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ARTICLE

Hypertension-related heart failure mortality among older adults in the United States: a nationwide analysis of demographic and regional trends

Muhammad Muneeb Ur Rehman,[1] Muhammad Sameer Arshad,[2] Muhammad Abdul Tawab,[1] Rahael Javaid,[2] Sunil Modi,[3] Marat Fudim[4]

[1]Shifa College of Medicine, Shifa International Hospital, Islamabad, Pakistan; [2]Baylor Scott and White Research Institute, Dallas, TX, USA; [3]Express Family Clinic, Allen, TX, USA; [4]Division of Cardiology, Duke University Hospital, Duke University School of Medicine, Durham, NC, USA

Abstract

Although hypertension (HTN) is a major risk factor for heart failure (HF), limited national data exist on trends in mortality where HF is the underlying cause of death and HTN is a contributing factor among older adults aged ≥65 years. The aim of the study is to evaluate temporal, demographic, and regional trends in HTN-related HF mortality among older US adults from 1999 to 2020. We used CDC WONDER (Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiologic Research) mortality data to identify deaths with HF as the underlying cause and HTN as a contributing cause in individuals aged ≥65 years. Age-adjusted mortality rates (AAMRs) per 100,000 were calculated by year, sex, race/ethnicity, region, and urban-rural status. Join-point regression was used to determine changes in trends over time. Between 1999 and 2020, 378,851 HTN-related HF deaths occurred, most in nursing homes/long-term care facilities (34.7%), at home (31.2%), or in medical facilities (24.6%). The AAMR rose from 31.8 in 1999 to 38.3 in 2005 (APC 3.2; 95% CI, 2.2-4.7), declined to 34.0 in 2009 (APC –2.6; 95% CI, –4.6 to –0.7), remained stable through 2014, and then increased sharply to 66.1 in 2020 (APC 10.9; 95% CI, 9.9-12.6). Women had higher overall mortality than men (41.7 vs. 37.5). NH Black adults had the highest rates (64.1), followed by NH White (38.9), NH American Indian/Alaska Native (38.3), Hispanic/Latino (34.3), and NH Asian/Pacific Islander (26.2). Mississippi had the highest state-level rate (109.6), while Hawaii had the lowest (20.2). Regionally, the West (48.5) exceeded the Northeast (29.8). Nonmetropolitan areas had higher mortality than metropolitan areas (44.9 vs. 39.5). We concluded that HTN-related HF mortality in older adults has risen markedly since 2014, with the greatest burden among women, NH Black adults, Western states, and rural populations. These findings underscore the need for improved HTN control and HF care in high-risk groups.

Key words: heart failure, hypertension, mortality, CDC WONDER, trends.

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**Correspondence to: Muhammad Muneeb Ur Rehman, Shifa College of Medicine, Shifa International Hospital, Pitras Bukhari Road, Sector H-8/4, Islamabad, Pakistan. E-mail: muneebqazi264@gmail.com*

Introduction

Heart failure (HF) and hypertension (HTN) are among the most prevalent causes of mortality associated with cardiovascular diseases.[1] HTN affects nearly 31.1% of the global adult population (1.39 billion adults).[2] In the United States (US), the prevalence of HTN from 2017 to 2020 was 64.1% among adults aged 65 to 74 years and 74.5% among adults aged 75 years or older.[3] HTN is responsible for a substantial economic burden of $131 billion, accounting for more than 3% of national healthcare expenditures in the US.[4] HF is a major public health concern affecting over 23 million people globally and over 5.8 million people in the US, and is associated with increased risk of morbidity and mortality.[5] The prevalence of HF increases with age, with approximately a 4-fold higher prevalence (8-9%) among adults older than 65 years in the US.[6] HF costs over $32 billion in treatment expenditures in the US. The prevalence of HF is expected to increase to 8.5% by the year 2030.[7]

HTN is one of the major risk factors in the development of HF. This is attributed to left ventricular hypertrophy, diastolic dysfunction, and HTN-related cardiac remodeling.[8] HTN accounts for nearly 39% of HF cases in men and 59% in women. Hypertensive men have a 2-fold higher risk, while hypertensive women have a 3-fold higher risk of developing HF.[9] HTN is associated with increased mortality in patients with HF. According to a study, hypertensive adults aged 65–84 who developed heart failure had a 76% mortality rate over a median follow-up of 6.7 years.[9] Antihypertensive medications reduce the incidence of HF by nearly 50%. Moreover, several trials have shown that these medications reduce mortality rates in patients with HF.[10]

Unlike prior national mortality studies that examined HF or HTN in isolation, this analysis is a complementary surveillance study that specifically evaluates deaths in which HF was the underlying cause, and HTN was coded as a contributing cause among adults aged ≥65 years. While this approach cannot establish individual-level causality, it provides important population-level data on the evolving burden of coexisting HTN and HF in an aging US population. Identifying the demographic and regional patterns of HTN-related HF mortality is crucial to identifying at-risk populations and providing targeted interventions. Therefore, we conducted this study to analyze various temporal, demographic, and geographic trends in HTN-related HF mortality among U.S. adults aged 65 years and older, using national mortality data from 1999 to 2020.

Methods

Setting and study population

Using codes from the International Statistical Classification of Diseases and Related Health Problems-10th Revision (ICD-10), death certificate data were obtained from the CDC WONDER (Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiologic Research) database and analyzed for HTN-related HF mortality among older adults from 1999 to 2020. Adult deaths (≥ 65 years) that happened between 1999 and 2020 were included. Previous studies have used a similar age cutoff for older adults.[11,12] The multiple cause of death data was utilized to identify individuals aged 65 years and above, with HF as the underlying cause of death and HTN as a contributing cause. ICD-10 codes I10-I15 were used for HTN, and I11.0, I13.0, I13.2, and I50.x for HF. Similar codes for HTN and HF have been used in previous studies.[13,14] Because death certificate data depends on physician coding practices, we used a surveillance definition for HTN-related HF mortality. This was defined as deaths where HF was the underlying cause and HTN was a contributing cause. Consequently, the trends reported here only reflect the mortality burden of people with these co-occurring diagnoses and should be interpreted as epidemiologic associations rather than direct etiologic associations. As this study followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) reporting requirements and used a deidentified government-issued public use data collection, it did not need authorization from the local institutional review board.

Data extraction

The extracted data included total population, year, sex, age, race/ethnicity, region, urban-rural classification, place of death, and state. Race/ethnicity was categorized as non-Hispanic (NH) White, NH Black or African American, Hispanic or Latino, NH Asian or Pacific Islander, and NH American Indian or Alaskan Native. The place of death was categorized into the decedent's home, medical facilities, nursing homes or long-term care facilities, hospice centers, and others. The census regions were divided into the Northeast, the Midwest, the South, and the West. The population was evaluated using the National Center for Health Statistics Urban-Rural Classification Scheme, divided into urban [large metropolitan area (population ≥1 million), medium/small metropolitan area (population 50,000-999,999)], and rural (population <50,000) categories.[15]

Statistical analysis

To analyze national trends in HTN-related HF mortality, crude and age-adjusted mortality rates (AAMR) per 100,000 population were calculated by sex, year, race/ethnicity, state, and urban-rural status with 95% CIs from 1999 to 2020. The number of HTN-related HF deaths was divided by the total US population of that year to calculate the crude mortality rates. The AAMRs were calculated by standardizing the number of deaths to the 2000 U.S population.[16] To measure annual nationwide trends in HF mortality associated with HTN, the Joinpoint Regression Program (Joinpoint V 5.2.0.0, National Cancer Institute) was used to calculate the annual percent change (APC) with 95% CI in AAMR.[17] This technique uses log-linear regression models when temporal variation occurs to identify significant changes in AAMR across time. Model selection was performed using the Monte Carlo Permutation method to identify the simplest model that best fit the data, allowing for a maximum of 3 joinpoints (4 segments) for the study duration. APCs were classified as rising or falling using 2-tailed t-testing if the slope showing the change in mortality showed a significant deviation from zero. A $p<0.05$ was considered statistically significant. To validate our primary findings and to address potential misclassification bias inherent to contributing-cause coding, we conducted a formal sensitivity analysis. We restricted mortality data to only hypertensive heart disease with HF (I11.0) as the underlying cause of death, from 1999 to 2020.

Results

Between 1999 and 2020, a total of 378,851 HTN-related deaths occurred among older patients (aged ≥65 years) with HF (Supplementary Table 1). Among these, 34.7% occurred in nursing homes/long-term care facilities, 31.2% occurred at home, 24.6% occurred in medical facilities, and 4% occurred in hospices (Supplementary Table 2).

Overall trends for hypertension-related mortality in heart failure

The AAMR for HTN-related deaths in patients with HF was 31.8 in 1999 and 66.1 in 2020. There was a rise in overall AAMR from 1999 to 2005 (APC: 3.2; 95% CI: 2.2 to 4.7), followed by a decrease from 2005 to 2009 (APC: -2.6; 95% CI: -4.6 to -0.7). There was a period of stability from 2009 to 2014 (APC: 0.7; 95% CI: -0.7 to 9.7), which was followed by a significant increase in AAMR from 2014 to 2020 (APC: 10.9; 95% CI: 9.9 to 12.6) (Figure 1) (Supplementary Tables 3 and 4).

Gender stratification

The overall AAMRs were consistently higher in older women compared to older men throughout the study duration (overall AAMR women: 41.7; 95% CI: 41.6 to 41.9; men: 37.5; 95% CI: 37.2 to 37.7). In 1999, the AAMR for older women was 34 (95% CI: 33.2 to 34.7), which increased to 41.1 in 2005 (APC: 3.2; 95% CI: 2.2 to 4.4), followed by a decrease to 35.9 in 2009 (APC: -3; 95% CI: -4.8 to -1.2). There was a period of stability until 2014 (APC: 0.05; 95% CI: -1.1 to 8.8), followed by a substantial rise to 65.4 in 2020 (APC: 10.2; 95% CI: 9.4 to 11.7). Likewise, the AAMR for older men in 1999 was 26.6 (95% CI: 25.7 to 27.6), which increased to 32.1 in 2005 (APC: 3.2; 95% CI: 2.1 to 5.9), followed by a period of stability until 2011 (APC: -0.7; 95% CI: -3.7 to 0.4). There was an increase in AAMR to 36.9 in 2015 (APC: 4.8; 95% CI: 2.1 to 8.9), followed by a significant increase to 65.8 in 2020 (APC: 12.8; 95% CI: 11.7 to 14.9) (Figure 1) (Supplementary Tables 3 and 4).

Racial stratification

The overall AAMRs were the highest in NH Black or African American patients (AAMR: 64.1; 95% CI: 63.6 to 64.7), followed by NH White (AAMR: 38.9; 95% CI: 38.8 to 39.1), NH American Indian or Alaska Native (AAMR: 38.3; 95% CI: 36.3 to 40.3), Hispanic or Latino (AAMR: 34.3; 95% CI: 33.9 to 34.8), and NH Asian or Pacific Islander (AAMR: 26.2; 95% CI: 25.6 to 26.8). For the NH American Indian or Alaska Native population, there was a period of stability from 1999 to 2014 (APC: 3.1; 95% CI: -1.9 to 4.7), followed by an increase until 2020 (APC: 9.6; 95% CI: 6.4 to 19.1). For NH Asian or Pacific Islanders, there was a period of stability from 1999 to 2006 (APC: 2.5; 95% CI: -0.05 to 13.9), followed by a decline until

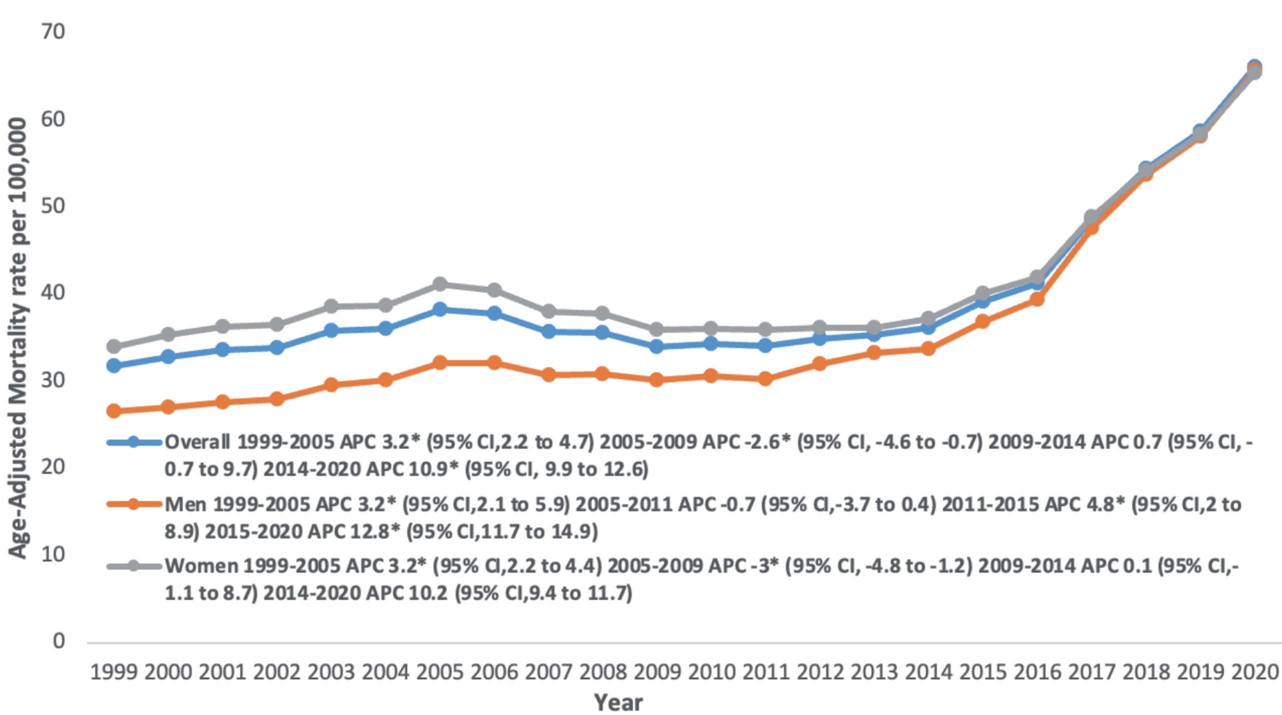

Figure 1. Overall and sex-stratified hypertension-related heart failure age-adjusted mortality rates per 100,000 in older adults in the United States, 1999 to 2020. *Indicates that the annual percentage change (APC) is significantly different from zero at α=0.05.

2014 (APC: -2.8; 95% CI: -9.9 to -0.7), and an increase from 2014 to 2020 (APC: 7.8; 95% CI: 5.4 to 12.4). For both the NH Black or African American and the Hispanic or Latino population, there were multiple periods of stability until 2015. For NH Black or African Americans, there was an increase in AAMR from 2015 to 2018 (APC: 6; 95% CI: 0.5 to 7.2), followed by a significant rise until 2020 (APC: 11.3; 95% CI: 8.5 to 13.5). For Hispanic or Latino people, there was an increase in AAMR from 2015 to 2020 (APC: 9.9; 95% CI: 6.4 to 16.8). For NH Whites, there was a rise in AAMR from 1999 to 2005 (APC: 3.6; 95% CI: 2.3 to 5.6), followed by two periods of stability until 2014, and a substantial increase from 2014 to 2020 (APC: 11.9; 95% CI: 10.7 to 14.2) (Figure 2) (Supplementary Tables 3 and 5).

Geographical stratification

There was a significant variation in AAMRs across different states. Mississippi had the highest mortality rates (AAMR: 109.6; 95% CI: 107.3 to 111.9), while Hawaii had the lowest (AAMR: 20.2; 95% CI: 19 to 21.5). States in the top 90th percentile with the highest AAMRs included Mississippi, Oklahoma, Tennessee, Washington, and Arkansas. States with the lowest AAMRs in the lower 10th percentile included Hawaii, Connecticut, Massachusetts, Delaware, and Alaska (Figure 3) (Supplementary Table 6). Throughout the study duration, the highest mortality was seen in the Western region (AAMR: 48.5; 95% CI: 48.2 to 48.9), followed by the Southern (AAMR: 43.2, 95% CI: 43 to 43.4), Midwestern (AAMR: 38.2; 95% CI: 37.9 to 38.4), and Northeastern (AAMR: 29.8; 95% CI: 29.6 to 30.1) (Supplementary Table 7).

Throughout the study duration, nonmetropolitan areas had greater AAMRs than metropolitan areas, with overall AAMRs of 44.9 (95% CI: 44.6 to 45.2) and 39.5 (95% CI: 39.4 to 39.6), respectively. The AAMRs for both nonmetropolitan and metropolitan areas increased from 1999 to 2005 (nonmetropolitan: APC: 3.9; 95% CI: 2.9 to 5.1; metropolitan: APC: 2.9; 95% CI: 2 to 4.3). For nonmetropolitan areas, the AAMRs declined from 2005 to 2011 (APC: -1.9; 95% CI: -3.8 to -0.9), followed by an increase until 2015 (APC: 3.1; 95% CI: 0.5 to 6.4), and a further rise until 2020 (APC: 12; 95% CI: 11.1 to 13.4). For metropolitan areas, the AAMRs decreased from 2005 to 2009 (APC: -2.6; 95% CI: -4.5 to 0.9), followed by a period of stability until 2014 (APC: 0.8; 95% CI: -0.3 to 8.8), and a significant increase from 2014 to 2020 (APC: 10.9; 95% CI: 10 to 12.3) (Figure 4) (Supplementary Tables 3 and 8).

Sensitivity analysis

The AAMR for hypertensive heart disease with HF was 21.6 in 1999, which increased to 25.2 in 2005 (APC: 2.6; 95% CI: 1.0 to 5.2), followed by a decrease to 22.9 in 2013 (APC: -1.2; 95% CI: -3.6 to -0.2). The AAMR remained stable from 2013 to 2016 (APC: 6.7; 95% CI: -0.9 to 9.1). There was a sharp rise in AAMR from 26.6 in 2016 to 42.6 in 2020 (APC: 12.1; 95% CI: 10.6 to 15.9).

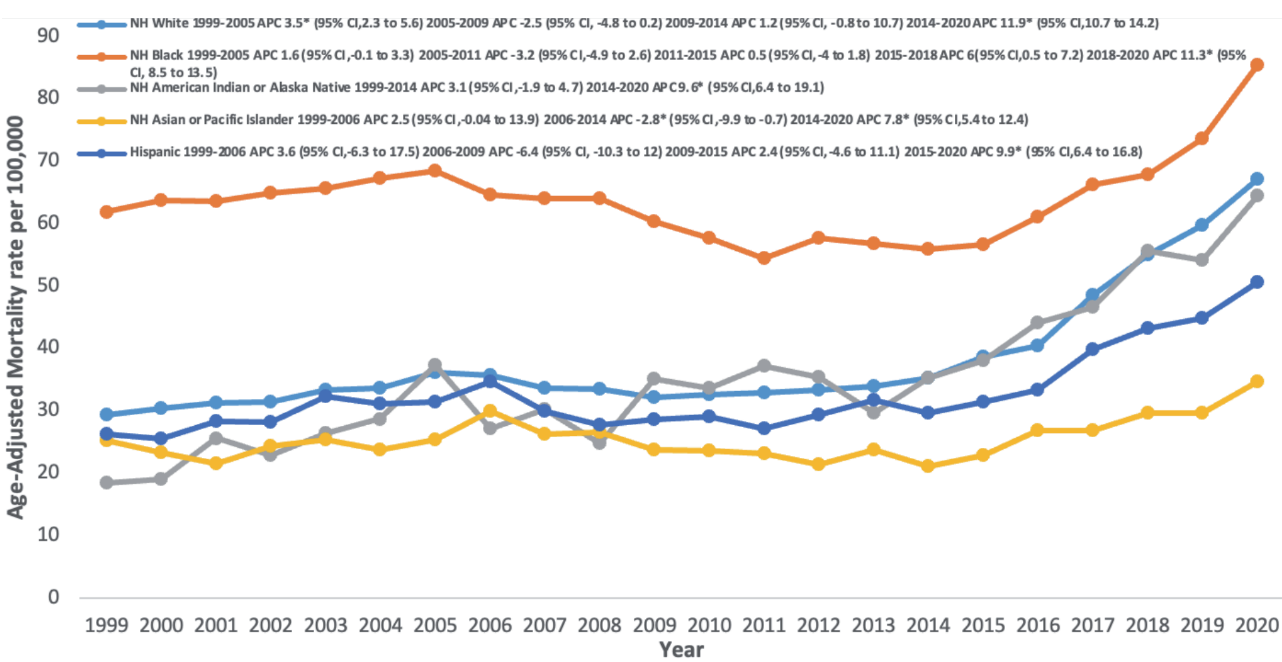

Figure 2. Hypertension-Related Heart Failure age-adjusted mortality rates per 100,000 Stratified by Race in Older Adults in the United States, 1999 to 2020. *Indicates that the annual percentage change (APC) is significantly different from zero at α=0.05.

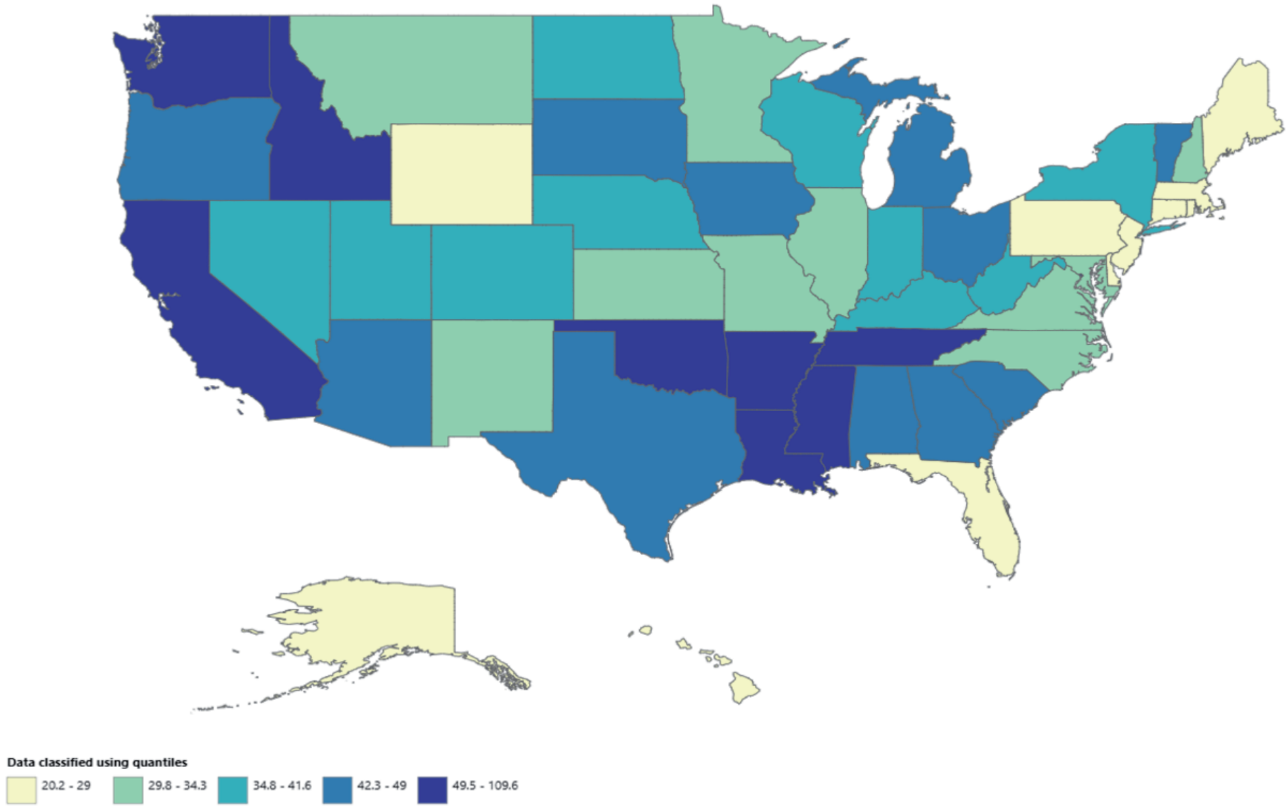

Figure 3. Hypertension-Related Heart Failure age-adjusted mortality rates per 100,000 Stratified by States in Older Adults in the United States, 1999 to 2020.

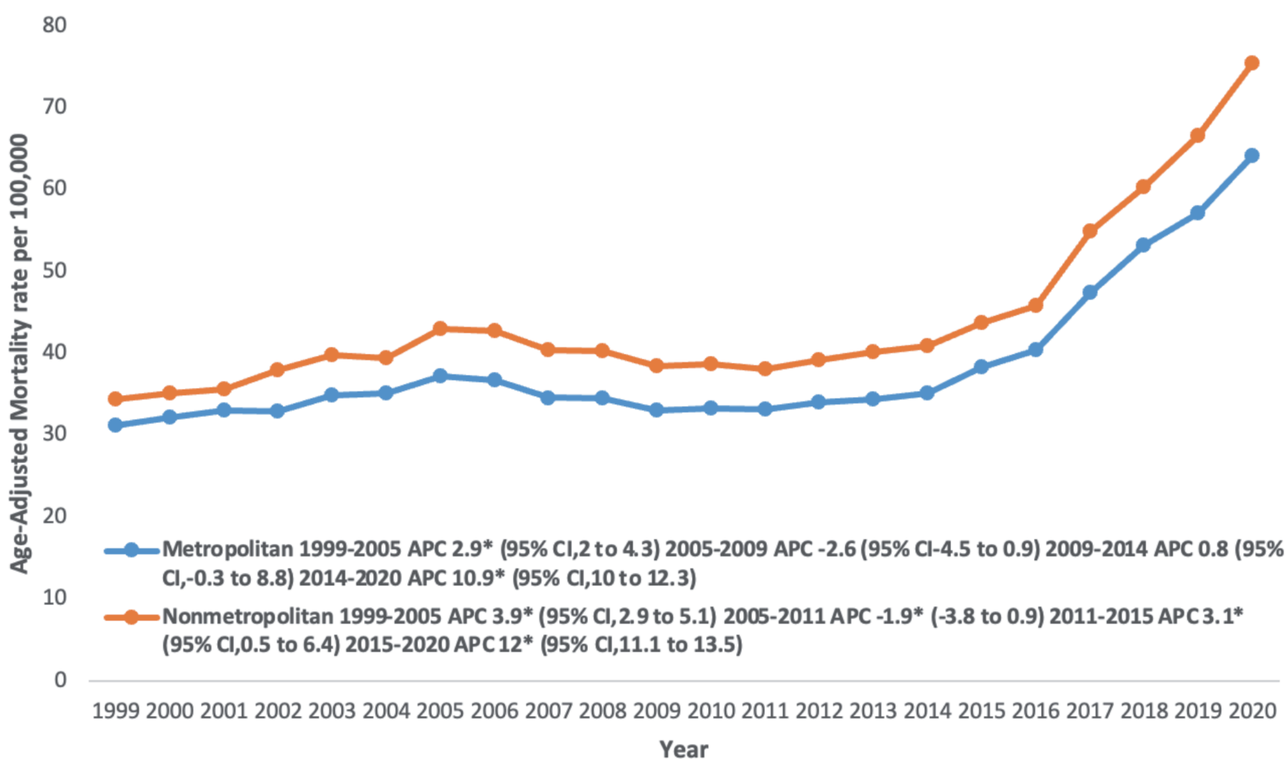

Figure 4. Hypertension-related Heart Failure age-adjusted mortality rates per 100,000 Stratified by Urban-Rural Status in Older Adults in the United States, 1999 to 2020.

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Discussion

In our nationwide analysis of CDC WONDER data for HTN-related HF mortality trends among US adults aged 65 years and older between 1999 and 2020, we report several key findings. First, the overall AAMR more than doubled during this time, with a sharp increase after 2014. Second, women had higher AAMR than men. Third, NH Black or African American people had the highest AAMR compared to all other racial groups in this age group. Fourth, regional disparities in AAMRs were also observed; nonmetropolitan areas had higher AAMRs than metropolitan areas, and the Western region had the highest mortality among census regions. These findings highlight the growing burden of coexisting HTN and HF in the aging U.S. population. Understanding these demographic, regional, and temporal trends and disparities is crucial to inform evidence-based policies that enhance HTN control, improve access to HF management, and allocate resources effectively to reduce preventable cardiovascular deaths in this high-risk population.

Our findings are consistent with a previous study that demonstrated rising mortality trends due to HF among older adults.[18] However, our study uniquely reports that HTN as a contributing cause in HF deaths has sharply accelerated in the past decade. These increasing mortality trends could be attributed to multiple reasons. The prevalence of HTN and HF increases with age.[3,6] This is because aging is associated with arterial stiffness, impaired neurohormonal and autonomic regulation, and endothelial dysfunction, which results in worsening of HTN.[19,20] Moreover, aging results in decreased beta-adrenergic stimulation, impaired inotropic and chronotropic responses, dysregulation of calcium release, and impaired cardiac contractility.[21] These factors, along with a higher incidence of cardiovascular risk factors in the older population,[22] result in higher prevalence and worsening of HF in this age group. The number of older individuals in the US is increasing with time.[23] Additionally, aging is associated with higher mortality due to HF, with 1 and 5-year mortality rates of 7.4% and 24.4% for 60-year-olds and 19.5% and 54.5% for 80-year-olds, respectively.[21] The sharp rise in mortality trends after 2014 for different demographic and ethnic groups could be attributed to decreased blood pressure control after 2014. HTN control improved from 32.2% in 1999-2000 to 53.8% in 2009-2010.[24,25] The HTN control stayed constant from 2009 to 2014 at 53.8%.[26] This is consistent with our finding of a period of relative stability from 2009 to 2014. However, from 2015-2018, adults aged ≥60 years had a substantial reduction in blood pressure (BP) due to a significant decline in HTN awareness and treatment effectiveness.[27] According to data from the US National Health and Nutrition Examination Survey (NHANES), only 43.7% adults with HTN in the US had controlled BP.[26] The sharp rise in HTN-related HF mortality observed after 2014 in our analysis parallels nationally documented declines in hypertension control, particularly among adults aged ≥60 years, despite relatively stable awareness and treatment rates.[26,27] After steady improvements through the early 2010s, population-level blood pressure control plateaued and subsequently worsened, which temporally aligns with the inflection points identified in our Joinpoint analysis. The consistency of this increase across sex, racial/ethnic, regional, and urban–rural subgroups, along with the disproportionately higher mortality observed among women, non-Hispanic Black adults, and nonmetropolitan populations, supports the interpretation that loss of effective and sustained BP control, treatment inertia, and disparities in longitudinal cardiovascular care are key population-level contributors to the rising mortality burden among older adults with HF. These factors, in conjunction with polypharmacy concerns, frailty, and therapeutic inertia in older adults, may explain why older patients are experiencing worsening outcomes despite advancements in management. The inflection points identified by Joinpoint regression are interpreted descriptively and are contextualized using established epidemiologic data, including national trends in hypertension awareness, treatment, and control, rather than implying discrete causal events. These findings have important implications for public health planning. Analyzing the hypertension-related HF mortality trends allows for the timely identification of high-risk populations and informs the development of various effective preventive strategies aimed at improving HTN control and HF management in older adults.[18] Healthcare professionals can use this data to implement community-level interventions that reduce the burden of cardiovascular mortality in this high-risk population.[28]

We also observed significant gender disparities, with older women demonstrating higher AAMRs than older men. This is in contrast to a previous study where older men had higher HF mortality rates.[18] One of the reasons could be that HTN is more common in older women aged 65 years or older compared to men in the same age group (70.2% *vs* 65.4%).[3] This can be explained by the inherent biological differences between the 2 sexes, including differences in sex hormones and gene expression.[29,30] Elderly women have a higher risk of morbidity and mortality from cardiovascular diseases, especially those with HF.[31] Additionally, the prevalence of HF increases with age, and older women have a greater risk compared to men. The incidence rates of HF at each 10-year interval after 65 are doubled for men and tripled for women, especially for heart failure with preserved ejection fraction (HFpEF).[32] HTN has a greater association with HF in women compared to men.[33] Furthermore, women are less frequently referred for specialized treatment or diagnostic evaluations, and they receive fewer interventions, such as revascularization, implantable cardioverter defibrillators (ICDs), cardiac resynchronization therapy (CRT), or mechanical circulatory support.[32] This is consistent with higher mortality trends observed among women in our study.

Our results demonstrate significant differences in mortality rates among different racial groups. Older NH Black or African American (AA) adults had the highest AAMRs, while NH Asian or pacific islanders had the lowest. This is consistent with the prevalence of these conditions. NH AAs have the highest prevalence of both HTN and HF compared to other racial groups.[3,33] Additionally, the proportion of people with wellcontrolled BP was lower in NH AAs compared to other racial groups, which could be attributed to poor educational status and low income.[34] NH AAs also have a higher incidence of other cardiovascular risk factors and mortality from HF compared to other racial groups.[5] Previous studies have reported that NH Asians have the lowest prevalence of HTN and HF compared to other groups.[35,36] A study demonstrated that AAMRs for HF per 100,000 were highest for NH Black individuals at 41.4, followed by NH Whites at 33.1, NH American Indian or Alaska Natives at 21.1, Hispanic or Latinos at 18.18, and NH Asian or Pacific Islander individuals at 12.9 in 2020.[6] This is entirely consistent with our findings of mortality rates in these groups. These disparities could be due to differences in underlying pathophysiology, sociocultural factors, environmental and behavioral factors.[37] Targeted policies for reducing racial disparities should focus on improving access to care and expanding community-based prevention programs. Culturally tailored interventions might help in addressing differences in treatment, awareness, and outcomes among high-risk groups like older NH black adults.

Significant regional variations were also observed in our study. Mississippi had the highest HTN-related HF mortality rates across all states. In Census regions, the Western region had the highest AAMRs, while the Northeastern region had the lowest. This is in contrast to previous data, which suggests that the Midwestern region has the highest prevalence and mortality rates due to HF.[18,38] However, when HTN is the contributing cause, the Western region has the highest mortality burden. Mississippi has the highest cardiovascular mortality across the entire US.[38] This is consistent with our findings. These disparities could be due to variations in healthcare quality, changes in population demographics, and specific regional patterns of uncontrolled HTN. Our findings highlight the need for large, population-based studies to investigate the underlying causes of regional variations in HTN-related HF mortality. Understanding these differences is crucial to formulate region-specific strategies and optimize healthcare delivery across the U.S.

We also observed that nonmetropolitan areas have higher HTN-related HF mortality rates than metropolitan areas. This is consistent with previous studies.[18,39] The elevated AAMRs in rural regions may be associated with a low socioeconomic status, a lack of healthcare infrastructure, a scarcity of healthcare providers, and a reduced ability to access preventive services.[40] Access to primary and specialty care should be strengthened, which can help improve HTN control and reduce HF-related mortality in underserved rural areas. Although formal sensitivity analyses and multivariable adjustment were not feasible using aggregate death certificate data, several analytic features support the robustness of these findings. All mortality rates were age-adjusted to the 2000 U.S. standard population to account for population aging, and disparities persisted across sex, racial/ethnic, regional, and urban–rural strata. Importantly, the relative excess mortality observed among non-Hispanic Black adults, residents of Western states, and nonmetropolitan populations was consistent over time and became more pronounced after 2014, arguing against demographic shifts alone as an explanation. These patterns are therefore best interpreted as stable population-level disparities rather than causal effects at the individual level.

Limitations

Our study has several limitations. First, this study relies on death certificate–based ICD-10 coding, which may be subject to misclassification or underreporting of hypertension as a contributing cause in patients with heart failure. However, the use of a consistent ICD-10 framework across the entire study period and the presence of parallel trends across demographic and geographic subgroups support the interpretation that the observed patterns reflect population-level epidemiologic changes rather than isolated shifts in coding practices. This interpretation is further strengthened by our sensitivity analysis, which showed that mortality due to hypertensive heart disease with HF followed a similar upward trend over the last decade. Second, while we used HTN as the contributing cause and HF as the underlying cause of death, the causal relationship cannot be confirmed due to the observational nature of the data. Third, our analysis does not account for individual-level important clinical factors such as ejection fraction, medication use, comorbidities, or healthcare access, which could influence outcomes. Fourth, Cause-of-death data from CDC WONDER do not include clinical phenotypes such as ejection fraction; therefore, we could not stratify deaths by HFrEF vs HFpEF, which is particularly relevant given the disproportionate contribution of hypertension to HFpEF in older adults. Lastly, although stratification was performed by major demographic and geographic variables, residual confounding may still exist due to unmeasured socioeconomic and environmental factors.

Conclusions

In this nationwide analysis of CDC WONDER data, we found that HTN-related HF mortality among U.S. adults aged 65 years and older has increased substantially over the past two decades, with a particularly sharp rise since 2014. This upward trend was consistent across nearly all demographic and geographic subgroups, including sex, race, region, and urban–rural status. Women, NH Black individuals, residents of the Western US, and those living in nonmetropolitan areas had higher mortality rates. These findings highlight an urgent public health concern and emphasize the need for efforts to improve HTN control and HF management in older adults.

Contributions

All the authors made a substantive intellectual contribution, read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Conflict of interest

The authors declare no potential conflict of interest.

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Online supplementary material:

Supplementary Table 1. Hypertension-related heart failure mortality trends, stratified by sex among older adults in the US, 1999-2020.

Supplementary Table 2. Hypertension-related heart failure mortality stratified by place of death, among older adults in the US, 1999-2020.

Supplementary Table 3. Annual percent change (APC) of hypertension-related heart failure age-adjusted mortality rate per 100,000 among older adults in the US, 1999-2020.

Supplementary Table 4. Overall and sex stratified hypertension-related heart failure age-adjusted mortality rates per 100,000 in older adults in the US, 1999-2020.

Supplementary Table 5. Hypertension-related heart failure age-adjusted mortality rates per 100,000, stratified by race among older adults in the US, 1999-2020.

Supplementary Table 6. Hypertension-Related heart failure age-adjusted mortality rates per 100,000, stratified by states among older adults in the US, 1999-2020.

Supplementary Table 7. Hypertension-related heart failure age-adjusted mortality rates per 100,000, stratified by census regions among older adults in the US, 1999-2020.

Supplementary Table 8. Hypertension-related heart failure age-adjusted mortality rates per 100,000, stratified by urban-rural classification among older adults in the US, 1999-2020.