Journal of the American Heart Association

ORIGINAL RESEARCH

Proportionate and Absolute Vascular Disease Mortality by Race and Sex in the United States From 1999 to 2019

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BACKGROUND: Despite the known significant morbidity and mortality associated with cardiovascular disease and peripheral vascular disease (PVD), contemporary data describing racial demographics in PVD mortality are scarce.

METHODS AND RESULTS: Using the multiple causes of death file from the Centers for Disease Control and Prevention's Wide-Ranging Online Data for Epidemiologic Research, we analyzed the trends of age-adjusted mortality (AAMR) for PVD and its subtypes (aortic aneurysm/dissection, arterial thrombosis, venous thrombosis/disease, pulmonary embolism), by race and sex between 1999 and 2019. Of the 17 826 871 deaths attributed to cardiovascular disease, a total of 888 187 (5.0%) PVD deaths were analyzed during the study period (12.4% Black, 85.6% White). Between 1999 and 2019, AAMR for PVD decreased by 52% (24.8–11.8 per 100 000 people) in the overall population. Despite a decrease in the overall mortality across all race and sex groups, Black men and Black women continued to have higher mortality for PVD (1.5×), aortic dissection (1.8×), arterial thrombosis (1.3×), and venous thrombosis/disease (2.0×) mortality compared with White men and White women in 2019. While there was a 53% decrease in PVD among White individuals (AAMR 24.5–11.5 per 100 000), there was only a 43% decrease (30.0–17.1) in PVD AAMR in Black individuals between 1999 and 2019. The ratio of PVD AAMR increased from 1.2 (1999) to 1.5 (2019) in Black men/White men and from to 1.3 (1999) to 1.5 (2019) in Black women/White women. Similar trends were noted in aortic dissection (Black men/White men, 1.2–1.8; and Black women/White women, 1.5–1.7), arterial thrombosis (Black men/White men, 1.0–1.3; and Black women/White women, 0.9–1.3), and venous thrombosis/disease (Black men/White men, 1.7–1.8; and Black women/White women, 1.7–2.0).

CONCLUSIONS: In this retrospective review of death certificate data in the United States, we demonstrate continued significant disparities between Black and White populations in PVD mortality and its subtypes. Future studies should investigate etiologies and social determinants of PVD mortality.

Key Words: disparities ■ mortality ■ PVD ■ race ■ vascular

Over the past 2 decades, overall mortality rates among adults in the United States have substantially decreased in both Black and White individuals.[1,2] Despite considerable reductions during this period, cardiovascular disease (CVD) remains the leading cause of death in the United States.[3] Although there are known disparities between Black and White individuals in the treatment and outcomes of CVD, including heart failure, stroke, and myocardial infarction,[4] contemporary data regarding peripheral vascular disease (PVD) and racial demographics are lacking.[5]

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Supplemental Material is available at https://www.ahajournals.org/doi/suppl/10.1161/JAHA.121.025276

For Sources of Funding and Disclosures, see page 10.

JAHA is available at: www.ahajournals.org/journal/jaha

CLINICAL PERSPECTIVE

What Is New?

- Between 1999 and 2019, there remain continued and significant disparities between Black and White populations in peripheral vascular disease mortality and its subtypes.
- Black men and Black women continue to have higher mortality for peripheral vascular disease (1.5×), aortic dissection (1.8×), arterial thrombosis (1.3×), and venous thrombosis/disease (2.0×) mortality compared with White men and White women in 2019.

What Are the Clinical Implications?

- Clinical and public health efforts focusing on prevention, awareness, and long-term risk stratification among Black individuals are urgently needed to optimize care.
- Specifically, focused interventions targeting vascular mortality are needed.

Nonstandard Abbreviations and Acronyms

AAMR	age-adjusted mortality ratio
PVD	peripheral vascular disease

PVD remains underdiagnosed and undertreated,[6] with an estimated prevalence of over 200 million individuals worldwide. PVD contains a wide spectrum of disease including arterial thrombosis, aortic dissection, and venous thromboembolism.[7] The mortality associated with PVD is known to be equivalent or higher than those with associated CVD,[8] with prior studies demonstrating annual mortality with PVD as high as 8.2% compared with 6.3% for myocardial infarction%.[9] Understanding the current trends of PVD mortality is critical for developing risk stratification tools and treatment models to improve outcomes. Prior studies have been insufficient in characterizing demographics and subtypes of PVD mortality. Herein, we sought to identify the pattern of PVD mortality that has evolved over the past 2 decades. For this, we used the Centers for Disease Control and Prevention's Wide-Ranging Online Data for Epidemiologic Research database[10,11] to identify the change in PVD mortality from 1999 to 2019 by racial background.

METHODS

This retrospective study utilized a publicly accessible cause of death data in the Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiologic Research database. This database contains national mortality and population data based on death certificates of US residents, and has been well validated in population based studies of cardiovascular mortality.[10,12] This database contains detailed information including background demographics, geographic data, diagnosis codes, and mortality. All the data examined for this analysis were population-level data that are publicly available. As such, no institutional review approval was required.

Individuals aged <18 years or individuals with unknown age at the time of death on the death certificate were excluded from this analysis. We first analyzed the demographics for the general population, followed by overall CVD and, subsequently, each vascular subtype. We used age-adjusted mortality rate (AMMR), which is standardized to the 2000 US Census to control for the difference in population age distribution that may have effects on mortality rates. To calculate the AAMR we selected the category/*International Classification of Diseases* (*ICD*) code "Disease of the circulatory system" (*ICD, Tenth Revision* [*ICD-10*] codes I00–I99) (CVD) as the underlying cause of death. We then examined PVD (*ICD-10* I70-I78 [Diseases of arteries, arterioles, and capillaries]; *ICD-10* I80–89 [Diseases of vein, lymphatic vessel, lymph nodes, not elsewhere classified including phlebitis and thrombophlebitis]; and *ICD-10* I26 [pulmonary embolism]). Following this, we explored the various subtypes of PVD including aortic aneurysm (*ICD-10* I71.1 [Thoracic aortic aneurysm]; *ICD-10* I71.2 [Thoracic aortic aneurysm, without mention of rupture]; *ICD-10* I71.3 [Abdominal aortic aneurysm, ruptured]; *ICD* I71.4 [Abdominal aortic aneurysm, without mention of rupture]; *ICD-10* I71.5 [Thoracoabdominal aortic aneurysm, ruptured]; *ICD-10* I71.6 [Thoracoabdominal aortic aneurysm, without mention of rupture]; *ICD-10* I71.8 [Aortic aneurysm of unspecified site, ruptured]; *ICD-10* I71.9 [Aortic aneurysm of unspecified site, without mention of rupture]), aortic dissection (*ICD-10* I71.0 [dissection of aorta]), arterial thrombosis (*ICD* I74 [arterial embolism and thrombosis], *ICD-10* I77 [other disorders of arteries and arterioles] and *ICD-10* I78 [diseases of the capillaries]), venous thrombosis/disease (*ICD-10* I80–89 [Diseases of vein, lymphatic vessel, lymph nodes, not elsewhere classified including phlebitis and thrombophlebitis]), and pulmonary embolism (*ICD-10* I26) (Table S1). We plotted the AAMR per 100 000 individuals. We then compared the AAMR by sex and race (eg, Black men age-adjusted rate divided by White men age-adjusted rate). All deaths for 1999 to 2019 reported in the database are classified using the *ICD-10* diagnosis codes. Race was reported by informant (next of kin) or funeral director on the death certificate.

The primary outcome was PVD age-adjusted mortality rate (AAMR) from 1999 to 2019 in the overall population and racial/sex subgroups (Black versus White, men

Table 1. CVD Baseline Characteristics

Demographics	CVD mortality, n (%)	Vascular disease mortality, n (%)	Aortic dissections, n (%)	Aortic aneurysm, n (%)	Arterial thrombosis, n (%)	Venous thromboembolism, n (%)	Pulmonary embolism, n (%)	All-cause mortality in general population, n (%)
	n=17 826 871	n=888 187	n=7085	n=180 385	n=35 832	n=81 442	n=169 517	n=52 545 375
Sex								
Female	9 126 472 (51.2)	464 259 (52.3)	28 913 (40.8)	73 433 (40.7)	20 137 (56.2)	43 324 (53.2)	94 713 (55.9)	26 338 226 (50.1)
Male	8 700 399 (48.8)	423 928 (47.7)	41 942 (59.2)	106 952 (59.3)	15 695 (43.8)	38 118 (46.8)	74 804 (44.1)	26 207 149 (49.9)
Age at death, y								
18–24	22 840 (0.1)	3191 (0.4)	430 (0.6)	166 (0.1)	214 (0.6)	943 (1.0)	1616 (0.8)	546 815 (1.0)
25–34	89 402 (0.5)	11 150 (1.3)	1778 (2.5)	615 (0.3)	536 (1.5)	2927 (3.6)	4741 (2.8)	969 557 (1.9)
35–44	312 905 (1.8)	27 265 (3.1)	5198 (7.3)	1491 (0.8)	1094 (3.1)	6833 (8.4)	10 529 (6.2)	1 678 859 (3.2)
45–54	935 777 (5.3)	55 249 (6.2)	10 294 (14.5)	4041 (2.2)	2547 (7.1)	11 601 (14.2)	18 824 (11.1)	3 678 540 (7.0)
55–64	1 821 881 (10.2)	95 605 (10.8)	13 331 (18.8)	15 058 (8.4)	5068 (13.0)	13 109 (16.1)	26 599 (15.7)	6 444 490 (12.3)
65–74	2 833 715 (15.9)	156 094 (17.6)	13 893 (19.6)	40 518 (22.5)	8079 (22.6)	13 215 (16.2)	33 007 (19.5)	9 359 781 (17.8)
75–84	4 926 454 (27.6)	249 849 (28.1)	15 790 (22.3)	67 199 (37.3)	10 200 (28.5)	16 302 (20.0)	40 908 (24.1)	13 901 138 (26.5)
85+	6 883 897 (38.6)	289 784 (32.6)	10 141 (14.3)	51 297 (28.4)	8094 (22.6)	16 638 (20.4)	33 491 (19.8)	15 966 195 (30.4)
Race								
American Indian or Alaska Native	80 236 (0.5)	3783 (0.4)	258 (0.4)	641 (0.4)	253 (0.6)	464 (0.4)	720 (0.6)	315 387 (0.6)
Asian or Pacific Islander	367 519 (2)	13 888 (1.6)	2635 (3.7)	3781 (2.1)	640 (1.8)	921 (0.8)	1397 (2.0)	1 074 304 (2.0)
Black or African American	2 125 844 (11.9)	1110,132 (12.4)	10 770 (15.2)	12 646 (7.0)	3973 (11.1)	14 982 (17.8)	30 214 (11.6)	6 112 222 (11.6)
White	15 253 272 (85.6)	760 384 (85.6)	57 192 (80.7)	163 317 (90.5)	30 966 (86.4)	65 075 (80.9)	137 186 (85.7)	45 043 462 (85.7)
Census region								
Region 1	3 531 203 (19.8)	161 518 (18.2)	12 566 (17.7)	36 032 (20.0)	6580 (18.4)	14 785 (18.2)	27 405 (16.2)	9 936 215 (18.9)
Region 2	4 178 057 (23.4)	229 389 (25.8)	17 481 (24.7)	47 811 (26.5)	8910 (24.9)	18 655 (22.9)	43 355 (25.6)	12 275 000 (23.4)
Region 3	6 717 134 (37.6)	325 989 (36.7)	24 828 (35.0)	62 455 (34.6)	13 565 (37.9)	29 529 (36.3)	74 743 (44.1)	20 104 567 (38.3)
Region 4	3 400 477 (19.0)	171 291 (19.3)	15 980 (22.6)	34 087 (18.9)	6777 (18.9)	18 473 (22.7)	24 014 (14.2)	10 229 593 (19.5)
Ethnicity								
Hispanic or Latino	893 438 (5.0)	36 827 (4.1)	3908 (5.5)	5646 (3.1)	1891 (5.3)	4911 (6.0)	5895 (3.5)	2 964 068 (5.6)
Not Hispanic	16 933 433 (95.0)	888 187 (95.9)	70 855 (94.5)	174 360 (96.9)	33 941 (94.7)	81 442 (94.0)	163 622 (96.5)	49 581,307 (94.4)

CVD indicates cardiovascular disease.

versus women). We calculated the AAMR to evaluate trends by racial demographic in patients within each subset of PVD who died over the prior 20 years.

To examine the proportionate PVD mortality of all CVD, we divided each PVD subtype by all-cause CVD mortality (proportionate PVD mortality). To calculate proportionate mortality, we used the category diseases of the circulatory system (*ICD-10* codes I00–I99) as the underlying cause of death as the denominator and selected the PVD subtype deaths as the numerator.

In an exploratory secondary analysis, we examined the percentage of mortality by age group and PVD subtype. Since we excluded individuals aged <18 years, we established our first group as 18 to 24 years, followed by each age group according to decade of life (25–34, 35–44, etc). We then explored the median age of death by racial demographic for each PVD subtype.

RESULTS

Baseline demographics of the individuals who met the inclusion criteria and by PVD subtype are displayed in Table 1. Overall, 888 187 PVD deaths were analyzed during the study period. PVD accounted for 5.0% of the total CVD mortality (17 826 871 people). CVD and certain PVD subtypes like venous thrombosis consisted

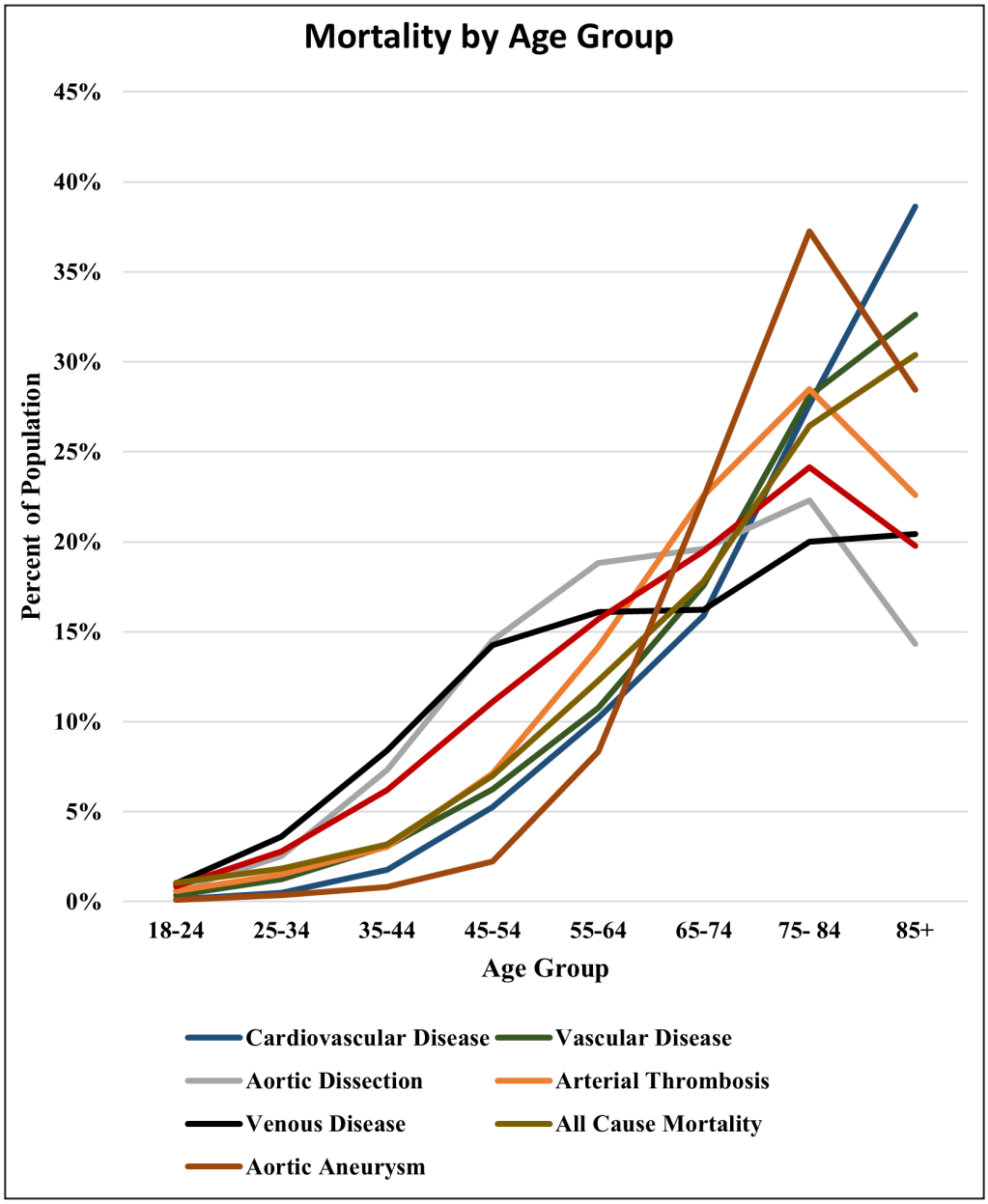

Figure 1. Overall percentage of mortality (%) by age group, in patients aged ≥18 years, 1999–2019.

Table 2. Median Age of Mortality and Interquartile Range (25th–75th Percentile)

	Median age (25th–75th Percentile)
Cardiovascular disease	80 (69–87)
Vascular disease	78 (66–86)
Dissection	67 (53–79)
Aortic aneurysm	78 (70–84)
Arterial thrombosis	74 (63–83)
Venous disease	68 (52–81)
Pulmonary embolism	71 (56–81)
All-cause mortality	76 (63–85)

of a higher percentage of women and Black individuals compared with the overall general population mortality. We demonstrated slight regional differences, with the Midwest (region 2) having higher rates of proportionate of vascular disease (AAMR PVD divided by CVD mortality) (5.5%) and aortic aneurysm (1.1%). Meanwhile, the Southern region demonstrated higher proportional mortality of pulmonary embolism mortality (1.1%). During the study period (1999–2019), the Southern region (region 3) had the highest total number of PVD deaths in Black individuals (62 114, 56.4% of Black PVD deaths), and White non-Hispanic individuals (246 534, 34.1% of White non-Hispanic PVD deaths), followed by the Midwest region (region 2) (Table S2).

When mortality was examined on age alone, the highest mortality was observed in the age group ≥85 years from CVD, overall PVD, and venous thrombosis/disease in comparison with the general population. Conversely, the highest mortality in the age group of 75 to 84 was attributed to arterial thrombosis, aortic aneurysm, and pulmonary embolism (Figure 1 and Table S3). When we examined the median age for each disease (Table 2), we found that the median age of mortality for certain PVD subtype dissection (67 years), arterial thrombosis (74 years), venous thrombosis/disease (68 years), and pulmonary embolism (71 years) is generally lower than the median age of all-cause mortality (76 years).

Between 1999 and 2019, AAMR for PVD decreased by 52% (24.8–11.8 per 100 000 people) in the general population. However, while there was a 53% (24.5–11.5 per 100 000) decrease in PVD AAMR in White individuals, there was only a corresponding 43% decrease (30–17.1 per 100 000) in Black individuals. Proportionate PVD of CVD mortality decreased by 22.3% overall; however, in White individuals, it decreased by 23.8% (5.6%–4.3%) compared with 7.5% in Black individuals (5.2%–4.9%).

Black women and Black men had higher PVD AAMR (14.9 and 19.7 per 100 000) compared with White women and White men (10.0 and 13.2 per 100 000) (Figure 2A). When comparing the AAMR ratio of PVD mortality in Black men/White men, there was an increase in 25% of AAMR (1.2–1.5) and a 16% increase in the AAMR Black women/White women (1.3–1.5) (Figure 2B). This finding was consistent across all vascular subtypes: aortic dissection (Black men/White men 1.2 to 1.8 and Black women/White women 1.5 to 1.7, Figure 3A and 3B), arterial thrombosis (Black men/White men 1.0 to 1.3 and Black women/White men 0.9 to 1.3, Figure 4A and 4B), and venous thrombosis/disease (Black men/White men 1.7–1.8 and Black women/White women 1.7–2.0, Figure 5A and 5B). Aortic aneurysm (Figure S1) demonstrated a rise of 37% increase in mortality ratio in Black men/White men (0.58–0.80) compared with a decrease of 12% in Black women/White women (0.9–0.8). Black men and Black women continue to have a 1.3–2.0× fold higher mortality for PVD (1.5×), aortic dissection (1.8×), arterial thrombosis (1.3×), and venous thrombosis/disease (2.0×) mortality compared with White men and White women.

In our final exploratory analysis, overall proportionate CVD mortality decreased in all populations regardless of sex or race. However, Black women and Black men experienced significantly less decrease in proportionate PVD mortality (6.5 and 9.4%, respectively) compared with White women and White men (21.3% and 27.1%, respectively). Compared with Black individuals, White individuals consistently had greater decreases in proportionate PVD mortality and across almost all vascular subtypes (Table S4), with the only exception being venous thrombosis/disease and pulmonary embolism in men, and aortic aneurysm in women. Table S4 shows the relative changes in proportionate mortality by PVD type and demographics.

For PVD, there was a 52% decrease of AAMR of Hispanics (15.4–7.3) compared with 50.9% reduction in non-Hispanic White individuals (25.2–12.3). Subtype-specific analysis in Hispanic versus non-Hispanic individuals was not possible because of small absolute numbers.

DISCUSSION

In this retrospective analysis of a national death certificate registry spanning 2 decades, we demonstrated that while the AAMR for PVD decreased by 52% in the overall population, there was a 53% decrease in White individuals compared with only a decrease of 43% in Black individuals. This disproportionate finding was consistent across all vascular subtypes. When examining the AAMR of Black individuals compared with White individuals, we see an unwavering disparity for PVD (1.5×), aortic dissection (1.8×), arterial thrombosis (1.3×), and venous thrombosis/disease (2.0×) in mortality rates.

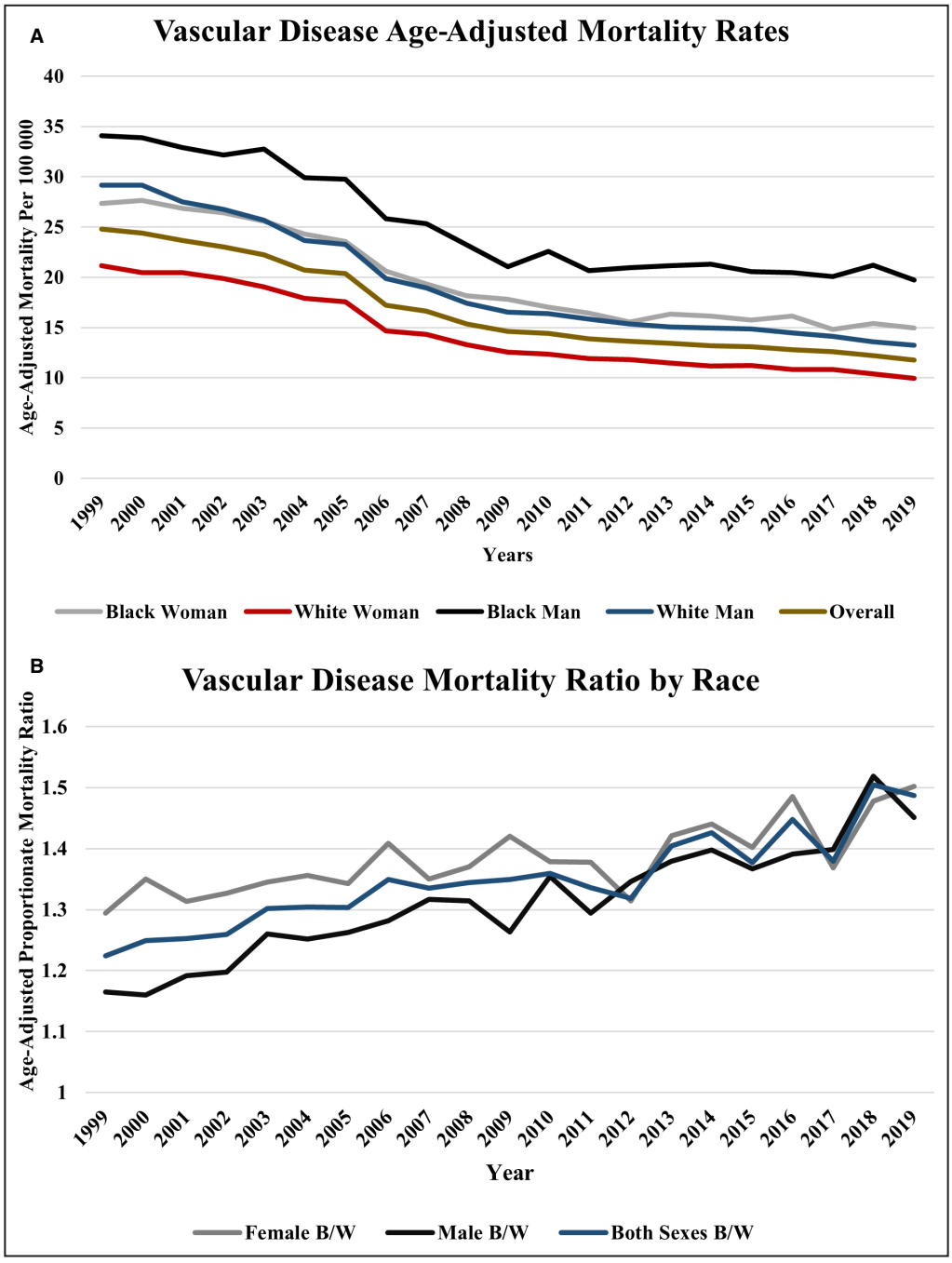

Figure 2. Trend of vascular disease age-adjusted mortality rates and ratio.
A, Overall trend vascular disease age-adjusted mortality rates. **B**, Overall trend of vascular disease mortality ratio by race and sex. B/W indicates Black/White.

Our study is similar in design to Nwancha et al,[13] which used the publicly available database to determine patterns and trends in peripheral artery disease mortality and race. Nwancha et al demonstrated a 1.2× higher rate of peripheral arterial disease as the underlying cause of death in Black compared with White individuals. Our study expands on these findings, including a more comprehensive approach to examine different vascular subtypes and plotting temporal trends. Other analyses have investigated differences in cardiovascular mortality based on race.[14,15] Tajeu et al showed demographic-adjusted Black to White CVD mortality with a hazard ratio of 2.23 (95% CI, 1.87–2.65), where CVD risk factors accounted for 56.6% (95% CI, 42.0%–77.2%) and 41.3% (95% CI, 22.9%–65.3%) of the Black to White CVD mortality difference. Nonetheless, few

studies have investigated PVD and subtypes in the breakdown of cardiovascular disease mortality,[16] and our study aims to fill this gap in knowledge.

Our results demonstrate that arterial thrombosis, venous thrombosis/disease, and pulmonary embolism affect relatively younger individuals (median age <80 years) compared with CVD and general population all-cause mortality (median age ≥80 years). This finding is reflected in a higher percentage of individuals aged >85 years with CVD, accounting for a larger percentage of the mortality in all-cause and cardiovascular disease mortality. This highlights the importance of earlier recognition of these specific PVD subtypes (arterial thrombosis, venous thrombosis/disease, pulmonary embolism), as these conditions have significant morbidity and mortality in relatively younger individuals. Interestingly, there are mild regional variations within the United States. The Midwest demonstrated a slightly higher proportion of vascular disease mortality (out of overall CVD mortality, 5.5%) and aortic aneurysm (1.1%), while the South demonstrated higher proportional mortality of pulmonary embolism (1.1%). Additionally, the Southern region had higher total numbers of deaths (both Black and White), and the Midwest demonstrated the higher AAMR for PVD. Reasons explaining this regional variation is difficult; however, there is a known larger population of Black individuals within the Southern region of the US Census district

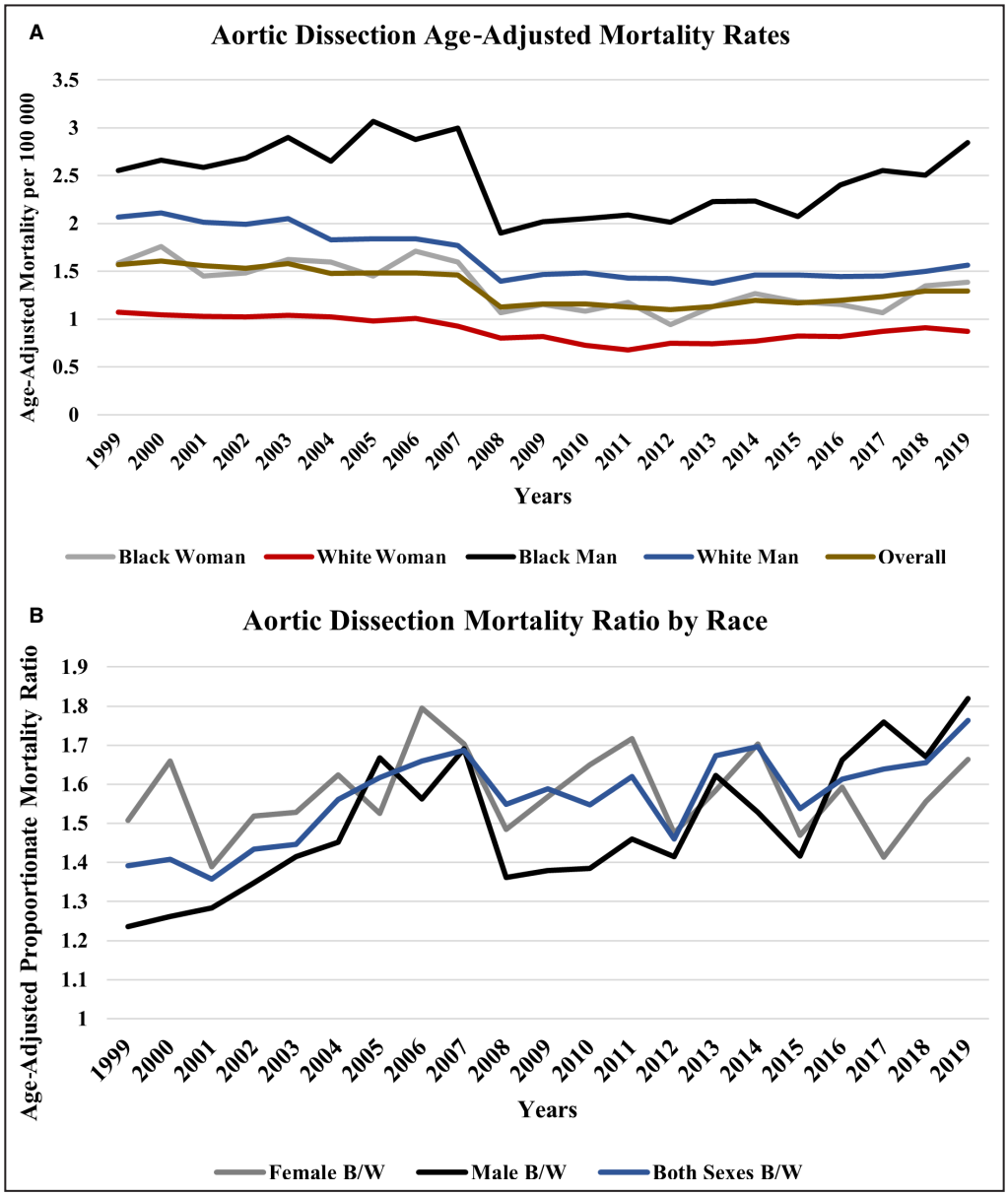

Figure 3. Trend of aortic dissection age-adjusted mortality rates and ratio.
A, Overall trend aortic dissection age-adjusted mortality rates. **B**, Overall trend of aortic dissection mortality ratio by race and sex. B/W indicates Black/White.

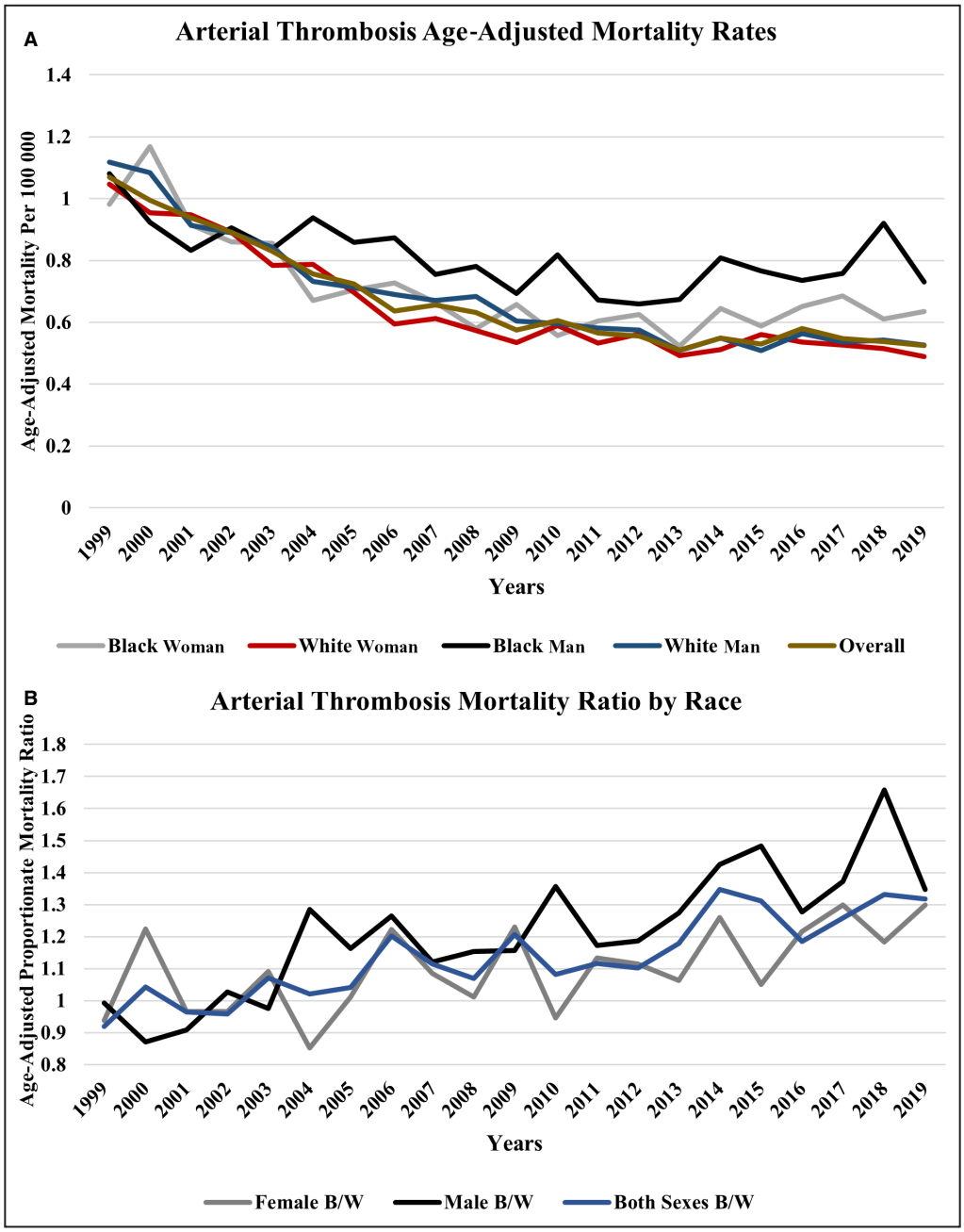

Figure 4. Trend of arterial thrombosis age-adjusted mortality rates and ratio.
A, Overall trend arterial thrombosis age-adjusted mortality rates. **B**, Overall arterial thrombosis mortality ratio by race and sex. B/W indicates Black/White.

accounting for the higher overall totals. The politicization of health care may have also impacted these regional trends. Regardless, development of earlier diagnostic tools,[17] improved risk stratification calculators, and enhanced treatment models to improve outcomes in this younger population is necessary.

The proportionate PVD and subtype mortality allows us to examine the mortality rates caused by PVD out of all CVD. When examining proportionate PVD mortality, we demonstrated decreasing rates of overall PVD and aortic dissection in all groups regardless of sex or race. However, Black women and Black men had significantly less decrease in PVD mortality, especially in arterial thrombosis, where Black women had a rise of 2.6% and Black men had a decrease in 0.4% compared with White women (decrease of 19%) and White men (decrease of 26.8%) in proportionate mortality. Furthermore, despite decades of medical advancements in novel oral anticoagulants to treat thrombosis, as well as the use of statins and

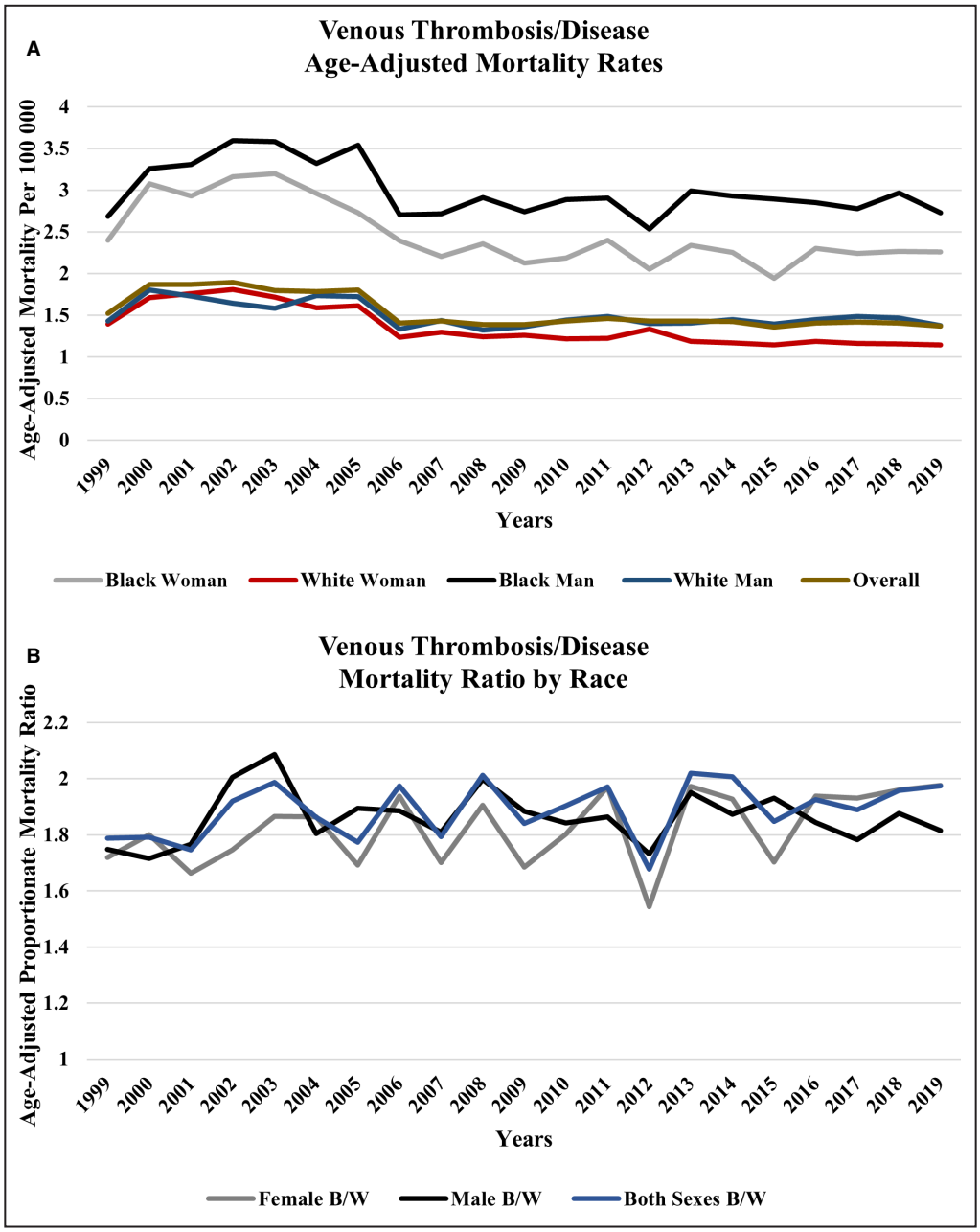

Figure 5. Trend of venous thrombosis/disease age adjusted mortality rates and ratio.
A, Overall trend venous thrombosis/disease age-adjusted mortality rates. **B**, Overall venous thrombosis/disease mortality ratio by race and sex. B/W indicates Black/White.

antiplatelet medications to improve CVD mortality, we demonstrated an overall rising proportionate AAMR of arterial thrombosis, venous thrombosis/disease, and pulmonary embolism. We want to highlight that while overall incidence of CVD is declining, arterial thrombosis, venous thrombosis/disease, and pulmonary embolism are becoming a larger burden of CVD mortality. The absolute differences in the rates between racial demographics show there are still significant and growing disparities in subtypes of PVD. We hope these results highlight the critical need to continue research to identify determinants of PVD outcomes. Of notable exception, the AAMR in aortic aneurysm in Black individuals was lower than White individuals. This is congruent with prior literature, where the incidence of aortic aneurysm was 2-fold higher in White than Black men.[18] However, despite this known difference in prevalence,[19] there is a disproportionate increase in Black mortality, with a rising ratio of mortality of Black men compared with White men (37% increase in 2019 compared with 1999, Black men/White men [0.58–0.80]). Interestingly, this is the isolated vascular subtype in

which proportionate Black female mortality dropped further than White female mortality (of 12% in Black women/White women [0.9–0.8]). Reasons explaining these findings are unclear but may involve Black women having a higher competing risk of mortality from other causes (cardiovascular or noncardiovascular causes).

Finally, while we investigated the ratio of PVD burden in women versus men, we did not find any striking difference in the predilection for mortality in sex (unlike the differences seen for race). We used AAMR to overcome the potential barrier of the higher life expectancy in women. The reasons underpinning the sex differences are still not fully elucidated[20] but clearly remain relatively consistent across the prior decades.

Factors explaining these results remain an area of debate. Biologic mechanisms may include glucose metabolism and insulin resistance in Black populations, which may contribute to some discrepant rates between Black and White individuals; however, this alone clearly does not explain the significant variation.[5] Disparities in income, housing, educational level, access to health care, and trust of the health care system as a whole are perpetual social and environmental obstacles faced by the Black population.[21] Black individuals have higher rates of medical comorbidities like hypertension,[22] obesity, and diabetes, in addition to the association of cigarette smoking and subclinical PVD.[23] This can be compounded by chronic stress leading to dysregulation of hormones, endothelium, vascular hyperactivity, and metabolic disturbances.[5] Regardless of the underpinning mechanisms, PVD disproportionately and detrimentally impacts Black individuals. Despite 20 years of emphasis in PVD recognition and treatment, we showed continued (and growing, in some subtypes) disparities in AAMR between Black and White individuals. We hope these findings bring forth further awareness to our health care providers and alight future research on social and geographic determinants of health and disparities in PVD outcomes, like county-level social vulnerability indexes and disease-specific outcomes.

Our study has several limitations that perpetually accompany epidemiologic studies. The primary limitation stems from the utilization of the Centers for Disease Control and Prevention's Wide-Ranging Online Data for Epidemiologic Research database. While consistently used in large, population-based studies, there are inevitably errors with misclassified data/information. Unfortunately, our ability to determine confounders like comorbidities and inability to correctly adjudicate or validate outcomes is a limitation.[12] Second, this study compared only mortality rates between Black and White adults. Trends of other racial demographics were unable to be included, as they are not consistently reported (Hispanic, Asian, Native American). This highlights an area for future improvements in our national databases to minimize racial misclassification. Finally, there may be systemic differences between PVD and the general population on how deaths were classified. For example, if the cause of death is unclear for an individual, it is conceivable that the death could be attributed to PVD. Despite these limitations, this study provides sufficient data and scope to examine the temporal and demographic patterns of PVD and represents a complementary and substantial contribution to the existing PVD mortality literature to encourage future research.

CONCLUSIONS

In this retrospective review of the multiple cause of death data in the United States, our findings demonstrate continued significant disparities between Black and White populations in overall PVD mortality, as well as the subtypes of vascular involvement. This is a call to action to improve equity and eradicate disparity in the treatment of vascular diseases. Changes must occur at multiple levels to help improve/address outcomes in this vulnerable population, starting with education in the communities, engagement of providers and hospital systems, and alteration of societal guidelines to highlight current deficiencies.

ARTICLE INFORMATION

Received January 10, 2022; accepted June 6, 2022.

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Sources of Funding

None.

Disclosures

Dr Li is on the advisory board for Inari Medical and Boston Scientific and is a consultant for Abbott Vascular and Philips. Dr Shishehbor is a consultant for Abbott Vascular, Medtronic, Terumo, Philips, and Boston Scientific. No other authors have any disclosures.

Supplemental Material

Tables S1–S4
Figure S1

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SUPPLEMENTAL MATERIAL

Table S1. Table of Abbreviations, ICD 10 codes

Disease	Abbreviation	ICD 10 Codes
Cardiovascular Disease	CVD	I00-I99 Diseases of the Circulatory System
Vascular Disease	PVD	ICD I70-I78 Diseases of arteries, arterioles, and capillaries; ICD I80-89 Diseases of vein, lymphatic vessel, lymph nodes, not elsewhere classified including Phlebitis and thrombophlebitis; ICD I26 pulmonary embolism
Aortic Aneurysm	AA	I71.1 (Thoracic aortic aneurysm, ruptured); I71.2 (Thoracic aortic aneurysm, without mention of rupture); I71.3 (Abdominal aortic aneurysm, ruptured); I71.4 (Abdominal aortic aneurysm, without mention of rupture); I71.5 (Thoracoabdominal aortic aneurysm, ruptured); I71.6 (Thoracoabdominal aortic aneurysm, without mention of rupture); I71.8 (Aortic aneurysm of unspecified site, ruptured); I71.9 (Aortic aneurysm of unspecified site, without mention of rupture)
Aortic Dissection	AD	I71.0 Dissection of aorta
Arterial Thrombosis	AT	I74 Arterial embolism and thrombosis, I77 Other disorders of arteries and arterioles, I78 Diseases of the capillaries
Venous Thrombosis/disease	VTD	I80-I89 Diseases of the Vein, lymphatic vessels, and lymph nodes
Pulmonary Embolism	PE	I26 Pulmonary Embolism

Table S2. Census Population, Cardiovascular and Peripheral Vascular Deaths by Race

Population	Northeast (Region 1)	Midwest (Region 2)	South (Region 3)	West (Region 4)	Total
Total Population	897,089,480 (18.4%)	1,059,819,518 (21.7%)	1,797,628,788 (36.9%)	1,120,154,667 (23.0%)	4,874,692,453 (100%)
Black Population	111,944,234 (18.2%)	106,296,276 (17.2%)	338,207,638 (54.9%)	60,113,411 (9.7%)	616,561,559 (100%)
White Non-Hispanic Population	646,195,687 (19.5%)	861,970,373 (26.0%)	1,156,377,818 (34.8%)	653,702,782 (19.7%)	3,318,246,660 (100.0%)
White Hispanic Population	80,778,048 (13.1%)	53,653,636 (8.7%)	229,410,829 (37.2%)	252,264,965 (40.9%)	616,107,478 (100.0%)
Total Deaths	9,936,215 (18.9%)	12,275,000 (23.4%)	20,104,567 (38.3%)	10,229,593 (19.5%)	52,545,375 (100%)
Black Deaths	984,901 (16.1%)	1,156,448 (18.9%)	3,448,247 (56.4%)	522,626 (8.6%)	6,112,222 (100%)
White Non-Hispanic Deaths	8,342,312 (19.8%)	10,776,420 (25.6%)	15,235,536 (36.2%)	7,693,753 (18.3%)	42,048,021 (100.0%)
White Hispanic Deaths	403,537 (14.0%)	178,780 (6.2%)	1,144,102 (39.6%)	1,164,635 (40.3%)	2,891,054 (100.0%)
Total CVD Deaths	3,531,203 (19.8%)	4,178,057 (23.4%)	6,717,134 (37.7%)	3,400,477 (19.1%)	17,826,871 (100.0%)
Black CVD Deaths	347,813 (16.4%)	400,530 (18.8%)	1,187,804 (55.9%)	189,697 (8.9%)	2,125,844 (100.0%)
White Non-Hispanic CVD Deaths	2,985,504 (20.8%)	3,680,561 (25.7%)	5,090,112 (35.5%)	2,589,137 (18.0%)	14,345,314 (100.0%)
White Hispanic CVD Deaths	126,577 (14.5%)	47,864 (5.5%)	353,974 (40.6%)	342,407 (39.3%)	870,822 (100.0%)
Total PVD Deaths	161,594 (18.2%)	229,523 (25.8%)	326,212 (36.7%)	171,387 (19.3%)	888,187 (100%)
Black PVD Deaths	16,501 (15.0%)	22,309 (20.3%)	62,114 (56.4%)	9,208 (8.4%)	110,132 (100.0%)
White Non-Hispanic PVD Deaths	137,837 (19.1%)	202,161 (28.0%)	246,534 (34.1%)	136,394 (18.9%)	722,926 (100.0%)

White Hispanic PVD Deaths	**4,803 (13.4%)**	**2,488 (7.0%)**	**13,767 (38.5%)**	**14,733 (41.2%)**	**35,791 (100.0%)**

PVD (peripheral vascular disease), CVD (cardiovascular disease), percentages expressed as percent of row total

Table S3. Percent Mortality by Age Group, aged 18 years and older, 1999 to 2019

Age	Cardiovascular Disease	Vascular Disease	Aortic Dissection	Aortic Aneurysm	Arterial Thrombosis	Venous Disease	Pulmonary Embolism	All Cause Mortality
18-24	0.13%	0.36%	0.61%	0.09%	0.60%	1.00%	0.84%	1.04%
25-34	0.50%	1.26%	2.51%	0.34%	1.50%	3.59%	2.80%	1.85%
35-44	1.76%	3.07%	7.34%	0.83%	3.05%	8.39%	6.21%	3.20%
45-54	5.25%	6.22%	14.53%	2.24%	7.11%	14.24%	11.10%	7.00%
55-64	10.22%	10.76%	18.81%	8.35%	14.14%	16.10%	15.69%	12.26%
65-74	15.90%	17.57%	19.61%	22.46%	22.55%	16.23%	19.47%	17.81%
75-84	27.63%	28.13%	22.28%	37.25%	28.47%	20.02%	24.13%	26.46%
85+	38.62%	32.63%	14.31%	28.44%	22.59%	20.43%	19.76%	30.39%

Table S4. Percent Mortality of Cardiovascular Disease by each Vascular Subtype and Percent Change by Race

Race	Disease	1999	2019	Percent Decrease
Black Female	CVD	42.88%	33.76%	-21.28%
	PVD	5.51%	5.15%	-6.54%
	AD	0.32%	0.48%	49.78%
	AA	0.68%	0.38%	-43.54%
	AT	0.20%	0.21%	2.64%
	VTD	0.48%	0.79%	63.95%
	PE	1.51%	1.69%	11.77%
White Female	CVD	41.02%	28.97%	-29.36%
	PVD	5.74%	4.51%	-21.40%
	AD	0.29%	0.39%	36.06%
	AA	1.00%	0.82%	-18.74%
	AT	0.27%	0.23%	-16.48%
	VTD	0.38%	0.50%	31.25%
	PE	1.06%	1.13%	7.08%
Black Male	CVD	38.08%	33.45%	-12.14%
	PVD	5.01%	4.54%	-9.43%
	AD	0.38%	0.66%	74.53%
	AA	0.93%	0.87%	-5.57%
	AT	0.16%	0.16%	-0.37%
	VTD	0.40%	0.62%	56.56%
	PE	1.21%	1.20%	-0.72%
White Male	CVD	40.23%	30.73%	-23.62%
	PVD	5.55%	4.05%	-27.12%
	AD	0.39%	0.48%	21.89%

	AA	1.73%	0.98%	-43.39%
	AT	0.21%	0.15%	-26.83%
	VTD	0.27%	0.43%	60.98%
	PE	0.74%	0.86%	15.58%

CVD (Cardiovascular disease, percent of overall mortality), PVD (Vascular disease), AD (Aortic dissection), AA (Aortic aneurysm), AT (Arterial thrombosis), VTD (Venous thrombosis/disease), PE (Pulmonary embolism)

Positive results (e.g., venous thrombosis/disease and pulmonary embolism in females) signify a rise in mortality in 2019 compared to 1999 due to the specified diagnosis. For instance, BF had a rise of proportionate arterial thrombosis by 2.6% in 2019 compared to 1999 (displayed 2.6%) compared to WF which had a decrease of proportionate arterial thrombosis by 17% (displayed as -16.5%).

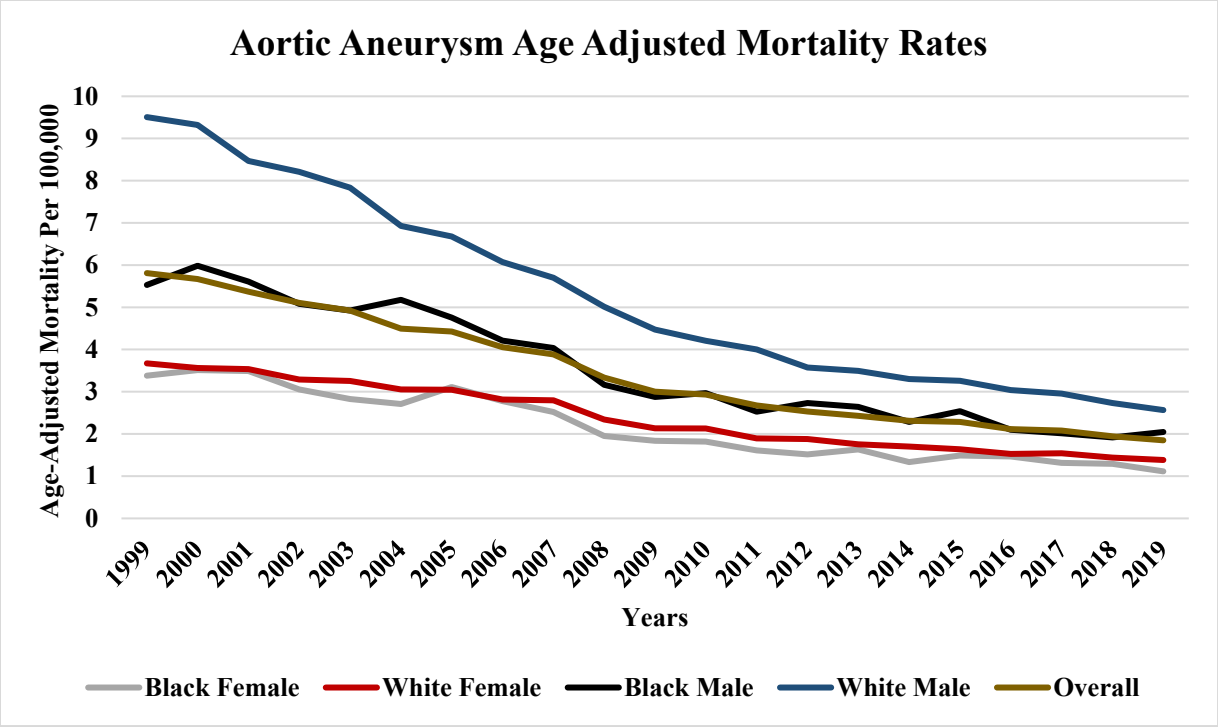

Figure S1A. Overall Aortic Aneurysm Mortality Rates by Race

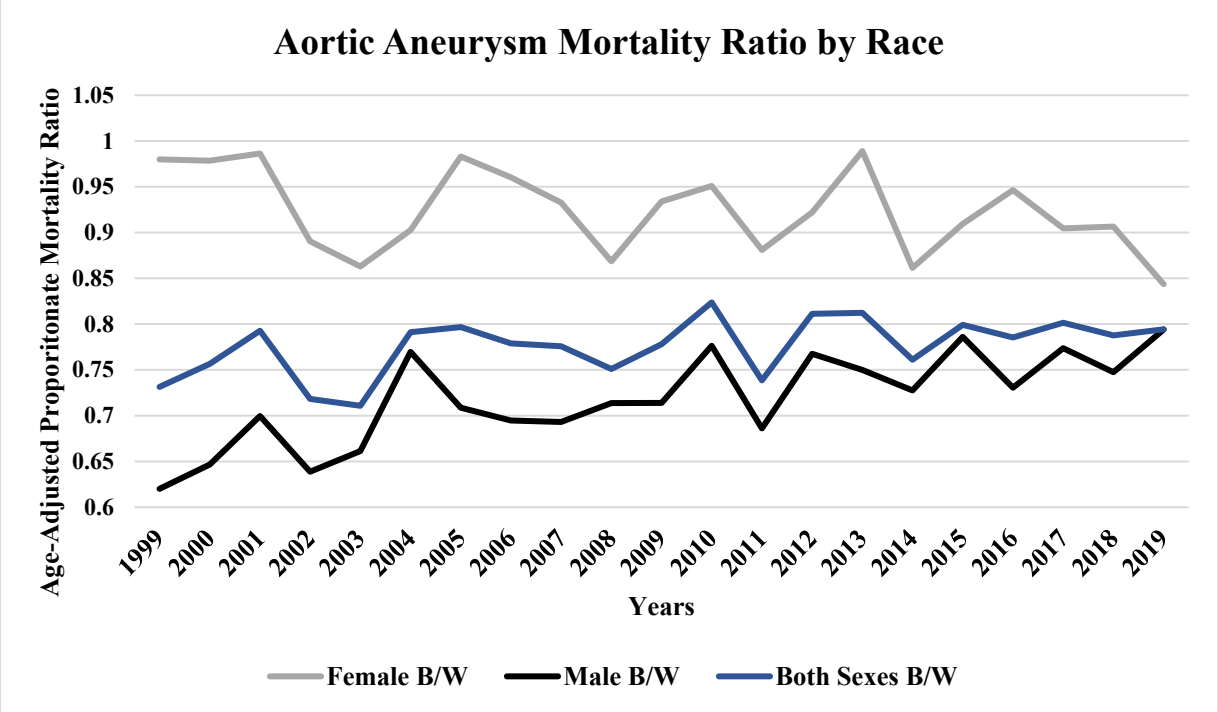

Figure S1B. Overall Aortic Aneurysm Mortality Ratio by Race and Sex