Circulation: Heart Failure

ORIGINAL ARTICLE

Dilated Cardiomyopathy–Related Mortality in the United States: Demographic and Regional Trends Over the Past 2 Decades

Ali Bin Abdul Jabbar, MD; Muhammad Abdullah Javed, MD; Selma F. Mohammed, MD, PhD

BACKGROUND: Dilated cardiomyopathy (DCM) is a common cause of heart failure and is associated with substantial morbidity and mortality. However, data on mortality trends and disparities in DCM mortality in the United States are limited. The objective of this study is to define trends and demographic and regional disparities in DCM-related mortality in the United States.

METHODS: Data from the Centers for Disease Control and Prevention Wide-ranging Online Data for epidemiological Research were analyzed from 2004 to 2022 for DCM-related mortality in the US population >15 years. Age-adjusted mortality rates (AAMRs) per 100 000 people and associated annual percent changes were analyzed using Joinpoint regression analysis. Mortality trends were stratified by sex, race and ethnicity, age group, census region, urbanization classification, and state.

RESULTS: Between 2004 and 2022, 138 076 DCM-related deaths were reported in the study population. The AAMR decreased from 4.41 in 2004 to 1.98 in 2019 with an average annual percentage change of −5.09 (95% CI, −5.40 to −4.86), after which it increased slightly to 2.22 in 2021. Men consistently had 2- to 2.5-fold higher AAMR compared with women. Non-Hispanic Black people had the highest AAMR. The highest mortality rate during the study period was seen in the older population (age≥75 years). Regionally, the Midwest and South had the highest AAMR in 2004, which was overtaken by the West US after 2010. Rural-urban areas had similar AAMRs for most years.

CONCLUSIONS: DCM-related mortality decreased over the past 2 decades, with a slight increase observed during the COVID-19 pandemic. Despite the decreasing trend, sex and racial disparities persisted, with men and Black people having the highest AAMR, whereas regional disparities changed, with the Midwest and South census regions showing an improvement compared with the West of the United States.

Key Words: cardiomyopathy, dilated ■ demography ■ heart failure ■ mortality ■ United States

Dilated cardiomyopathy (DCM) is a myocardial disorder defined as left ventricular dilatation and systolic dysfunction not explained by coronary artery disease or abnormal loading conditions like valvular disease or hypertension.[1] Contemporary data on the prevalence of DCM are lacking and have been historically underestimated. DCM is twice as common as hypertrophic cardiomyopathy, and based on indirect observations from data of hypertrophic cardiomyopathy, it is estimated that >1 in 250 individuals are affected with DCM.[2,3]

The cause of DCM can be broadly classified into familial and nonfamilial according to the European Society of Cardiology and into genetic, mixed, or acquired by the American Heart Association.[4,5] Familial disease accounts for 20% to 50% of cases of DCM, with the most common inheritance pattern being autosomal dominant. Of these cases, 30% to 40% have an identifiable genetic mutation, with the most common being a truncating mutation in titin, accounting for 25% of familial DCM cases.[6] More than 50 genes have been implicated

Correspondence to: Ali Bin Abdul Jabbar, MD, Division of Internal Medicine, Department of Medicine, Creighton University, 7710 Mercy Rd, Ste 301, Omaha, NE 68124-2368. Email alibinabduljabbar@creighton.edu
This manuscript was sent to Kristina H. Haugaa, MD, PhD, Guest Editor, for review by expert referees, editorial decision, and final disposition.
Supplemental Material is available at https://www.ahajournals.org/doi/suppl/10.1161/CIRCHEARTFAILURE.125.012987.
For Sources of Funding and Disclosures, see page 13.

Circulation: Heart Failure is available at www.ahajournals.org/journal/circheartfailure

WHAT IS NEW?

- The overall dilated cardiomyopathy–related mortality decreased from 2004 to 2019 in the United States, which is discordant with the increasing heart failure–related mortality trend. A slight increase was observed during the COVID-19 pandemic.
- Despite the decreasing mortality trends, sex and racial disparities persisted, with men and Black people having the highest age-adjusted mortality rate, whereas regional disparities changed, with the Midwest and South regions showing more prominent improvement compared with the West region of the United States.

WHAT ARE THE CLINICAL IMPLICATIONS?

- The discordant findings of improving dilated cardiomyopathy–related mortality and worsening heart failure mortality call for a better understanding of the factors contributing to different disease trajectories for the underlying heart failure causes.

Nonstandard Abbreviations and Acronyms

AAMR	age-adjusted mortality rate
AAPC	average annual percentage change
APC	annual percent change
BAG3	Bcl-2–associated athanogene 3
CDC WONDER	Centers for Disease Control and Prevention Wide-ranging Online Data for epidemiological Research
DCM	dilated cardiomyopathy
HF	heart failure
NH	non-Hispanic

in the pathogenesis of DCM.[2] Among acquired causes, myocarditis, drugs/toxins, and peripartum cardiomyopathy are commonly seen.[7]

In addition to heart failure (HF), DCM can be associated with a variety of cardiac manifestations, including mitral valve regurgitation, atrial fibrillation, ventricular arrhythmias, supraventricular tachycardia, and atrioventricular blocks.[8] The age-adjusted mortality rate (AAMR) for HF has been increasing over the past decade.[9] The increased mortality has not been consistently described for various cardiomyopathies. Data on mortality and disparities in DCM, which is a major cause of HF across the United States, are limited. This underscores the unmet need to understand DCM mortality in the United States. The objective of this study is to define trends of DCM mortality and disparities among demographic and regional subgroups. This study will help guide future screening, diagnosis, and management strategies for DCM and HF.

METHODS

Data Availability Statement

All data and materials obtained for this study are provided as Supplement Material and are publicly available at the Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiological Research (CDC WONDER) and can be accessed at https://wonder.cdc.gov/.

Study Design, Database, and Study Population

For the cross-sectional study, CDC WONDER, available at https://wonder.cdc.gov/, was used to identify DCM mortality in the US population aged ≥15 years because DCM is rare in younger age groups.[10] CDC WONDER database provides a reliable record of US death certificates compiled from 57 vital-statistics jurisdictions. The Multiple Cause-of-Death Public Use Records of death certificates were used to extract DCM as an underlying or contributing cause on nationwide death certificate records. We extracted data regarding DCM-related deaths and population sizes from 2004 to 2022 using the *International Classification of Diseases, Tenth Revision* code I42.0.[11] The study was exempt from institutional review board approval, as the CDC WONDER database contains deidentified, publicly available aggregate data.

Demographic and Regional Variables

Data extracted for analysis included sex, race and ethnicity, age groups, region, state, and urban-rural classification. Sex is categorized as men or women based on what is entered on the death certificate. Race and ethnicity groups were divided into non-Hispanic (NH) White, NH Black, NH Asian or Pacific Islander, NH American Indian or Alaska Native, and Hispanic or Latino populations based on what was listed on the patient's death certificate. Regions were classified into Northeast, Midwest, South, and West according to the Census Bureau definitions. Age groups were divided into young (15–44 years), middle-aged (45–74 years), and older (≥75 years). For urban-rural classification, the National Center for Health Statistics Urban-Rural Classification Scheme was used to divide the population into Urban, which included large metropolitan (population ≥1 million), medium/small metropolitan (population 50 000–999 999), and rural, which captured nonmetropolitan (population <50 000) per the 2013 US census classification.[12]

Statistical Analysis

Population sizes, crude mortality rates, and AAMR for deaths related to DCM were obtained from the CDC WONDER database. Crude mortality rates were calculated by dividing the number of DCM-related deaths by the US population aged ≥15 years. AAMR per 100 000 were calculated by standardizing the DCM-related deaths in the US population aged ≥15 years to the CDC standard population (year 2000 US population) aged ≥15 years as described previously, using the formula in Table S1.[13] The study used the Joinpoint Regression Program (Joinpoint Version 5.3.0 available from the National

Cancer Institute, Bethesda, MD) to analyze trends in mortality over time from 2004 to 2019.[14] This program identifies significant changes in annual mortality trends by fitting models of linear segments. The annual percentage change (APC) with 95% CIs for the AAMRs was calculated for the line segments connecting a Joinpoint. The weighted average of the APCs was calculated and reported as average APCs (AAPCs), along with corresponding 95% CIs, to summarize the reported mortality trend for the entire study period. APCs and AAPCs were identified as increasing or decreasing based on whether the change in mortality over the time interval significantly differed from 0 using a 2-tailed *t* test. Statistical significance was set at $P \leq 0.05$. The years from 2020 to 2022 were not used in the Joinpoint analysis to prevent the changes in mortality during the COVID-19 pandemic from impacting the long-term trend analysis. Instead, the percentage change in AAMR from 2019 (considered pre–COVID-19 pandemic) to 2021 was calculated to compare various subgroups (Table).

RESULTS

Figures 1 through 5 and the Table summarize the key findings. Supporting data and figures are given in Supplemental Material.

Overall

Between the years 2004 and 2022, there were 138 076 reported deaths related to DCM in the United States. Of these, 88 969 (64.43%) were men, whereas 49 107 (35.57%) were women. 98 480 (71.32%) deaths were in NH White people, 25 014 (18.12%) were NH Black people, 9701 (7.03%) were Hispanic adults, 3143 (2.28%) were NH Asian or Pacific Islander adults, and 1112 (0.81%) were NH American Indian or Alaskan Native adults. In total, 64 650 (46.82%) of the deaths were in middle-aged (45–74) adults, 54 562 (39.51%) were in older (≥75) adults, whereas 18 864 (13.66%) were in young (15–44) adults (Figure 1; Table; Table S2).

Overall, the AAMR decreased by 55.1% from 4.41 (95% CI, 4.32–4.49) in 2004 to 1.98 (95% CI, 1.93–2.03) in 2019, with an AAPC of −5.09 (95% CI, −5.40 to −4.86). This was followed by a 12.12% increase from 2019 to 2021 to an AAMR of 2.22 (95% CI, 2.17–2.28) in 2021 (Figure 1; Table; Table S3). Overall, the AAMR of DCM decreased by 51.9% from 4.41 (95% CI, 4.32–4.49) in 2004 to 2.12 (95% CI, 2.07–2.17) in 2022. During the same period, the AAMR for HF increased by 10% from 125.7 (95% CI, 125.24–126.16) in 2004 to 138.26 (95% CI, 137.86–138.67) in 2022 (Figure 2).

Demographic Differences in AAMR in DCM

Sex Stratified

Both men and women had a decline in DCM-related AAMR, although men consistently had 2- to 2.5-fold higher AAMR than women. In men, the AAMR decreased from 6.42 (95% CI, 6.26–6.58) in 2004 to 2.84 (95% CI, 2.75–2.93) in 2019, with an AAPC of −5.24 (95% CI, −5.57 to −4.99). From 2004 to 2014, the APC in AAMR for men was −6.46 (95% CI, −7.04 to −6.09), which decreased from 2014 to 2019 to −2.75 (95% CI, −4.07 to −0.08; Figure 3; Table).

In women, the AAMR decreased from 2.89 (95% CI, 2.79–2.98) in 2004 to 1.2 (95% CI, 1.14–1.25) in 2019, with an AAPC of −5.59 (95% CI, −5.94 to −5.31). For women, the APC in AAMR showed a similar trend; it was −7.40 (95% CI, −8.30 to −6.85) from 2004 to 2012 and decreased to −3.48 (95% CI, −4.40 to −2.02) from 2012 to 2019 (Figure 3; Table; Table S3).

Race Stratified

All races and ethnic groups except the NH American Indian or Alaska Native population had a significant decline in DCM-related AAMR from 2004 to 2019. For DCM-related mortality, NH Black people, had the highest AAMR throughout the years 2004 to 2016, after which it was similar to the NH American Indian or Alaska Native population. For the NH Black population, the AAMR decreased from 8.38 (95% CI, 8–8.77) in 2004 to 3.22 (95% CI, 3.02–3.42) in 2019. The AAMR APC was −8.00 (95% CI, −9.17 to −7.38) from 2004 to 2015, which decelerated to −0.58 (95% CI, −4.31 to 7.84) from 2015 to 2019. NH Asian or Pacific Islander remained the group with the lowest mortality with an AAMR that decreased from 2.79 (95% CI, 2.39–3.2) in 2004 to 0.92 (95% CI, 0.77–1.07) in 2019 with an AAPC of −6.99 (95% CI, −7.72 to −6.02). NH American Indian or Alaska Native—the only group that did not see a significant drop in the AAMR—changing from 4.73 (95% CI, 3.58–6.15) in 2004 to 2.75 (95% CI, 2.04–3.61) in 2019 with an AAPC of −2.01 (95% CI, −4.45 to 0.63). In NH White people, the AAMR decreased from 4.02 (95% CI, 3.93–4.11) in 2004 to 1.91 (95% CI, 1.85–1.97) in 2019 with an AAPC of −4.81 (95% CI, −5.14 to −4.53). Lastly, in the Hispanic/Latino population, the AAMR decreased from 3.28 (95% CI, 2.97–3.58) in 2004 to 1.5 (95% CI, 1.36–1.63) in 2019, with an AAPC of −5.31 (95% CI, −6.69 to −4.41; Figure 3; Table; Table S3).

Age Group Stratified

The older (≥75) population had the highest AAMR among all age groups, which decreased from 26.68 (95% CI, 25.91–27.44) to 9.06 (95% CI, 8.68–9.45) in 2019 with an AAPC of −7.02 (95% CI, −7.65 to −6.62). The APC was −8.54 (95% CI, −10.09 to −7.94) from 2004 to 2014, which decreased to −3.89 (95% CI, −6.38 to 2.24) from 2014 to 2019. The young (15–44) age group had an AAMR of 1.01 (95% CI, 0.96–1.07) in 2004, which decreased to 0.7 (95% CI, 0.65–0.74) in 2019 with an AAPC of −2.41 (95% CI, −2.66 to −2.08). The APC was −0.92 (95% CI, −2.56 to 2.36) from 2004 to 2007, which increased to −4.73 (95% CI, −7.14 to −3.88) from 2007 to 2013 and decreased to

Table. Dilated Cardiomyopathy AAMR for 2004, 2019, and 2021, AAPC in AAMR From 2004 to 2019, and Percentage Change in AAMR From 2004 to 2019 and 2019 to 2021 for Overall Mortality and Stratified by Sex, Race and Ethnicity, Census Region, Age Group, and Rural-Urban Status

	Crude no. of deaths (2004)	AAMR (95% CI) (2004)	Crude number of deaths (2019)	AAMR (95% CI) (2019)	AAPC from 2004 to 2019 (95% CI)	Crude no. of deaths (2021)	AAMR (95% CI) (2021)	Percentage change from 2004 to 2019, %	Percentage change from 2019 to 2021, %
Overall	10217	4.41 (4.32 to 4.49)	5904	1.98 (1.93 to 2.03)	−5.09 (−5.40 to −4.86)	6661	2.22 (2.17 to 2.28)	−55.10	12.12
Sex stratified									
Male	6304	6.42 (6.26 to 6.58)	3888	2.84 (2.75 to 2.93)	−5.24 (−5.57 to −4.99)	4438	3.24 (3.14 to 3.33)	−55.76	14.08
Female	3913	2.89 (2.79 to 2.98)	2016	1.20 (1.14 to 1.25)	−5.59 (−5.94 to −5.31)	2223	1.36 (1.3 to 1.42)	−58.48	13.33
Race and ethnicity stratified									
NH American Indian or Alaska Native	66	4.73 (3.58 to 6.15)	54	2.75 (2.04 to 3.61)	−2.01 (−4.45 to 0.63)	79	3.99 (3.14 to 5.01)	−41.86	45.09
NH Asian or Pacific Islander	203	2.79 (2.39 to 3.2)	152	0.92 (0.77 to 1.07)	−6.99 (−7.72 to −6.02)	174	1.04 (0.88 to 1.2)	−67.03	13.04
NH Black	1896	8.38 (8 to 8.77)	1060	3.22 (3.02 to 3.42)	−6.08 (−6.80 to −5.65)	1135	3.44 (3.23 to 3.65)	−61.58	6.83
NH White	7493	4.02 (3.93 to 4.11)	4082	1.91 (1.85 to 1.97)	−4.81 (−5.14 to −4.53)	4581	2.24 (2.18 to 2.31)	−52.49	17.28
Hispanic	527	3.28 (2.97 to 3.58)	534	1.50 (1.36 to 1.63)	−5.31 (−6.69 to −4.41)	602	1.57 (1.44 to 1.7)	−54.27	4.67
Census region stratified									
Northeast	1655	3.5 (3.33 to 3.67)	751	1.34 (1.24 to 1.43)	−6.09 (−6.99 to −5.59)	854	1.54 (1.43 to 1.64)	−61.71	14.93
Midwest	2569	4.78 (4.6 to 4.97)	1345	2.06 (1.95 to 2.17)	−5.19 (−5.89 to −4.69)	1508	2.41 (2.28 to 2.53)	−56.90	16.99
South	3861	4.71 (4.56 to 4.86)	2157	1.93 (1.85 to 2.01)	−6.07 (−6.41 to −5.77)	2383	2.12 (2.04 to 2.21)	−59.02	9.84
West	2132	4.33 (4.14 to 4.51)	1651	2.42 (2.3 to 2.54)	−3.64 (−4.04 to −3.26)	1916	2.82 (2.69 to 2.95)	−−44.11	16.53
Age groups stratified									
Young (15–44)	1185	1.01 (0.96 to 1.07)	841	0.70 (0.65 to 0.74)	−2.41 (−2.66 to −2.08)	1070	0.84 (0.79 to 0.89)	−30.69	20.00
Middle age (45–74)	4343	4.89 (4.75 to 5.04)	2950	2.44 (2.35 to 2.53)	−4.45 (−4.89 to −4.07)	3337	2.69 (2.59 to 2.78)	−50.10	10.25
Elderly (≥75)	4689	26.68 (25.91 to 27.44)	2113	9.06 (8.68 to 9.45)	−7.02 (−7.65 to −6.62)	2254	10 (9.59 to 10.41)	−66.04	10.38
Urbanization status stratified*									
Rural	1783	4.32 (4.12 to 4.53)	945	2.02 (1.89 to 2.16)	−4.59 (−5.20 to −4.05)	1129*	2.41 (2.26 to 2.56)*	−53.24	19.31*
Urban	8434	4.42 (4.32 to 4.51)	4959	1.97 (1.92 to 2.03)	−5.19 (−5.43 to −4.98)	5420*	2.12 (2.06 to 2.18)*	−55.43	7.61*

AAMR indicates age-adjusted mortality rate; AAPC, average annual percentage change; and NH, non-Hispanic.
*Rural-urban population data not available after 2020, thus, 2020 was used instead of 2021.

−0.78 (95% CI, −1.66 to 0.75) from 2013 to 2019. The AAMR in the middle age group (45–74) was 4.89 (95% CI, 4.75–5.04) in 2004, which decreased to 2.44 (95% CI, 2.35–2.53) in 2019 with an AAPC of −4.45 (95% CI, −4.89 to −4.07). The APC was −6.25 (95% CI, −8.54 to −5.33) from 2004 to 2011, which decreased to −2.86 (95% CI, −3.82 to −0.70) from 2011 to 2019 (Figure 4; Table; Table S3).

Regional Differences in AAMR of DCM

Census Region–Based Differences

In 2004, AAMR was highest in the Midwest at 4.78 (95% CI, 4.6–4.97) and South at 4.71 (95% CI, 4.56–4.86), followed closely by the West at 4.33 (95% CI, 4.14–4.51) with the Northeast region having the lowest AAMR at 3.5 (95% CI, 3.33–3.67). Overall, the AAMR decreased in all 4

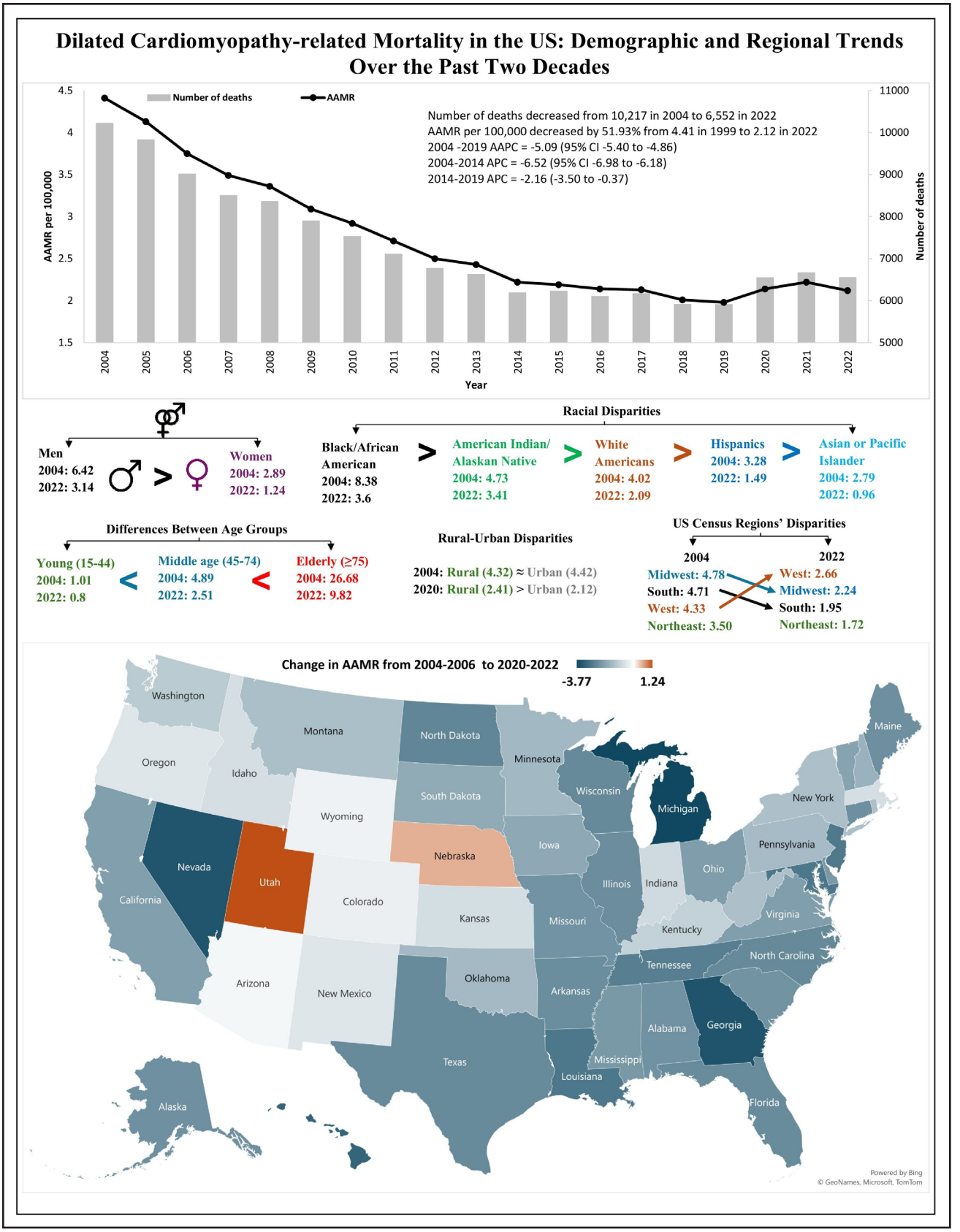

Figure 1. Central illustration.
Summary of the key findings of the study for dilated cardiomyopathy–related mortality in the United States from 2004 to 2022. Note: the *y* axis does not start at 0 to make differences prominent. All values are age-adjusted mortality rate (AAMR) unless specified otherwise. AAPC indicates average annual percentage change; and APC, annual percentage change.

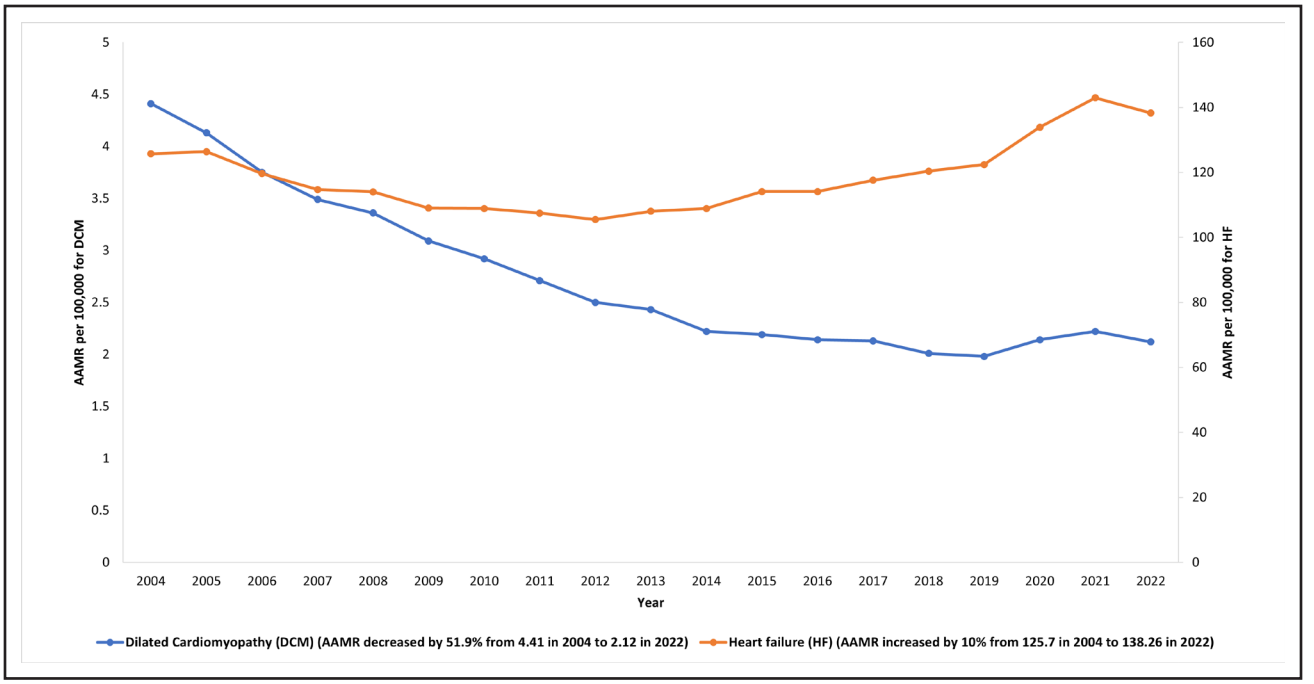

Figure 2. Comparison of age-adjusted mortality rates (AAMRs) for dilated cardiomyopathy and heart failure from 2004 to 2022 in the United States.

Note: The *y* axis for dilated cardiomyopathy (DCM) is on the **left** and for heart failure (HF) is on the **right** side of the graph; a separate axis is used for each to highlight the discordant trend between DCM and HF.

regions from 2004 to 2019, followed by a slight increase from 2019 to 2022. In the Midwest, the AAMR decreased from 4.78 (95% CI, 4.6–4.97) in 2004 to 2.06 (95% CI, 1.95–2.17) in 2019, with an AAPC of −5.19 (95% CI, −5.89 to −4.69). In the South, the AAMR decreased from 4.71 (95% CI, 4.56–4.86) in 2004 to 1.93 (95% CI, 1.85–2.01) in 2019, with an AAPC of −6.07 (95% CI, −6.41 to −5.77). In the West, the AAMR decreased the least, from 4.33 (95% CI, 4.14–4.51) in 2004 to 2.42 (95% CI, 2.3–2.54) in 2019 with an AAPC of −3.64 (95% CI, −4.04 to −3.26), placing it at the highest AAMR after 2010. In the Northeast, the AAMR decreased the most from 3.5 (95% CI, 3.33–3.67) to 1.34 (95% CI, 1.24–1.43) in 2019, with an AAPC of −6.09 (95% CI, −6.99 to −5.59; Figure 5; Table; Table S4).

Rural Versus Urban Differences

Throughout the study period, the average AAMR across rural and urban populations was similar for most years. For the urban population, the AAMR decreased from 4.42 (95% CI, 4.32–4.51) in 2004 to 1.97 (95% CI, 1.92–2.03) in 2019, with an AAPC of −5.19 (95% CI, −5.43 to −4.98). The APC was −6.61 (95% CI, −6.97 to −6.31) from 2004 to 2014, which decreased to −2.28 (95% CI, −3.33 to −0.84) from 2014 to 2019. For the rural population, the AAMR decreased from 4.32 (95% CI, 4.12–4.53) in 2004 to 2.02 (95% CI, 1.89–2.16) in 2019, with an AAPC of −4.59 (95% CI, −5.20 to −4.05). The APC was −6.26 (95% CI, −9.12 to −5.28) from 2004 to 2012, which decreased to −2.66 (95% CI, −4.22 to 2.20) from 2012 to 2019 (Figure 5; Table; Table S4).

State-Level Differences

Large state-level variations in AAMR exist within the United States. From 2004 to 2006, the highest AAMR was in Hawaii at 7.86, whereas the lowest AAMR was in Massachusetts at 1.78. Hawaii continued to have the highest AAMR of 4.76 from 2017 to 2019 and 4.68 from 2020 to 2022, while the lowest AAMR during 2017 to 2019 and 2020 to 2022 was in Connecticut at 0.71 and 0.73, respectively. From 2004 to 2006 to 2017 to 2019, the overall AAMR decreased across all US states except Utah, which saw an increase in AAMR from 1.84 in 2004 to 2006 to 2.51 in 2017 to 2019. The largest decrease in AAMR during this period was in Michigan, from 6.07 in 2004 to 2006 to 2.36 in 2017 to 2019. In contrast, from 2017 to 2019 to 2020 to 2022, most of the states experienced an increase in AAMR; with the highest increase in Nebraska from 1.29 in 2017 to 2019 to 2.7 in 2020 to 2022, whereas some states continued decreasing trend in AAMR with the highest decrease being in Rhode Island from 2.2 in 2017 to 2019 to 1.15 in 2020 to 2022 (Figure 6; Figures S1 and S2; Table S5).

Changes in AAMR of DCM during the COVID-19 pandemic

From 2019 to 2021, the overall AAMR increased by 12.12%, with a similar increase in men and women at

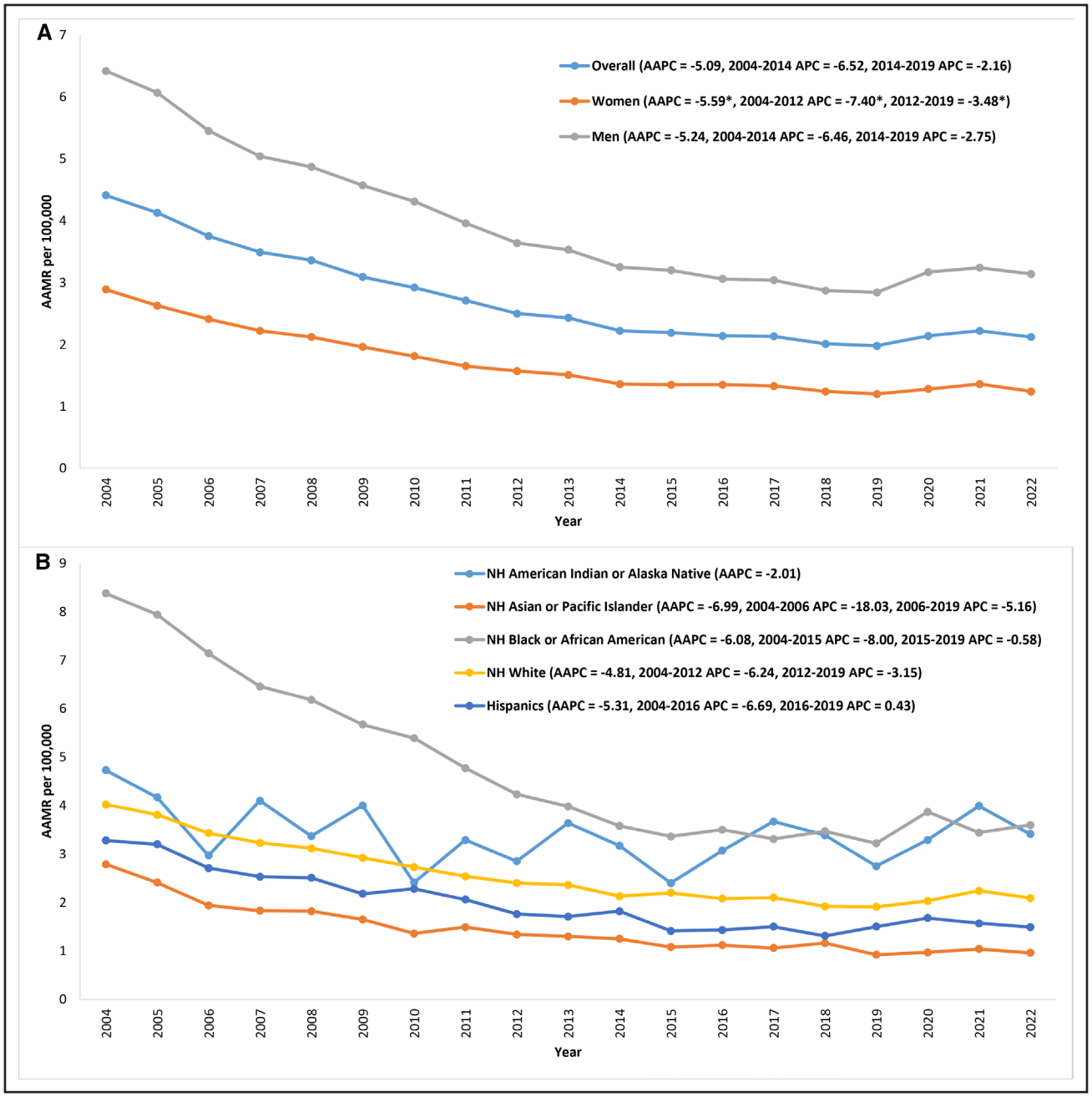

Figure 3. Dilated cardiomyopathy–related age-adjusted mortality rates (AAMRs) in the United States, 2004 to 2022, stratified by sex and race/ethnicity.

A, Overall and sex; and **B**, race and ethnicity. AAPC indicates average annual percentage change; APC, annual percentage change; and NH, non-Hispanic.

14.08% and 13.33%, respectively. Among race and ethnic groups, the highest increase in AAMR was in the NH American Indian or Alaskan Native population at 45.09%, whereas Hispanic/Latino people had the smallest increase at 4.67%. The Midwest had the highest increase in AAMR at 16.99%, followed closely by the West at 16.53%, whereas the South had the lowest increase at 9.84%. The young (15–44 years) age group had the highest increase in AAMR at 20%, while middle-aged (45–74 years) and older (≥75) populations had similar increases at 10.25% and 10.38%, respectively. Rural and urban populations saw a similar increase in AAMR from 2004 to 2019. However, the rural population had a higher increase at 19.31% from 2019 to 2020 compared with the urban population, which saw an increase of 7.61% (Table).

DISCUSSION

Our study highlights several important novel findings and trends regarding DCM-related mortality in the United States. Overall, the AAMR decreased from 2004

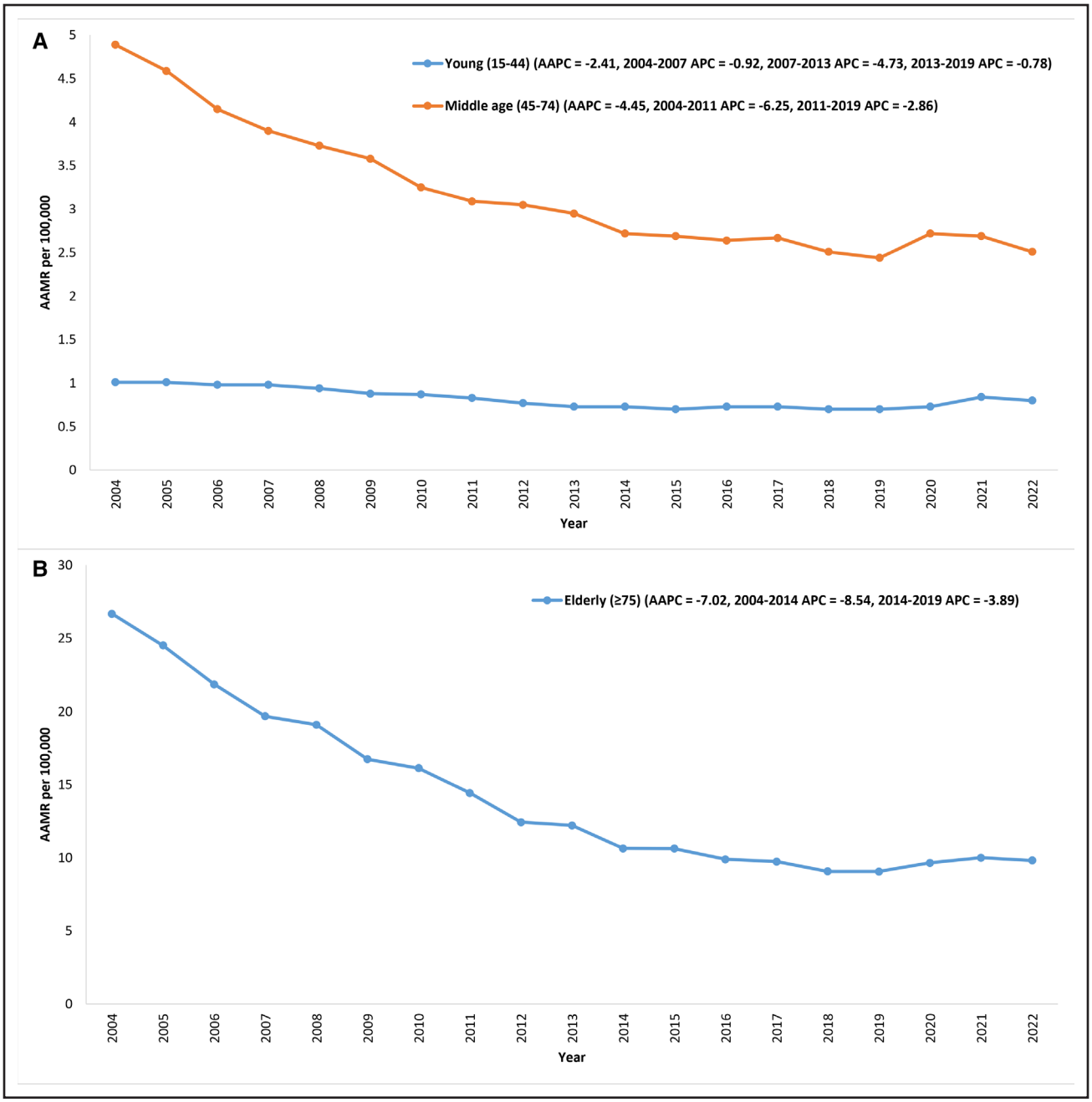

Figure 4. Dilated cardiomyopathy–related age-adjusted mortality rates (AAMR) in the United States, 2004 to 2022, stratified by age groups.
A, Young (25–44-year-old) and middle (45–74-year-old) age groups; and **B**, older (≥75-year-old) age group. AAPC indicates average annual percentage change; and APC, annual percentage change.

to 2019. However, a slight increase was observed during the COVID-19 pandemic era from 2019 to 2022. The highest mortality rate during the study period was seen in men, age ≥75 years, and in the urban population. Among racial/ethnic groups, NH Black people had the highest mortality rate. Among geographic regions, the Midwest was the region with the highest mortality rate. Our findings contribute essential insight into the epidemiology of cardiomyopathies and HF in the United States and provide clarification to the paradoxical increase in HF mortality rates since 2012, despite advances in HF medical and device therapies. Our findings suggest that mortality trends among different cardiomyopathies and underlying HF causes differ. Improvement in our understanding of DCM, medical, and device therapy may have contributed to the decrease in DCM-related mortality, whereas other causes of HF that have not witnessed such advancement continue to have increasing mortality. Our data underscore the need to define mortality trends for the

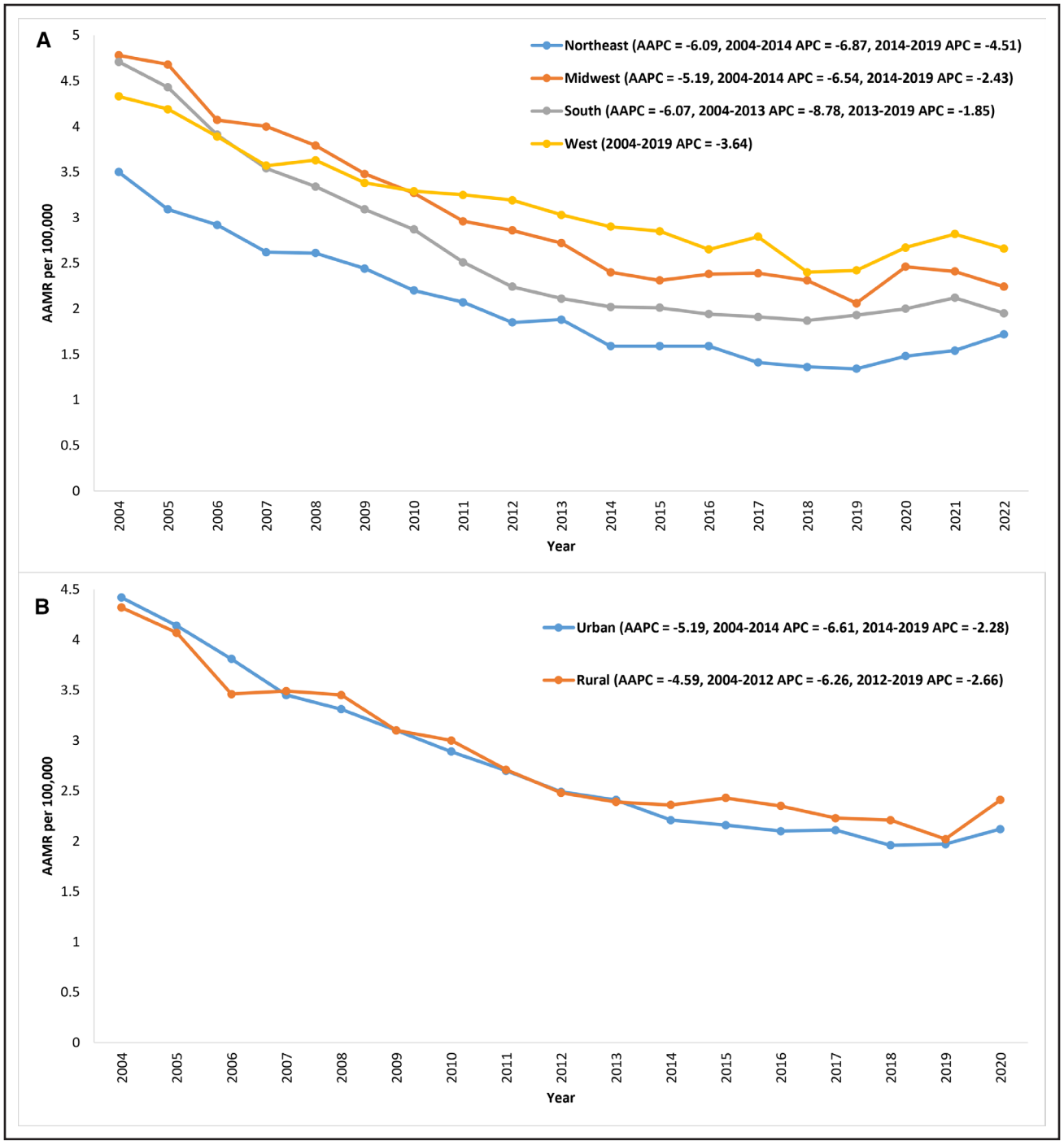

Figure 5. Dilated cardiomyopathy–related age-adjusted mortality rates (AAMRs) in the United States, 2004 to 2022 stratified by US census regions and rural-urban classification.
A, US census regions; and **B**, rural-urban classification. AAPC indicates average annual percentage change; and APC, annual percentage change.

various HF causes to guide preventative and therapeutic interventions.

Similar to our study, data from the Swedish Heart Failure Registry, the Italian population, and Japanese registries also showed a decrease in DCM-related mortality over time.[15–20] Our study is a much larger and contemporary US-based analysis. In a large single-center Italian registry, Merlo et al found a steady decline in mortality in patients with DCM from 1978 to 2015 over a mean follow-up of 12±8 years.[18] The reduction in mortality was primarily due to a reduction in cardiovascular mortality, most notably sudden cardiac death. Notably, they observed trends for earlier referral from the onset of symptoms, milder disease, and hence the

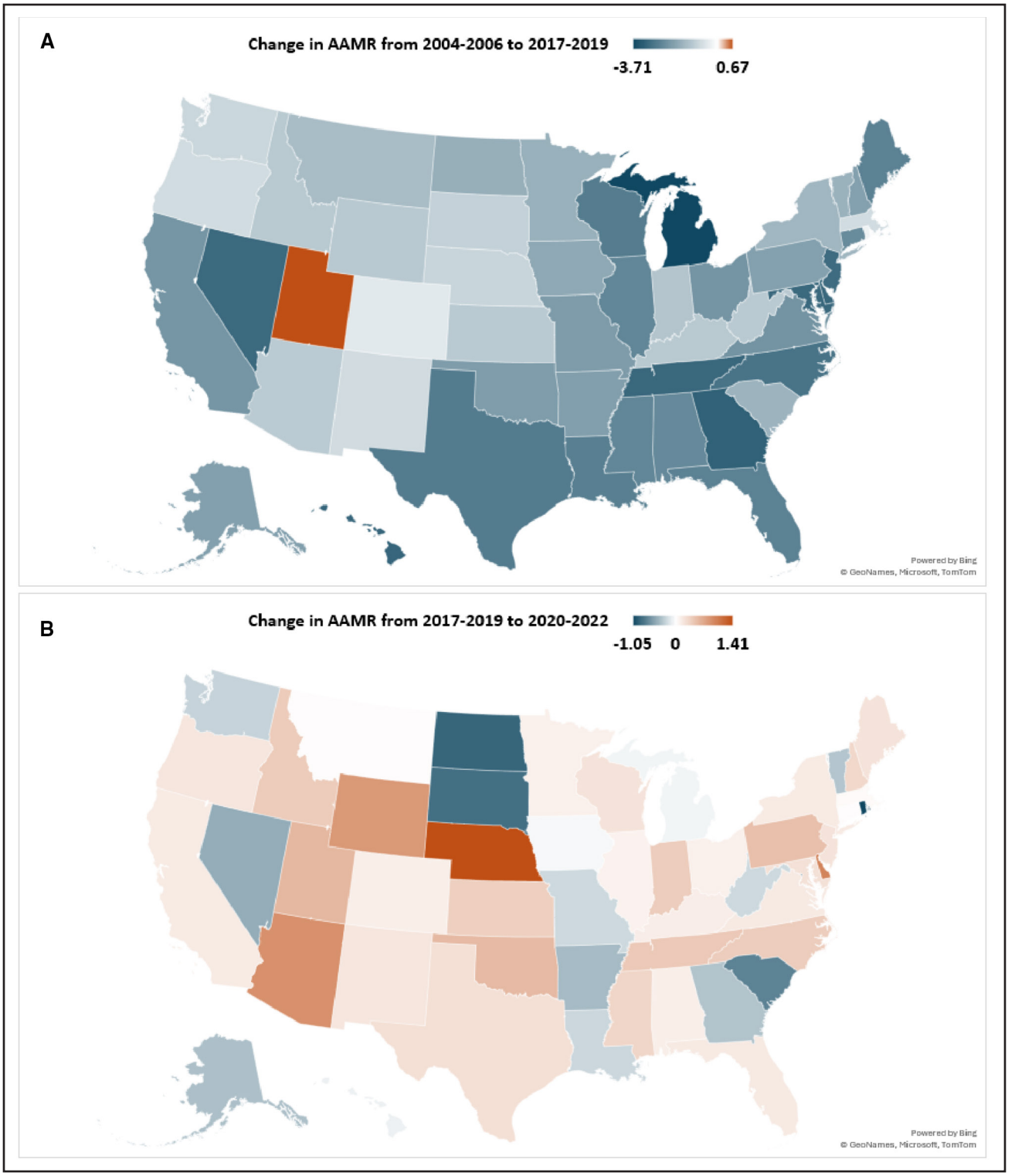

Figure 6. State-level change in dilated cardiomyopathy–related age-adjusted mortality rates (AAMRs) in the United States. **A**, From 2004 to 2006 to 2017 to 2019; and **B**, from 2017 to 2019 to 2020 to 2022.

diagnosis of DCM in the years 2005 to 2015. They have also looked at various causes of DCM and found a worse prognosis in patients with genetic, postmyocarditis, or idiopathic DCM compared with other causes.[18] Consistent with the Italian findings, in the Swedish HF registry 2003 to 2015, patients with DCM had a higher percentage of women, manifested milder disease, and were more likely to receive guideline-directed medical therapy and implantable defibrillators. They observed decreased mortality over time. However, follow-up

was limited to only 1 year.[20] Similarly, in a small Japanese registry, DCM-related 3-year mortality improved between 2005 and 2014.[19] This was coupled with increased implementation of guideline-directed medical therapy and was paralleled by improvement in the prognosis of HF.[19,21] Collectively, these studies show improved outcomes of DCM through 2015. Although DCM mortality improved, HF mortality worsened after 2012. This novel observation suggests discrepant mortalities among different underlying cardiomyopathies, and HF causes explain the discordant trends observed. Our study calls for a better understanding of disease trajectories for the different underlying cardiomyopathies and HF causes.

There are several potential explanations for our findings. First, advancements in diagnostics lead to earlier identification and initiation of therapies. Early diagnosis of DCM is associated with improved survival.[22] For instance, DCM is a highly heritable condition, with around 30% to 40% of cases being familial, and with more genes being identified and genetic testing becoming widely available, more asymptomatic and milder cases are being identified, which could benefit from early intervention. Second, over the past decades, guideline-directed medical therapy for HF with reduced ejection fraction has evolved and is the cornerstone for DCM management with proven morbidity and mortality benefits. Third, the wider availability of implantable cardioverter defibrillators has contributed to a decrease in the risk of sudden cardiac death, as shown in multiple registries. Although the role of implantable defibrillators for primary prevention in DCM has been a topic of major debate since the DANISH trial (Defibrillator Implantation in Patients With Nonischemic Systolic Heart Failure) was published, a long-term follow-up did show a reduction in all-cause mortality, cardiovascular death, and sudden cardiac death in younger patients <70 years of age.[23,24]

In our study, men had approximately a 2-fold higher mortality rate as compared with women over the years, which is consistent with the overall sex distribution of the disease, as the prevalence of nongenetic DCM is 2.5:1 male to female, whereas for familial/genetic, it is 1.7:1 male to female.[25] Studies from multiple countries are consistent with the above finding.[26,27] Notably, male sex is an established risk factor for HF and DCM. This can be attributed to a lack of cardioprotective sex hormones such as estradiol in men, greater systolic dysfunction, myocardial fibrosis, and increased apoptosis.[25,27,28]

NH Black people had the highest mortality as compared with other races, which persisted throughout the study period despite an overall decline in mortality across all racial subgroups. They also have a 1.5- to 2-fold higher mortality as compared with age-matched White people with DCM.[29] The increased incidence could be attributed to several genetic factors. Black patients have a higher prevalence of familial DCM compared with White patients, but have fewer clinically actionable variants.[30,31] For example, truncating variants in truncating mutation in titin were more prevalent in women of African ancestry with postpartum cardiomyopathy than in women of European ancestry with postpartum cardiomyopathy.[32] Similarly, mutations in another gene that encodes BAG3 (Bcl-2–associated athanogene 3) associated with early onset DCM are more prevalent in Black individuals.[33] The Black population has a higher prevalence of comorbid conditions like hypertension, diabetes, and obesity, which could worsen the progression of DCM and adverse social determinants of health.[34] A study demonstrated that Black patients with DCM had lower household income, less access to private health insurance, and lower education as compared with Hispanic and White populations with DCM.[35] These differences emphasize the need to understand and address social determinants of health to improve DCM outcomes.[36]

Our study showed that the highest mortality rate among different age groups was in the older population, ≥75 years of age. Aging, in general, is associated with increased inflammation and mitochondrial dysfunction and is an independent risk factor for cardiovascular disease, along with having a negative impact on ventricular function.[37,38] Furthermore, Sirt1 (Sirtuin 1), a key regulator of metabolic pathways, and its decreased expression have been described in older individuals with DCM in a sex-independent manner.[39] Limited data exists assessing the association of age in DCM patients; however, similar studies on other types of cardiomyopathies exist. One such study reports an increased presence of traditional cardiovascular risk factors like hypertension as compared with hypertrophic cardiomyopathy–related sudden cardiac death risk factors in this population, which could explain the increased mortality rate in this age group.[40] It should also be noted that deaths in the older population from non-DCM causes could also contribute to the high mortality rate seen in this age group.

Our study included extensive contemporary US data and is the only study with comprehensive data for DCM mortality in the United States through 2022. However, our study has several limitations. The CDC WONDER implemented *International Classification of Diseases, Tenth Revision* codes for reporting the cause of death in 1999, whereas the clinical coding conversion to *International Classification of Diseases, Tenth Revision* occurred in 2014 in the United States. The cause of death entered by physicians can potentially be influenced by their use of *International Classification of Diseases, Ninth Revision* codes in clinical practice, which may lead to misclassification bias. The database lacks information regarding confounders such as comorbidities and social determinants of health, which may affect mortality in our study's different demographic and regional subgroups. The

rural-urban stratified analysis was conducted from 2004 to 2020, as the database does not report population data for rural and urban areas or mortality rates beyond 2020. The CDC WONDER also lacks information regarding the mode of death. AAMRs standardized to the 2000 US population (CDC Wonder default standard population) were used for this analysis, which may not account for potential changes in the US population structure.

Conclusions

DCM-associated mortality in the United States decreased from 2004 to 2019, with a slight increase thereafter. Despite the decreasing mortality trends, sex and racial disparities persisted, with men and the Black population having the highest AAMR, whereas regional disparities changed, with the Midwest and South regions showing more prominent improvement compared with the West region of the United States. The discordant findings of improving DCM-related mortality and worsening HF mortality call for a better understanding of the factors contributing to different disease trajectories for the underlying HF causes.

ARTICLE INFORMATION

Received February 27, 2025; accepted December 8, 2025.

Affiliations

Division of Internal Medicine (A.B.A.J.) and Division of Cardiology (S.F.M.), Department of Medicine, Creighton University, Omaha, NE. Department of Medicine, Baylor College of Medicine, Houston, TX (M.A.J.).

Author Contributions

Dr Abdul Jabbar had full access to all the study data and is responsible for its integrity and the accuracy of the data analysis. Drs Abdul Jabbar and Mohammed contributed to concept and design. Drs Abdul Jabbar and Javed contributed to acquisition, analysis, or interpretation of data. Drs Abdul Jabbar, Javed, and Mohammed drafted the manuscript. Drs Abdul Jabbar, Javed, and Mohammed contributed to the critical review of the manuscript for important intellectual content. Dr Abdul Jabbar contributed to the statistical analysis. Dr Abdul Jabbar and Mohammed contributed to administrative, technical, or material support. Dr Mohammed contributed to supervision.

Sources of Funding

None.

Disclosures

None.

Supplemental Material

Tables S1–S5
Figures S1 and S2

REFERENCES

1. Pinto YM, Elliott PM, Arbustini E, Adler Y, Anastasakis A, Böhm M, Duboc D, Gimeno J, de Groote P, Imazio M, et al. Proposal for a revised definition of dilated cardiomyopathy, hypokinetic non-dilated cardiomyopathy, and its implications for clinical practice: a position statement of the ESC Working Group on Myocardial and Pericardial Diseases. *Eur Heart J*. 2016;37:1850–1858. doi: 10.1093/eurheartj/ehv727
2. Heymans S, Lakdawala NK, Tschöpe C, Klingel K. Dilated cardiomyopathy: causes, mechanisms, and current and future treatment approaches. *Lancet*. 2023;402:998–1011. doi: 10.1016/S0140-6736(23)01241-2
3. Hershberger RE, Hedges DJ, Morales A. Dilated cardiomyopathy: the complexity of a diverse genetic architecture. *Nat Rev Cardiol*. 2013;10:531–547. doi: 10.1038/nrcardio.2013.105
4. Elliott P, Andersson B, Arbustini E, Bilinska Z, Cecchi F, Charron P, Dubourg O, Kühl U, Maisch B, McKenna WJ, et al. Classification of the cardiomyopathies: a position statement from the European Society of Cardiology Working Group on Myocardial and Pericardial Diseases. *Eur Heart J*. 2008;29:270–276. doi: 10.1093/eurheartj/ehm342
5. Maron BJ, Towbin JA, Thiene G, Antzelevitch C, Corrado D, Arnett D, Moss AJ, Seidman CE, Young JB; American Heart Association. Contemporary definitions and classification of the cardiomyopathies: an American Heart Association Scientific Statement from the Council on Clinical Cardiology, Heart Failure and Transplantation Committee; Quality of Care and Outcomes Research and Functional Genomics and Translational Biology Interdisciplinary Working Groups; and Council on Epidemiology and Prevention. *Circulation*. 2006;113:1807–1816. doi: 10.1161/CIRCULATIONAHA.106.174287
6. Sweet M, Taylor MRG, Mestroni L. Diagnosis, prevalence, and screening of familial dilated cardiomyopathy. *Expert Opin Orphan Drugs*. 2015;3:869–876. doi: 10.1517/21678707.2015.1057498
7. Orphanou N, Papatheodorou E, Anastasakis A. Dilated cardiomyopathy in the era of precision medicine: latest concepts and developments. *Heart Fail Rev*. 2022;27:1173–1191. doi: 10.1007/s10741-021-10139-0
8. Jefferies JL, Towbin JA. Dilated cardiomyopathy. *Lancet*. 2010;375:752–762. doi: 10.1016/S0140-6736(09)62023-7
9. Abdul Jabbar AB, May MT, Deisz M, Tauseef A. Trends in heart failure-related mortality among middle-aged adults in the United States from 1999-2022. *Curr Probl Cardiol*. 2025;50:102973. doi: 10.1016/j.cpcardiol.2024.102973
10. Multiple cause of death data on CDC WONDER. Accessed January 21, 2025. https://wonder.cdc.gov/mcd.html
11. ICD-10: International Statistical Classification of Diseases and Related Health Problems: Tenth Revision. Accessed January 21, 2025. https://iris.who.int/handle/10665/42980
12. Ingram DD, Franco SJ. NCHS Urban-Rural Classification Scheme for Counties. *Vital Health Stat 2*. 2014;1-73. Accessed January 21, 2025. https://pubmed.ncbi.nlm.nih.gov/24776070/
13. Anderson RN, Rosenberg HM. Age standardization of death rates: implementation of the year 2000 standard. *Natl Vital Stat Rep*. 1998;47:1–16, 20.
14. Joinpoint Regression Program. Accessed January 21, 2025. https://surveillance.cancer.gov/joinpoint/
15. Merlo M, Pivetta A, Pinamonti B, Stolfo D, Zecchin M, Barbati G, Di Lenarda A, Sinagra G. Long-term prognostic impact of therapeutic strategies in patients with idiopathic dilated cardiomyopathy: changing mortality over the last 30 years. *Eur J Heart Fail*. 2014;16:317–324. doi: 10.1002/ejhf.16
16. Zuin M, Rigatelli G, Porcari A, Merlo M, Bilato C, Roncon L, Sinagra G. Trends in age and sex-specific dilated cardiomyopathy mortality in Italy, 2005-2017. *J Cardiovasc Med (Hagerstown)*. 2023;24:530–536. doi: 10.2459/JCM.0000000000001512
17. Castelli G, Fornaro A, Ciaccheri M, Dolara A, Troiani V, Tomberli B, Olivotto I, Gensini GF. Improving survival rates of patients with idiopathic dilated cardiomyopathy in Tuscany over 3 decades: impact of evidence-based management. *Circ Heart Fail*. 2013;6:913–921. doi: 10.1161/CIRCHEARTFAILURE.112.000120
18. Merlo M, Cannatà A, Pio Loco C, Stolfo D, Barbati G, Artico J, Gentile P, De Paris V, Ramani F, Zecchin M, et al. Contemporary survival trends and aetiological characterization in non-ischaemic dilated cardiomyopathy. *Eur J Heart Fail*. 2020;22:1111–1121. doi: 10.1002/ejhf.1914
19. Ushigome R, Sakata Y, Nochioka K, Miyata S, Miura M, Tadaki S, Yamauchi T, Sato K, Onose T, Tsuji K, et al; CHART-2 Investigators. Temporal trends in clinical characteristics, management and prognosis of patients with symptomatic heart failure in Japan—report from the CHART Studies. *Circ J*. 2015;79:2396–2407. doi: 10.1253/circj.CJ-15-0514
20. Sjöland H, Silverdal J, Bollano E, Pivodic A, Dahlström U, Fu M. Temporal trends in outcome and patient characteristics in dilated cardiomyopathy, data from the Swedish Heart Failure Registry 2003–2015. *BMC Cardiovasc Disord*. 2021;21:307. doi: 10.1186/s12872-021-02124-0
21. Ushigome R, Sakata Y, Nochioka K, Miyata S, Miura M, Tadaki S, Yamauchi T, Sato K, Onose T, Tsuji K, et al; CHART-2 Investigators. Improved long-term prognosis of dilated cardiomyopathy with implementation of evidenced-based medication—report from the CHART studies. *Circ J*. 2015;79:1332–1341. doi: 10.1253/circj.CJ-14-0939
22. Silverdal J, Sjöland H, Pivodic A, Dahlström U, Fu M, Bollano E. Prognostic differences in long-standing vs. recent-onset dilated cardiomyopathy. *ESC Heart Fail*. 2022;9:1294–1303. doi: 10.1002/ehf2.13816

23. Køber L, Thune JJ, Nielsen JC, Haarbo J, Videbæk L, Korup E, Jensen G, Hildebrandt P, Steffensen FH, Bruun NE, et al; DANISH Investigators. Defibrillator implantation in patients with nonischemic systolic heart failure. *N Engl J Med*. 2016;375:1221–1230. doi: 10.1056/NEJMoa1608029
24. Yafasova A, Butt JH, Elming MB, Nielsen JC, Haarbo J, Videbæk L, Olesen LL, Steffensen FH, Bruun NE, Eiskjær H, et al. Long-term follow-up of DANISH (The Danish study to assess the efficacy of ICDs in patients with nonischemic systolic heart failure on mortality). *Circulation*. 2022;145:427–436. doi: 10.1161/CIRCULATIONAHA.121.056072
25. Jain A, Norton N, Bruno KA, Cooper LT, Atwal PS, Fairweather D. Sex differences, genetic and environmental influences on dilated cardiomyopathy. *J Clin Med*. 2021;10:2289. doi: 10.3390/jcm10112289
26. McNamara DM, Starling RC, Cooper LT, Boehmer JP, Mather PJ, Janosko KM, Gorcsan J, Kip KE, Dec GW; IMAC Investigators. Clinical and demographic predictors of outcomes in recent onset dilated cardiomyopathy: results of the IMAC (Intervention in Myocarditis and Acute Cardiomyopathy)-2 study. *J Am Coll Cardiol*. 2011;58:1112–1118. doi: 10.1016/j.jacc.2011.05.033
27. Halliday BP, Gulati A, Ali A, Newsome S, Lota A, Tayal U, Vassiliou VS, Arzanauskaite M, Izgi C, Krishnathasan K, et al. Sex- and age-based differences in the natural history and outcome of dilated cardiomyopathy. *Eur J Heart Fail*. 2018;20:1392–1400. doi: 10.1002/ejhf.1216
28. Di-Marco A, Brown PF, Claver E, Bradley J, Nucifora G, Ruiz-Cueto M, Dallaglio PD, Rodriguez M, Comin-Colet J, Anguera I, et al. Ventricular arrhythmias and sudden death in nonischemic dilated cardiomyopathy: matter of sex or scar? *J Card Fail*. 2022;28:1278–1286. doi: 10.1016/j.cardfail.2022.01.019
29. Coughlin SS, Gottdiener JS, Baughman KL, Wasserman A, Marx ES, Tefft MC, Gersh BJ. Black-White differences in mortality in idiopathic dilated cardiomyopathy: the Washington, DC, dilated cardiomyopathy study. *J Natl Med Assoc*. 1994;86:583–591.
30. Huggins GS, Kinnamon DD, Haas GJ, Jordan E, Hofmeyer M, Kransdorf E, Ewald GA, Morris AA, Owens A, Lowes B, et al; DCM Precision Medicine Study of the DCM Consortium. Prevalence and cumulative risk of familial idiopathic dilated cardiomyopathy. *JAMA*. 2022;327:454–463. doi: 10.1001/jama.2021.24674
31. Jordan E, Kinnamon DD, Haas GJ, Hofmeyer M, Kransdorf E, Ewald GA, Morris AA, Owens A, Lowes B, Stoller D, et al; DCM Precision Medicine Study of the DCM Consortium. Genetic architecture of dilated cardiomyopathy in individuals of African and European Ancestry. *JAMA*. 2023;330:432–441. doi: 10.1001/jama.2023.11970
32. Ware JS, Li J, Mazaika E, Yasso CM, DeSouza T, Cappola TP, Tsai EJ, Hilfiker-Kleiner D, Kamiya CA, Mazzarotto F, et al; IMAC-2 and IPAC Investigators. Shared genetic predisposition in peripartum and dilated cardiomyopathies. *N Engl J Med*. 2016;374:233–241. doi: 10.1056/NEJMoa1505517
33. Myers VD, Gerhard GS, McNamara DM, Tomar D, Madesh M, Kaniper S, Ramsey FV, Fisher SG, Ingersoll RG, Kasch-Semenza L, et al. Association of variants in BAG3 with cardiomyopathy outcomes in African American individuals. *JAMA Cardiol*. 2018;3:929–938. doi: 10.1001/jamacardio.2018.2541
34. Khan S, Mulukutla S, Thoma F, Bhonsale A, Kancharla K, Estes Iii NAM, Jain SK, Saba S. Outcomes of Blacks versus Whites with cardiomyopathy. *Am J Cardiol*. 2021;148:151–156. doi: 10.1016/j.amjcard.2021.02.039
35. Coughlin SS, Pearle DL, Baughman KL, Wasserman A, Tefft MC. Diabetes mellitus and risk of idiopathic dilated cardiomyopathy. The Washington, DC Dilated Cardiomyopathy Study. *Ann Epidemiol*. 1994;4:67–74. doi: 10.1016/1047-2797(94)90044-2
36. Ntusi NAB, Sliwa K. Impact of racial and ethnic disparities on patients with dilated cardiomyopathy: JACC focus seminar 7/9. *J Am Coll Cardiol*. 2021;78:2580–2588. doi: 10.1016/j.jacc.2021.10.021
37. Gude NA, Broughton KM, Firouzi F, Sussman MA. Cardiac ageing: extrinsic and intrinsic factors in cellular renewal and senescence. *Nat Rev Cardiol*. 2018;15:523–542. doi: 10.1038/s41569-018-0061-5
38. Olivetti G, Melissari M, Capasso JM, Anversa P. Cardiomyopathy of the aging human heart. Myocyte loss and reactive cellular hypertrophy. *Circ Res*. 1991;68:1560–1568. doi: 10.1161/01.res.68.6.1560
39. Barcena ML, Pozdniakova S, Haritonow N, Breiter P, Kühl AA, Milting H, Baczko I, Ladilov Y, Regitz-Zagrosek V. Dilated cardiomyopathy impairs mitochondrial biogenesis and promotes inflammation in an age- and sex-dependent manner. *Aging (Milano)*. 2020;12:24117–24133. doi: 10.18632/aging.202283
40. Minhas AMK, Wyand RA, Ariss RW, Nazir S, Shahzeb Khan M, Jia X, Greene SJ, Fudim M, Wang A, Warraich HJ, et al. Demographic and regional trends of hypertrophic cardiomyopathy-related mortality in the United States, 1999 to 2019. *Circ Heart Fail*. 2022;15:e009292. doi: 10.1161/CIRCHEARTFAILURE.121.009292