

Trend analysis of Myocardial Infarction and Cerebrovascular Disease Related Mortalities from 1999- 2023, a CDC Wonder analysis

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Abstract

Background

Myocardial infarction (MI) and cerebrovascular disease (CeVD) are leading causes of death in the United States. Although each has been studied separately, long-term national trends in mortality where the two coexist are not well characterised. We examined trends and demographic and geographic disparities in mortality attributable to co-occurring MI and CeVD among US adults from 1999 to 2023.

Methods

We performed a retrospective analysis of the Centers for Disease Control and Prevention Wide-ranging Online Data for Epidemiologic Research (CDC WONDER) Multiple Cause of Death database (1999–2023), identifying deaths that listed both acute MI (ICD-10 I21–I22) and CeVD (ICD-10 I60–I69) among the causes of death. Age-adjusted mortality rates (AAMRs) per 100,000, standardised to the 2000 US standard population, were calculated and stratified by sex, race/ethnicity, age, urbanisation, census region and state. Temporal trends were assessed with Joinpoint regression, yielding annual and average annual percent changes (APC and AAPC) with 95% confidence intervals (CIs); a two-sided $p < 0.05$ was considered significant. Reporting followed the STROBE guideline.

Results

A total of 263,921 deaths were identified. The overall AAMR fell from 7.88 (95% CI 7.76–7.99) in 1999 to 2.55 (95% CI 2.50–2.61) in 2023 (AAPC – 4.61; 95% CI – 5.86 to – 3.35), although it rose non-significantly during 2018–2021. Men had higher AAMRs than women (4.87 vs 3.52). Non-Hispanic (NH) Black adults had the highest burden (6.44) compared with NH White (3.91), NH Other (3.67) and Hispanic adults (3.55). AAMR increased markedly with age and was highest in adults aged ≥ 65 years (21.89). Rural areas exceeded urban areas (5.49 vs 4.02), and the South (4.45) and Midwest (4.17) had the highest regional rates; Mississippi (7.79) was highest and Utah (2.37) lowest among states. Most deaths occurred in medical facilities (59.6%).

Conclusions

Mortality from co-occurring MI and CeVD declined substantially over 25 years but plateaued or rose around 2018–2021, and pronounced disparities persist by sex, race/ethnicity, age and geography. Targeted, equity-focused prevention and improved access to timely cardiac and stroke care are needed for high-burden populations and regions.

Background

Myocardial infarction (MI) and cerebrovascular disease (CeVD) represent the leading causes of death in the United States, ranking first and fifth in terms of overall mortality in accordance with latest national health data (1). Each year, MI causes over 400,000 deaths, while CeVD causes around 160,000 deaths, collectively

representing roughly 25% of all deaths in the United States (2, 3). MI mortality has decreased significantly during the last 25 years, with more than 60% decline in deaths due to MI since 1999 (4). Despite this development, MI continues to be among the leading causes of premature death, particularly in certain demographic groups. (5).

CeVD mortality has followed a somewhat different trajectory. While overall CeVD mortality declined substantially until the early 2010s, recent data show a plateau and possibly minor rises in mortality rates among younger persons and groups with underlying risk factors such as hypertension and diabetes (6, 7). Moreover, stroke related deaths remain one of the leading causes of chronic disability and death in the U.S, with a notable increase in hospitalizations and mortality in certain geographic regions and minority populations (8, 9).

Nonetheless, recent study literature has primarily focused on short-term survival rates and hospital-based cohorts. (10, 11) Population-level studies over long periods that incorporate several demographic aspects remain limited (10, 11). Although several population-based studies investigated MI or CeVD separately, none have assessed both conditions together, despite their common coexistence and shared risk architecture. (5, 6, 7)

The CDC WONDER database provides a strong foundation for investigating these trends and disparities, and combining data from government health statistics, epidemiological research, and public health reports improves interpretation and broadens understanding (12). This study aims to evaluate trends and disparities in MI and CeVD mortality in the US using the CDC WONDER database from 1999 to 2023, using population-level data stratified by age, sex, race, and geography. Highlighting these patterns will support targeted public health policies and interventions designed to reduce cardiovascular mortality and address persistent inequities.

Methods

Study setting and population

We conducted a retrospective analysis of mortality data in the United States using the Centers for Disease Control and Prevention's (CDC) Wide-Ranging Online Data for Epidemiologic Research (WONDER) Multiple Cause of Death database (1999–2023) (13). We defined MI with cerebrovascular disease (CeVD)-related deaths as death records that reported both an acute myocardial infarction (MI) and cerebrovascular disease (CeVD) as causes of death. Deaths were identified in which both myocardial infarction (ICD-10 codes I21–I22) and cerebrovascular disease (ICD-10 codes I60–I69) were listed among the multiple causes of death. We included all deaths among individuals aged 15 years and older on the death certificate. Cases with suppressed data (less than 10 fatalities in a cell, under CDC WONDER's privacy guideline) were omitted from the studies. As the present study involved publicly available, de-identified data, approval from the institutional review board was waived.

Variables and Data Extraction

We calculated the age-adjusted mortality rate (AAMR) for each group of interest in terms of deaths per 100,000 persons per year, adjusted for the 2000 U.S. standard population. The CDC's WONDER query yielded

AAMRs with 95% confidence intervals and corresponding crude death numbers. We investigated mortality trends and disparities across several demographic and geographic stratifications, including sex (male and female). race/ethnicity: non-Hispanic White, non-Hispanic Black, Hispanic, and non-Hispanic Other (including American Indian/Alaska Native and Asian/Pacific Islander, grouped due to small numbers), age groups: younger adults (15–44 years), middle-aged adults (45–64 years), and older adults (≥ 65 years), urbanization refers to the distinction between urban and rural counties of residency, as described by the National Center for Health Statistics (metropolitan counties are considered urban, non-metropolitan counties are considered rural) (16), region: U.S. Census regions (Northeast, Midwest, South, West) (15) and States. We also tabulated the distribution of place of death (location where the death occurred), as reported in the death certificate data (e.g. hospital/medical facility, nursing home or long-term care, home, hospice, or other location).

Statistical Analysis

Trends in annual age-adjusted mortality rates were assessed using the Joinpoint Regression Program (National Cancer Institute, Version 5.0.2). Temporal trends were analyzed with Joinpoint regression, which models log-linear segments over time on the mortality data and identifies points where the slope ('joinpoints') statistically changes using permutation testing. Each joinpoint indicates a statistically significant change in the slope of the underlying trend. The log-transformed AAMR was modelled as a function of year using weighted least squares (with weights proportionate to the rate's inverse variance), as per standard NCI Joinpoint settings. The software used permutation testing to determine the optimum number of joinpoints (up to a predefined maximum). We determined the annual percent change (APC) in mortality rate for each segment of the trend, and we computed the average annual percent change (AAPC) as a summary measure for the entirety of 1999–2023 period, each with its own 95% confidence interval. Statistical significance was assumed at a two-sided $p < 0.05$ for trend alterations or inter-group comparisons. All analyses were conducted on aggregate, de-identified data; thus, there was no need for consent at the subject level. We have adhered to the STROBE criteria (14) for reporting of observational studies in the preparation of this manuscript.

Results

Between 1999 and 2023, MI with cerebrovascular disease (CeVD) accounted for a total of 263,921 fatalities among individuals aged 15 years and older in the United States (Table 1). (Supplementary Table 1) This death toll was prevalent across various settings, with the leading most occurring in medical Facilities (59.6%), 20.1% in nursing homes/long term care facilities, 15.7% in descendant's home, 2.39% at other locations and 2.17% in hospice facilities (Supplementary Table 2).

Table 1
Deaths and mortality rates for myocardial infarction with cerebrovascular
disease, US, 1999–2023

Variable	Deaths (n)	AAMR per 100,000 (95% CI)
Overall population	263921	4.10 (4.03–4.18)
Sex		
Men	128722	4.87 (4.74–5.01)
Women	135199	3.52 (3.43–3.62)
US census region		
Northeast	45017	3.48 (3.32–3.64)
Midwest	61083	4.17 (4.01–4.33)
South	103312	4.45 (4.31–4.58)
West	54509	4.00 (3.84–4.17)
Race/ethnicity		
NH Black or African American	36024	6.44 (6.11–6.77)
NH White	202673	3.91 (3.82–3.99)
NH Other	9013	3.67 (3.11–3.87)
Hispanic or Latino	15486	3.55 (3.26–3.84)
Age group		
15–44 years	2801	0.09 (0.07–0.10)
45–64 years	36590	1.91 (1.82–2.01)
65–85 + years	224530	21.89 (21.45–22.33)
Urbanisation (2013 NCHS)		
Urban	181193	–
Rural	54732	–
Place of death		
Medical facility	59.6%	–
Decedent's home	15.7%	–
Hospice facility	2.17%	–
Nursing home / long-term care	20.1%	–
Other	2.39%	–

AAMR, age-adjusted mortality rate; CI, confidence interval; NCHS, National Center for Health Statistics; NH, non-Hispanic. ¶Crude mortality rate is reported for age groups instead of AAMR. ¶Percentages are shown for place of death; AAMR is not applicable. Place-of-death percentages are from Supplementary Table 2.

Annual Trends for MI with Cerebrovascular Disease-Related AAMR Among Adults

The overall age-adjusted mortality rate (AAMR) for myocardial infarction with cerebrovascular disease (CeVD)-related deaths among adults decreased from 7.88 (95% CI: 7.76–7.99) in 1999 to 2.55 (95% CI: 2.50–2.61) in 2023, corresponding to an overall decline (AAPC: -4.61; 95% CI: -5.86 to -3.35; $p < 0.001$) (Fig. 1). Joinpoint analysis demonstrated a significant decline from 1999–2002 (APC = -5.52; 95% CI: -8.47 to -2.43; $p = 0.0023$), followed by a steeper decrease from 2002–2009 (APC = -9.02; 95% CI: -10.16 to -7.86; $p < 0.001$) and a continued decline from 2009–2018 (APC = -3.49; 95% CI: -4.41 to -2.55; $p = 0.006$). A non-significant increase in AAMR was observed from 2018–2021 (APC = 6.41; 95% CI: -2.50 to 16.15; $p = 0.146$) followed by a non-significant decline from 2021–2023 (APC = -8.13; 95% CI: -16.04 to 0.52; $p = 0.062$) (Fig. 1; Supplementary Table 3).

Age-adjusted mortality rate (AAMR) per 100,000 population with Joinpoint-derived trend segments. MI, myocardial infarction.

MI with Cerebrovascular Disease-Related AAMR Stratified by Sex

The AAMR decreased for both men and women from 1999 to 2023. Among men, AAMR declined from 9.38 (95% CI: 9.17–9.60) in 1999 to 3.08 (95% CI: 2.99–3.17) in 2023. Similarly, among women, AAMR decreased from 6.86 (95% CI: 6.72–7.01) to 2.14 (95% CI: 2.07–2.21).

Across the study period, men exhibited significantly higher mean AAMRs compared to women (men: 4.87; 95% CI: 4.74–5.00 vs. women: 3.53; 95% CI: 3.43–3.62). Overall, AAMR declined significantly in both sexes, with a slightly greater magnitude of decline observed among women (women: AAPC = -4.69; 95% CI: -5.59 to -3.79; $p < 0.001$; men: AAPC = -4.64; 95% CI: -5.98 to -3.29; $p < 0.001$).

Among men, AAMR declined steeply from 1999–2010 (APC = -8.25; 95% CI: -8.79 to -7.72; $p < 0.001$), followed by a less steep decline from 2010–2018 (APC = -2.60; 95% CI: -3.90 to -1.29; $p = 0.008$), a non-significant increase from 2018–2021 (APC = 7.56; 95% CI: 2.30 to 18.43; $p = 0.126$), and a subsequent decline from 2021–2023 (APC = -9.54; 95% CI: -17.9 to -0.27; $p = 0.044$).

Among women, AAMR declined from 1999–2002 (APC = -4.58; 95% CI: -8.06 to -0.96; $p = 0.017$), followed by a steeper decrease from 2002–2006 (APC = -10.1; 95% CI: -13.8 to -6.17; $p < 0.001$), and a continued decline through 2014 (APC = -6.47; 95% CI: -7.74 to -5.18; $p < 0.001$), after which a stable trend was observed from 2014–2023 (APC = -0.59; 95% CI: -1.57 to 0.40; $p = 0.222$) (Fig. 2; Supplementary Table 4).

AAMR per 100,000 for men and women with Joinpoint-derived trend segments.

MI with Cerebrovascular Disease-Related AAMR Stratified by Race/Ethnicity

The AAMR decreased across all racial/ethnic groups from 1999 to 2023: Hispanic (6.71 to 2.17), non-Hispanic (NH) Black (12.18 to 3.88), NH White (7.50 to 2.51), and NH Others (7.80 to 1.83). Modest heterogeneity in AAMRs was observed across groups, with the highest mean among NH Black individuals (6.44; 95% CI: 6.11–6.77), compared to NH White (3.91; 95% CI: 3.82–3.99), NH Others (3.67; 95% CI: 3.11–3.87), and Hispanic individuals (3.55; 95% CI: 3.26–3.84). Overall, AAMR declined significantly across all racial/ethnic groups (Hispanic: AAPC = -4.44; 95% CI: -5.15 to -3.73; $p < 0.001$; NH Black: AAPC = -4.62; 95% CI: -5.28 to -3.95; $p < 0.001$; NH White: AAPC = -4.46; 95% CI: -5.28 to -3.95; $p < 0.001$; NH Others: AAPC = -5.69; 95% CI: -7.50 to -3.77; $p < 0.001$). Among Hispanic individuals, AAMR declined from 1999–2013 (APC = -7.31), followed by a stable trend from 2013–2023 (APC = -0.27). Among NH Black individuals, AAMR declined from 1999–2014 (APC = -7.58), followed by a non-significant increase from 2014–2023 (APC = 0.53). Among NH White individuals, AAMR declined from 1999–2002 (APC = -5.71), followed by a steeper decrease from 2002–2009 (APC = -8.97) and a continued decline through 2018 (APC = -3.29), before a non-significant increase from 2018–2021 (APC = 6.30), and a subsequent decline from 2021–2023 (APC = -6.87). In NH Others, AAMR declined from 1999–2015 (APC = -7.64), followed by a non-significant increase from 2015–2021 (APC = 2.46), and a subsequent decline from 2021–2023 (APC = -13.15) (Fig. 3; Supplementary Table 5).

AAMR per 100,000 by race/ethnicity with Joinpoint-derived trend segments. NH, non-Hispanic.

MI with Cerebrovascular Disease- Related AAMR Stratified by Age-Group:

The AAMR decreased across all age groups from 1999 to 2023: younger adults (0.12 to 0.09), ages 45–64 (2.70 to 1.82), ages 65+ (43.40 to 11.87). Differences in AAMRs were observed across age groups, with the highest mean AAMR among older adults (21.9; 95% CI: 21.5–22.3), followed by middle-aged adults (1.90; 95% CI: 1.82–2.01) and younger adults (0.09; 95% CI: 0.07–0.10). Overall trends demonstrated a significant decline in AAMR among older adults (AAPC = -5.26; 95% CI: -6.49 to -4.01; $p < 0.001$) and middle-aged adults (AAPC = -1.66; 95% CI: -2.83 to -0.47; $p = 0.006$), while rates remained stable among younger adults (AAPC = 0.05; 95% CI: -1.52 to 1.66; $p = 0.947$).

Among younger adults, AAMR declined from 1999–2014 (APC = -2.99), followed by a non-significant increase from 2014–2023 (APC = 5.34). Among middle-aged adults, AAMR declined from 1999–2010 (APC = -4.98), followed by a stable trend from 2010–2018 (APC = 0.61), a significant increase from 2018–2021 (APC = 10.34), and a subsequent decline from 2021–2023 (APC = -8.74). Among older adults, AAMR declined from 1999–2002 (APC = -5.05), followed by a steeper decrease from 2002–2009 (APC = -9.23) and a continued decline through 2018 (APC = -4.68), before a non-significant increase from 2018–2021 (APC = 4.36), and a subsequent decline from 2021–2023 (APC = -7.64) (Fig. 4; Supplementary Table 6).

Crude mortality rate per 100,000 by age group with Joinpoint-derived trend segments.

MI with Cerebrovascular Disease-Related AAMR Stratified by Geographical Regions

a. Stratified By Urbanization:

The AAMR decreased in both urban and rural areas from 1999 to 2020. In urban areas, the AAMR declined from 7.58 to 2.63 in 2020, while in rural areas it decreased from 9.23 to 4.08.

Throughout the study period, rural areas consistently exhibited higher AAMRs than urban areas (mean AAMR: 5.49 [95% CI: 5.28–5.70] vs. 4.02 [95% CI: 3.93–4.09]). Overall trends showed significant declines in both rural (AAPC: -4.28; 95% CI: -5.43 to -2.91; $p < 0.001$) and urban populations (AAPC: -5.06; 95% CI: -5.96 to -4.16; $p < 0.001$).

In urban areas, AAMR declined from 1999–2002 (APC = -5.67), followed by a steeper decrease from 2002–2009 (APC = -9.20), and a continued decline through 2014 (APC = -4.68) and 2018 (APC = -1.78), before a non-significant increase from 2018–2020 (APC = 3.65).

In rural areas, AAMR declined from 1999–2002 (APC = -4.77) and more sharply from 2002–2006 (APC = -8.86), followed by a continued decrease from 2006–2014 (APC = -4.67) and 2014–2020 (APC = -4.66), with a stable trend observed thereafter (APC = 0.06). (Fig. 5) (Supplementary Table 7)

AAMR per 100,000 for urban versus rural counties with Joinpoint-derived trend segments.

b. Stratified By Census:

The AAMR decreased across all U.S. census regions from 1999 to 2023. In the Northeast, the AAMR decreased from 6.8 in 1999 to 1.86 in 2023; in the Midwest, from 8.62 to 2.49; in the South 8.42 to 2.93 and in the West, from 7.25 to 2.63

On average, over the study period, the highest mean AAMRs were observed in the south (mean AAMR: 4.45 ; 95% CI: 4.31 TO 4.58, followed by the midwest (mean AAMR: 4.17; 95% CI: 4.01 TO 4.24), west (mean AAMR: 4.00; 95% CI: =3.84 TO 4.17), and Northeast regions (mean AAMR: 3.48; 95% CI: 3.22 TO 3.64).

The AAMR of all four regions showed a decline from 1999 to 2023, with the decrease most pronounced in the Midwest region [Midwest: AAPC = -6.43, (95% CI:-3.76 to -7.29) p value < 0.001]; South region: AAPC = -5.67, (95% CI:-3.21 to -6.90) p value < 0.001]; Northeast region: AAPC = -5.04 (95% CI: (-6.20 to -3.98) p value < 0.001];West: AAPC = -3.95, (95% CI:(-4.59 to -3.29) p value < 0.001].

The AAMR trend for the Northeast showed a decline from 1999 to 2002 (APC = -3.66), followed by a decrease from 2002 to 2006 (APC = -11.8). A slight decrease in trend was seen from 2006 to 2013 (APC: -5.50) followed by further surge till 2023 (APC: -2.27). The AAMR trend for the Midwest showed an decreasing period from 1999 to 2001 (APC =-5.89), followed by decline between 2001 to 2009 (APC =-9.31), and then a continued decline by 2018 (APC = -3.86) There was an increase from 2018 to 2021 (APC = 6.41) and final surge was seen till 2023 (APC: -8.82). The AAMR for the South showed a declining trend between 1999 and 2012 (APC = -7.35), followed by a continued decline between 2012 and 2018 (APC = -1.89) with a significant spike by 2021 (APC = 6.29), further followed by a significant decline by 2023 (APC = -6.84). The AAMR trend for the West experienced a decrease from 1999 to 2013 (APC = -7.13) followed by an increase by 2023 (APC = 0.69). (Fig. 6) (Supplementary Table 8)

AAMR per 100,000 by US census region with Joinpoint-derived trend segments.

c. Stratified By State:

Variations in AAMRs were observed among different states, with AAMRs ranging from as low as 2.37 (95% CI: 2.21 TO 2.53)) in Utah to as high as 7.79 (95% CI:7.55 TO 8.02)) in Mississippi. States falling within the top 90th percentile included Arkansas, Kentucky, Maryland, North Carolina, North Dakota which had approximately twice as high AAMRs compared to states in the lower 10th percentile, which included Montana, Nebraska, Nevada, New Hampshire and New York. (Supplementary Table 9)

Discussion

Our CDC analysis provides an extensive evaluation of trends existing within the mortality rates associated with the coexistence of MI and cerebrovascular disease (CeVD) in the U.S. from a definitive time period of 1999–2023. Even though our analysis showed an overall decline in the AAMR across the time period, there were significant disparities amongst the subgroups. Most of the fatalities took place in medical facilities, followed by nursing homes and decedent's homes. Men, NH Black, and older adults all experienced a higher AAMR when compared to other groups in their respective categories of demographic variables. Similarly, a higher mortality rate was witnessed in rural areas, the Midwest and Southern census regions, and several high-burden states that include Mississippi and Arkansas in the categories of geographical variables respectively.

Although AAMR for the study period seemed to regress by an AAPC of -4.6%, the decline was not found to be steady, as the analysis showed a rise in AAMR during 2018–2021, the COVID-19 era. This rise in the trend could be duly accredited to the increasing sedentary lifestyle of people and decreased physical activity in lockdown(17). Even though the AAMR has been declining ever since, the risk remains, making our study relevant to combat the danger by emphasizing on the need for prevention strategies and targeted public health interventions for the vulnerable population in U.S.

Our analysis portrayed gender-based disparities associated with MI and cerebrovascular disease (CeVD). Even though the AAMR declined, men consistently showed a higher mortality rate as compared to women. Men exhibiting a higher risk of cardiovascular disease and cerebrovascular mortality than women are particularly consistent with prior studies conducted (18)(19). Men being at a higher risk for cerebrovascular disease (CeVD) and cardiovascular disease is due to a complex interplay of biological and lifestyle factors. Androgens, the male sex hormones, directly target the cerebral vasculature and have been proven to show both progressive and detrimental effects, including pro-inflammatory effects (20). Literature suggests that androgens do play a role in exacerbating hypertension, stroke, and in modulating atherosclerosis. Androgens are also thought to cause obesity and insulin resistance that can contribute to MI and CeVD (21). In contrast, estrogen, the protective hormone, favours vascular protection by anti-inflammatory actions and improved endothelial functions (22). Along with the biological factors, physical inactivity, tobacco consumption, smoking, and poor dietary habits are some of the lifestyle factors that are more prevalent among men, which can cause cardiovascular disease and CeVD (23, 24). These findings highlight the need for more preventive strategies for men targeted towards sedentary lifestyle habits and towards public health surveillance that can look out for the risk factors in both the sexes.

Profound and persistent disparities in cardiovascular and cerebrovascular disease (CeVD) mortality, delineated by geography, race, and socioeconomic status were noted. A primary finding is the considerably high mortality in the Southern United States, a region historically designated as the "Stroke Belt" and "Heart Failure Belt." This disparity is driven by a multifactorial etiology, including a higher prevalence of risk factors like hypertension and obesity (25). Underlying these clinical factors are significant social determinants of health; data shows stark income and educational disparities in annual incomes and overall literacy rate (26). A critical biological mediator is chronic inflammation, with evidence suggesting that IL-6, which regulates inflammatory reactions, provides a pathway through which chronic psychosocial stress exacerbates cerebrovascular disease (CeVD) and cardiovascular disease risk in these communities (27). State-level disparities include the highest mortality rate in Mississippi and the lowest mortality rate in Utah. Multiple factors including ethnicities, access to healthcare resources, and socio-economic conditions play a pivotal role in determining these mortality rates.

Demographically, the burden is most severe among Non-Hispanic Black (NH Black) individuals, highlighting systemic failures in public health and clinical care. Despite higher rates of hypertension diagnosis and more intensive anti-hypertensive treatment, NH Black individuals had a systolic blood pressure that was 2.7 mmHg higher than their White counterparts, indicating inadequate control. This is rooted in structural inequities, including a higher baseline prevalence of conditions like obesity—affecting 46.1% of NH Black women compared to 22.1% of White women—and significant socioeconomic barriers. Unique psychobiological pathways are also implicated, as factors like smoking history and specific coping mechanisms were significant correlates of higher blood pressure in older African American men (26).

These disparities are further intensified by geographic economic inequality. Rural areas exhibit the highest Age-Adjusted Mortality Rates (AAMRs) for ischemic heart disease, heart failure, and stroke (28). This is intrinsically linked to a deficient healthcare infrastructure leading to limited access to advanced care; 65% of census tracts beyond a 60-minute drive from an advanced stroke center are rural, affecting 20% of the US adult population (29). The median drive time to advanced stroke care is nearly double that to basic care, a problem aggravated by accelerating rural hospital closures (28, 29). These geographic barriers coincide with a higher burden of disease and socioeconomic disadvantage, creating a cycle of poor health outcomes (29).

Finally, the location of death is a powerful indicator of the underlying social, economic, and medical journey that led to a person's death. A significant proportion of deaths due to cardiovascular disease and cerebrovascular disease (CeVD) occur within medical facilities. Either they are patients with advanced chronic conditions that increase with age, and their death in a nursing or hospice facility represents the culmination of progressive functional decline (30). Secondly, in-hospital mortality often results from acutely severe events, where patients arrive with catastrophic neurological injury or exacerbated chronic conditions that prove fatal despite hospital admission, as is the case for major cardiovascular diseases like MI and stroke (31).

Limitations

This study is subject to several limitations. Firstly, death certificate data was used, which may contain inaccuracies. Secondly, the absence of clinical history in the database minimizes the ability to contextualize mortality trends. Finally, a lack of socioeconomic data prevents any analysis of how healthcare access may have influenced the outcomes.

Conclusions

Over the 25-year period from 1999 to 2023, age-adjusted mortality from co-occurring myocardial infarction and cerebrovascular disease among US adults declined by an average of 4.6% per year, but this progress was interrupted by a plateau and transient rise around 2018–2021 and was unevenly distributed. Men, non-Hispanic Black adults, older adults, rural residents and populations in the Southern and Midwestern regions continued to experience disproportionately high mortality. These persistent disparities underscore the need for targeted, equity-focused prevention, better control of modifiable cardiovascular risk factors, and expanded access to timely acute cardiac and stroke care in underserved regions.

Abbreviations

MI	
myocardial infarction	
CeVD	
cerebrovascular disease	
AAMR	
age-adjusted mortality rate	
APC	
annual percent change	
AAPC	
average annual percent change	
CI	
confidence interval	
ICD-10	
International Classification of Diseases, Tenth Revision	
CDC	
Centers for Disease Control and Prevention	
WONDER	
Wide-ranging Online Data for Epidemiologic Research	
NCHS	
National Center for Health Statistics	
NH	
non-Hispanic	
STROBE	
Strengthening the Reporting of Observational Studies in Epidemiology	
IL-6	
interleukin-6	
US	
United States.	

Declarations

Ethics approval and consent to participate

Not applicable. This study used publicly available, fully de-identified aggregate mortality data from the CDC WONDER database and did not involve human participants, identifiable individual data or human tissue. Institutional review board approval and informed consent were therefore not required and were waived.

Consent for publication

Not applicable.

Availability of data and materials

The datasets analysed during the current study are publicly available from the CDC WONDER Multiple Cause of Death database (<https://wonder.cdc.gov/>). All data supporting the conclusions of this article are included within the article and its additional files.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

AA led the study concept and design and drafted the primary manuscript. HSN developed the methods and led critical revision of the manuscript. MSF led interpretation of the results and coordinated submission and review. MAK made major intellectual contributions to the discussion and to data visualisation. HM contributed to interpretation and the discussion. MQ conducted data extraction and dataset preparation. RM contributed to the analysis and oversight of data processing. HMIR provided supervision and critical review of the manuscript. All authors read and approved the final manuscript.

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Figures

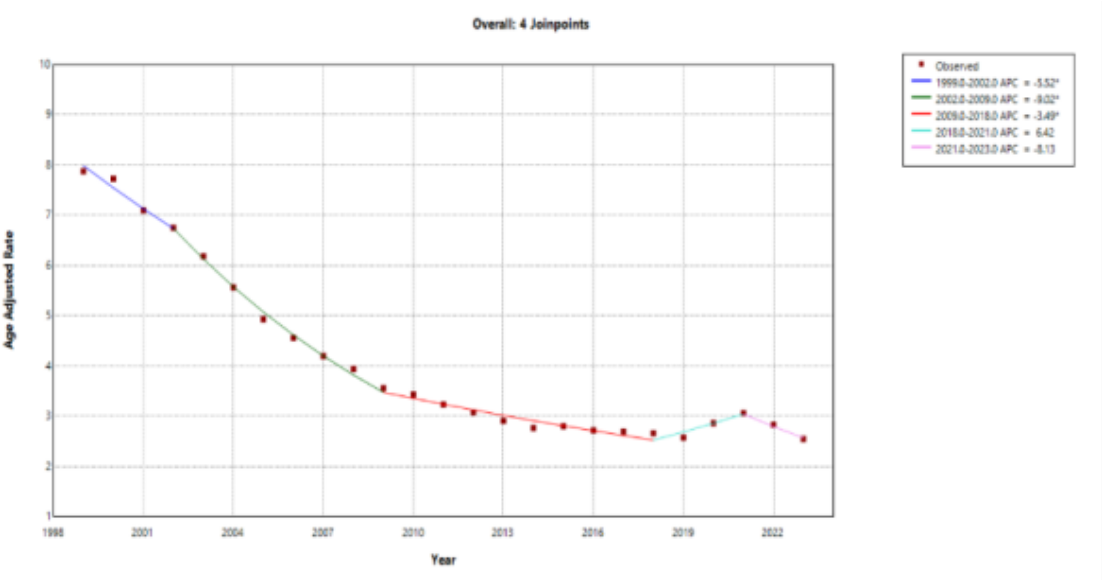


Figure 1

Overall trend in age-adjusted mortality for MI with cerebrovascular disease, US, 1999–2023

Age-adjusted mortality rate (AAMR) per 100,000 population with Joinpoint-derived trend segments. MI, myocardial infarction.

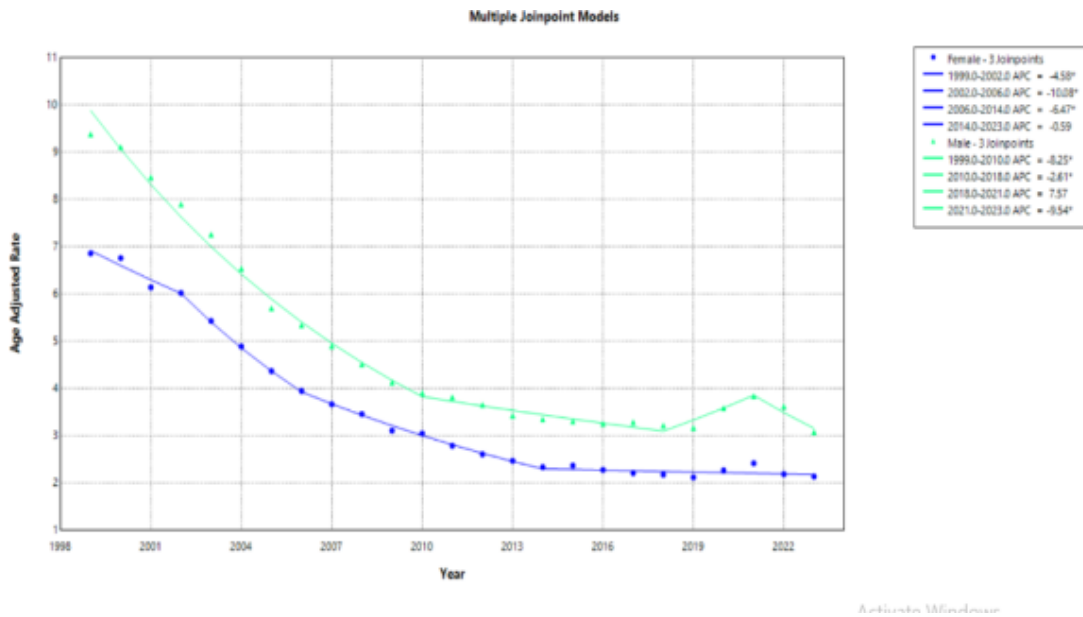


Figure 2

Sex-stratified age-adjusted mortality for MI with cerebrovascular disease, US, 1999–2023
AAMR per 100,000 for men and women with Joinpoint-derived trend segments.

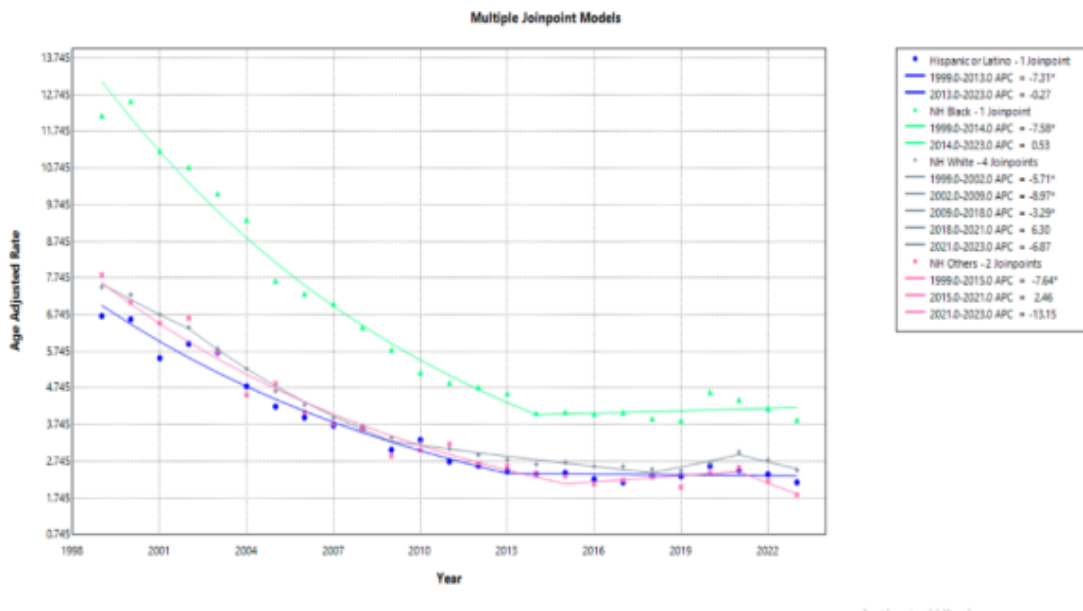


Figure 3

Race/ethnicity-stratified age-adjusted mortality for MI with cerebrovascular disease, 1999–2023
AAMR per 100,000 by race/ethnicity with Joinpoint-derived trend segments. NH, non-Hispanic.

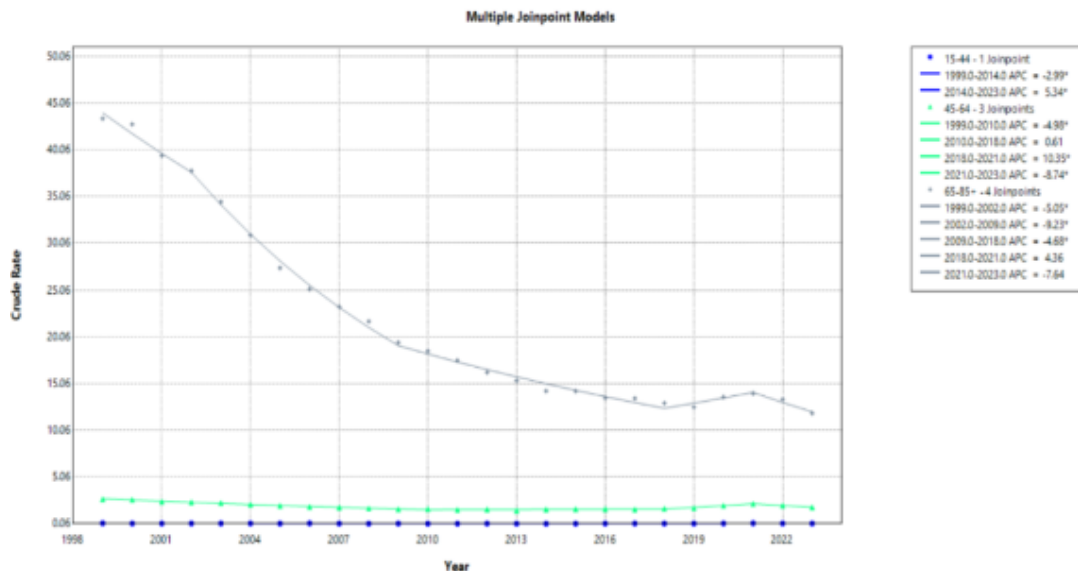


Figure 4

Age-stratified mortality for MI with cerebrovascular disease, US, 1999–2023

Crude mortality rate per 100,000 by age group with Joinpoint-derived trend segments.

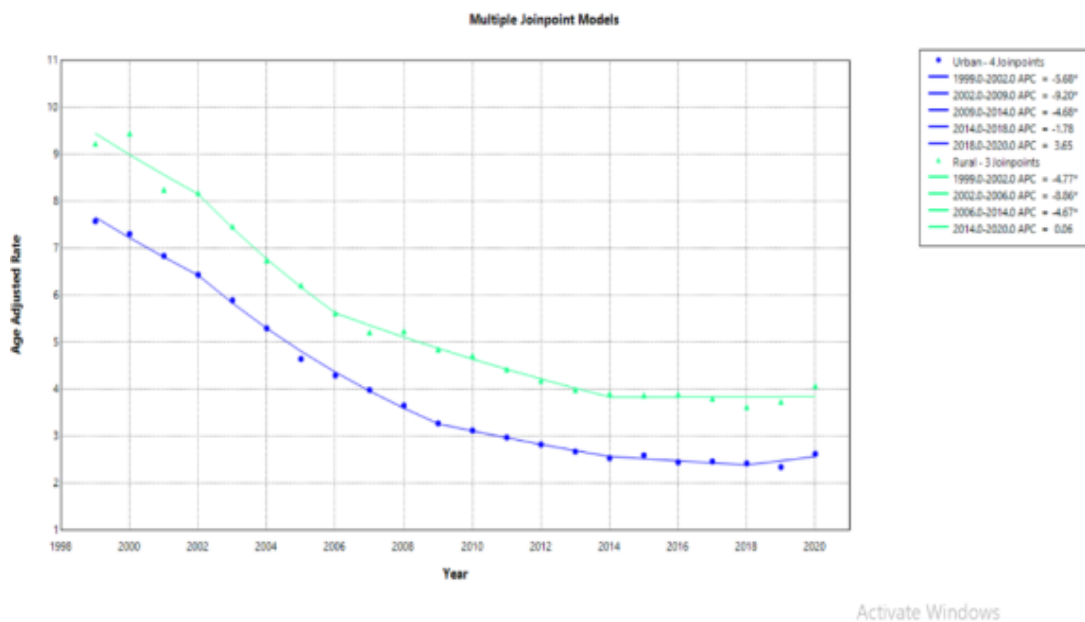


Figure 5

Urbanisation-stratified age-adjusted mortality for MI with cerebrovascular disease, 1999–2020

AAMR per 100,000 for urban versus rural counties with Joinpoint-derived trend segments.

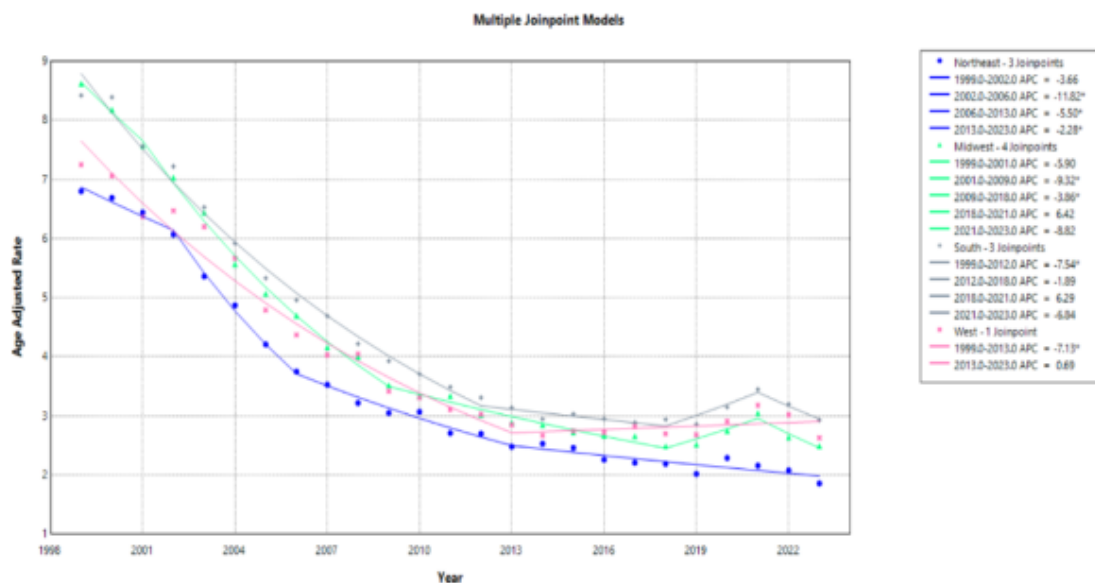


Figure 6

Census-region age-adjusted mortality for MI with cerebrovascular disease, US, 1999–2023

AAMR per 100,000 by US census region with Joinpoint-derived trend segments.

Supplementary Files

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- [MICVDAdditionalfile1supplementarytables.docx](#)