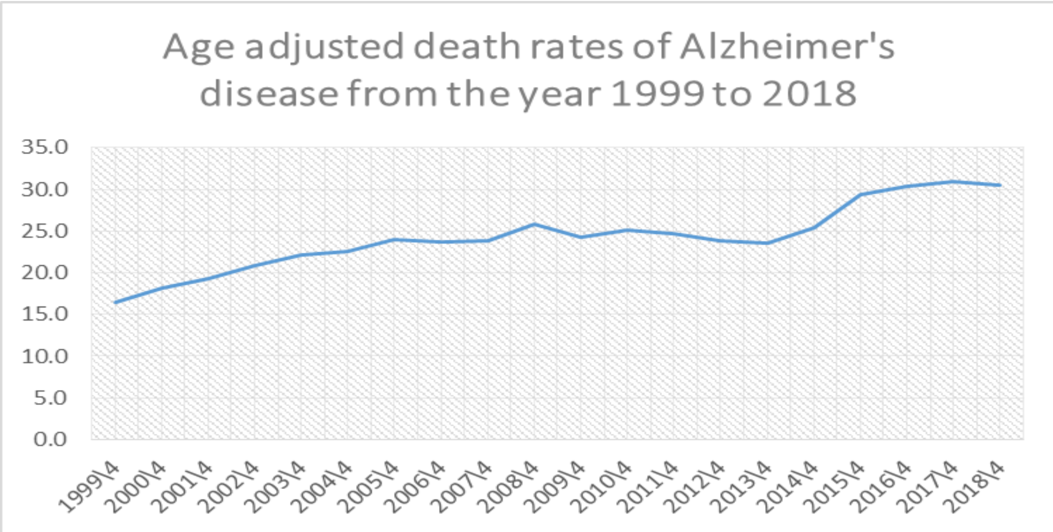

Fig. 13. Adjusted death rate from Alzheimer's

The graph displays the age-adjusted death rates related to Human Immunodeficiency Virus (HIV) disease from 1999 to 2018. Here are the key observations:

I. **Trend:** The line graph shows a steady decline in the death rates over the specified period. This decline indicates significant progress in managing and treating HIV.
II. **Date Range:** The x-axis represents time in quarters from 1999 to 2018.
III. **Death Rates:** The y-axis represents the age-adjusted death rates, with values ranging from 0.0 to 6.0. The rates have consistently decreased over the years.

The findings from the graph indicate significant progress in the management and treatment of HIV, as evidenced by the steady decline in age-adjusted death rates from 1999 to 2018.

The chart provided is a line graph titled "Age-adjusted death rates of unintentional injuries." It shows the trend of age-adjusted death rates due to the condition.

The blue line in the graph represents the trend of these death rates over the years.

The death rates appear relatively stable, fluctuating around 40 per 100,000 population until around 2013 to 2015. After this point, there is a noticeable increase in the death rate, reaching close to 60 per 100,000 population by 2017.

The chart shows that the age-adjusted death rates due to unintentional injuries have been relatively stable from 1989/91 to around 2013/15. However, there has been a significant increase in these rates from 2013 upward. This suggests that the incidence of deaths due to unintentional injuries has increased in recent years.

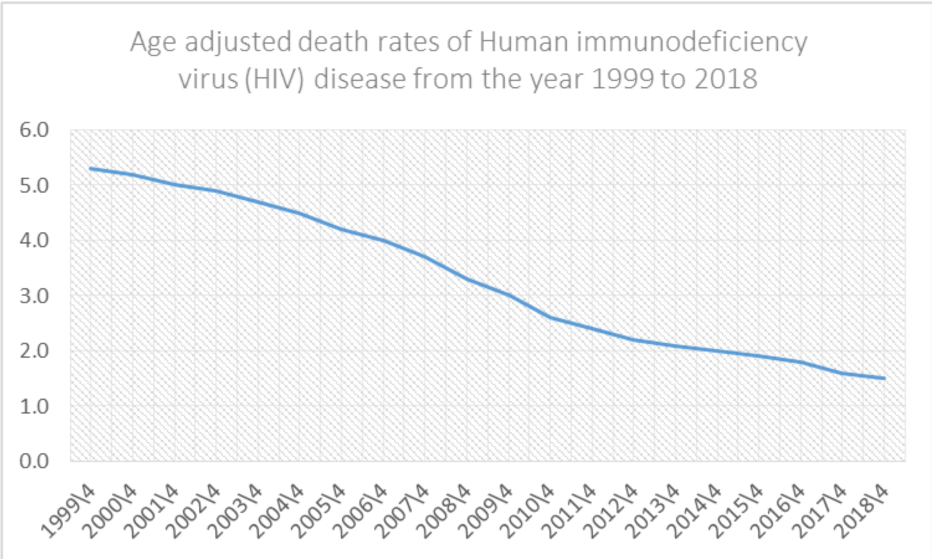

Fig. 14. Adjusted death rate from Human immunodeficiency virus (HIV) disease

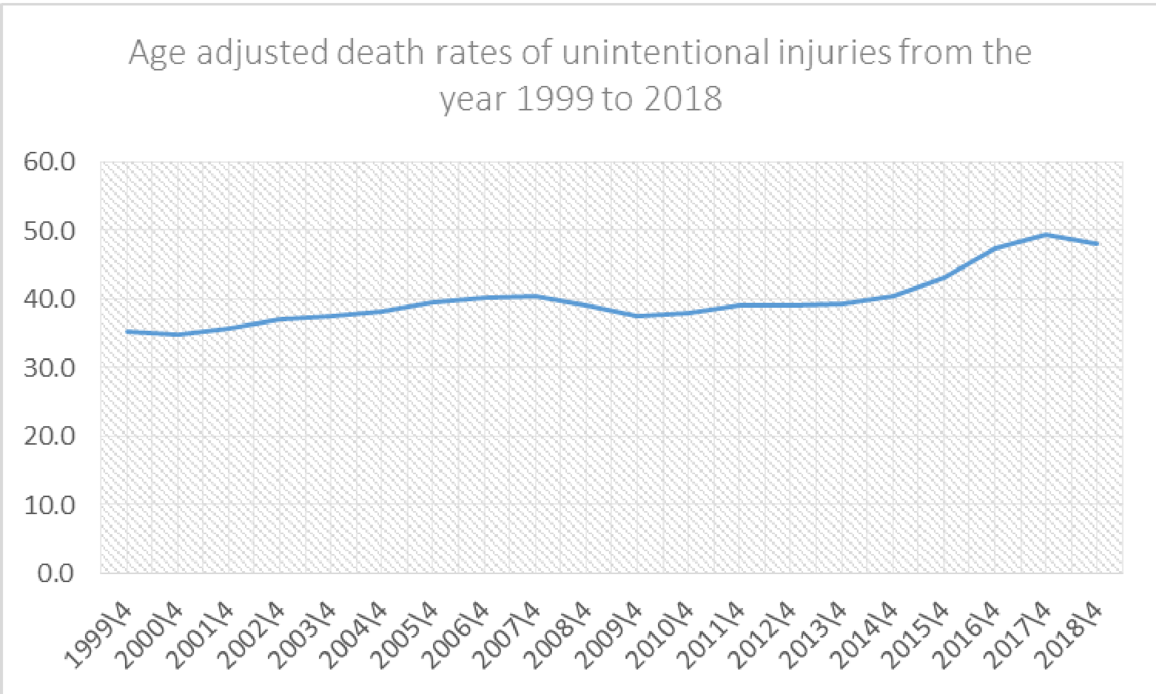

Fig. 15. Adjusted death rate from unintentional injuries

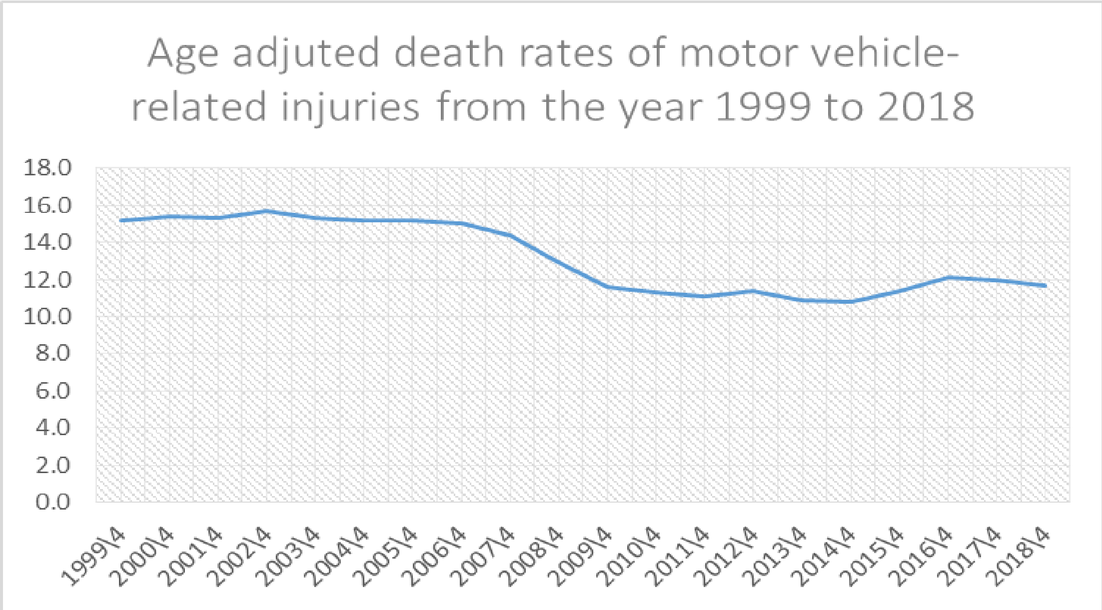

Fig. 16. Adjusted death rate from Motor vehicle-related injuries

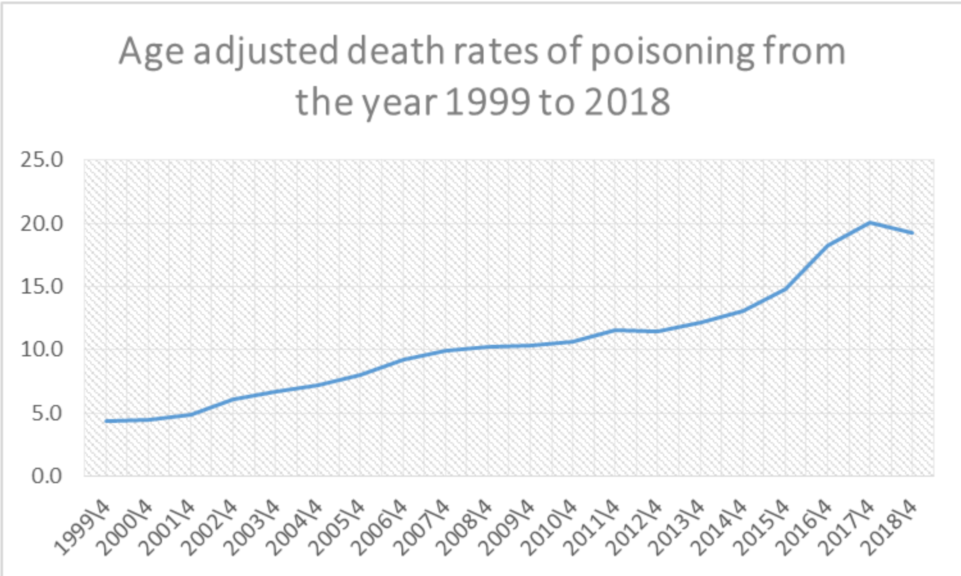

Fig. 17. Adjusted death rate from poisoning

The chart above is a line graph titled "Motor vehicle-related injuries." It shows the trend of motor vehicle-related injuries from 1999/4 to 2018/4.

I. **Trend:** The death rates remained relatively stable from 1999 until around 2006. However, they increased noticeably after that point.
II. **Date Range:** The x-axis represents time in one-year intervals, starting from 1999 and ending in **2018**.
III. **Death Rates:** The y-axis shows the age-adjusted death rates, ranging from 0 to 18.

The graph indicates that the number of deaths due to unintentional injuries has increased over this period.

The chart provided is a line graph titled "Age-adjusted death rates of Poisoning." It shows the trend of age-adjusted death rates due to poisoning.

The x-axis represents the years from 1999 to 2018, while the y-axis indicates the age-adjusted death rates of poisoning. The blue line in the graph represents the trend of these death rates over the years. From 1989 to 2004, the line is relatively flat, indicating that the death rates were stable. However, post-2004, the graph shows a noticeable upward trend, indicating increased death rates.

The chart shows a significant rise in the age-adjusted death rates due to poisoning from around 2004 to 2017. The death rate in 2017 is more than double compared to the early 2000s. This suggests that poisoning-related deaths have become a more severe issue over this period.

The chart provided is a line graph titled "Age-adjusted death rates of nephritis, nephrotic syndrome, and nephrosis." It shows the trend of age-adjusted death rates due to these conditions from 1999 to 2018.

The x-axis of the chart represents the years from 1999 to 2018, while the y-axis represents the death rates. The blue line on the chart represents the age-adjusted death rates for the mentioned diseases. From 1999, there was a slight increase in death rates, peaking around the years 2007 to 2009. After this peak, there was a sharp decline in death rates until around 2014. From 2014 to 2018, the death rates appear to stabilize, with a slight decreasing trend.

The chart shows that the death rates for Nephritis, nephrotic syndrome, and nephrosis increased until around 2009, after which they significantly decreased. This could suggest improvements in healthcare or disease management strategies during this period.

The x-axis of the chart represents the years from 1999 to 2018, while the y-axis represents the death rates. The blue line on the chart represents the age-adjusted death rates for Suicide. From 1999 to 2018, there was a steady increase in suicide rates, indicating that Suicide has become more prevalent over these years.

The chart shows a steady increase in the age-adjusted death rates of Suicide from 1999 to 2018. This suggests that Suicide has become a more significant issue over this period. Economic meltdown and financial recession could be culprits, especially from 2008 to 2011.

The graph represents the age-adjusted death rates of homicide from 1999 to 2018. The y-axis indicates the death rate, ranging from 0.0 to 8.0, and the x-axis represents 1999 to 2018.

The death rate started at around 6 in 1999, experienced a slight increase until the early 2000s, and then gradually decreased to about five around mid-2014. After that, there is a slight increase again towards 2018. This suggests that while there have been fluctuations, the overall trend shows a decrease in the age-adjusted death rates of homicide over this period.

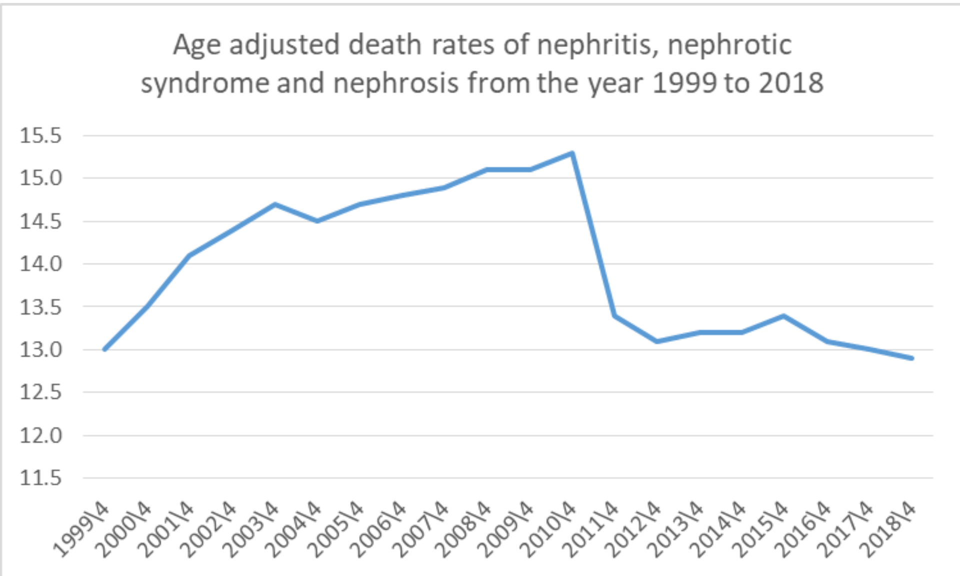

Fig. 18. Adjusted death rate from Nephritis, nephrotic syndrome and nephrosis

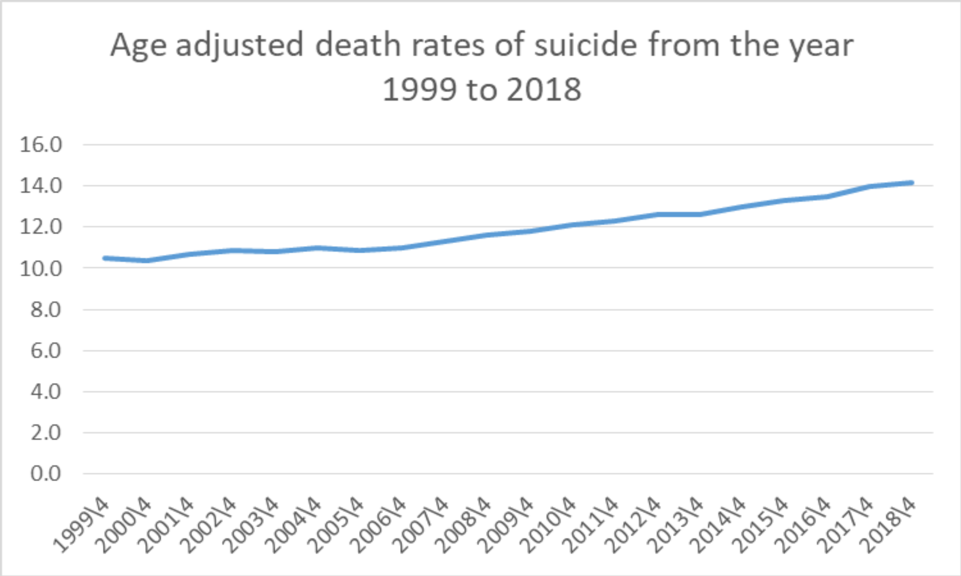

Fig. 19. Adjusted death rate from Suicide

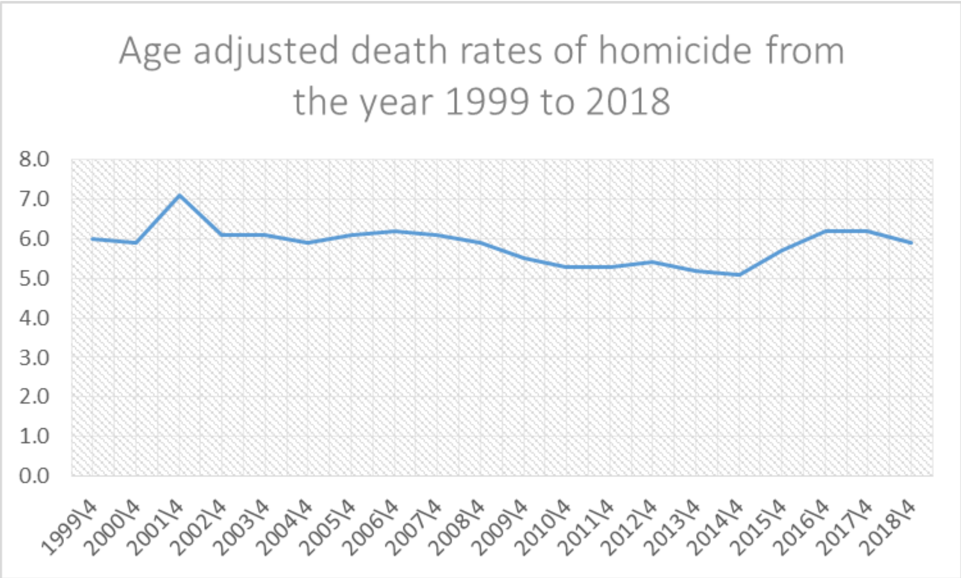

Fig. 20. Adjusted death rate from homicide

The above chart is a stacked area chart representing the age-adjusted death rate for various diseases from 1999 to 2018. The descriptive image shows:

I. **Diseases of the Heart (Orange):** This area dominates the chart, indicating that heart diseases have been the leading cause of death over these years. However, there has been a noticeable decline in deaths due to heart disease over time.
II. **Malignant Neoplasms (Dark Blue):** This area shows slight increases or stability over time, suggesting that the death rate due to malignant neoplasms (cancer) has either slightly increased or remained stable.
III. **Chronic Lower Respiratory Diseases (Light Blue):** This area remains relatively stable, indicating that the death rate due to chronic lower respiratory diseases has not changed significantly.
IV. **Other Diseases:** The remaining colors represent other diseases or causes of death with lower death rates than those mentioned above.

The simple extrapolation is that while heart diseases remain a major cause of death, there is a positive trend showing a decrease in the death rate due to these diseases from 1999 to 2018. However, the death rates for malignant neoplasms and chronic lower respiratory diseases show slight increases or stability, indicating a need for continued focus on prevention and treatment strategies for these conditions.

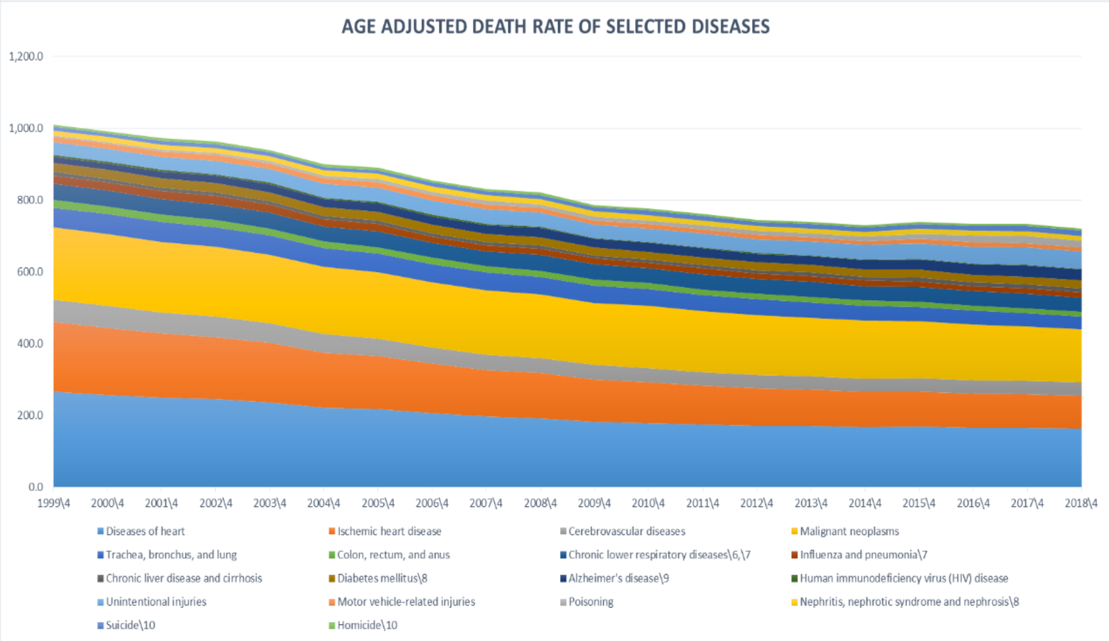

Fig. 21. Adjusted death rate for various diseases in Stacked format

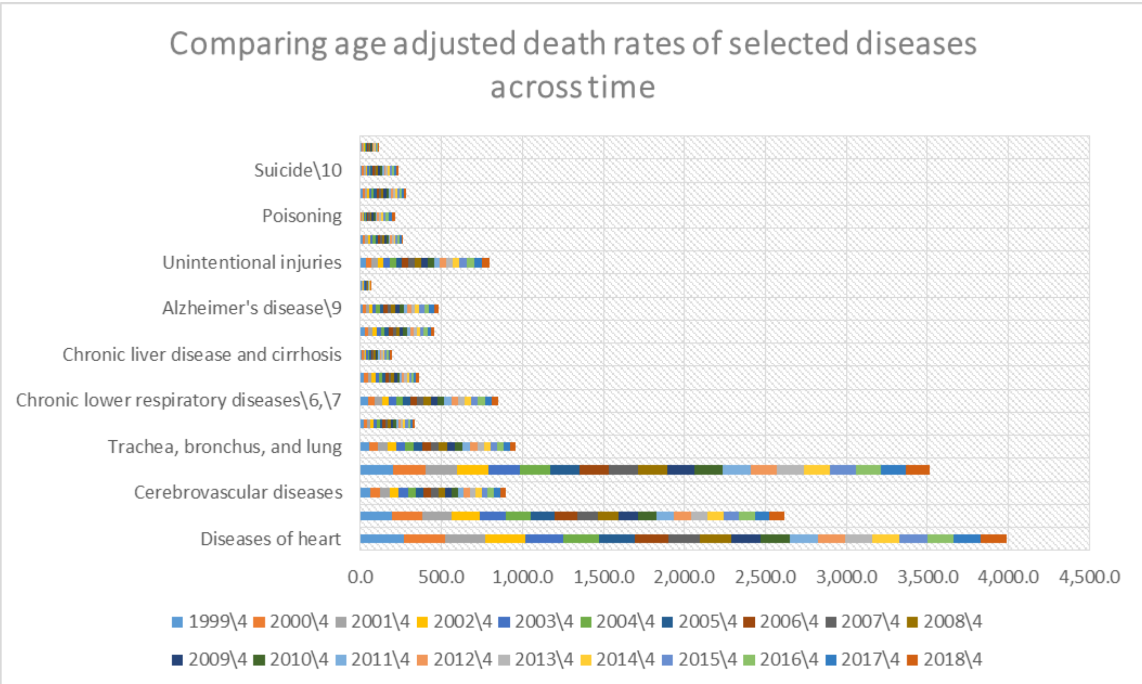

Fig. 22. Charts showing a comparison of the age-adjusted death rate of nine (9) most common causes of death across time

The graph affirms the following:

I. Diseases of the heart account for the largest proportion at 25%.
II. Malignant neoplasms, which include various types of cancers, account for 20%.
III. Unintentional injuries make up 18% of the adjusted death rates.

Other diseases and conditions, including various forms of respiratory diseases, diabetes, Alzheimer's, HIV/AIDS, poisoning, and suicide/homicide, make up the remaining proportions.
The chart illustrates that heart disease, cancer, and unintentional injuries are the leading causes of death. This information can be useful for healthcare professionals and policymakers to prioritize resources and interventions.

The titled "AGE ADJUSTED DEATH RATES OF ALL CAUSES OF DEATH OF MALE COMPARED TO THAT OF FEMALE" provides insights into the age-adjusted death rates for males and females from 1999 to 2014. The key observations based on gender comparison, trends, and specific data points are:

I. **Gender Comparison:**
 a. The blue bars represent males, while the orange bars represent females.
 b. Throughout the years, the death rate for males has consistently been higher than that for females.

II. **Overall Trends:**
 a. Both genders have experienced a decline in death rates over this period.
 b. This decline is evident in the decreasing heights of the bars for both males and females.

III. **Specific Data Points:**
 a. In 1999, the death rate for males was 1,061, while for females, it was 734.
 b. By 2018, the death rate for males had decreased to 855, and for females, it was 611.

Despite the overall decline in death rates, males consistently faced higher mortality rates compared to females during these years. The gap between male and female death rates has decreased over the years. While the death rate for males has seen a significant reduction, the death rate for females has remained relatively constant with a slight increase. This suggests improvements in health and longevity for males over this period. However, it is important to note that this interpretation is based on the chart and may require further context or data for a comprehensive understanding. Please consult with a health professional or researcher for more detailed insights.

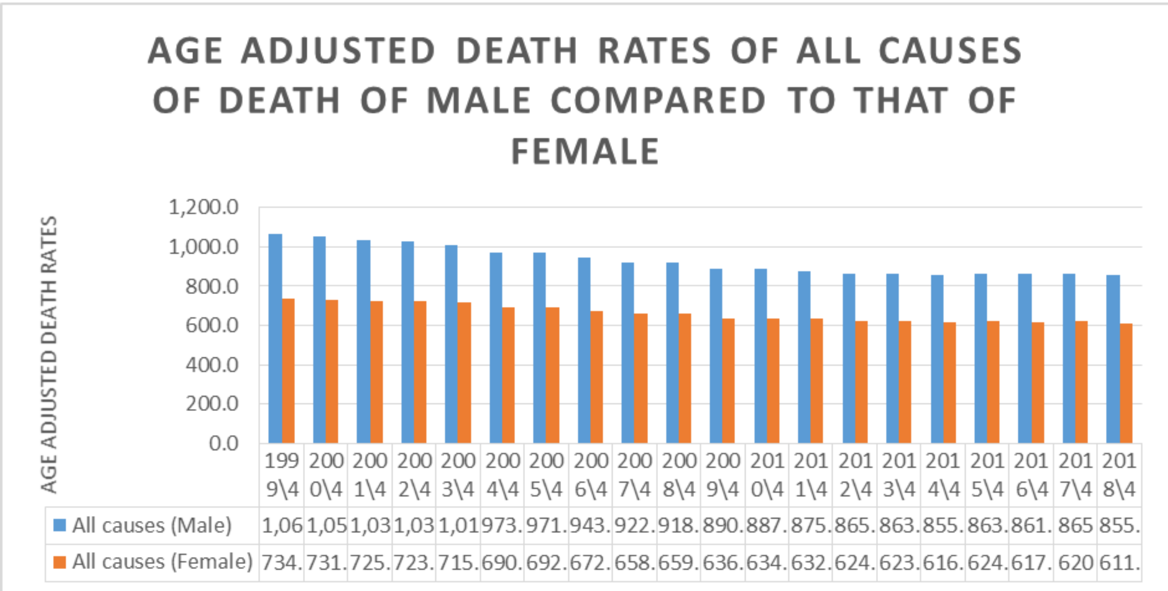

Fig. 23. Charts comparing the Adjusted death rate of all causes of death between males and females

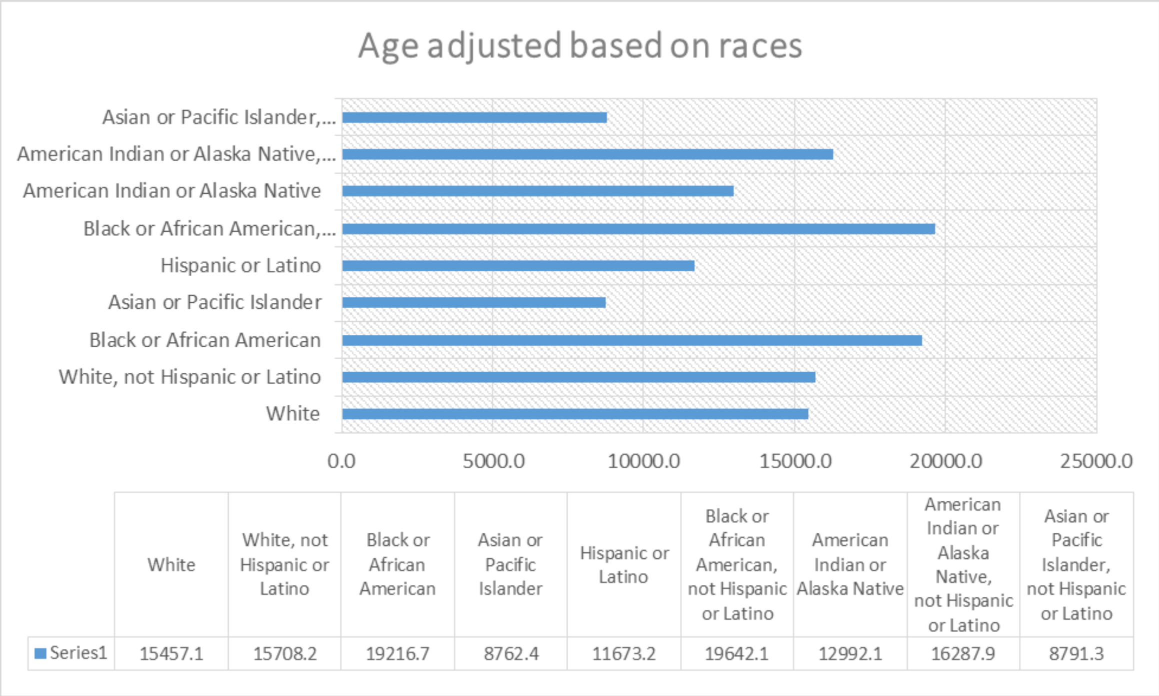

Fig. 24a. Adjusted death rate based on races

The chart above displays age-adjusted death rates based on race.

The chart includes several racial and ethnic groups, and these are:

- White (not Hispanic or Latino)
- Black or African American
- Asian or Pacific Islander
- Hispanic or Latino
- American Indian or Alaska Native (not Hispanic or Latino)
- Black or African American (not Hispanic or Latino)
- Asian or Pacific Islander (not Hispanic or Latino)

The key observations from the graph are:

I. Asian or Pacific Islander: This group has the lowest age adjustment value of 8762.4.
II. American Indian or Alaska Native, Hispanic, or Latino: This group has an age adjustment value of 11673.2.
III. Black or African American, Hispanic, or Latino: Their age adjustment is slightly higher at 12992.1.
IV. White, not Hispanic or Latino: This group has a higher value of 15457.1.
V. Black or African American: They have an even higher age adjustment value of 15708.2.
VI. Hispanic or Latino: This category alone has a significantly higher value at 19624.1.
VII. American Indian or Alaska Native, not Hispanic or Latino: Their age adjustment is 16287.9, which is lower than that of the Hispanic or Latino but higher than those mentioned before.
VIII. Asian or Pacific Islander, not Hispanic or Latino: This chart's average age adjustment value is 8791.3.

The graph displays the death rates for the following groups:

- White (not Hispanic or Latino)
- Black or African American
- Asian or Pacific Islander
- Hispanic or Latino

These rates are age-adjusted, meaning they account for differences in age distribution among the groups.

The key observations from the graph are:

I. For most of the years, the death rate for Black or African American individuals is higher compared to other groups.

II. The White (not Hispanic or Latino) group generally has the lowest death rate.
III. The Asian or Pacific Islander group shows a relatively consistent trend over the years.
IV. The Hispanic or Latino group has a fluctuating pattern. The chart shows that the age adjustment values vary significantly among racial and ethnic groups. The Asian or Pacific Islander group (not Hispanic or Latino) and the Hispanic or Latino group have the highest age adjustment values. Meanwhile, the Asian or Pacific Islander group (including those who are also Hispanic or Latino) has the lowest age adjustment value.

The graphs (24a and 24b) show that the age adjustment values vary significantly among racial and ethnic groups. The Asian or Pacific Islander group (not Hispanic or Latino) and the Hispanic or Latino group have the highest age adjustment values. Meanwhile, the Asian or Pacific Islander group (including those who are also Hispanic or Latino) has the lowest age adjustment value.

Regression analysis: To investigate the relationship between two numerical variables, x and y, we measure the values of x and y on each individual in our sample. We plot the points on a scatter diagram and say we have a linear relationship if the data approximate a straight line. Suppose we believe y is dependent on x, with a change in y being attributed to a change in x rather than the other way around. In that case, we can determine the linear regression line (the regression of y on x) that best describes the straight-line relationship between the two variables.

We would compare age-adjusted death rates for all causes for both males and females. The aim is to determine the *correlation* and investigate the relationship between "All causes (Male)" and "All causes (Female)" to understand how they are correlated.

We conducted a Pearson correlation coefficient test to assess the strength and significance of the correlation between "All causes (Male)" and "All causes (Female)."

Tests for assumptions: Before performing the regression analysis, we need to check if the assumption of linear regression is met using the parameters below (see model summary; Table 1):

1. There is a linear relationship between x and y.
2. Independence of observations.
3. Homoscedasticity.
4. Normality of residuals.
5. There is no perfect multicollinearity.
6. No autocorrelation.

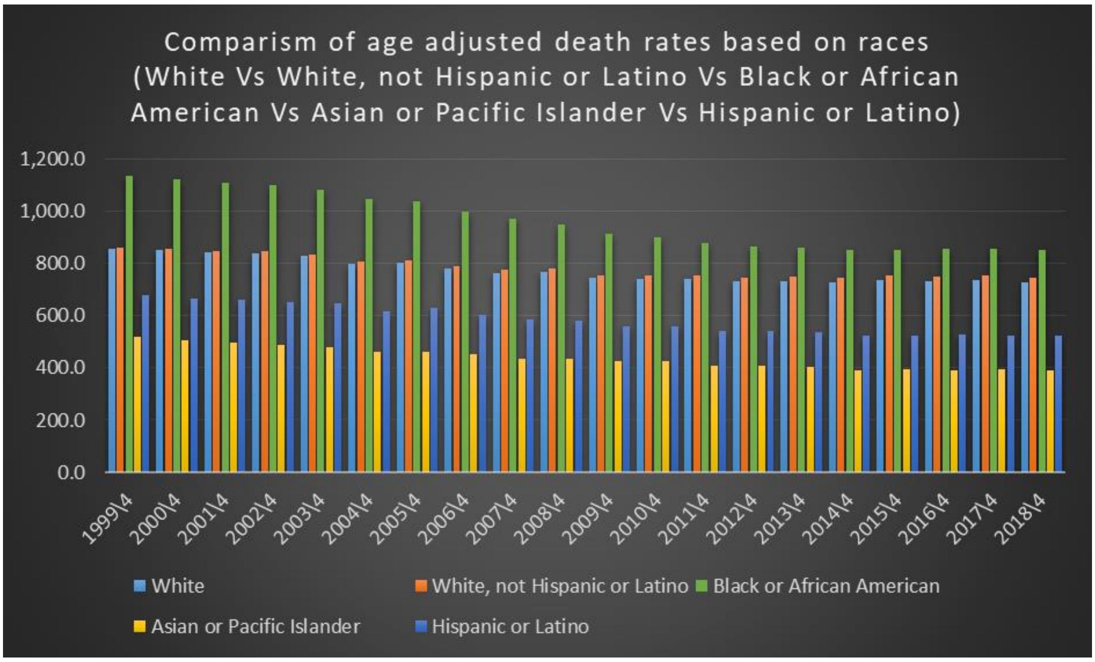

Fig. 24b. Adjusted death rate from races

Table 1. Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.996[a]	.992	.992	6.7240	.992	2313.551	1	18	.000

[a.] *Predictors: (Constant), All causes (Female)*
[b.] *Dependent Variable: All causes (Male)*

Table 2. ANOVA

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	104599.994	1	104599.994	2313.551	.000[b]
	Residual	813.814	18	45.212		
	Total	105413.808	19			

[a.] *Dependent Variable: All causes (Male)*
[b.] *Predictors: (Constant), All causes (Female)*

Table 3. Coefficients

Coefficients											
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-176.104	23.054		-7.639	.000					
	All causes (Female)	1.671	.035	.996	48.099	.000	.996	.996	.996	1.000	1.000

[a.]*Dependent Variable: All causes (Male)*

Table 4. Collinearity diagnostics

Collinearity Diagnostics					
Model	**Dimension**	**Eigenvalue**	**Condition Index**	**Variance Proportions**	
				(Constant)	**All causes (Female)**
1	1	1.998	1.000	.00	.00
	2	.002	30.635	1.00	1.00

[a.] *Dependent Variable: All causes (Male)*

Table 5. Residual statistics

Residuals Statistics					
	Minimum	**Maximum**	**Mean**	**Std. Deviation**	**N**
Predicted Value	845.347	1050.372	930.440	74.1975	20
Std. Predicted Value	-1.147	1.616	.000	1.000	20
Standard Error of Predicted Value	1.506	2.912	2.086	.424	20
Adjusted Predicted Value	843.973	1046.535	930.252	74.0081	20
Residual	-8.7938	16.6276	.0000	6.5446	20
Std. Residual	-1.308	2.473	.000	.973	20
Stud. Residual	-1.377	2.743	.013	1.046	20
Deleted Residual	-9.8945	20.4651	.1883	7.5693	20
Stud. Deleted Residual	-1.414	3.495	.053	1.167	20
Mahal. Distance	.003	2.613	.950	.783	20
Cook's Distance	.000	.869	.083	.193	20
Centered Leverage Value	.000	.138	.050	.041	20
a. Dependent Variable: All causes (Male)					

We can conveniently infer from the model summary (Table 1) results that:

I. The regression model has an adjusted R-squared of 0.992, indicating that approximately 99.2% of the variability in the dependent variable (“All causes (Male)”) can be explained by the independent variable (“All causes (Female)”).
II. The sig f. is less than 0.05, indicating the model is fit and significant.
III. The estimate's standard error is approximately 6.7240. This means that, on average, the predicted values of "All causes (Male)" obtained from the regression model are within approximately 6.7240 units of the actual observed values.

I. The regression model is statistically significant ($p < 0.001$) based on the F-statistic of 2313.551.
II. The residual sum of squares is 813.814, and the total sum is 105413.808.
III. The ANOVA results indicate that the regression model, which includes the independent variable "All causes (Female)," is highly significant in predicting the dependent variable "All causes (Male)." The large F-statistic (2313.551) and the very low p-value ($p < 0.001$) suggest that the model explains a significant amount of variation in "All causes (Male)" beyond what would be expected by chance.

Therefore, we reject the null hypothesis and conclude that the regression model is statistically significant.

Interpretation of Coefficients:

I. Upon examining the Variance Inflation Factor (VIF) as a measure of multicollinearity, the VIF (1.00) is below 10, signifying the absence of multicollinearity. The projected outcomes are accurate and precise.
II. The regression analysis suggests that the independent variable “All causes (Female)” has a highly significant and strong positive effect on the dependent variable “All causes (Male).”Each unit increase in “All causes (Female)” is associated with an approximately 1.671 unit increase in “All causes (Male),” holding other variables constant.

The following are findings from the analysis of Collinearity Diagnostics:

I. Dimension refers to the number of factors included in the collinearity assessment.
II. This analysis has two dimensions: one for the constant term and one for the independent variable "All causes (Female)."
III. The eigenvalue for the first dimension (which includes the constant term) is relatively high, indicating that this dimension explains most of the variance in the data. However, the eigenvalue for the second dimension (which includes the independent variable "All causes (Female)") is very low, suggesting that this dimension explains minimal variance in the data.

The following are findings from the analysis of residual statistics:

I. These statistics assess the quality and distribution of the residuals in the regression model. They help to evaluate the regression analysis assumptions, such as normality, homoscedasticity, and independence of residuals.
II. From the result, it is noticed that the residuals appear to be centered around zero, which is desirable in a regression analysis.

This is a graph of linearity assessment with the x-axis representing the observed cumulative probability (Cum Prob) and the y-axis representing the expected cumulative probability under normality. Most data points are near or on this line, indicating that they closely follow a normal distribution but with slight deviations.

In the plot, the data points align reasonably well with the diagonal line, suggesting that the residuals are approximately normally distributed. This is a positive sign for the linearity assumption.

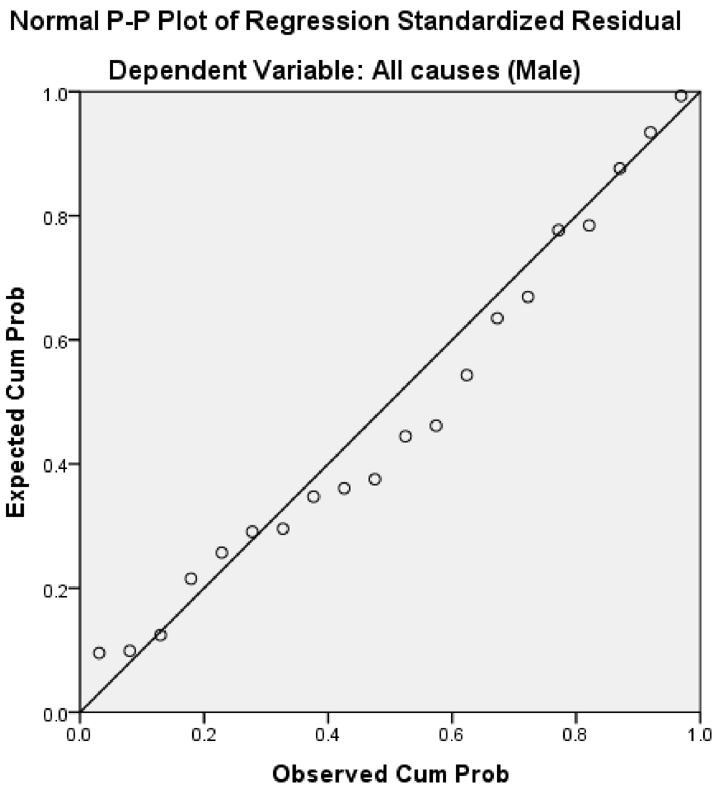

Fig. 25. Linearity assessment

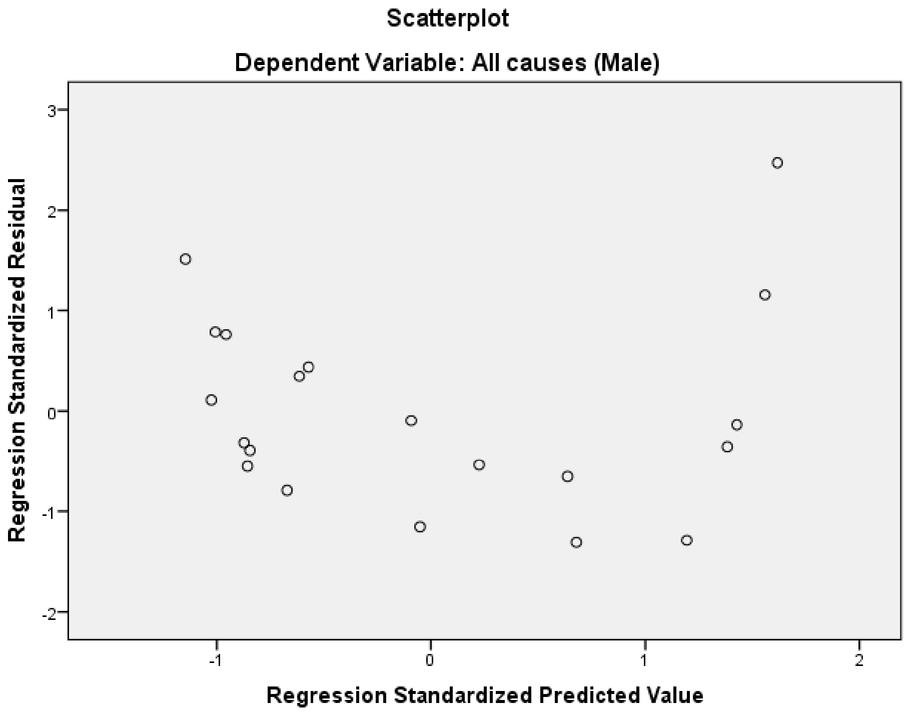

Fig. 26. Linearity assessment

Table 6. Descriptive analysis

Descriptive Statistics			
	Mean	**Std. Deviation**	**N**
All causes (Male)	930.440	74.4855	20
All causes (Female)	662.225	44.4044	20

Table 7. Descriptive analysis (Correlation)

Correlations			
		All causes (Male)	**All causes (Female)**
Pearson Correlation	All causes (Male)	1.000	.996
	All causes (Female)	.996	1.000
Sig. (1-tailed)	All causes (Male)	.000	.000
	All causes (Female)	.000	.000
N	All causes (Male)	20	20
	All causes (Female)	20	20

We can predict our values using the equation Y=$Y = B_o + B_1 x$ from the results. In this case, our Bo (intercept) is -176.104452, B_1 (slope) is 1.670949, and xi is the independent variable (i.e., all causes of females). The coefficient for the predictor variable (All causes—Female) is 1.671, indicating that the dependent variable is expected to increase by 1.671 units for each unit increase in the predictor variable.

Hypotheses: Null Hypothesis (H0): There is no significant correlation between "All causes (Male)" and "All causes (Female)" (i.e., Pearson correlation coefficient ρ=0). Alternative Hypothesis (H1): There is a significant positive correlation between "All causes (Male)" and "All causes (Female)" (i.e., Pearson correlation coefficient ρ>0).

Hypotheses: Null Hypothesis (H0): There is no significant correlation between "All causes (Male)" and "All causes (Female)" (i.e., Pearson correlation coefficient ρ=0). Alternative Hypothesis (H1): There is a significant positive correlation between "All causes (Male)" and "All causes (Female)" (i.e., Pearson correlation coefficient ρ>0).

The explorations from the data analysis are:

I. **Significance Level:** Based on the provided correlation results, the p-value for both variables is 0.000 (two-tailed), indicating strong evidence against the null hypothesis. Therefore, we will set the significance level (α) at 0.05.
II. **Decision rule:** If the p-value is less than 0.05, we will reject the null hypothesis and conclude that there is a significant positive correlation between "All causes (Male)" and "All causes (Female)."If the p-value is greater than or equal to 0.05, we will fail to reject the null hypothesis, suggesting no significant correlation between the variables.

If the null hypothesis is rejected, it implies that there is a strong positive correlation between "All causes (Male)" and "All causes (Female)."This finding may have implications for understanding health outcomes and risk factors across genders. If the null hypothesis is not rejected, it suggests no significant correlation between the variables, which may lead to further investigation into other potential factors influencing health outcomes.

4. DISCUSSION

In 2020, many of the 10 leading causes of death changed rank order due to the emergence of COVID-19 as a leading cause of death in the United States. The leading causes of death in 2019 were, in rank order: Diseases of the heart; Malignant neoplasms; COVID-19; Accidents (unintentional injuries); Cerebrovascular diseases; Chronic lower respiratory diseases; Alzheimer's disease; Diabetes mellitus; Influenza and Pneumonia; and Nephritis, nephrotic syndrome and nephrosis [7,8]. They accounted for 74.1% of all deaths occurring in the United States. The infant mortality rate in the United States for 2019 was 558.3 infant deaths per 100,000 live births and remains relatively stable compared to 2018 [9,10].

The dynamics and trend of mortality prior to 2019 have diverse dimensions, complexity, and analysis. The study statistically illustrates the mortality pattern for 2 decades ending in 2018. In the study, differences in the rankings are evident by age, race (Hispanic origin), and sex. Leading causes of infant death were in rank order: Congenital malformations, deformations, and chromosomal abnormalities; Disorders related to short gestation and low birth weight, not elsewhere classified; Sudden infant death syndrome; Accidents (unintentional injuries); hemorrhage [affected by maternal complications of pregnancy; Newborn affected by complications of placenta, cord, and membranes; Bacterial sepsis of newborn; Respiratory distress of newborn; Diseases of the circulatory system; and Neonatal hemorrhage [4,10,11,12].

The U.S. experienced a mix of declining and increasing mortality trends influenced by chronic diseases and the opioid epidemic. Global mortality trends were largely influenced by a broader range of factors, including significant reductions in communicable disease and maternal and child mortality in many regions. The difference further highlights the impact of healthcare infrastructure, public health policies, and socioeconomic conditions on mortality rates.

The descriptive analysis shows a significant decrease in the age-adjusted death rates due to Influenza and Pneumonia from 1999/04 to 2018/4. This suggests that there has been a substantial improvement in the prevention, diagnosis, and treatment of these conditions over the years. Although the age-adjusted death rates have reduced compared to previous years, there is an upward spike (2017-2018), indicating an increase in the adjusted death rates. The age-adjusted death rates of chronic lower respiratory diseases have improved or declined from 1999 to 2018.

There is a significant decrease in the age death rates due to trachea, bronchus, and lung diseases from 1999/4 to 2018/4. This suggests that there has been a substantial improvement in the prevention, diagnosis, and treatment of these conditions over the years. Malignant neoplasms show a marginal change at the outset from 1999/4 to 2018/4, then a declining trend can be observed. Heart-related conditions remain the leading cause of mortality. The findings indicate significant progress in the management and treatment of HIV, as evidenced by the steady decline in age-adjusted death rates from 1999 to 2018. The analysis of age-adjusted death rates related to Alzheimer's disease over 20 years (from 1999 to 2018) reveals a concerning trend. Despite a slight dip in death rates observed around 2004 to 2008, the overall trajectory shows a notable increase in death rates associated with Alzheimer's disease during this timeframe. This upward trend suggests a growing burden of Alzheimer's disease on public health over the years studied. The Asian or Pacific Islander group (not Hispanic or Latino) and the Hispanic or Latino group have the highest age adjustment values. Meanwhile, the Asian or Pacific Islander group (including those who are also Hispanic or Latino) has the lowest age adjustment value.

The mortality rate trends in the United States from 1999 to 2018 are unique compared to global mortality trends during the same period. Various factors, including healthcare infrastructure, public health policies, and disease prevalence, influence these differences.

The regression analysis reveals a strong and statistically significant relationship between the number of causes in females and males. The model, with an impressive R-square of 0.996, suggests that approximately 99.6% of the variability in male causes can be explained by the number of causes in females. Both the constant term and the coefficient for the predictor variable are statistically significant.

5. CONCLUSION

In the United States, mortality rates significantly changed from 1999 to 2018, influenced by various factors, including advances in medical knowledge, technological input, and the opioid epidemic. During this period, temporal statistical analysis was used to study the effects of these factors on mortality rates across different age groups and genders while adjusting for racial and ethnic differences.

Several studies have highlighted the change in public health trends during this period. For instance, a report by the Centers for Disease Control and Prevention (CDC) noted that the age-adjusted death rate in the United States declined by 14% from 1999 to 2017, which was driven primarily by reductions in death from heart disease, cancer, and other leading causes of death. However, in this period, there was also an increase in mortality rates from causes like drug overdoses, suicides, and chronic liver disease, which have impacted specific demographic groups disproportionately.

Therefore, based on the results, we can conclude that the number of causes in females strongly predicts the number of causes in males.

6. LIMITATIONS

These are secondary data. The retrospective design poses bias.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

DATA SOURCE

National Center for Health Statistics, National Vital Statistics System; Vital statistics of the United States, 1980. Volume II—Mortality, part A. 1985; public-use 2018 Mortality File; and Xu JQ, Murphy SL, Kochanek KD, Arias E. Deaths: Final data for 2019. National Vital Statistics Reports; vol 70 no 8. Hyattsville, MD: National Center for Health Statistics. 2021. Available from: https://www.cdc.gov/nchs/data/nvsr/nvsr70/nvsr70-08-508.pdf. See Sources and Definitions, National Vital Statistics System (NVS).

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COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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