

REVIEW

Mortality trends in essential hypertension and type 2 diabetes among older adults in the United States

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ABSTRACT

Background: Essential hypertension and type 2 diabetes mellitus frequently coexist in older adults, increasing cardiovascular morbidity and mortality risks. Despite advancements in care, recent evidence shows that cardiovascular mortality has plateaued, with increased hypertension-related deaths in the U.S. This study aims to analyze mortality trends in older adults (≥65) with both conditions and examine disparities based on demographics and geography.

Hypothesis: We hypothesized that age-adjusted mortality rates (AAMRs) for older adults with coexisting hypertension and diabetes significantly increased from 1999 to 2024, with variations by sex, race/ethnicity, region, and urbanization.

Methods: We conducted a retrospective analysis using the CDC WONDER database, identifying deaths from 1999-2024 where essential hypertension (ICD-10 I10) and type 2 diabetes (ICD-10 E11.x) were listed as causes. Mortality rates were calculated per 100,000, and Joinpoint regression analyzed trends.

Results: From 1999 to 2024, there were 331,823 eligible deaths (aggregate AAMR 60.3/100,000). The AAMR rose sharply from 10.1 in 1999 to 106.1 in 2021, before slight declines in 2022-2024. Males had higher mortality rates than females and experienced steeper increases. Significant racial/ethnic disparities were observed, with American Indian/Alaska Native and Hispanic seniors seeing notable declines post-2021, while rates for White and Black seniors plateaued. Regionally, the West and South showed the highest increases, with rural counties experiencing a greater surge than metropolitan areas.

Conclusions: Mortality due to coexisting hypertension and diabetes among U.S. older adults rose dramatically from 1999 to 2021, with significant demographic and regional disparities. A recent plateau in mortality trends suggests potential shifts, highlighting the need for targeted public health interventions for high-risk groups to address this dual epidemic in an aging population.

Keywords: Mortality, essential hypertension, type 2 diabetes, United States.

Introduction

Hypertension and diabetes are pervasive and interrelated health problems in older adults. In the United States, over 29% of people ≥65 have diabetes [1], and approximately 70%-80% of those also have hypertension [2]. In one study, more than 80% of older diabetics had coexistent hypertension [3]. This multimorbidity greatly heightens risks: hypertension is a leading driver of cardiovascular disease and kidney failure, and in patients with diabetes, it amplifies the risk of heart failure, stroke, and mortality [2]. Globally, high blood pressure is the leading risk factor for death, implicated in an estimated 13.5% of all deaths each year[4]. Diabetes is similarly formidable,

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responsible for around 1.5 million deaths worldwide in 2019 and ranking among the top ten causes of death [5].

In the U.S., improvements in cardiovascular mortality over the past decades have recently stagnated. National Vital Statistics data show that while age-adjusted heart disease death rates declined through 2010, mortality from hypertension and diabetes has been rising or plateauing in the 2010s [6,7]. Hypertension-related death rates increased from 2000 to 2013, and diabetes deaths surged 15% in 2020 alone during the COVID-19 pandemic. Older adults, in particular, have experienced adverse trends: one study noted a plateau in diabetes mortality and a slower decline in heart disease mortality among seniors after 2011[6]. Another recent analysis of U.S. death certificates found that combined cardiometabolic mortality (from cardiovascular causes and diabetes) actually began increasing after 2014, especially in older and minority populations. These troubling patterns suggest that the longstanding gains against cardiovascular and metabolic diseases may be reversing for the nation's elders [8].

However, the extent of the mortality burden specifically attributable to coexisting hypertension and type 2 diabetes in older Americans – and how it varies across demographic groups remains inadequately characterized. Both conditions often appear together on death certificates of older persons, reflecting their intertwined pathophysiology (e.g., diabetic nephropathy exacerbating hypertension) and combined impact on fatal outcomes [2]. Understanding the trends in these dual-condition deaths can inform whether care of high-risk multimorbid patients has improved or worsened over time. It can also illuminate which subpopulations are most affected and may benefit from targeted interventions.

We therefore analyzed nationwide data from 1999 to 2024 on deaths among adults aged 65 and above that involved both essential hypertension and type 2 diabetes. We sought to quantify temporal trends in the mortality rates of this co-morbid condition cluster and to examine differences by sex, race/ethnicity, geographic region, and urban vs. rural residence. We hypothesized that mortality rates have risen substantially over the past two decades, with disproportionate increases among certain demographic groups. Clarifying these trends is critical for public health planning as the U.S. population ages – the number of adults ≥65 has already doubled since 2000 [from ~35 million to ~72 million projected by 2040] and as hypertension and diabetes prevalence continue to climb in older age groups [9]. Findings from this study can help inform clinical strategies and community interventions to curb excess mortality in seniors living with both hypertension and diabetes.

Methods

Data source and case definition

We used the Centers for Disease Control and Prevention (CDC) Wide-Ranging Online Data for Epidemiologic Research (WONDER) mortality database[10]. This database contains U.S. death certificate data as compiled by the National Center for Health Statistics. We accessed the Multiple Cause-of-Death files for years 1999-2024 [released 2023], which include both underlying and contributing causes of death coded to the International Classification of Diseases, Tenth Revision (ICD-10). Using WONDER's query system, we identified all deaths of U.S. residents aged 65 years or older where the ICD-10 codes for Essential (primary) hypertension (I10) and Type 2 diabetes mellitus (E11, including all E11.0–E11.9 subcodes) were both listed among the multiple causes of death. In accordance with the TITAN Guidelines 2025 for transparent use of AI in scholarly communication, no AI tools were used in the research design, data collection, analysis, or interpretation; AI assistance was limited solely to language refinement during manuscript preparation[11]. This definition captures decedents in whom hypertension and type 2 diabetes co-occurred as causes (either as the underlying cause or as significant contributing conditions on the death certificate). We included all such deaths in each year from 1999 through 2024. Deaths were aggregated by year of occurrence; for 2022-2024, data are provisional. Population denominators and other cause-of-death data were obtained via the same system, using intercensal and postcensal population estimates provided by the NCHS (with the 2020 Census incorporated) [12].

Outcome measures

The primary outcome was the annual age-adjusted mortality rate (AAMR) for deaths involving both hypertension and diabetes, expressed per 100,000 population. Age adjustment used the direct method to the 2000 U.S. standard population (the standard utilized by CDC for mortality statistics). We also examined crude death rates and total death counts to assess the absolute burden. Stratified analyses were conducted by sex (male, female), race/ethnicity (categorized as non-Hispanic White, non-Hispanic Black, American Indian or Alaska Native [AI/AN], and Hispanic – as reported on death certificates), by Census region (Northeast, Midwest, South, West), and by urbanicity of county (metro vs. non-metro, using the NCHS Urban-Rural Classification). We obtained stratified death counts and rates from CDC WONDER by specifying group-by variables (e.g., year, race, region, and urbanization) in separate queries. When aggregating data over multiple years or categories, we used the "Show Totals" option to include overall sums and rates.

Trend analysis

We used joinpoint regression to quantitatively characterize time trends and identify change-points (joinpoints) in the mortality trajectories. Joinpoint regression is a form of piecewise log-linear regression that finds points where the slope of a trend significantly changes [13]. We utilized the National Cancer Institute's Joinpoint software (version 5.0) to model the AAMR trends for the overall population and for each subgroup. The modeling started with zero joinpoints (a single linear trend) and sequentially tested for additional joinpoints using Monte Carlo permutation tests, following standard methods by Kim et al. [14]. The maximum number of joinpoints allowed was set to 4 (given 25 years of data), and a minimum of 3 years between joinpoints was enforced. For each segment between joinpoints, we estimated the Annual Percent Change (APC) in the mortality rate with its 95% confidence interval (CI). We also computed the Average Annual Percent Change (AAPC) over the entire 1999-2024 period for summary purposes. Statistical significance for trend changes and APCs was determined at the 0.05 level. To illustrate trends, we plotted the AAMRs over time with joinpoint segment fits for key subgroups.

Statistical software

Data aggregation and age adjustment were performed through CDC WONDER's online interface. Joinpoint regression was carried out in Joinpoint software [13]. All rates are reported per 100,000 population per year, age-adjusted unless otherwise specified. Because this study analyzed publicly available de-identified data, it was exempt from institutional review board review.

Results

Overall mortality trends

A total of 331,823 deaths of adults aged ≥65 from 1999 through 2024 listed both essential hypertension and type 2 diabetes as causes. This reflects the substantial mortality burden of these comorbid conditions in older Americans. The annual number of these dual-cause deaths rose dramatically over the study period – from 3,485 in 1999 to a peak of 56,931 in 2021 – outpacing the growth of the older population. The crude mortality rate increased roughly ten-fold [in 1999,to 102.6 in 2024], and the age-adjusted mortality rate (AAMR) increased by a similar magnitude (from 10.1 to 95.9 per 100,000; see Table 1 and Supplementary Table 1). From 1999 to 2024, the majority of essential hypertension and type 2 diabetes mellitus–related deaths in our study occurred in medical facilities, accounting for approximately 32.4 % of the total 478,098 deaths. Nursing homes/LTCFs and home settings contributed significantly as well, constituting approximately 28.9 % and 31.6 %, respectively (Supplementary Table 2).

Overall Trends: 1999-2001 is an explosive increase, with AAMR rising by approximately +60% per year (APC = +59.99%, 95%CI 18.9-103.7%, p < 0.000001). This corresponds to the AAMR jump from ~10 to ~25 per 100,000 in just two years. 2001-2016: a more gradual but sustained increase (APC = +2.84%, 95%CI 0.8%-3.8%, p = 0.027), during which the AAMR rose from ~25 to ~50. 2016-2021: a marked re-acceleration, with AAMR climbing by +12.57% annually (95%CI 8.6%-20.3%, p = 0.0004). This late surge coincided with the years immediately before and during the COVID-19 pandemic; the AAMR spiked from 50.5 in 2015 to 106.1 in 2021. 2021-2024: the model identified a possible inflection in 2021, with rates flattening or slightly declining thereafter (APC = –3.54%, 95%CI -10.3% to +1.35%, p = 0.18). By 2024, the AAMR had dipped to 95.9, suggesting a pause in the rising trend. However, the post-2021 decrease was not statistically significant for the overall population, indicating a plateau more than a definitive downturn (Supplementary Tables 1 and 3).

Sex differences

Throughout 1999-2024, men had higher mortality rates than women for the hypertension–diabetes combination. Over the entire period, 56.2% of the deaths were in men. The male AAMR was 13.4 in 1999, compared to 8.5 in females, and by 2021 had reached 127.8, compared to 89.5 in females. Figure 1 displays the sex-specific trends. Both sexes experienced the sharp increase in early 1999-2001 (APCs ~+65%/year for both, p < 0.000001). During the long 2001-2017 period, men's mortality rose faster (APC = +3.92%/year, 95%CI 2.6%-4.8%) than women's (APC = +2.46%/year, 95%CI 0.8%-3.4%); both trends were significant (p = 0.0016 and p = 0.019, respectively). Notably, men showed virtually no plateau in the early 2010s – their rates climbed steadily – whereas women experienced a slight slowing (women's APC 2001-2017 was smaller, and for 2001-2014 it was +2.0%, p < 0.05, followed by a minor uptick).

From 2017 to 2021, both sexes saw a dramatic upswing: male APC = +14.93%/year (95%CI 10.2%-20.7%, p < 0.000001) and female APC = +13.41% (95%CI 7.8%-20.5%, p = 0.002). This corresponds to the period when national AAMR roughly doubled (particularly from 2019 to 2021, partly due to the pandemic). By 2021, the male–female mortality gap was sizable, with the rate for males ~1.4 times that of females. After 2021, a slight decline occurred in both sexes (APC –3.7% in men, –4.3% in women), but neither decrease was statistically significant. In 2022-2024, the male AAMR remained about 30-35 per 100k higher than the female AAMR [e.g., 116.5 vs 80.0 in 2024] (Supplementary Tables 1, 3, and 4).

Race and ethnicity trends

There were striking racial/ethnic disparities in mortality, and the magnitude and timing of trends differed by group (Figure 2). Table 1 summarizes key APCs by race. Early in the study period (circa 1999-2003), older Black and American Indian/Alaska Native (AI/AN) populations had the highest mortality from the hypertension–diabetes combination, with AAMRs roughly double those of Whites and Hispanics. For example, in 2000, the AAMR for Black seniors was 44.7, and for AI/AN 32.0, compared to 27.4 for Whites and 28.0 for Hispanics. The initial 1999-2001 surge was evident in all groups except Hispanics: Non-Hispanic White, Black, and AI/AN seniors saw APCs of +56% to +63% per year in that brief interval (p<0.001), reflecting a rapid early rise in mortality across those groups. By contrast, among Hispanic older adults, the increase appeared slightly delayed and more gradual: their joinpoint model did not isolate 1999-2001 as a distinct segment, instead showing a steady climb through 2018 (AAPC +5.8%/year, p≈0.02).

During the mid-period (2001-2015), White Americans exhibited a modest upward trend (APC 2.2%-4.0%, p = 0.003), whereas Black older adults showed a flat trend (APC +2.24%, 95% CI –5.7 to +3.3%, p = 0.15). AI/AN seniors showed a non-significant trend (2002-2016, p = 0.19). By the early 2010s, the mortality gap between Black and White individuals narrowed, although Black

Table 1. Demographic Characteristics of Essential HTN & T2DM Deaths in the USA, 1999-2024.

Variable	Deaths n (%)	AAMR 1999-2024 (per 100 000)
Overall Population	478,098 (100.00%)	49.91
Men	331,823 (69.40%)	66.22
Women	357,486 (74.77%)	50.59
Northeast	87,130 (18.22%)	37.50
Midwest	168,314 (35.20%)	63.82
South	235,430 (49.24%)	53.56
West	198,435 (41.51%)	74.13
American Indian or Alaska Native	5,400 (1.13%)	88.29
Black or African American	79,712 (16.67%)	78.93
White	500,218 (104.63%)	52.67
Hispanics	86,621,293 (18117.89%)	74.62
Metropolitan	375,383 (78.52%)	47.55
Non-metropolitan	102,715 (21.48%)	60.59
Medical facility	154,938 (32.41%)	–
Nursing home / LTCF	138,312 (28.93%)	–
Hospice	14,215 (2.97%)	–
Home	151,014 (31.59%)	–
Other	18,748 (3.92%)	–

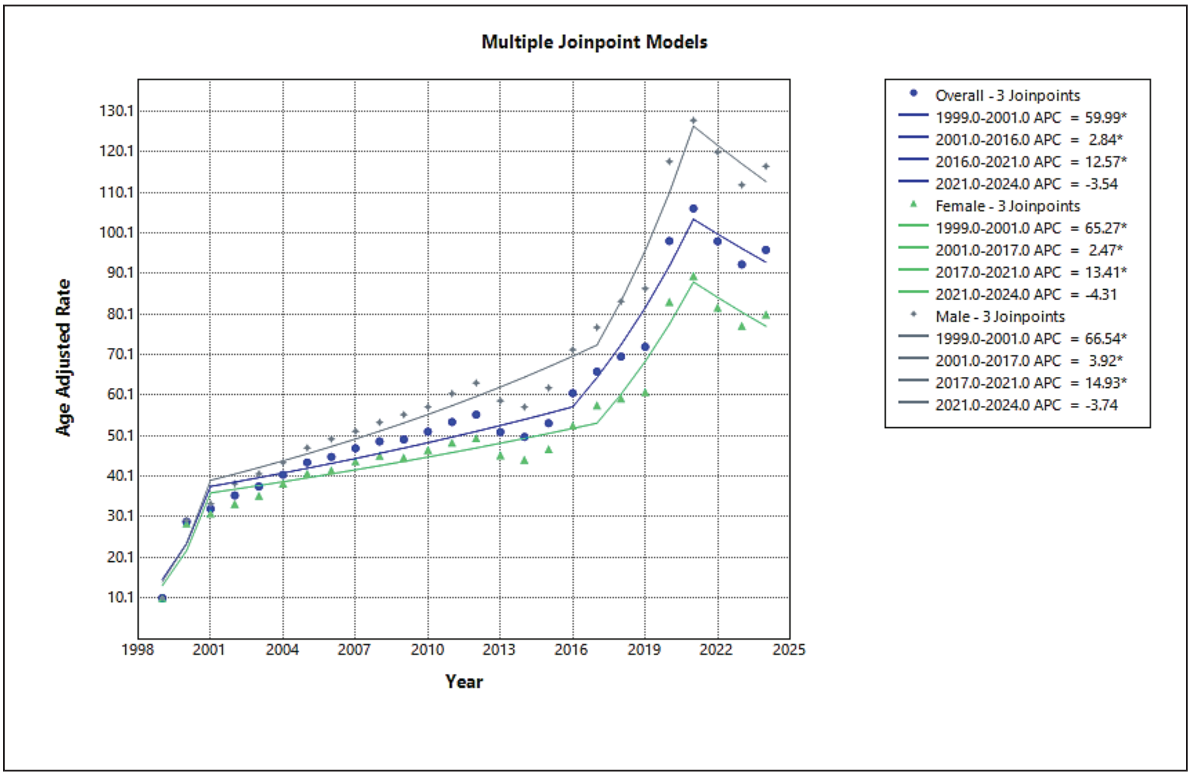

***Figure 1.** National mortality rates (age-adjusted) for co-occurring essential hypertension and type 2 diabetes in adults ≥65, 1999–2024. The overall rate rose steeply in the early 2000s and again in the late 2010s, with a slight decline after 2021. Male and female rates are shown separately: men had higher mortality and a faster increase in recent years than women.*

AAMRs remained higher (2015: White 61.9 vs Black ~72 per 100k). In the late 2010s, a dramatic increase occurred across all groups, especially among Hispanics (APC +19.7%, 95%CI 10.2%-25.3%, $p < 0.000001$), AI/AN (APC 12.6%, 95%CI 7.5%-21.8%, $p < 0.000001$), and Whites (APC +16.4%, 95%CI 9.7%-20.3%, p =

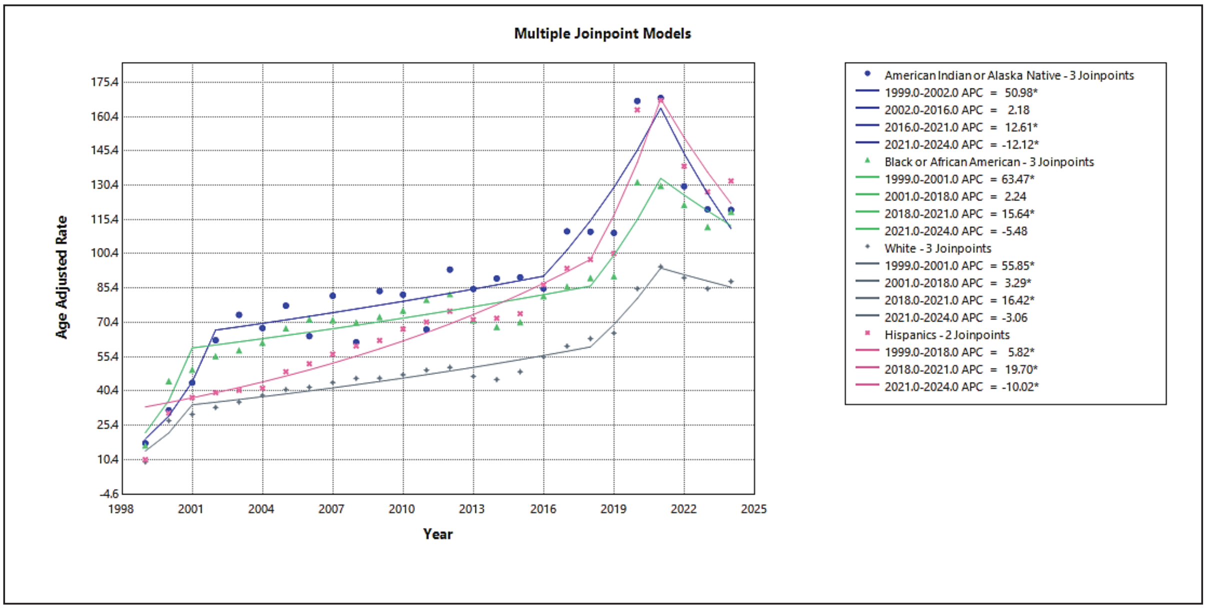

Figure 2. *Age-adjusted mortality rates for older adults (65+) with coexisting hypertension and diabetes, by race/ethnicity, 1999–2024. Early in the period, non-Hispanic Black and American Indian/Alaska Native (AI/AN) seniors had the highest rates, but by the late 2010s Hispanic and AI/AN rates surged above others. A recent downturn after 2021 is notable in the AI/AN and Hispanic groups. (AI/AN: blue; Black: green; White: grey; Hispanic: pink.)*

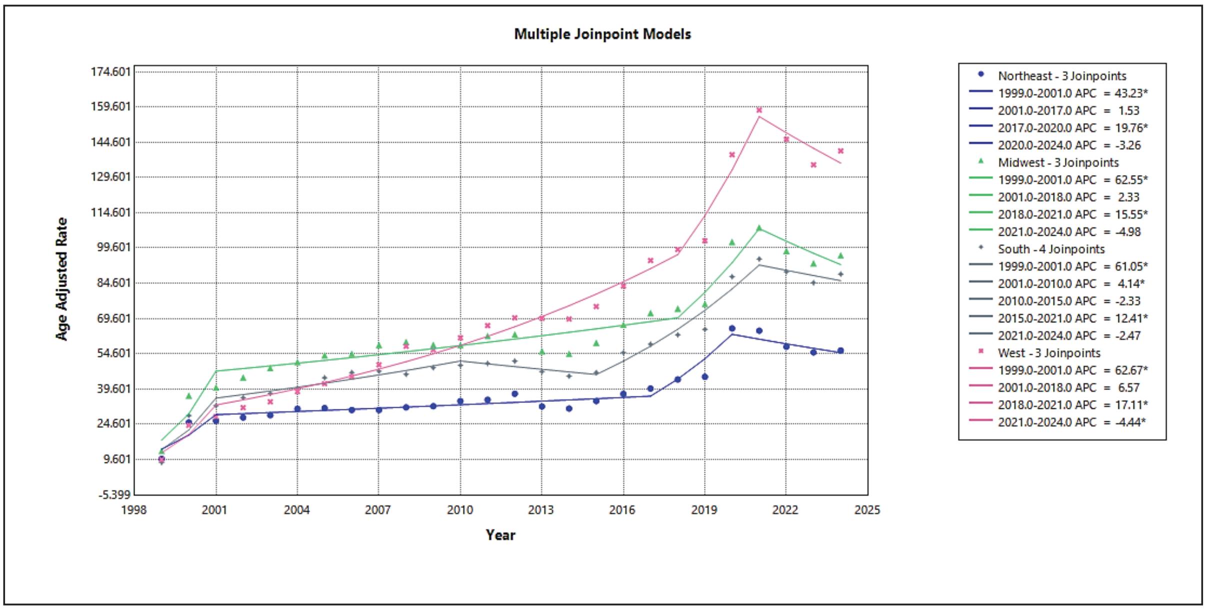

Figure 3. *Age-adjusted mortality rates for co-occurring hypertension and diabetes among older adults, by U.S. Census region (1999–2024). The West (magenta) experienced the most dramatic increase, overtaking the South (grey) by the late 2010s. The Midwest (green) showed intermediate rates, and the Northeast (blue) remained the lowest. A plateau or decline after 2020 is seen in most regions, most notably in the West.*

0.0016). Blacks also had a late rise (2018-2021 APC +15.6%, 95%CI 6.1%-21.5%, p = 0.011). By 2021, AI/AN and Hispanic elders had slightly higher AAMRs than Black elders, while White seniors narrowed the gap with Black seniors (Supplementary Tables 1, 3, and 5).

Post-2021, trends diverged

Hispanic AAMR fell from 163.7 to 128.9 (APC = –10.0%/year, 95%CI –19.5 to –4.2%, p = 0.0012) and AI/AN AAMR from 168.5 to 119.6 (APC = –12.1%/year, 95%CI –21.2 to –5.4%). In contrast, White (APC –3.06%, p = 0.15) and Black seniors (APC –5.48%, p = 0.078) saw smaller, non-significant changes. By 2024, the AAMRs were AI/AN and Black (~120), Hispanic (~129), and White (~88), indicating that while disparities persist, the racial gap has somewhat narrowed overall.

Geographic and regional patterns

When examined by U.S. Census region, mortality trends for the hypertension–diabetes combination revealed

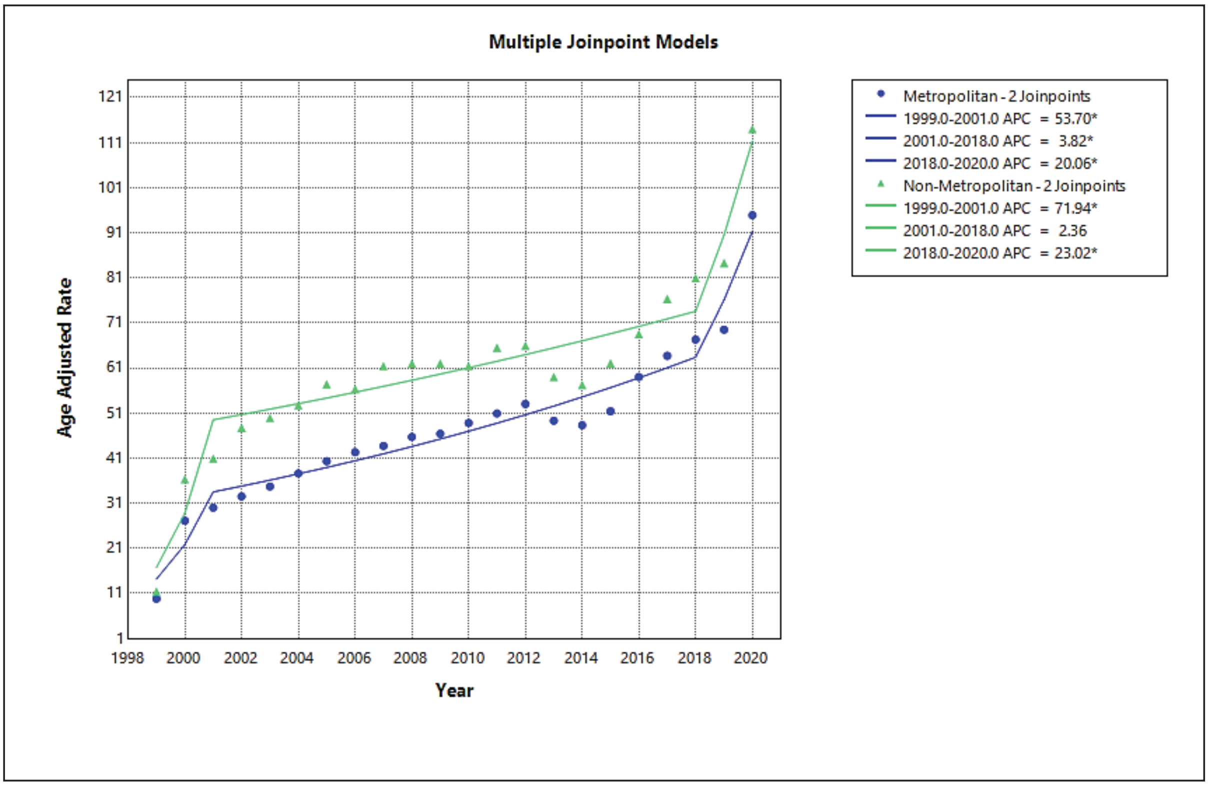

Figure 4. *Mortality trends in metropolitan vs. non-metropolitan areas for older adults with hypertension and diabetes, 1999–2020. Rural (non-metro, green line) areas have higher age-adjusted mortality than urban (metro, blue line) areas across the period. Both saw rapid increases in 1999–2001 and 2018–2020. The rural–urban gap widened in absolute terms over time, reaching ~19 per 100k in 2020.*

clear geographic variations (Figure 3). Historically, the South, which has the nation's highest prevalence of hypertension and diabetes, contributed the most deaths (41% of total deaths in 1999-2024) and had among the highest rates. In 1999, the AAMR in the South was 8.4, slightly lower than the Midwest's 13.3 but higher than the West (9.6) and Northeast (9.9). However, trajectories over time differed: the Western region showed the most explosive growth in later years, while the Northeast remained comparatively low.

From 1999 to ~2004, all regions experienced significant rises, with APCs of +43.2%/year in the Northeast, +62.6% in the Midwest, +61.1% in the South, and +62.7% in the West (all $p < 0.000001$). By 2003, AAMRs ranged between 25 and 35. From 2001 to mid-2010s, trends diverged: Northeast had APC +1.53%/year (95%CI –0.3 to +2.3%, p = 0.067), Midwest APC +2.33%/year (95%CI –0.4 to +3.3%, $p = 0.060$), South had an increase (APC +4.14%/year, $p = 0.011$) then a non-significant decline (APC –2.33%, $p = 0.22$), and the West was up (APC +6.57%/year, 95%CI –1.8 to +7.5%, $p = 0.071$) with most increases after 2010. By 2015, rankings showed the Midwest highest (AAMR ~72), South ~66, West ~60, Northeast ~28. In the late 2010s, mortality spikes were noted, especially in the South (APC +12.41%, 95%CI 9.8–20.3%, $p = 0.0004$) and West (APC +17.11%, 95%CI 9.7–21.5%, $p < 0.000001$) from 2018–2021. The Midwest had APC +15.55% ($p = 0.013$) and the Northeast APC +19.76% (95%CI 10.7–24.9%, $p < 0.000001$) from 2017–2020. By 2021, the West's AAMR nearly doubled (from 85.1 in 2018 to 158.3), making it the highest region. Post-2020, trends stabilized or improved: West had a significant decline (APC = –4.44%, 95%CI –11.4 to –0.1%, $p = 0.046$) to AAMR 140.9 in 2024; Northeast declined (APC –3.26%, $p = 0.052$) to 56.0. South (APC –2.47%, $p = 0.30$) and Midwest (–4.98%, $p = 0.083$) showed non-significant decreases. By 2024, regional differences remained, with the West at ~141, Midwest 96.5, South 88.5, and Northeast 56.0 (Supplementary Tables 3 and 6).

Urban–rural differences

A pronounced urban–rural mortality gap was evident. We stratified data by metropolitan (metro) vs non-metropolitan (non-metro) counties (using the NCHS urban–rural classification, where "non-metro" includes both micropolitan and non-core rural counties). Older adults in rural areas consistently had higher death rates from the hypertension–diabetes combination than those in urban areas throughout 1999–2020.

In 1999, the AAMR was 9.8 in metro counties compared to 11.4 in non-metro counties, showing a 16% relative difference. Both areas experienced a spike from early 1999–2001 (metro APC +53.7%, rural APC +71.9%, both $p < 0.000001$). By 2001, the rural rate (41.3) surpassed the urban rate (30.0). From 2001–2018, metro APC was +3.82% (95% CI 2.5–4.5%, $p = 0.0096$) and non-metro APC was +2.36% (95% CI –0.04 to 3.27%, $p = 0.052$), indicating a plateau in rural areas. By 2018, metro AAMR was 83.2, and non-metro was 111.9. The late 2010s saw a surge, especially in rural counties. From 2018 to 2020, metro AAMR rose from 83.2 to 117.7 (APC +20.06%, 95% CI 9.0–27.1%, $p < 0.000001$). In non-metro counties, AAMR increased from 99.9 in 2017 to 120.0 in 2020 (estimated APC +23.0%, 95% CI ~7.1–32.0%, $p < 0.000001$). By 2020, non-metro AAMR was 114.0 versus 94.9 for metro, with older adults in rural areas having about 20% higher mortality. Preliminary data for 2021–2022 suggest both rates plateaued or slightly declined post-2020. The rural disadvantage likely persists, as indicated by stagnant rural diabetes mortality rates from 1999 to 2018 and an increasing rural–urban gap in cardiometabolic deaths, attributed to disparities in healthcare access, socioeconomic challenges, and higher disease burdens in rural communities (Figure 4, Supplementary Tables 3 and 7).

State level differences

Across the full 1999–2024 period, West Virginia showed the nation's highest age-adjusted mortality rate (AAMR) for essential hypertension and type 2 diabetes at 88.1 deaths per 100 000, followed by Ohio (84.2), California (82.9), Oklahoma (75.5), and North Dakota (74.5). At the opposite end of the spectrum, Massachusetts recorded the lowest AAMR (18.7 per 100 000), with Nevada (20.9), Louisiana (23.0), Connecticut (26.1), and New Jersey (29.3) rounding out the five states with the most favorable mortality profiles (Supplementary Table 8).

Discussion

In this national study spanning 25 years, we found that the convergence of essential hypertension and type 2 diabetes has become an increasingly lethal combination for older Americans, albeit with recent hopeful signs. Mortality rates for seniors with these co-occurring conditions have risen dramatically since 1999, roughly doubling each decade until the early 2020s. The overall age-adjusted mortality rate climbed about tenfold from 1999 to its peak in 2021, far outstripping population aging alone. This finding highlights the growing impact of dual chronic disease burdens in our aging society. Both hypertension and diabetes are common among older adults, and their coexistence exponentially increases risks of heart failure, stroke, kidney disease, and other fatal complications. Our results quantify how those risks translated into population mortality over time. Importantly, we observed a flattening or slight decline in death rates after 2021 – suggesting a potential turning point, though it is too early to declare a sustained reversal. Nonetheless, any recent improvement is encouraging, given that prior to the COVID-19 pandemic, the trajectory was unmistakably upward.

Comparing our findings to prior literature, we see both consistencies and new insights. Earlier analyses documented that U.S. hypertension and diabetes mortality outcomes were worsening in the 2010s. Shah et al. [6]reported a plateau in diabetes and a modest rise in hypertension mortality from 2011–2017 [6]. Our study specifically focused on deaths where both hypertension and diabetes were present, and we similarly found a significant acceleration around that period – e.g., a joinpoint in 2016 marking an upswing in the combined-condition mortality. This aligns with risk factor trends: blood pressure and glucose control improvements stalled in the mid-2000s, and obesity levels continued to climb, leading to more severe multimorbidity in older adults [8]. The mid-2010s also saw widening disparities; for example, our data show White Americans' mortality began rising faster, closing the gap with Blacks, which matches observations of rising mortality among middle-aged and older Whites due to cardiometabolic and "diseases of despair" factors in the 2010s.

We found pronounced demographic disparities. In our analysis, older male patients had about 40–50% higher mortality than females by 2020, and their rates increased more rapidly in recent years. This echoes the sex differences noted in hypertension-related cardiovascular disease outcomes and may be due to men having more severe hypertension, lower treatment adherence, or greater comorbidity burden (e.g., higher rates of co-occurring coronary disease) at a given age. Racial disparities remain stark: non-Hispanic Black seniors consistently suffered the highest or near-highest mortality rates until 2021, reflecting well-known inequities in chronic disease management, access to care, and social determinants of health [7]. Our finding that Black rates did not improve at all from 2001–2018 (whereas White rates did modestly) underscores that Black Americans missed out on whatever small gains were made in that period, widening the relative disparity. On a positive note, Black mortality did not worsen as sharply as some others during the pandemic and afterward, perhaps due to focused public health efforts or community resilience.

Meanwhile, American Indian/Alaska Native (AI/AN) and Hispanic populations experienced a striking surge in mortality in the late 2010s, overtaking other groups by 2020. The extremely high 2021 AAMR in AI/AN elders (around 169 per 100k) likely reflects the intersecting vulnerabilities faced by many Native communities – high baseline rates of diabetes and hypertension, compounded by socioeconomic disadvantages and initially devastating impacts of COVID-19 [15]. Encouragingly, both AI/AN and Hispanic groups then saw significant mortality declines after 2021 in our data. This corresponds with reports that AI/AN communities mounted effective COVID-19 vaccination campaigns and public health responses in 2021–2022, mitigating further excess deaths. Hispanic Americans, who experienced disproportionate COVID-19 mortality in 2020, also saw some recovery in life expectancy by 2022. Despite these improvements, their mortality from the hypertension–diabetes cluster remains elevated above pre-pandemic levels, signaling ongoing risk that needs addressing (e.g., through culturally tailored chronic disease programs) [15].

Geographically, we demonstrated that the Western U.S. had an unexpectedly steep rise in late-period mortality, surpassing the historically high-mortality Southern states. This was somewhat surprising, as the South has long been known for greater burdens of diabetes, obesity, and hypertension (the "Stroke Belt" phenomenon) [16]. Our data indeed show the South consistently had high rates, but the West caught up and briefly exceeded the South around 2020–2021. This could be attributable to

Western states like California and Arizona having large populations of older adults with diabetes (including many Hispanic and Asian Americans) who were hit hard by COVID-19. Another factor may be that the West had a more rapid growth of the elderly population (e.g., retirees in Sun Belt states) [17], amplifying absolute deaths. The Northeast's comparatively low mortality is consonant with other reports of better hypertension control and lower diabetes prevalence in that region [16]. The Northeast also benefited from strong public health measures during COVID-19's later waves, potentially limiting additional mortality. Overall, these regional patterns align with a recent study by Jain et al. [8], who found significant geographic disparities in combined CVD–diabetes mortality and noted a general worse burden in the South and parts of the West [8]. Our findings reinforce that cardiovascular-metabolic health initiatives must particularly focus on the South and rural West (e.g., Indigenous communities, the Southwest border region) to reduce these inequities.

Perhaps our most concerning finding is the urban–rural gap. We observed that rural older adults had consistently higher mortality, and this gap widened over time – consistent with the "persistent disparities" noted in other research [18]. By 2020, the rural mortality rate for hypertension+diabetes was about 20% higher than the urban rate. Dugani et al. [16]similarly reported that rural counties saw no improvement in diabetes mortality from 1999 to 2018, whereas urban counties had declines [16]. Our work extends this by showing that rural areas not only lagged, but actually had some of the steepest increases during the pandemic era. Contributing factors likely include fewer healthcare resources (e.g., less access to endocrinologists or hypertension specialists, longer travel distances to clinics), higher poverty rates, and demographic factors (older, sicker populations remain in rural areas due to urban migration of younger individuals). Social and structural challenges – such as hospital closures in rural America and limited public health infrastructure – may have exacerbated the impact of COVID-19 and hindered chronic disease management [19]. The implication is clear: targeted interventions (such as telemedicine for rural diabetes care, mobile clinics for blood pressure management, and community health worker programs) are needed to bridge the gap. National initiatives to address rural health disparities in chronic disease outcomes are strongly warranted by our data and others.

It is noteworthy that our analysis captured the influence of the COVID-19 pandemic on this specific mortality category. The years 2020–2021 correspond to the largest single-year jumps in our trends, after which 2022–2024 show a correction. Diabetes and hypertension were frequently listed as contributing conditions in COVID-related deaths (e.g., a patient with COVID-19 whose underlying health issues included hypertension and diabetes would meet our inclusion). Thus, the pandemic's toll on those with chronic cardiometabolic diseases is directly reflected here. National statistics have documented that diabetes-related death rates rose ~15% in 2020, and hypertension-related death rates also spiked in 2020–2021 – our findings concur, showing a sharp inflection in 2020 [19,20]. The slight downturn post-2021 likely indicates both the waning acute impact of COVID-19 (due to vaccines and treatments) and the resumption of healthcare services for chronic conditions. This offers a hopeful sign that with focused effort, the excess mortality can be curbed. However, it also serves as a warning: people with multiple chronic conditions like hypertension and diabetes are extremely vulnerable in public health crises, and improving their baseline health could confer resilience against future shocks.

Public health and clinical implications

The sustained increase in mortality among older adults with hypertension and diabetes calls for multipronged action. Firstly, better primary care and care coordination for seniors with multiple chronic conditions is essential. This includes aggressive management of blood pressure and blood glucose to guideline targets, which has been shown to reduce complications [2]. Yet achieving control is challenging in older patients who often have other comorbidities (e.g., chronic kidney disease) and polypharmacy concerns. Geriatric-focused chronic disease management, possibly via team-based care (including pharmacists, dietitians, and diabetes educators), could help. Secondly, prevention efforts must start earlier in life to prevent older adults from reaching such a high-risk multimorbidity status. The generation now entering senior years (the Baby Boomers) has high cumulative exposure to obesity and sedentary lifestyles; population strategies to reduce obesity and improve cardiovascular health can pay dividends in reducing future hypertension/diabetes mortality [21].

Our data on disparities indicate that interventions should be culturally tailored and community-specific. For example, in Black communities, improving healthcare access and trust, combating therapeutic inertia in hypertension treatment [7], and addressing social determinants (like food deserts and stress) are crucial. In AI/AN communities, support for tribal health programs and continued funding of the Special Diabetes Program for Indians (SDPI) are evidence-based measures that have shown success in improving outcomes. The sharp rise in Hispanic mortality suggests a need for sustained outreach (in language-appropriate formats) about managing diabetes and hypertension, and improving access to care for older Hispanics who may have barriers due to immigration status or socioeconomic factors. Rural health investments are particularly critical: expanding telehealth infrastructure, incentivizing clinicians to practice in rural areas, and community paramedicine programs could alleviate the rural healthcare shortage and improve chronic disease follow-up [16].

Finally, these findings highlight a need to strengthen the public health surveillance and emergency response for vulnerable chronic disease patients. Many of the deaths in 2020–2021 might have been preventable with better protections for those with hypertension and diabetes (for instance, prioritizing them for COVID-19 vaccinations and treatments, ensuring continuity of care during lockdowns). Learning from this, public health agencies should integrate chronic disease considerations into disaster planning – e.g., maintaining medication supply chains and remote monitoring of high-risk patients during pandemics or other crises. Additionally, renewed public health campaigns on blood pressure control and diabetes management in the post-COVID era could reclaim some of the lost progress. The recent plateau in mortality we observed is an opportunity to push the trend back down through concerted action.

Limitations

This study has several limitations. First, it is an ecological analysis of death certificate data, which depend on the accuracy of cause-of-death reporting. The coding of multiple causes (particularly contributing causes like diabetes or hypertension) may have changed over time. For example, physicians may have become more likely to list these conditions on death certificates in later years, which could inflate trends. The sharp increase from 1999 to 2001 might partly reflect the introduction of ICD-10 coding in 1999 and improved capture of multiple causes. We attempted to mitigate this by focusing on joinpoint-identified trend changes, but some early trend artifacts are possible. Second, our case definition requires both ICD-10 I10 and E11 codes on the death record. We did not distinguish which was underlying versus the contributing cause – thus our mortality measure represents a combination of scenarios (e.g., a primary cause of stroke with hypertension and diabetes as contributors, or primary diabetes with hypertensive heart disease secondary, and so on). We cannot ascribe the death solely to one condition; rather, it is the joint presence that we measured. This limits clinical interpretation, since some deaths might be more driven by one condition than the other. Nonetheless, from a population perspective, it captures the burden of multimorbidity. Third, we restricted to age ≥65, so our findings do not cover younger adults. There is evidence that hypertension and type 2 diabetes are affecting middle-aged Americans with increasing mortality as well, particularly in rural and minority groups. Our focus on older adults was to align with Medicare-age populations and because absolute mortality is highest in this group. Fourth, for some subgroups (notably AI/AN and to a lesser extent Hispanic), small numbers in early years and possible data quality issues (misclassification of race on death certificates) could affect the trends. We saw some year-to-year fluctuation in AI/AN rates that might be due to data instability. We combined multiple years in joinpoint segments to reduce random noise. Fifth, the last years (2021–2024) include provisional data (especially 2023–2024 are incomplete). These rates could be revised slightly as final data become available, and caution is warranted in interpreting the post-2021 dip. We truncated some analyses (e.g., urban/rural) at 2020 due to data availability by county urbanization only through 2020 in our source. Finally, while we extensively analyzed temporal patterns, we can only speculate on the causes of these trends. We did not have individual-level data on treatments, risk factor levels, or social determinants. Our discussion of potential factors (obesity prevalence, healthcare access, COVID-19, and so on) is inferential based on external data. Future research using linked datasets or cohort studies could clarify the causal drivers behind the observed mortality trends.

Conclusions

In conclusion, our study underscores that essential hypertension and type 2 diabetes in combination pose a mounting mortality threat to older adults, but also that this is a modifiable toll. The recent hint of decline in some groups (e.g., AI/AN and Hispanic elders post-2021) demonstrates that improvements are achievable. A comprehensive strategy involving public health initiatives, health care delivery improvements, and community-level interventions is needed to address the intertwined epidemics of hypertension and diabetes. By doing so, we can strive to ensure that our increasing longevity is not undermined by preventable deaths from these common chronic diseases. The time to act on these findings – to redouble chronic disease control efforts and to close the glaring disparity gaps – is now, before the next public health crisis finds us vulnerable again.

Ethics approval

As this study was based solely on publicly accessible, de-identified data from the CDC WONDER database, it did not involve human subjects directly and thus did not require institutional review board approval or informed consent.

Consent for publications

No individual-level or personally identifiable information is included, rendering publication consent irrelevant.

Conflict of Interest

The authors declare the absence of any financial, personal, or academic conflicts that might have influenced the conduct or outcomes of this study.

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Supplementary content (If any) is available online.

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