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National Trends and Disparities in Alzheimer's Disease–Related Mortality in the United States, 1979–2023: A CDC WONDER Analysis

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Abstract

Background

Alzheimer’s disease (AD) represents a growing public health challenge in the United States, yet long-term national mortality trends across demographics remain incompletely characterized.

Objective

To evaluate temporal trends in AD-related mortality in the U.S. from 1979 to 2023 and examine disparities by sex, race, census region, and state.

Methods

A population-based, retrospective analysis was conducted using the CDC WONDER Multiple Cause-of-Death database. AD-related deaths were identified using ICD-9-CM code 331.0 (1979–1998) and ICD-10-CM code G30 (1999–2023). Age-adjusted mortality rates (AAMRs) per 100,000 population were calculated using the 2000 U.S. standard population. Joinpoint regression was applied to estimate annual percent change (APC) and average annual percent change (AAPC) with 95% confidence intervals (CIs).

Results

From 1979 to 2023, 2,430,795 AD-related deaths were recorded. National AAMRs increased markedly from 2.72 in 1979 to 216.95 in 2023 (AAPC: 10.61; 95% CI: 8.54–12.72; $p < 0.001$), with multiple phases of acceleration and recent modest declines after 2016. Women consistently exhibited higher AAMRs than men. White individuals had higher mortality rates than Black individuals throughout the study period, although both groups experienced significant increases. Regionally, the West had the highest AAMRs, followed by the South, Midwest, and Northeast. Substantial state-level heterogeneity was observed, with the steepest increases in Mississippi, Tennessee, and West Virginia.

Conclusions

AD-related mortality has risen substantially in the U.S. over the past four decades, with pronounced disparities among demographics. These findings underscore the need for targeted prevention strategies and resource allocation to address the growing and uneven burden of AD mortality.

1. INTRODUCTION

Alzheimer's disease (AD) has become an urgent public health concern in the U.S., carrying a heavy medical, financial, and social burden. In 2023, about 6.7 million Americans aged 65 and older were reported to be living with AD, a number projected to rise sharply in the coming years as the population ages and life expectancy increases.(1) The prevalence of Alzheimer's has grown steadily over the past several decades, driven by demographic shifts and the rising incidence of age-related neurodegenerative conditions. (2)

In 2020, combined costs of healthcare and long-term care for people with Alzheimer's and other dementias were estimated at $305 billion, with projections suggesting that the costs will approach over $1 trillion by 2050 if trends persist. (3) Apart from the economic impact, Alzheimer's disease results in substantial caregiver burden, with over 11 million Americans providing unpaid care, many experiencing high levels of emotional and physical stress. (4) Even though there have been important advances in early detection and biomarker research that help us understand Alzheimer's disease better, the long-term patterns of Alzheimer related deaths are still not well described, especially when looking at different populations and regions. (5) Factors such as improved diagnostic tools, better access to healthcare, and an aging population have all influenced mortality over time, but there are still only a few detailed nationwide studies that have truly explained long-term AD mortality trends. (6)

Despite this heavy burden, long-term time trends in Alzheimer's mortality, 1979–2023 prevalence, and relevant projections up to 2050 are little explored. Filling this gap is crucial to identify vulnerable demographics to better allocate resources in not only managing their disease symptoms but also helping inform preventative care measures. In order to address this, we aim to analyse long-term patterns of Alzheimer's disease mortality in the U.S. between 1979 and 2023, and forecast the burden of deaths till 2050.

2. METHODS

2.1 Population and study design

The CDC Wonder (Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiologic Research) database was employed to retrieve death certificates on Alzheimer’s-related mortality from 1979 to 2023. (7) We collected death records for patients aged 65 and older with International Classification of Diseases-9-Clinical Modification (ICD-9-CM) code: 331.0 for the years 1979 to 1998 and ICD-10-CM code: G30 from 1999 to 2023.(7) The Multiple Cause-of-Death Public Use records were utilized to ensure the inclusion of all instances where Alzheimer's was recorded as either a direct or underlying cause of death. As the analysis was performed using aggregated, de-identified mortality data from a publicly accessible database, individual-level variables such as mean age were not available; therefore, calculation of the mean age of participants was not possible. Given that the data were extracted from a publicly accessible database, institutional review board approval was not required. This study was conducted in accordance with the reporting guidelines established by the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) standards. (8)

2.2 Data Abstraction

The data extracted for analysis specifically included variables such as gender, race, state, and census region. Gender categories included male and female. Racial groups were classified as White and Black. (9) This classification follows the categories established by the CDC WONDER database and has been used in prior studies. The U.S. was further divided into four regions based on the U.S. Census Bureau classification: Northeast, Midwest, South, and West.

2.3 Statistical Analysis

To standardize related deaths, age-adjusted mortality rates (AAMRs) per 100,000 population were calculated using the annual national population totals from the US Census Bureau and the 2000 US standard population, along with the corresponding 95% confidence intervals (CIs). (10) Temporal trends were assessed using the Joinpoint Regression version 5.2.0 (National Cancer Institute). (11) Annual percent change (APC) and its corresponding 95% CI in the AAMRs were computed using this software. Substantial shifts in annual mortality trends were identified by

fitting linear segments at points where evident changes over time were observed. The Monte Carlo permutation method was utilized to determine the annual percentage change (APC) in AAMRs, along with 95% confidence intervals (CIs). To indicate the overall trend in mortality from 1979 to 2023, the average annual percentage change (AAPC) was calculated as a weighted mean of the APCs, with associated 95% CIs. A two-tailed t-test (test for parallelism) was performed to determine whether the APC and AAPC values indicated an increase or decrease in deaths during the study period. A p-value of < 0.05 was regarded as statistically significant.

3. RESULTS

3.1 Annual trends

Between 1979 and 2023, a total of 2,430,795 Alzheimer-related deaths were recorded. During this period, AAMR increased substantially, rising from 2.72 (95% CI: 2.51 to 2.93) in 1979 to 216.95 (95% CI: 215.68 to 218.22) in 2023, with an AAPC of 10.61 (95% CI: 8.54 to 12.72, p < 0.001). The increase was initially substantial from 1979 to 1985 (APC: 54.12; 95% CI: 38.46 to 71.56, p < 0.001), followed by a small rise from 1985 to 1997 (APC: 5.35; 95% CI: 3.79 to 6.93). AAMR experienced a massive surge from 1997 to 2000 (APC: 30.56; 95% CI: 11.95 to 52.25), and an increase from 2000 to 2008 (APC: 3.69; 95% CI: 2.25 to 5.16). A small decrease was observed from 2008 to 2013 (APC: -1.66; 95% CI: -4.52 to 1.29), followed by an increase from 2013 to 2016 (APC: 10.19; 95% CI: 1.32 to 19.83) and finally, a moderate decline occurred from 2016 to 2023 (APC: -1.14; 95% CI: -2.17 to -0.11) **(**Fig. 1, **Supplementary Table 1, Central Illustration).**

3.2 Gender

Across the duration of the study period, adult women exhibited slightly higher AAMRs compared to adult men (overall AAMR for women: 139.38, 95% CI: 138.02-140.73; for men: 107.83, 95% CI: 106.18-109.48). On average, the AAMR of both men and women increased from 1999 to 2023, with women exhibiting a significantly greater magnitude of increment than men [Women: AAPC: 11.48, (CI: 9.10 to 13.91) (p value < 0.001); Men: AAPC: 9.22, (CI: 6.91 to 11.58) (p value < 0.001)].

The AAMR for adult men had a tremendous increase from 1979 to 1985 (APC: 51.04; 95% CI: 34.46 to 69.66) (p value < 0.001), followed by an increase in AAMR from 1985 to 1997 (APC: 3.42; 95% CI: 1.49 to 5.39) (p value < 0.001). There was a significant rise in AAMR from 1997 to 2000 (APC: 27.87; 95% CI: 3.74 to 57.61) (p value = 0.022), followed by a small increase from 2000 to 2020 (APC: 2.09; 95% CI: 1.71 to 2.47) (p value < 0.001). Finally, the trend in AAMR witnessed a decline from 2020 to 2023 (APC: -4.83; 95% CI: -9.66 to 0.25) (p value = 0.061). The AAMR for adult women initially showed a massive surge from 1979 to 1985 (APC: 57.20; 95% CI: 38.27 to 78.71) (p value < 0.001), followed by a slight increase between 1985 and 1997 (APC: 6.45; 95% CI: 4.70 to 8.24) (p value < 0.001), after which AAMR manifested a surge in trend between 1997 and 2000 (APC: 30.61; 95% CI: 10.96 to 53.75) (p value = 0.002). There was a rise in AAMR between 2000 and 2005 (APC: 6.01; 95% CI: 2.23 to 9.94) (p value = 0.003), followed by a slight decrease from 2005 to 2013(APC: -0.03; 95% CI: -1.38 to 1.34) (p value = 0.964), and an increase from 2013 to 2016 (APC: 9.82; 95% CI: 0.34 to 20.19) (p value = 0.043). Lastly, a decline in AAMR was experienced from 2016 to 2023 (APC: -0.79; 95% CI: -1.89 to 0.31) (p value = 0.152) **(**Fig. 1, **Supplementary Table 1, Supplementary Table 3)**

3.3 Race/Ethnicity

Throughout the study period, AAMRs were consistently higher among White individuals compared to Black individuals. Between 1979 and 2023, 2,131,359 Alzheimer's-related deaths occurred among Whites. The AAMR rose

from 2.88 (95% CI: 2.65 to 3.11) in 1979 to 228.23 (95% CI: 226.81 to 229.65) in 2023, with an AAPC of 10.47 (95% CI: 7.82 to 13.19, p < 0.001). A significant rise was observed from 1979 to 1985 (APC: 54.15; 95% CI: 33.48 to 78.01, p < 0.001), followed by a modest increase from 1985 to 1997 (APC: 5.14; 95% CI: 3.02 to 7.31, p = 0.002). The AAMR rose rapidly from 1997 to 2000 (APC: 32.89; 95% CI: 7.63 to 64.08, p = 0.010), followed by an increase from 2000 to 2020 (APC: 2.36; 95% CI: 1.97 to 2.76, p < 0.001). Lastly, there was a decline in AAMR from 2020 to 2023 (APC: -4.43; 95% CI: -9.55 to 0.98, p = 0.103). In contrast, 162,484 Alzheimer's-related deaths occurred in Blacks. Black individuals experienced an increase in AAMR from 1.12 (95% CI: 0.69 to 1.73) in 1979 to 192.23 (95% CI: 188.16 to 196.31) in 2023, with an AAPC of 11.51 (95% CI: 9.93 to 13.10, p < 0.001). This included a sharp rise from 1979 to 1987 (APC: 39.64; 95% CI: 31.77 to 47.97, p < 0.001) and a moderate increase from 1987 to 1997 (APC: 6.86; 95% CI: 5.15 to 8.60, p < 0.001). The AAMR rose markedly from 1997 to 2000 (APC: 33.40; 95% CI: 18.28 to 50.46, p < 0.001) and from 2000 to 2005 (APC: 9.10; 95% CI: 6.38 to 11.90, p < 0.001), followed by a decrease from 2005 to 2013 (APC: -0.13; 95% CI: -1.04 to 0.78, p = 0.766). The AAMR recorded an increase from 2013 to 2016 (APC: 10.39; 95% CI: 4.31 to 16.83, p = 0.002) and from 2016 to 2020 (APC: 1.40; 95% CI: -1.13 to 3.98, p = 0.266), followed by a sharp decline from 2020 to 2023 (APC: -5.95; 95% CI: -8.27 to -3.56, p < 0.001). **(**Fig. 2, **Supplementary Table 2, Supplementary Table 4)**

3.4 Census Region:

From 1979 to 2023, the highest mortality was observed in the West (AAMR: 149.65; 95% CI: 147.11 to 152.18), followed by the South (AAMR:136.04; 95% CI: 134.21 to 137.86), Midwest (AAMR:132.38; 95% CI: 130.20 to 134.56) and Northeast regions (AAMR: 87.37; 95% CI: 85.46 to 89.28). The AAMR of all the regions manifested an upward trend between 1999 and 2023, with the increase most pronounced in South, followed by Midwest, West and Northeast [South: AAPC: 11.31, (CI: 8.75 to 13.94) (p value < 0.001); Midwest: AAPC: 10.08, (CI: 7.77 to 12.43) (p value < 0.001); West: AAPC: 9.93, (CI: 7.47 to 12.44) (p value < 0.001); Northeast: AAPC: 9.02, (CI: 6.83 to 11.26) (p value < 0.001).

The West experienced a massive surge from 1979 to 1985 (APC: 50.18; 95% CI: 31.66 to 71.31) (p value < 0.001), followed by a small rise from 1985 to 1997 (APC: 3.51; 95% CI: 1.48 to 5.59) (p value < 0.001). The AAMR then witnessed a large hike from 1997 to 2000 (APC: 37.20; 95% CI: 12.54 to 67.28) (p value = 0.003), and a small increase from 2000 to 2021 (APC: 2.48; 95% CI: 2.17 to 2.79), (p value < 0.001), finally there was a downward spike from 2021 to 2023 (APC: -7.28; 95% CI: -15.26 to 1.46), (p value = 0.097). Similarly, in the Northeast there was a massive increase from 1979 to 1986 (APC: 38.15; 95% CI: 26.21 to 51.21) (p value < 0.001), followed by a small increase from 1986 to 1997 (APC: 3.91; 95% CI: 1.63 to 6.24) (p value < 0.001), a significant incline from 1997 to 2000 (APC: 35.18; 95% CI: 9.56 to 66.75) (p value = 2.92), and a minor increase from 2000 to 2023 (APC: 0.93; 95% CI: 0.63 to 1.23) (p value < 0.001). In the Midwest, the AAMR increased rapidly from 1979 to 1986 (APC: 43.51; 95% CI: 29.92 to 58.52) (p value < 0.001), followed by a rise from 1986 to 1997 (APC: 4.66; 95% CI: 2.43 to 6.94) (p value < 0.001). The AAMR surged from 1997 to 2000 (APC: 32.20; 95% CI: 8.13 to 61.63) (p value = 0.008), followed by a small increase from 2000 to 2020 (APC: 2.34; 95% CI: 1.96 to 2.72) (p value < 0.001) and then a decrease from 2020 to 2023 (APC: -3.42; 95% CI: -8.60 to 2.05) (p value = 0.208). The South witnessed a tremendous increase 1979 to 1985 (APC: 59.91; 95% CI: 39.13 to 83.80 (p value < 0.001), followed by increases from 1985 to 1997 (APC: 6.37; 95% CI: -4.50 to 8.26) (p value < 0.001),1997 to 2000 (APC: 26.91; 95% CI: 6.30 to 51.50), (p value = 0.010), 2000 to 2005 (APC: 6.40; 95% CI: 2.27 to 10.69), (p value = 0.003). The AAMR then fell from 2005 to 2013 (APC: -0.92; 95% CI: -2.37 to 0.55) (p value = 0.207), succeeded by a rise from 2013 to 2016 (APC: 12.50; 95% CI: 2.43 to 23.57) (p value = 0.016). Lastly, a decline in AAMR was observed from 2016 to 2023 (APC: -2.05; 95% CI: -3.18 to -0.91) (p value < 0.001). **(**Fig. 3, **Supplementary Table 6, Supplementary Table 2, Table 1)**

3.5 States:

Variations in AAMRs were observed among different states, the top 3 states with the highest percentage increase were Mississippi (71,759.3%), Tennessee (45,821,1%), and West Virginia (26,976.4%), while the 3 states with the lowest percentage increase were Alaska (1,406.2%), District of Columbia (1,818.3%), and Massachusetts (1,914.1%). **(**Fig. 4, **Supplementary Table 5)**

4. DISCUSSION

The statistical data from four decades analyzed in this study demonstrated an increase in Alzheimer's disease-related mortality in the U.S. among older adults; the rise in Alzheimer's disease prevalence observed in our study aligns with a similar rise observed in other neurodegenerative disorders.(10) This increase in deaths is most prevalent among older adults, which is especially concerning given that age is one of the primary risk factors for Alzheimer's disease.(11) Another factor might be the rise in obesity in united states, especially considering that Midlife obesity has been shown to increase the risk of dementia, including AD.(11, 12) Another factor that may have contributed to the rise of AD is rising hypertension in the United States,(13) as hypertension is said to be the most prevalent dementia risk factor globally, affecting over 1 billion people. (14) We observed a consistent upward trajectory in overall AD-related mortality with some notable fluctuations. The pattern exhibited seven distinct phases: an initial explosive increase from 1979 to 1985, followed by modest growth from 1985 to 1997, then a massive surge from 1997 to 2000, continued increase through 2008, a brief plateau from 2008 to 2013, another uptick from 2013 to 2016, and finally a moderate decline from 2016 to 2023. Gender-based stratification revealed that women consistently had a higher mortality rate than men throughout the study period, with women showing a marked rate of increase over time. We also observed notable racial disparities, with White individuals demonstrating consistently higher mortality rates compared to Black individuals across the entire study duration. Geographic analysis showed substantial regional variation, with the West exhibiting the highest mortality rates, followed by the South, Midwest, and Northeast regions. State-level analysis also revealed disparities, with Mississippi, Tennessee, and West Virginia showing the steepest increases in mortality over the study period, while Alaska, the District of Columbia, and Massachusetts exhibited the lowest increases.

In regard to sex, we found that women exhibited higher AAMR from Alzheimer's disease compared to men. This difference is partly explained by women's longer life expectancy, which increases the likelihood of reaching ages at which dementia becomes more prevalent. Epidemiological studies consistently show a higher prevalence of AD in women over the age of 65. (15) This disparity may be partly explained by the decline in estrogen associated with menopause, which has been linked to increased AD risk, (16) as well as the higher rates of obesity observed in women, (17) a factor known to contribute to neurodegenerative disease risk. Something to take note of is that AD underreporting on death certificates occurs as physicians list immediate complications like pneumonia as the primary cause while omitting dementia entirely, or relegating it to secondary status. Many certificates fail to mention AD despite documented diagnoses. Men's higher cardiovascular mortality rates may overshadow AD reporting, creating artificial sex differences in recorded dementia deaths. (18)

Regarding race, white individuals showed higher mortality than blacks. Although studies have shown Blacks to be more susceptible and having a higher chance of developing dementia, data analysis revealed higher AAMR among Whites compared to Blacks.(19) This apparent disparity may be partly explained by the observation that Whites generally have a higher life expectancy than Blacks, and individuals older than 65 years are at the greatest risk of developing Alzheimer's disease. (20) Hence, it can be proposed that many Black individuals may not live long enough to develop Alzheimer's disease. Moreover, Black populations experience a higher burden of comorbidities, especially

cardiovascular diseases,(21) which could lead to earlier mortality and consequently underrepresentation of dementia as the cause of death. Furthermore, studies have also shown Blacks to be more likely to experience missed or delayed diagnoses of dementia,(22) further contributing to underreporting. Additionally, awareness regarding dementia and Alzheimer's has increased recently, leading to an increased likelihood of healthcare professionals recognizing, diagnosing, and listing Alzheimer's (dementia) as the cause of death compared to decades ago. Hence, this may amplify the apparent increase in mortality rates of Alzheimer's, especially in populations with access to better healthcare and diagnostic services—a group which is historically more likely to include Whites. One analysis also noted that the sharpest rise in dementia-related mortality coincided with broad changes in coding and certification practices. (20)

An increase in AD AAMR was observed across all U.S. census regions, with clear geographic disparities. The highest AAMR was observed in the West, followed by the South, Midwest, and Northeast regions, respectively. Firstly, the elevated rates in the West may partly be explained by the findings of a recent study linking Alzheimer's disease risk to air pollution, in particular long-term PM2.5 exposure. (23) Given that the Western region is more prone to wildfires, chronic exposure to PM2.5 could contribute to the increased hazard ratios for AD. Additionally, the West generally has lower death rates from competing causes, such as stroke, which might contribute to higher AD-related mortality. (24) The elevated AAMR in the south as compared to the Midwest and Northeast region might be explained by the stroke and the diabetic belt regions identified by studies; these regions overlap parts of the south and may increase the AD-related mortality, as stroke (25) and diabetes (26) can contribute to the development of dementia/AD. However, the presence of these belts, as well as the high cardiovascular mortality in the south, (27) might increase the overall mortality while potentially decreasing the AD AAMR, potentially explaining why West had an elevated AD AAMR compared to the south. The low AD-mortality of the Midwest and Northeast regions, as compared to the West and South regions, may be explained by the high educational attainment rate of the Northeast and the young population of the Midwest, both of which decrease the risk of Alzheimer's disease. Additionally, the Northeast region has a high density of hospitals (28), which may play a role in the earlier diagnosis and better management of Alzheimer's disease, further reducing the mortality rate. Cultural and reporting practices may further contribute to the observed differences, as in some regions, physicians may be more inclined to attribute death to cardiovascular or systemic conditions rather than dementia/AD.

It's essential to recognize multiple limitations in our study when interpreting the results. First of all, our study used death certificate data and ICD-coded deaths, which increases the chances of Alzheimer's disease being underreported or misidentified, especially in the setting of multiple comorbidities. Second, the lack of comprehensive clinical information, such as disease severity, medical comorbidities, or the length and type of therapy in the CDC Wonder database, further hindered our ability to account for underlying etiologies and treatment-related differences. Third, our analysis was limited to only the demographics available from 1979 to 2023, such as Black and White population data. Stratification by urbanization status was not done as this was not available from 1979 onwards. Finally, important social and structural determinants of health, including income, education, and neighbourhood disadvantage, were not available in the data, limiting a deeper understanding of disparities in disease burden and access to care.

5. CONCLUSION

In conclusion, AD-related mortality has increased from 1979–2023, owing in part to rising life expectancy and expanded healthcare access during the same period. Our analysis revealed gender disparities, with females exhibiting higher AAMR than males. Racial differences were also evident, with Whites having higher AAMRs than Blacks. Likewise, discrepancies were noted across U.S. census regions, with the West showing the highest AAMR,

followed by the South, Midwest, and Northeast, respectively. Identifying these demographic and regional patterns can help target prevention strategies, allocate resources more effectively, and design tailored interventions to mitigate AD mortality in the most affected populations.

Declarations

Ethics approval and consent to participate

This study utilized publicly available, de-identified mortality data obtained from the Centers for Disease Control and Prevention (CDC) Wide-ranging Online Data for Epidemiologic Research (WONDER) database. As the data are publicly accessible and contain no individual-level identifiers, this study does not involve human participants as defined by federal regulations and was therefore exempt from institutional review board (IRB) review. Formal ethics committee approval and informed consent were not required in accordance with U.S. Department of Health and Human Services regulations (45 CFR 46).

Consent for publication

Not applicable.

Competing interests

All authors declare no competing interests.

Clinical trial number

Not applicable.

Central Illustration

Trends in U.S. Alzheimers-Related mortality 1979 to 2023 among different demographics.

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Author Contribution

Wasay Mumtaz Awan contributed to writing—original draft preparation and writing—review and editing of the manuscript.Mohid Zulfiqar contributed to data curation, validation, formal analysis, visualization, and writing—review and editing. Hassan Abdul Aziz Dhedhi contributed to the study methodology and writing—review and editing. Ammad Uddin contributed to writing—original draft preparation and writing—review and editing. Taimor Mohammed Khan contributed to writing—original draft preparation and writing—review and editing. Hermann Yokolo contributed

to writing—original draft preparation and writing—review and editing. Muhammad Ahmed contributed to writing—original draft preparation and writing—review and editing.All authors reviewed and approved the final manuscript.

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Data Availability

The data supporting the findings of this study were obtained from the CDC WONDER online database (Centers for Disease Control and Prevention Wide-ranging Online Data for Epidemiologic Research). The datasets used and analyzed during the current study are publicly available and can be accessed at [*https://wonder.cdc.gov*] (https:/wonder.cdc.gov) .

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Figures

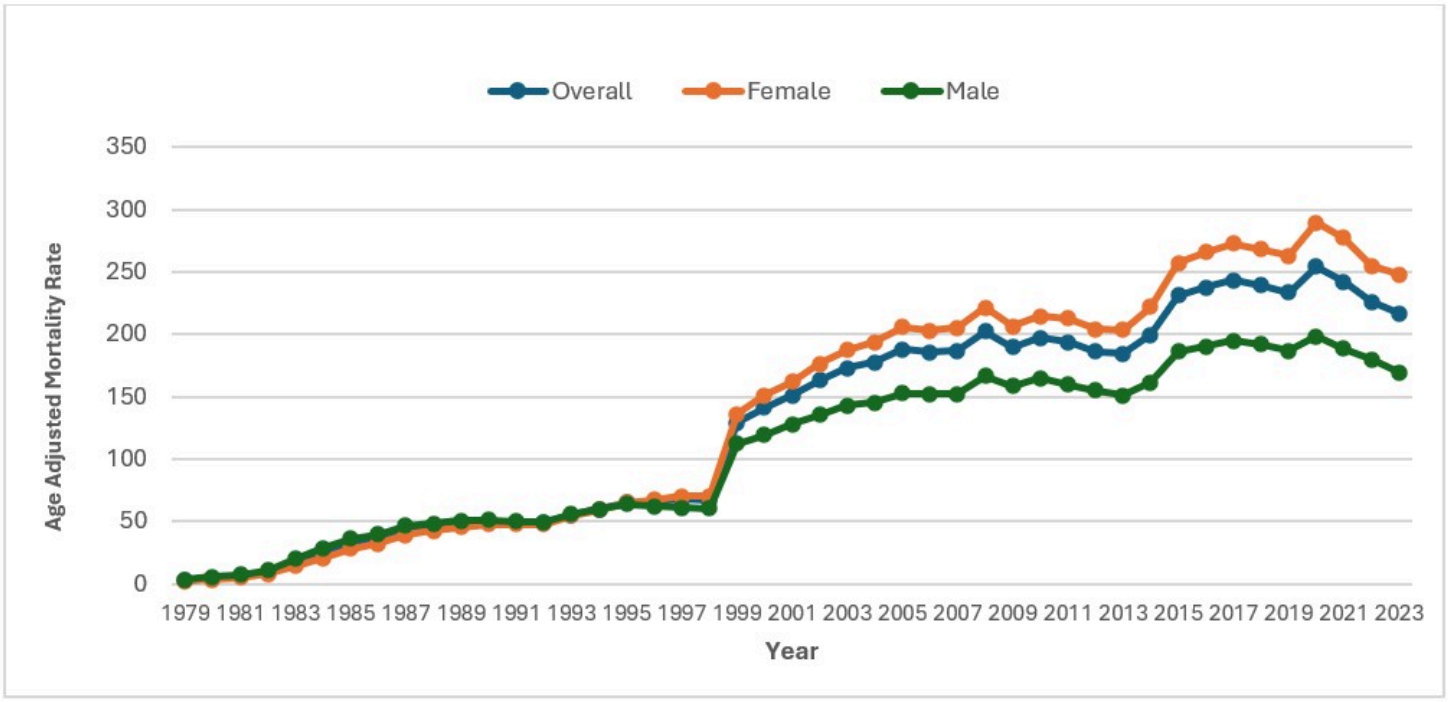


Figure 1

Sex-stratified Alzheimers-related AAMRs per 100,000 among old adults in the United States,1979–2023

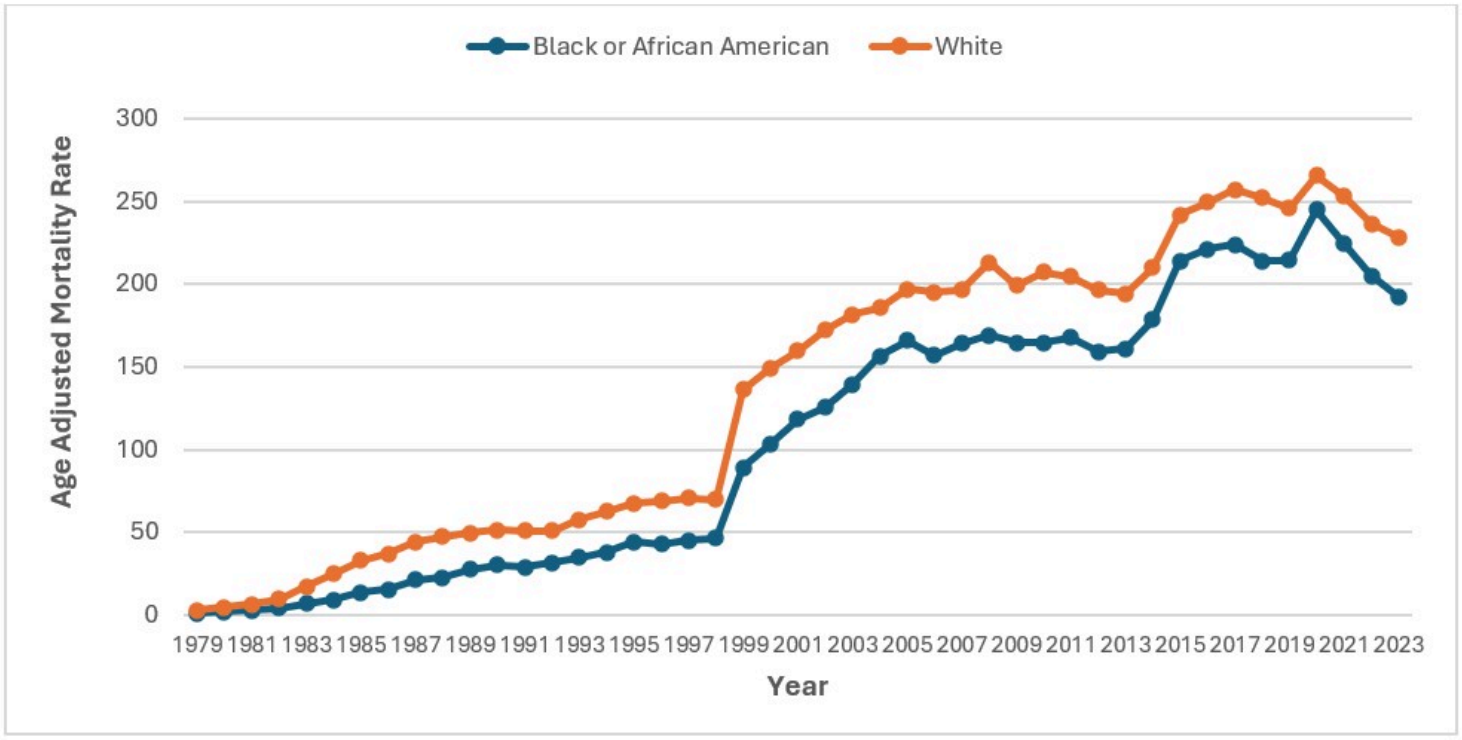


Figure 2

Race-stratified Alzheimers-related AAMRs per 100,000 among old adults in the United States,1979–2023

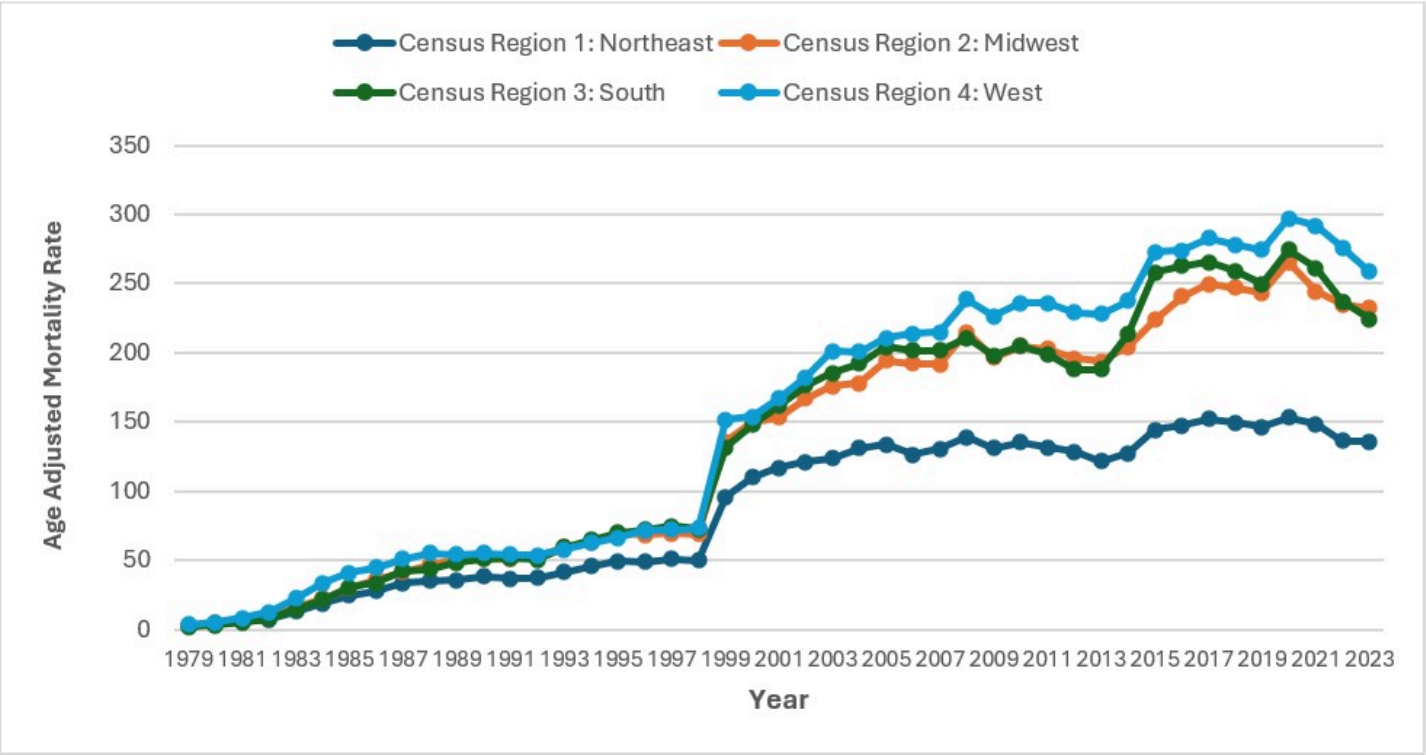


Figure 3

Census region-stratified Alzheimers-related AAMRs per 100,000 among old adults in the United States,1979–2023

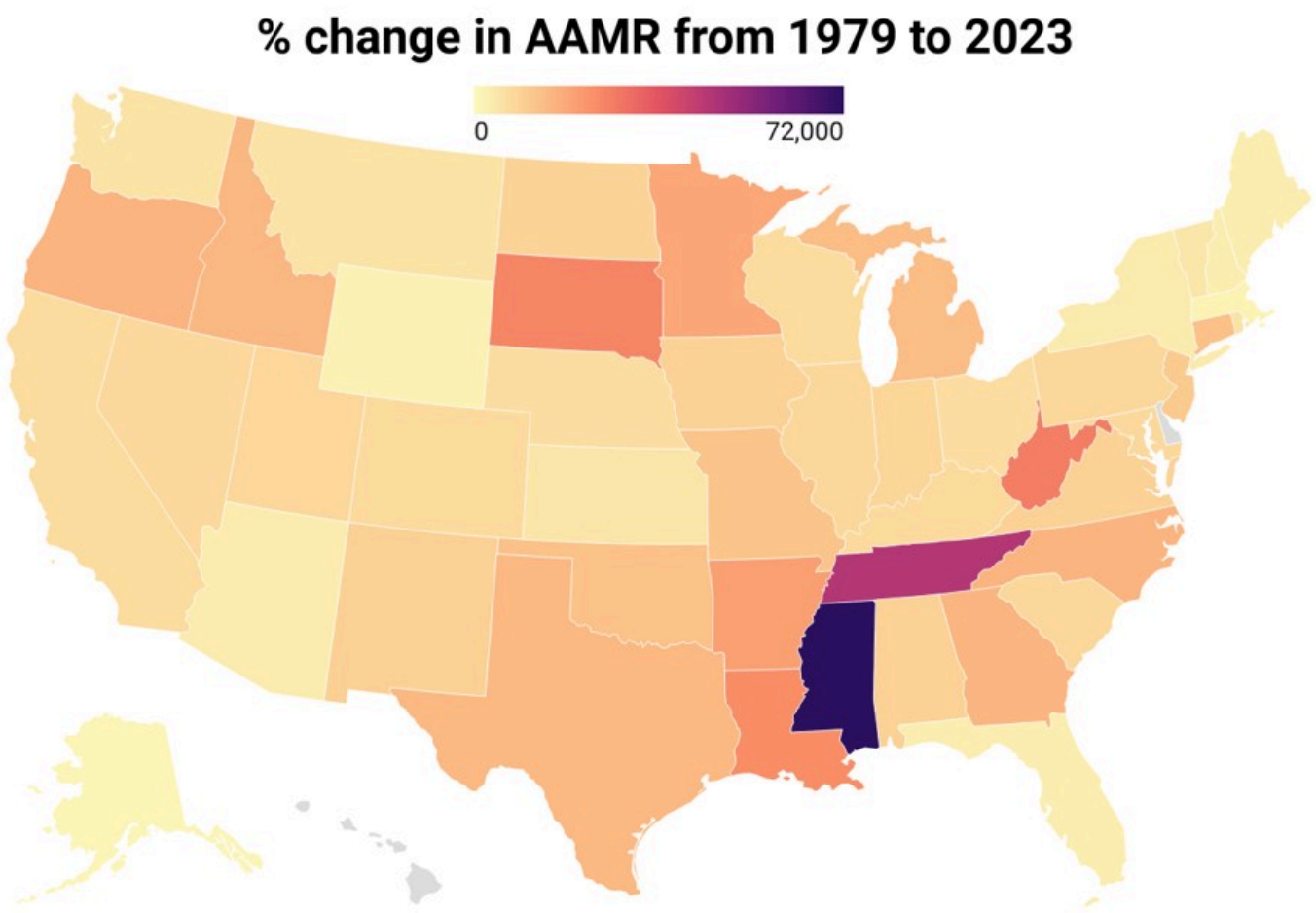


Figure 4

State-stratified Alzheimers-related AAMR percentage change among old adults in the United States,1979–2023

Supplementary Files

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- Alzheimerssupplementarytables.docx