

# Trends and Disparities in Heart Failure with Pneumonia, 1999-2023: Insights from the CDC WONDER Database.

**Saifullah Khan**

Dow University of Health Sciences

**Arham Kamil**

Dow University of Health Sciences

**Nisha Khalid**

Dow University of Health Sciences

**Muhammad Hussain**

Dow University of Health Sciences

**Muhammad Hassan**

Dow University of Health Sciences

**Javeria Nawaz**

Dow University of Health Sciences

**FNU Pirih**

People's University of Medical and Health Sciences

**Maria Baig**

Dow University of Health Sciences

**Hasibullah Aminpoor**

hasibaminpoor786@gmail.com

Kabul University of Medical Sciences "Abu Ali Ibn Sina"

**Jazza Aamir**

Dow University of Health Sciences

**Muhammad Khalid Afridi**

Dow University of Health Sciences

**Muhammad Salman Mustafa**

Dow University of Health Sciences

---

## Research Article

**Keywords:** Heart Failure, Pneumonia, Mortality, Trends, Disparities

**Posted Date:** April 23rd, 2026

**DOI:** <https://doi.org/10.21203/rs.3.rs-9089090/v1>

**License:** © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

**Additional Declarations:** No competing interests reported.

---

# Abstract

## Background:

Heart Failure (HF) is a major public health issue and a leading cause of morbidity and mortality in the United States and worldwide. Pneumonia remains a significant contributor, accounting for over 53,000 deaths and 2.6 million emergency department visits annually in the U.S. This study analyzed mortality among U.S. adults with coexisting HF and pneumonia.

## Methods:

Mortality trends from 1999 to 2023 were examined using the CDC WONDER database, focusing on HF (I50) and pneumonia (J12–J18). Age-adjusted mortality rates per 100,000 were calculated and stratified by demographics, geography, and metropolitan status. Joinpoint regression identified annual percentage change (APC) and average annual percentage change (AAPC) with 95% confidence intervals.

## Results:

From 1999–2023, 619,729 HF with pneumonia deaths occurred. AAMR declined from 18.55 to 8.65 (AAPC – 3.02; 95% CI – 4.31 to -1.71;  $p < 0.001$ ). Men had higher rates than women (13.96 vs. 9.97). Non-Hispanic Whites (11.85) had the highest mean AAMR, followed by Non-Hispanic Blacks (10.74) and Hispanics (9.01). Older adults bore the greatest burden (55.23) compared with middle-aged (1.87) and younger adults (0.21). Regionally, the Midwest led (12.31), with rural areas (15.48) exceeding urban (10.83). State-level variation ranged from West Virginia (18.44) to Florida (5.96).

## Conclusion:

Mortality from coexisting HF and pneumonia has declined, but significant disparities persist. Men, non-Hispanic Whites, older adults, and rural/Midwestern residents face the highest burden. Targeted public health interventions are essential to reduce these inequities.

## 1. Introduction

Heart failure (HF), the terminal stage of many cardiovascular diseases, is a growing global cause of morbidity and mortality. The 2021 Global Burden of Disease study estimated 56.5 million people living with HF—nearly double the 1990 figure. Age-standardized prevalence rose from 647.9 to 682.7 per 100,000, driven mainly by hypertension and ischemic heart disease (1). Although the absolute burden is highest in high-income regions, the fastest growth is in low- and middle-income countries, especially South Asia (2).

Pneumonia, a major infectious cause of death globally accounts for 450 million cases and nearly 4 million deaths annually (3). Its impact is particularly severe in children, older adults and individuals with cardiovascular comorbidities (4,5). Patients with HF are especially vulnerable as infections can cause endothelial dysfunction by decreasing Nitric oxide synthesis and can trigger systemic inflammatory cascade (6).

In the United States (US), the epidemiological burden mirrors the global trends. HF affect approximately 6.7 million US adults, with nearly 452,573 deaths annually reported in 2023, accounting for 14.6% of all death (7). Pneumonia continues to exert a parallel burden, responsible for 41,210 deaths and 1.2 million emergency visits each year (8). Hospital discharge data consistently reported HF and pneumonia among the leading cause of hospitalization, imposing a substantial clinical and economic burden on the healthcare system (9,10)

The coexistence of HF and pneumonia represents a convergence of chronic cardiovascular disease and acute Respiratory infections, producing a high-risk clinical state marked by excess morbidity, mortality and healthcare utilization. Centre of disease control (CDC) based epidemiological analysis are therefore essential to characterize the magnitude of this overlap, identify predictors of poor outcomes, and generate evidence that can drive both bedside management strategies and population-based prevention policies.

## **2. Methods**

### **2.1 STUDY DESIGN AND DATA SOURCE:**

This present study leveraged database of Centers for Disease Control and Prevention's Wide-ranging Online Data for Epidemiologic Research (CDC WONDER) (11) database, covering the time period from 1999 to 2023. The data were derived from U.S. death certificates as part of the Multiple Cause-of-Death Public Use data set, which include information from all 50 states and the District of Columbia. The database has been extensively used in prior epidemiologic studies for analyzing nationwide mortality trends.

### **2.2 STUDY POPULATION:**

For heart failure (I50) (12,13) and for pneumonia (J12-J18) (14) International Classification of Diseases, 10th Revision (ICD-10) codes were used. Deaths were included only if the condition recorded on the death certificate, either as the underlying cause or a contributing factor.

### **2.3 DATA ABSTRACTION:**

In this study, data were abstracted for key variables including year of death, demographic details (age, sex, race/ethnicity), and location of death. Deaths were categorized by location (medical facility, home, hospice, long-term care). Race/ethnicity included NH White, NH Black or African American, and Hispanic. Age groups were younger adults (25–44 years), middle-aged adults (45–64 years), and older adults ( $\geq 65$  years). Urban-rural status was assigned using the National Center for Health Statistics Urban-Rural Classification Scheme based on 2013 U.S. Census data (15). Geographic regions were classified by U.S. Census Bureau designations: Northeast, Midwest, South, and West. The study was exempt from institutional review board approval as it used deidentified publicly available data and was conducted in accordance with STROBE guidelines (16).

### **2.4 STATISTICAL ANALYSIS**

Age-adjusted mortality rates (AAMRs) per 100,000 were calculated by year, sex, race/ethnicity, age, state, and urban-rural status. Age adjustment was performed using the direct method, standardized to the year 2000 U.S. population. For analyzing national trends in AAMRs, the Joinpoint Regression Program (version 5.4.0) (17) from the National Cancer Institute was employed, which detects statistically significant shifts in trends over time

using log-linear models. Annual percent changes (APC) and 95% confidence intervals (CIs) were computed, and statistical significance was determined using a two-tailed P-value of < 0.05.

### 3. Results

Between 1999 and 2023, HF with pneumonia accounted for a total of 619,729 deaths among adults aged 25 years and more in the US (**Supplemental Table 1**). These deaths were prevalent across various places, with the leading most occurring in medical facilities (67.34%), (22.01%) in nursing home/long term care facilities, (6.15%) in decedent’s home, (2.58%) in hospice facilities, and (1.69%) at other locations (**Supplemental Table 2**) (Table 1).

Table 1

Mean AAMR and AAPC for Heart Failure-related deaths among U.S. adults aged  $\geq 25$  years with Pneumonia, 1999 to 2023.

| <b>Demographics</b>                                                      | <b>Deaths</b> | <b>Population</b> | <b>Mean Age-Adjusted Mortality Rate per 100,000 (95% CI)</b> | <b>AAPC (95% CI)</b>    |
|--------------------------------------------------------------------------|---------------|-------------------|--------------------------------------------------------------|-------------------------|
| <i>Overall</i>                                                           | 619,729       | 5163131262        | 11.53 (11.39 to 11.67)                                       | -3.02* 9-3.65 to -2.53) |
| <b>Sex</b>                                                               |               |                   |                                                              |                         |
| Male                                                                     | 287,458       | 2491041251        | 13.96 (13.70 to 14.22)                                       | -2.87* (-3.52 to -2.31) |
| Female                                                                   | 332,271       | 2672090011        | 9.97 (9.80 to 10.13)                                         | -3.30* (-3.89 to -2.88) |
| <b>Race</b>                                                              |               |                   |                                                              |                         |
| NH White                                                                 | 519,705       | 3528912956        | 11.85 (11.69 to 12.01)                                       | -2.95* (-3.52 to -2.53) |
| NH Black                                                                 | 50,013        | 602204655         | 10.74 (10.25 to 11.21)                                       | -2.52* (-3.60 to -1.76) |
| NH American Indian or Alaska Native                                      | 3,136         | 37910158          | 12.61 (10.31 to 15.02)                                       | -2.84* (-4.15 to -1.79) |
| NH Asian or Pacific Islander                                             | 12,889        | 281715534         | 7.22 (6.55 to 7.88)                                          | -3.23* (-4.07 to -2.33) |
| Hispanic                                                                 | 32,395        | 702028728         | 9.00 (8.48 to 9.52)                                          | -3.00* (-3.98 to -2.06) |
| <b>Age Group</b>                                                         |               |                   |                                                              |                         |
| Younger adults (25–44)                                                   | 4,364         | 2119405590        | 0.20 (0.18 to 0.24)                                          | 3.28* 92.67 to 4.06)    |
| Middle Aged adults (45–64)                                               | 39,237        | 1942357841        | 1.86 (1.77 to 1.96)                                          | 0.38 (-0.52 to 1.04)    |
| Older Adults (65+)                                                       | 576,128       | 1101367831        | 55.22 (54.52 to 55.93)                                       | -3.318 9-3.88 to -2.87) |
| <b>Census Region</b>                                                     |               |                   |                                                              |                         |
| South                                                                    | 224,654       | 1916380109        | 11.69 (11.45 to 11.94)                                       | -2.66* (-3.30 to -2.12) |
| West                                                                     | 125,434       | 1187526802        | 11.19 (10.88 to 11.49)                                       | -3.20* (-3.74 to -2.12) |
| Midwest                                                                  | 152,729       | 1110999093        | 12.31 (12.00 to 12.62)                                       | -3.29* (-3.96 to -2.77) |
| Northeast                                                                | 116,912       | 948225258         | 10.58 (9.61 to 10.18)                                        | -3.29* (-3.82 to -2.77) |
| • *Indicates that trend is statistically significant i.e. p value < 0.05 |               |                   |                                                              |                         |

| <i>Demographics</i>                                                      | <i>Deaths</i> | <i>Population</i> | <i>Mean Age-Adjusted Mortality Rate per 100,000 (95% CI)</i> | <i>AAPC (95% CI)</i>    |
|--------------------------------------------------------------------------|---------------|-------------------|--------------------------------------------------------------|-------------------------|
| <b>Urbanization</b>                                                      |               |                   |                                                              |                         |
| Rural                                                                    | 128,508       | 678634169         | 15.48 (15.09 to 15.87)                                       | -2.63* (-3.26 to -2.20) |
| Urban                                                                    | 407,598       | 3795213822        | 10.82 (10.67 to 10.98)                                       | -2.46* (-3.21 to -1.90) |
| • *Indicates that trend is statistically significant i.e. p value < 0.05 |               |                   |                                                              |                         |

## 3.1 Annual Trends for Heart Failure with Pneumonia-Related AAMR

The overall AAMR for HF with Pneumonia-related deaths among adults decreased from 18.55 in 1999 to 8.65 in 2023, with an AAPC of -3.02 (95% CI: -4.31 to -1.71; p value < 0.001) (Fig. 1). AAMR demonstrated a marginal decline in AAMR trend between 1999 and 2005 (APC: -2.59; 95% CI: -3.78 to -1.40; p value = 0.006), followed by a remarkable decline from 2005 to 2009 (APC: -11.11; 95% CI: -14.59 to -7.48; p value = 0.004). Subsequently, there was a further minor decline in AAMR from 2009 to 2018 (APC: -3.02; 95% CI: -4.04 to -1.98; p value = 0.005), after which AAMR experienced a sudden rise from 2018 to 2021 (APC: 19.46; 95% CI: 9.89 to 29.85; p value = 0.006). Finally, a sharp declining trend was observed from 2021 to 2023 (APC: -16.68; 95% CI -23.26 to -9.55; p value = 0.004) (**Supplemental Table 3**) (Fig. 1).

## 3.2 Heart Failure with Pneumonia-Related AAMR Stratified by Sex

The AAMR for both men and women decreased from 1999 to 2023. Among men, the AAMR decreased from 22.33 (95% CI: 21.95 to 22.72) in 1999 to 10.81 (95% CI: 10.62 to 11.01) in 2023. Similarly, among women, the AAMR decreased from 16.33 (95% CI: 16.1 to 16.57) to 7.09 (95% CI: 6.96 to 7.23).

Adult men exhibited slightly higher AAMRs compared to adult women (mean AAMR for men: 13.96, 95% CI: 13.71–14.22; for women: 9.97, 95% CI: 9.80-10.14). The AAMR of both, men and women decreased from 1999 till 2023. [Women: AAPC: -3.30, (95% CI: -4.76 to -1.83; p value = 0.001); Men: AAPC: -2.87, (95% CI: -4.20 to -1.52; p value = 0.003)].

The AAMR trend for adult women decreases marginally from 1999 to 2005 (APC: -2.59; 95% CI: -3.88 to -1.28; p value = 0.001), followed by a tremendous drop in AAMR trend between 2005 to 2009 (APC: -11.00; 95% CI: -14.96 to -6.85; p value = 0.001). The AAMR trend demonstrated a downward trend from 2009 to 2018 (APC: -3.39; 95% CI: -4.47 to -2.29; p value = 0.003), after which it experienced a surge from 2018 to 2021 (APC: 16.00; 95% CI: 5.49 to 27.56; p value = 0.005). Finally, enormous drop in AAMR trend occurred by 2024 (APC: -14.71; 95% CI: -22.35 to -6.31; p value = 0.003). The AAMR trend of the adult male initially reduced slightly from 1999 to 2005 (APC: -2.70; 95% CI: -4.04 to -1.34; p value = 0.001), which is followed by a tremendous decline from 2005 to 2009 (APC: -11.43; 95%CI: -15.39 to -7.27; p value = 0.001). Furthermore, it exhibited a minimal drop from 2009 to 2018 (APC: -2.72; 95% CI: -3.77 to -1.66; p value = 0.001) which is subsequently followed by a sudden hike from 2018 to 2021 (APC: 22.04; 95% CI: 12.34 to 32.57; p value = 0.002). Finally, a marked fall in AAMR

trend occurred from 2021 to 2023 (APC: -18.09; 95% CI: -24.51 to -11.11; p value = 0.002) (**Supplemental Table 4**) (Fig. 1).

### 3.3 Heart Failure with Pneumonia-Related AAMR Stratified by Age

The AAMR increased across all age groups from 1999 to 2023 except older Adults. [younger Adults: (0.21 to 0.32); middle-aged adults: (2.02 to 2.28)]. Among older adults the AAMR decreased from 1999 to 2023 (90.86 to 39.52).

Older adults exhibited highest mean AAMRs throughout the study period, followed by middle-aged and younger adults (25–44). (mean AAMR: older Adults: 55.23, 95% CI: 54.52–55.93; middle Aged Adults: 1.87, 95% CI: 1.77–1.96; younger Adults: 0.21, 95% CI: 0.18–0.24).

The AAMR of all the age groups increased profoundly from 1999 till 2023 [older Adults: AAPC: 8.23, (95% CI: 7.37 to 9.36; p value < 0.001); middle Aged Adults: AAPC: 5.20, (95% CI: 4.75 to 5.80; p value < 0.001); younger Adults: AAPC: 3.81, (95% CI: 2.44 to 6.06; p value < 0.001).

Among younger adults, the AAMR trend remained stable from 1999 to 2018, rose sharply from 2018 to 2021, and then dropped from 2021 to 2023. In middle-aged adults, the AAMR declined from 1999 to 2011, plateaued between 2011 and 2018, surged from 2018 to 2021, and then decreased from 2021 to 2023. Among older adults, the AAMR decreased from 1999 to 2005, declined further from 2005 to 2009, dropped slightly between 2009 and 2018, increased from 2018 to 2021, and then declined again from 2021 to 2023 (**Supplemental Table 5**) (Fig. 2).

### 3.4 Heart Failure with Pneumonia-Related AAMR Stratified by Race

The AAMR decreased across all racial/ethnic groups from 1999 to 2023: Hispanic (13.82 to 7.09); NH American Indian or Alaskan Native (16.2 to 9.78); NH Asian or Pacific Islander (11.53 to 5.59); NH White (19 to 8.95); and NH Black (16.39 to 9.08).

The highest mean AAMRs were recorded among NH American Indian or Alaskan Natives with only marginal differences among remaining racial/ethnic groups (mean AAMR: NH American Indian or Alaskan Natives: 12.61, 95% CI: 10.31 to 15.02; NH Whites: 11.85; 95% CI: 11.69 to 12.01; NH Blacks: 10.74; 95% CI: 10.26 to 11.22; Hispanics: 9.01; 95% CI: 8.48 to 9.53; NH Asian or Pacific Islanders: 7.22, 95% CI: 6.55 to 7.88).

The AAMR of all the races decreased profoundly from 1999 till 2023 [Hispanic: AAPC: -3.00, (95% CI: -3.98 to -2.06; p value < 0.001); NH Whites: AAPC: -2.95, (95% CI: -3.52 to -2.53; p value < 0.001); NH Blacks: AAPC: -2.52, (95% CI: -3.60 to -1.76; p value < 0.001); NH American Indian or Alaskan Native: AAPC = -2.84, (95% CI: -4.15 to -1.79; p value = 0.004); NH Asian or Pacific Islander: AAPC = -3.23, (95% CI: -4.07 to -2.33; p value = 0.004)].

The AAMR trend for Hispanic individuals fell between 1999 and 2018, rose from 2018 to 2021, and dropped from 2021 to 2023. For NH Black individuals, the AAMR trend decreased from 1999 to 2017, climbed between 2017 and 2021, and fell from 2021 to 2023. Among NH White individuals the AAMR trend reduced slightly from 1999 to 2005, declined from 2005 to 2009, dropped further from 2009 to 2018, rose between 2018 and 2021,

and turned downward from 2021 to 2023. For NH American Indian or Alaskan Native individuals, the AAMR trend decreased from 1999 to 2018, rose from 2018 to 2021, and fell from 2021 to 2023. Finally, the AAMR for NH Asian or Pacific Islander individuals reduced between 1999 and 2018, increased from 2018 to 2021, and dropped from 2021 to 2023 (**Supplemental Table 6**) (Fig. 3).

## **3.5 Heart Failure with Pneumonia-Related AAMR Stratified by Geographical Regions**

### **3.5.1 Stratified By Census:**

The AAMR decreased across all US census regions from 1999 to 2023. In the Northeast, the AAMR dropped from 17.21 in 1999 to 7.56 in 2023; in the Midwest, from 20.45 to 8.73; in the South, from 18.14 to 9.4; and in the West, from 18.32 to 8.25.

Notably, over the study period, the highest mean AAMR was observed in the Midwest (AAMR: 12.31; 95% CI: 12.01 to 12.62), followed by the South (mean AAMR: 11.70; 95% CI: 11.46 to 11.94), West (mean AAMR: 11.19; 95% CI: 10.89 to 11.50) and Northeast (mean AAMR: 10.59; 95% CI: 10.28 to 10.89). The AAMR of all the regions manifested a prominent surge in trend between 1999 and 2023 [Midwest: AAPC: -3.29, (95% CI: -5.27 to -1.27; p value = 0.001); Northeast: AAPC: -3.29, (95% CI: -4.92 to -1.63; p value = 0.001); West: AAPC: -3.20, (CI: -5.16 to -1.20; p value = 0.001); South: AAPC: -2.66, (95% CI: - .3.97 to -1.32; p value = 0.001)].

The AAMR trend for the Northeast declined between 1999 and 2005, dropped more sharply from 2005 to 2009, continued downward from 2009 to 2018, rose from 2018 to 2021, and decreased again between 2021 and 2023. For the Midwest, the AAMR trend decreased from 1999 to 2005, declined further from 2005 to 2009, fell again from 2009 to 2018, rose from 2018 to 2021, and dropped between 2021 and 2023. In the South, the AAMR trend decreased from 1999 to 2005, declined further from 2005 to 2009, continued downward from 2009 to 2018, rose between 2018 and 2021, and then fell from 2021 to 2023. For the West, the AAMR trend fell between 1999 and 2006, dropped steeply from 2006 to 2009, continued downward from 2009 to 2018, rose between 2018 and 2021, and turned downward again from 2021 to 2023 (**Supplemental Table 7**) (Fig. 4).

### **3.5.2 Stratified By Urbanization:**

The AAMR decreased in both urban and rural areas from 1999 to 2020. In urban areas, the AAMR decreased from 17.24 in 1999 to 10.56 in 2020, while in rural areas it decreased from 23.85 to 14.03.

Rural areas showed rather modestly higher AAMRs throughout the study period, with mean AAMR of 15.48 for Rural (95% CI: 15.09 to 15.88) and 10.83 for Urban (95% CI: 10.67 to 10.98). The overall trend in AAMR of both rural and urban areas decreased from 1999 to 2020 [(Rural: AAPC: -2.63, (95% CI: -3.76 to -1.48; p value = 0.008); (Urban: AAPC: -2.46, (95% CI: -3.83 to -1.08; p value < 0.005)].

For urban areas, the AAMR trend declined from 1999 to 2006, dropped more steeply between 2006 and 2009, continued downward from 2009 to 2018, and then spiked from 2018 to 2020. For rural areas, the AAMR showed a slight reduction between 1999 and 2005, fell more noticeably from 2005 to 2009, continued downward from 2009 to 2018, and then increased markedly from 2018 to 2020 (**Supplemental Table 8**) (Fig. 5).

### **3.5.3 Stratified By States:**

Disparities in AAMRs were noticeable among different states, with AAMRs ranging from as low as 5.96 (95% CI: 5.88–6.03) in Florida to 18.44 (95% CI: 17.97–18.9) in West Virginia. States falling within the top 90th percentile included Kentucky, Mississippi, West Virginia, Oklahoma, and Rhode Island which had approximately twice AAMRs compared to states in the lower 10th percentile which included Florida, Arizona, Nevada, Colorado, and Hawaii (**Supplemental Table 9**) (**Fig. 6**).

## 4. Discussion

In this study, we examined nationwide mortality data on HF with pneumonia among U.S. adults aged 25 years and older from 1999 to 2023. A total of 619,729 deaths were recorded, most frequently in medical facilities, followed by nursing homes, private residences, hospices, and other locations. Men had higher mortality rates than women. By race and ethnicity, NH White adults had the highest AAMRs, followed by NH Black, Hispanic, NH American Indian or Alaskan Native, and NH Asian or Pacific Islander adults. Older adults showed the highest burden. Midwest region recorded the highest mean AAMRs, followed by the South, West, and Northeast, while rural areas consistently showed higher rates than urban areas (**Fig. 7**).

HF disrupts pulmonary circulation, causing alveolar fluid buildup that favors microbial growth (18). Pneumonia then triggers decompensation via systemic inflammation, hypoxemia, and sympathetic overactivation (19,20). Inflammatory mediators like IL-6, TNF- $\alpha$ , and C-reactive protein impair contractility, stiffen ventricles, and promote arrhythmias (21,22). Hypoxemia, acidosis, and catecholamine excess further strain the heart (23,24), while capillary leaks and fluid resuscitation increase preload and pulmonary congestion (25). Comorbidities—diabetes, hypertension, obesity, and kidney disease—accelerate myocardial damage and weaken immunity (26). Smoking, alcohol misuse, poor therapy adherence, and low vaccination uptake against influenza and pneumococcus add to the mortality burden (27).

Sex-based disparities were consistent, with men showing higher age-adjusted mortality than women. Men with HF more often have ischemic cardiomyopathy, adverse remodeling, and stronger sympathetic activation, reducing resilience to pneumonia (28). Lack of estrogen's cardioprotective and anti-inflammatory effects, along with genetic immune and remodeling differences, may further raise male mortality (29). Women benefit from estrogen, especially before menopause, and more often have preserved ejection fraction, less vulnerable to fluid shifts (30,31). Behavioral factors add: men smoke and drink more, delay preventive care, and vaccinate less, while women engage more in healthcare and disease management (32–34). Mortality surged in both sexes from 2018–2021 with COVID-19 (35), but men's greater absolute burden highlights the need for tailored prevention addressing both biological and modifiable risks.

Elevated mortality in NH White adults reflects greater HF burden and reporting, whereas persistently high rates in NH Black adults stem from disproportionate risk factors, socioeconomic disadvantage, and structural barriers (36,37). Hispanic adults showed lower rates but sharp relative declines, linked to younger age structures and community support, though underinsurance and access remain concerns (38). NH American Indian and Alaska Native adults carried an intermediate burden from cardiometabolic risk and healthcare inequities (39). Consistently low AAMRs in Asian and Pacific Islander groups may reflect lower HF prevalence and healthier practices, though not uniformly protective (40,41). These patterns underscore the role of biology, comorbidity, culture, and systemic inequities, highlighting the need to address structural determinants of health.

Age was the strongest determinant of mortality. Older adults bore most of the burden, with AAMRs many times higher than younger groups, reflecting frailty, immunosenescence, and multimorbidity. Vulnerability was further heightened by reduced cardiac reserve, impaired renal clearance, diastolic dysfunction, polypharmacy, functional decline, and institutionalization (42,43). Middle-aged adults had intermediate mortality but a substantial share of deaths from obesity, diabetes, and hypertension (44). Younger adults had low absolute mortality, though relative rates rose with earlier cardiometabolic risks, substance use, and delayed care (45). These findings highlight the need for age-tailored prevention, with vaccination, chronic disease management, and early risk factor control key for older and middle-aged groups.

Geographic disparities were marked. Mortality was highest in the Midwest, lowest in the Northeast, and intermediate in the South and West, reflecting socioeconomic conditions, risk factors, and healthcare infrastructure (46). West Virginia, Kentucky, and Mississippi carried the greatest burden from poverty, obesity, smoking, and limited care (47), while Colorado and New Jersey reported much lower rates with stronger public health and tertiary access (48). Rural areas also had higher mortality than urban ones, driven by distance, physician shortages, fewer preventive services, and economic hardship (49,50). Place of death patterns showed further inequities: most patients died in medical facilities, but many in nursing homes, underscoring older adults' vulnerability and the need for earlier preventive and palliative strategies (51,52).

SARS-CoV-2 directly injured the myocardium through viral infiltration, systemic inflammation, and endothelial dysfunction, precipitating decompensation (53). Viral pneumonia compounded pulmonary congestion, hypoxemia, and fluid shifts, worsening outcomes (54). Indirectly, strained healthcare systems, delayed follow-up, and reduced preventive care further amplified mortality (55). These swings highlight the fragility of HF populations to infectious threats and the need for preparedness and resilient care pathways.

This study has several limitations. The analysis relied on CDC WONDER mortality data from death certificates, which may be subject to misclassification and coding errors, particularly during the COVID-19 pandemic. The lack of urbanization data from 2020 onwards limited our ability to conduct uniform analysis by 2024 for this stratification. The ecological nature of the dataset precludes adjustment for individual-level factors such as comorbidity severity, socioeconomic status, and access to care. It was also not possible to differentiate between HF subtypes or between community- and hospital-acquired pneumonia, each with different prognostic implications.

## 5. Conclusion

Between 1999 and 2023, HF with pneumonia caused significant morbidity and mortality in the US, with most deaths occurring in medical facilities among older adults. Disparities persisted across sex, age, race/ethnicity, geography, and urbanization, with men, NH whites, Midwestern populations, and rural areas showing higher mortality. These heterogeneous trends highlight the need for multidimensional, targeted public measures to reduce the nationwide mortality burden.

## Declarations

**Ethics Approval and Consent to participate:** Not applicable. This study utilized publicly available, de-identified data from the CDC WONDER database and did not involve human participants.

**Consent for publication:** Not applicable.

**Data Availability Statement:** The data supporting the findings of this study were obtained from the CDC WONDER online database (Centers for Disease Control and Prevention Wide-ranging Online Data for Epidemiologic Research). The datasets used and analyzed during the current study are publicly available and can be accessed at [CDC WONDER] (<https://wonder.cdc.gov>).

**Conflicts of Interests:** The authors declare no conflicts of interest.

**Funding:** The authors received no funds, grants, or financial support for this study.

**Authors' contributions:** Project administration handled by S.K. Visualization handled by F.P. and N.K. Writing handled by M.S.M, P.L, M.B, J.N, M.H, M.H, and A.K. Reviewing handled by M.K.A and J.A. Editing handled by all authors equally. Submission handled by M.S.M and H.A.

**Acknowledgments:** Not applicable

## References

1. Roth GA, Dorsey H, Decleene N, Razo C, Stark B, Johnson C. The global burden of heart failure: a systematic analysis for the Global Burden of Disease Study 2021. *Eur Heart J*. 2023 Nov 1;44(Suppl 2). doi:10.1093/eurheartj/ehad655.876
2. Wei S, Miranda JJ, Mamas MA, Zühlke LJ, Kontopantelis E, Thabane L, et al. Sex differences in the etiology and burden of heart failure across country income level: analysis of 204 countries and territories 1990–2019. *Eur Heart J Qual Care Clin Outcomes*. 2022 Dec 28;9(7):662 – 72. doi:10.1093/ehjqcco/qcac088
3. Sattar SBA, Nguyen AD, Sharma S. Bacterial pneumonia. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK513321/>
4. Luna CM, Palma I, Niederman MS, Membriani E, Giovini V, Wiemken TL, et al. The impact of age and comorbidities on the mortality of patients of different age groups admitted with community-acquired pneumonia. *Ann Am Thorac Soc*. 2016 Jul 11;13(9):1519-26. doi:10.1513/AnnalsATS.201512-848OC
5. Baldo V, Cocchio S, Baldovin T, Buja A, Furlan P, Bertoncillo C, et al. A population-based study on the impact of hospitalization for pneumonia in different age groups. *BMC Infect Dis*. 2014 Sep 5;14:485. doi:10.1186/1471-2334-14-485
6. Mancini D, Gibson GT. Impact of pneumonia in heart failure patients. *J Am Coll Cardiol*. 2021 Apr 1;77(16):1974-6. doi:10.1016/j.jacc.2021.03.010
7. Centers for Disease Control and Prevention. About heart failure [Internet]. Atlanta (GA): CDC; 2024 [cited 2025 Aug 21]. Available from: <https://www.cdc.gov/heart-disease/about/heart-failure.html>
8. Centers for Disease Control and Prevention. FastStats: pneumonia [Internet]. Atlanta (GA): CDC; [cited 2025 Aug 21]. Available from: <https://www.cdc.gov/nchs/fastats/pneumonia.htm>
9. Heidenreich PA, Fonarow GC, Opsha Y, Sandhu AT, Sweitzer NK, Warraich HJ, et al. Economic issues in heart failure in the United States. *J Card Fail*. 2022 Jan 24;28(3):453 – 66. doi:10.1016/j.cardfail.2021.12.017
10. Divino V, Schranz J, Early M, Shah H, Jiang M, DeKoven M. The annual economic burden among patients hospitalized for community-acquired pneumonia: a retrospective US cohort study. *Curr Med Res Opin*. 2019 Oct 1;36(1):151 – 60. doi:10.1080/03007995.2019.167514

11. Friede A, Reid JA, Ory HW. CDC WONDER: a comprehensive on-line public health information system of the Centers for Disease Control and Prevention. *Am J Public Health* 1993;83:1289–94. <https://doi.org/10.2105/AJPH.83.9.1289>.
12. Siddiqi R, Farhan SH, Shah SA, Mushahid H, Nasir MM, Moukarbel G V. National Trends in Heart Failure and Acute Myocarditis–Related Death Before and During the COVID-19 Pandemic. *Journal of the American Heart Association* 2025;14:38987. <https://doi.org/10.1161/JAHA.124.038987>/SUPPL\_FILE/JAH310858-SUP-0001-SUPINFO.PDF.
13. Ullah I, Ahmad O, Farooqi HA, Saleem R, Ahmed I, Irfan M, Khan AW, Khan E, Khan OA, Goyal A, Sattar Z, Farhan M, Carver C, Ahmed R, Asghar MS. Trends and disparities in heart failure-related mortality in the US adult population from 1999 to 2020. *Arch Med Sci Atheroscler Dis*. 2024 Dec 31;9:e241–e250. doi: 10.5114/amsad/199655.
14. Obianyo CM, Muoghalu N, Adjei EM, Njoku AN, Okoro NL, Sulaiman OB, et al. Trends and Disparities in Pneumonia-Related Mortality in the U.S. Population: A Nationwide Analysis Using the CDC WONDER Data. *Cureus* 2025;17. <https://doi.org/10.7759/CUREUS.83371>.
15. Ingram DD, Franco SJ. 2013 NCHS Urban-Rural Classification Scheme for Counties. *Vital Health Stat* 2 2014;1–73.
16. Elm E von, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. Strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *BMJ : British Medical Journal* 2007;335:806. <https://doi.org/10.1136/BMJ.39335.541782.AD>.
17. Joinpoint Regression Program n.d. <https://surveillance.cancer.gov/joinpoint/> (accessed April 12, 2025).
18. Mor A, Thomsen RW, Ulrichsen SP, Sørensen HT. Chronic heart failure and risk of hospitalization with pneumonia: A population-based study. *Eur J Intern Med* [Internet]. 2013 Jun 1 [cited 2025 Aug 22];24(4):349–53. Available from: <https://www.ejinme.com/action/showFullText?pii=S0953620513000794>
19. Stotts C, Corrales-Medina VF, Rayner KJ. Pneumonia-Induced Inflammation, Resolution and Cardiovascular Disease: Causes, Consequences and Clinical Opportunities. *Circ Res* [Internet]. 2023 Mar 17 [cited 2025 Aug 22];132(6):751–74. Available from: /doi/pdf/10.1161/CIRCRESAHA.122.321636?download=true
20. Jobs A, Simon R, de Waha S, Rogacev K, Katalinic A, Babaev V, et al. Pneumonia and inflammation in acute decompensated heart failure: a registry-based analysis of 1939 patients. *Eur Heart J Acute Cardiovasc Care* [Internet]. 2018 Jun 1 [cited 2025 Aug 22];7(4):362–70. Available from: <https://dx.doi.org/10.1177/2048872617700874>
21. Ahn J, Kim J. Mechanisms and consequences of inflammatory signaling in the myocardium. *Curr Hypertens Rep* [Internet]. 2012 Dec 18 [cited 2025 Aug 22];14(6):510–6. Available from: <https://link.springer.com/article/10.1007/s11906-012-0309-0>
22. Diwan A, Tran T, Misra A, Mann DL. Inflammatory Mediators and the Failing Heart: A Translational Approach. *Curr Mol Med* [Internet]. 2005 Mar 25 [cited 2025 Aug 22];3(2):161–82. Available from: <https://www.eurekaselect.com/article/8518>
23. Weber KT, Janicki JS, Maskin CS. Pathophysiology of cardiac failure. *Am J Cardiol* [Internet]. 1985 Jul 22 [cited 2025 Aug 22];56(3):B3. Available from: <https://www.ajconline.org/action/showFullText?pii=0002914985911889>
24. McElroy PA, Shroff SG, Weber KT. Pathophysiology of the Failing Heart. *Cardiol Clin* [Internet]. 1989 Feb 1 [cited 2025 Aug 22];7(1):25–37. Available from:

<https://www.sciencedirect.com/science/article/abs/pii/S0733865118304545?via%3Dihub>

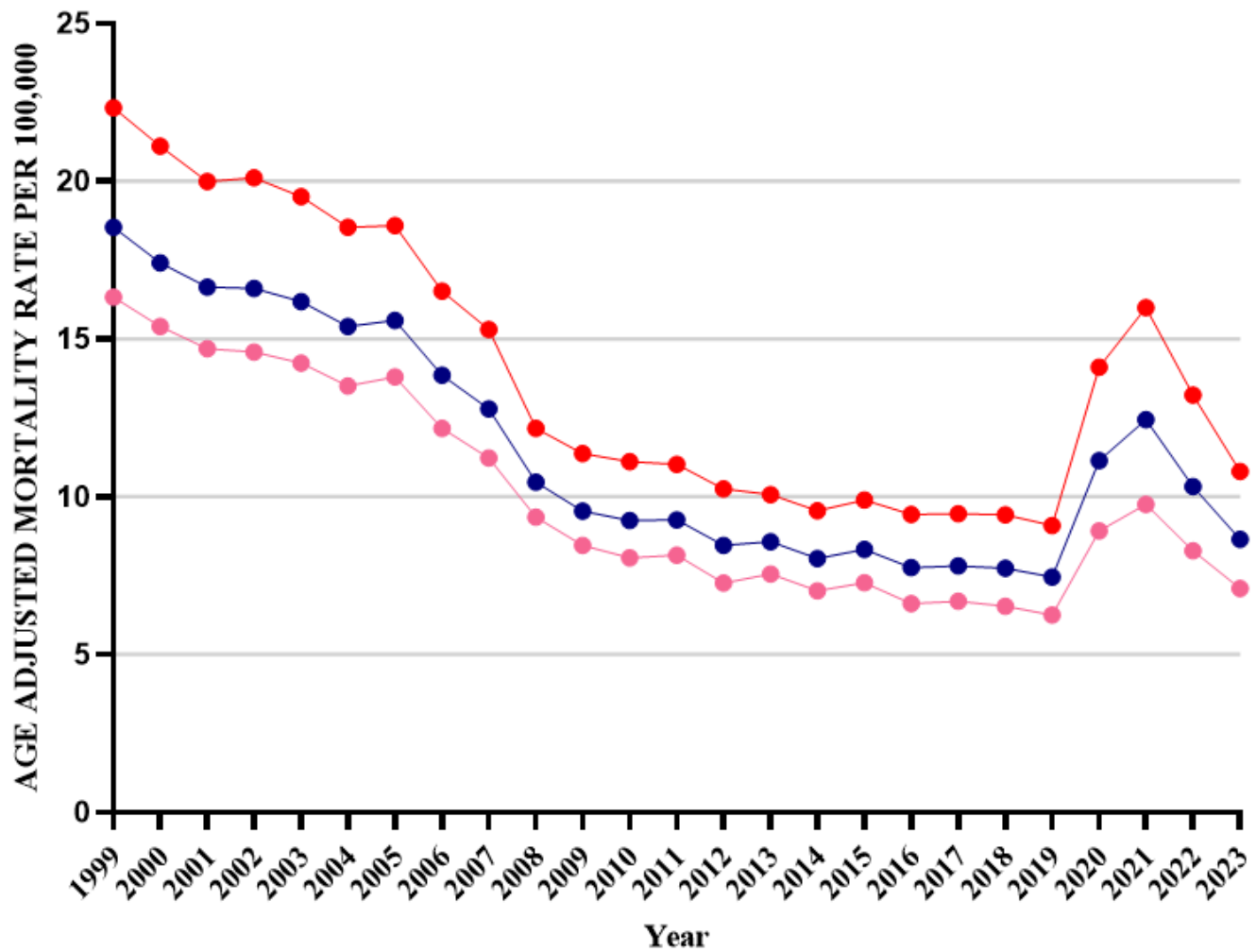
25. Orfanos SE, Mavrommati I, Korovesi I, Roussos C. Pulmonary endothelium in acute lung injury: From basic science to the critically ill. *Intensive Care Med* [Internet]. 2004 Sep 16 [cited 2025 Aug 22];30(9):1702–14. Available from: <https://link.springer.com/article/10.1007/s00134-004-2370-x>
26. Triposkiadis F, Xanthopoulos A, Parissis J, Butler J, Farmakis D. Pathogenesis of chronic heart failure: cardiovascular aging, risk factors, comorbidities, and disease modifiers. *Heart Fail Rev* [Internet]. 2022 Jan 1 [cited 2025 Aug 22];27(1):337–44. Available from: <https://link.springer.com/article/10.1007/s10741-020-09987-z>
27. Bhatt AS, DeVore AD, Hernandez AF, Mentz RJ. Can Vaccinations Improve Heart Failure Outcomes?: Contemporary Data and Future Directions. *JACC Heart Fail* [Internet]. 2017 Mar 1 [cited 2025 Aug 22];5(3):194–203. Available from: [/doi/pdf/10.1016/j.jchf.2016.12.007?download=true](https://doi/pdf/10.1016/j.jchf.2016.12.007?download=true)
28. Crabbe DL, Dipla K, Ambati S, Zafeiridis A, Gaughan JP, Houser SR, et al. Gender differences in post-infarction hypertrophy in end-stage failing hearts. *J Am Coll Cardiol* [Internet]. 2003 Jan 15 [cited 2025 Aug 22];41(2):300–6. Available from: <https://pubmed.ncbi.nlm.nih.gov/12535826/>
29. Casimir GJ, Lefèvre N, Corazza F, Duchateau J. Sex and inflammation in respiratory diseases: A clinical viewpoint. *Biol Sex Differ* [Internet]. 2013 Sep 1 [cited 2025 Aug 22];4(1):1–9. Available from: <https://bsd.biomedcentral.com/articles/10.1186/2042-6410-4-16>
30. Regitz-Zagrosek V, Brokat S, Tschope C. Role of Gender in Heart Failure with Normal Left Ventricular Ejection Fraction. *Prog Cardiovasc Dis* [Internet]. 2007 Jan 1 [cited 2025 Aug 22];49(4):241–51. Available from: <https://www.sciencedirect.com/science/article/abs/pii/S0033062006000958?via%3Dihub>
31. Shuaishuai D, Jingyi L, Zhiqiang Z, Guanwei F. Sex differences and related estrogenic effects in heart failure with preserved ejection fraction. *Heart Failure Reviews* 2022 28:4 [Internet]. 2022 Oct 3 [cited 2025 Aug 22];28(4):937–48. Available from: <https://link.springer.com/article/10.1007/s10741-022-10274-2>
32. Nathanson CA. Sex roles as variables in preventive health behavior. *J Community Health* [Internet]. 1977 Dec [cited 2025 Aug 22];3(2):142–55. Available from: <https://link.springer.com/article/10.1007/BF01674236>
33. Vaidya V, Partha G, Karmakar M. Gender Differences in Utilization of Preventive Care Services in the United States. <https://home.liebertpub.com/jwh> [Internet]. 2012 Feb 1 [cited 2025 Aug 22];21(2):140–5. Available from: [/doi/pdf/10.1089/jwh.2011.2876?download=true](https://doi/pdf/10.1089/jwh.2011.2876?download=true)
34. Verbrugge LM. Sex Differentials in Health. *Public Health Reports* [Internet]. 2021 [cited 2025 Aug 22];97(5):4480–4480. Available from: [https://link.springer.com/rwe/10.1007/978-3-030-22009-9\\_302172](https://link.springer.com/rwe/10.1007/978-3-030-22009-9_302172)
35. Mathai SV, Apple SJ, Xu X, Pang L, Flatow E, Friedman A, et al. Differential Mortality Among Heart Failure Patients Across Different COVID-19 Surges in New York City. *Journal for Healthcare Quality* [Internet]. 2024 Jul 1 [cited 2025 Aug 22];46(4):197–202. Available from: [https://journals.lww.com/jhqonline/fulltext/2024/08000/differential\\_mortality\\_among\\_heart\\_failure.1.aspx](https://journals.lww.com/jhqonline/fulltext/2024/08000/differential_mortality_among_heart_failure.1.aspx)
36. Minhas AMK, Talha KM, Abramov D, Johnson HM, Antoine S, Rodriguez F, et al. Racial and ethnic disparities in cardiovascular disease - analysis across major US national databases. *J Natl Med Assoc* [Internet]. 2024 Jun 1 [cited 2025 Aug 22];116(3):258–70. Available from: <https://www.sciencedirect.com/science/article/abs/pii/S0027968424000221?via%3Dihub>
37. Kim JE, Joo J, Kuku KO, Downie C, Hashemian M, Powell-Wiley TM, et al. Prevalence, Disparities, and Mortality of Cardiovascular-Kidney-Metabolic Syndrome in US Adults, 2011–2018. *American Journal of*

- Medicine [Internet]. 2025 Jun 1 [cited 2025 Aug 22];138(6):970–979.e7. Available from: <https://www.amjmed.com/action/showFullText?pii=S0002934325000634>
38. Ruiz JM, Steffen P, Smith TB. Hispanic mortality paradox: A systematic review and meta-analysis of the longitudinal literature. *Am J Public Health* [Internet]. 2013 Mar 6 [cited 2025 Aug 22];103(3):52–60. Available from: [/doi/pdf/10.2105/AJPH.2012.301103?download=true](https://doi.org/10.2105/AJPH.2012.301103?download=true)
  39. Breathett K, Sims M, Gross M, Jackson EA, Jones EJ, Navas-Acien A, et al. Cardiovascular Health in American Indians and Alaska Natives: A Scientific Statement from the American Heart Association. *Circulation* [Internet]. 2020 Jun 23 [cited 2025 Aug 22];141(25):E948–59. Available from: [/doi/pdf/10.1161/CIR.0000000000000773?download=true](https://doi.org/10.1161/CIR.0000000000000773?download=true)
  40. Chen MS. Cardiovascular health among Asian Americans/Pacific Islanders: An examination of health status and intervention approaches. *American Journal of Health Promotion* [Internet]. 1993 [cited 2025 Aug 22];7(3):199–207. Available from: [/doi/pdf/10.4278/0890-1171-7.3.199?download=true](https://doi.org/10.4278/0890-1171-7.3.199?download=true)
  41. Minhas AMK, Qavi AH, Ijaz SH, Khan MZ, Fudim M, Nasir K. Ethnic And Racial Disparities In Heart Failure Related Mortality Rates Among Older Adults; Data From CDC Wonder 1999–2019. *J Card Fail* [Internet]. 2022 Apr 1 [cited 2025 Aug 22];28(5):S110–1. Available from: <https://onlinejcf.com/action/showFullText?pii=S1071916422003852>
  42. Domínguez JP, Harriague CM, García-Rojas I, González G, Aparicio T, González-Reyes A. Insuficiencia cardiaca aguda en pacientes de 70 años o más: factores precipitantes de descompensación. *Rev Clin Esp* [Internet]. 2010 Nov 1 [cited 2025 Aug 22];210(10):497–504. Available from: <https://www.sciencedirect.com/science/article/abs/pii/S0014256510003450?via%3Dihub>
  43. Lalic S, Sluggett JK, Ilomäki J, Wimmer BC, Tan ECK, Robson L, et al. Polypharmacy and Medication Regimen Complexity as Risk Factors for Hospitalization Among Residents of Long-Term Care Facilities: A Prospective Cohort Study. *J Am Med Dir Assoc* [Internet]. 2016 Nov 1 [cited 2025 Aug 22];17(11):1067.e1. Available from: <https://www.jamda.com/action/showFullText?pii=S1525861016303711>
  44. Tian F, Chen L, Qian Z (Min), Xia H, Zhang Z, Zhang J, et al. Ranking age-specific modifiable risk factors for cardiovascular disease and mortality: evidence from a population-based longitudinal study. *EClinicalMedicine* [Internet]. 2023 Oct 1 [cited 2025 Aug 22];64. Available from: <https://www.thelancet.com/action/showFullText?pii=S2589537023004078>
  45. Wrigley-Field E, Raquib R V., Berry KM, Morris KJ, Stokes AC. Mortality Trends Among Early Adults in the United States, 1999–2023. *JAMA Netw Open* [Internet]. 2025 Jan 2 [cited 2025 Aug 22];8(1):e2457538–e2457538. Available from: <https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2829783>
  46. Tromp J, Teng THK. Regional Differences in the Epidemiology of Heart Failure. *Korean Circ J* [Internet]. 2024 Oct [cited 2025 Aug 22];54(10):591–602. Available from: <https://doi.org/10.4070/kcj.2024.0199>
  47. Rugg SS, Bailey A, Browning SR. Preventing cardiovascular disease in Kentucky: epidemiology, trends, and strategies for the future. *J Ky Med Assoc*. 2008;
  48. Flu, pneumonia death rates by state - Becker's Hospital Review | Healthcare News & Analysis [Internet]. [cited 2025 Aug 22]. Available from: [https://www.beckershospitalreview.com/quality/public-health/flu-pneumonia-death-rates-by-state/?utm\\_source=chatgpt.com](https://www.beckershospitalreview.com/quality/public-health/flu-pneumonia-death-rates-by-state/?utm_source=chatgpt.com)
  49. Gong G, Phillips SG, Hudson C, Curti D, Philips BU. Higher us rural mortality rates linked to socioeconomic status, physician shortages, and lack of health insurance. *Health Aff* [Internet]. 2019 Dec 1 [cited 2025 Aug 22];38(12):2003–10. Available from: [/doi/pdf/10.1377/hlthaff.2019.00722](https://doi.org/10.1377/hlthaff.2019.00722)

50. Verdejo HE, Ferreccio C, Castro PF. Heart Failure in Rural Communities. *Heart Fail Clin* [Internet]. 2015 Oct 1 [cited 2025 Aug 22];11(4):515–22. Available from:  
<https://www.sciencedirect.com/science/article/abs/pii/S1551713615000641?via%3Dihub>
51. Gruneir A, Mor V, Weitzen S, Truchil R, Teno J, Roy J. Where people die: A multilevel approach to understanding influences on site of death in America. *Medical Care Research and Review* [Internet]. 2007 Aug [cited 2025 Aug 22];64(4):351–78. Available from: [/doi/pdf/10.1177/1077558707301810?download=true](https://doi.org/10.1177/1077558707301810?download=true)
52. Pham R, Gorodeski EZ, Al-Kindi S. Social Vulnerability and Location of Death in Heart Failure in the United States. *Curr Probl Cardiol* [Internet]. 2023 Jul 1 [cited 2025 Aug 22];48(7). Available from:  
<https://pubmed.ncbi.nlm.nih.gov/36906162/>
53. Rossouw TM, Anderson R, Manga P, Feldman C. Emerging Role of Platelet-Endothelium Interactions in the Pathogenesis of Severe SARS-CoV-2 Infection-Associated Myocardial Injury. *Front Immunol* [Internet]. 2022 Feb 4 [cited 2025 Aug 23];13:776861. Available from: [www.frontiersin.org](http://www.frontiersin.org)
54. Ata F, Montoro-Lopez M, Awouda S, Elsukkar AA, Badr AH, Patel AAH. COVID-19 and heart failure: The big challenge. *Heart Views* [Internet]. 2020 [cited 2025 Aug 23];21(3):187. Available from:  
[https://journals.lww.com/hrtv/fulltext/2020/21030/covid\\_19\\_and\\_heart\\_failure\\_\\_the\\_big\\_challenge.14.aspx](https://journals.lww.com/hrtv/fulltext/2020/21030/covid_19_and_heart_failure__the_big_challenge.14.aspx)
55. Roy CM, Brennan Bollman E, Carson LM, Northrop AJ, Jackson EF, Moresky RT. Assessing the indirect effects of COVID-19 on healthcare delivery, utilization and health outcomes: a scoping review. *Eur J Public Health* [Internet]. 2021 Jul 13 [cited 2025 Aug 23];31(3):634–40. Available from:  
<https://dx.doi.org/10.1093/eurpub/ckab047>

## Figures

## Heart Failure with Pneumonia associated AAMR Stratified by Sex and Overall per 100,000 Population

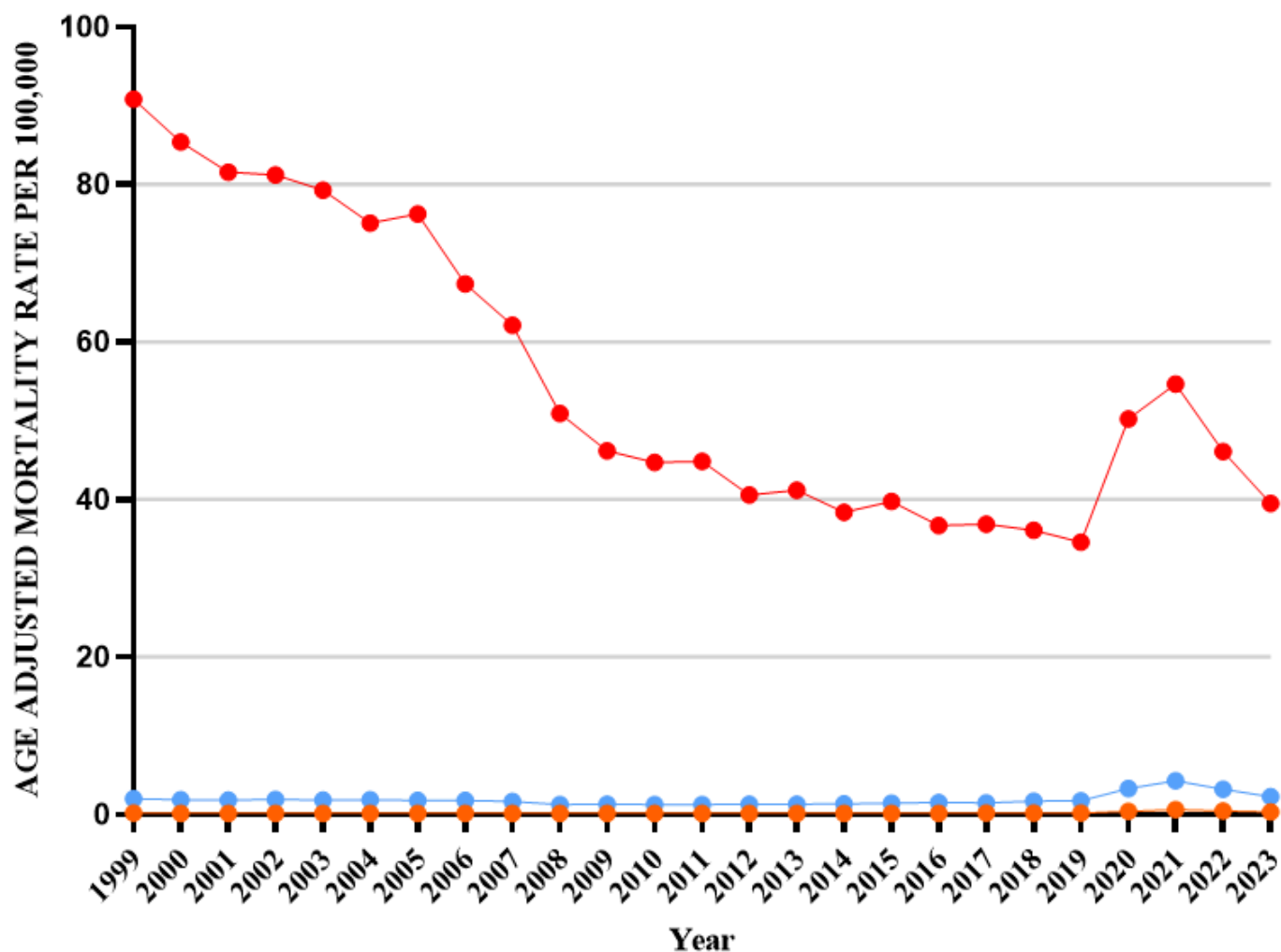


- Male:** 1999-2005: APC -2.70 (-4.41 to 1.18), 2005-2009: APC -11.43 (-15.99 to -7.57), 2009-2018: APC -2.72 (-4.82 to 0.77), 2018-2021: APC 22.04 (15.24 to 26.47), 2021-2023: APC -18.09 (-25.28 to -11.54)
- Female:** 1999-2005: APC -2.59 (-4.06 to 0.00), 2005-2009: APC -11.00 (-14.70 to -7.82), 2009-2018: APC -3.39 (-5.14 to -0.96), 2018-2021: APC 16.00 (9.82 to 19.73), 2021-2023: APC -14.71 (-21.62 to -7.85)
- Overall:** 1999-2005: APC -2.59 (-4.13 to 0.53), 2005-2009: APC -11.11 (-15.21 to -7.57), 2009-2018: APC -3.02 (-5.02 to 0.16), 2018-2021: APC 19.46 (12.79 to 23.64), 2021-2023: APC -16.68 (-23.98 to -9.59)

Figure 1

See image above for figure legend

## Heart Failure with Pneumonia associated AAMR Stratified by Age per 100,000 Population

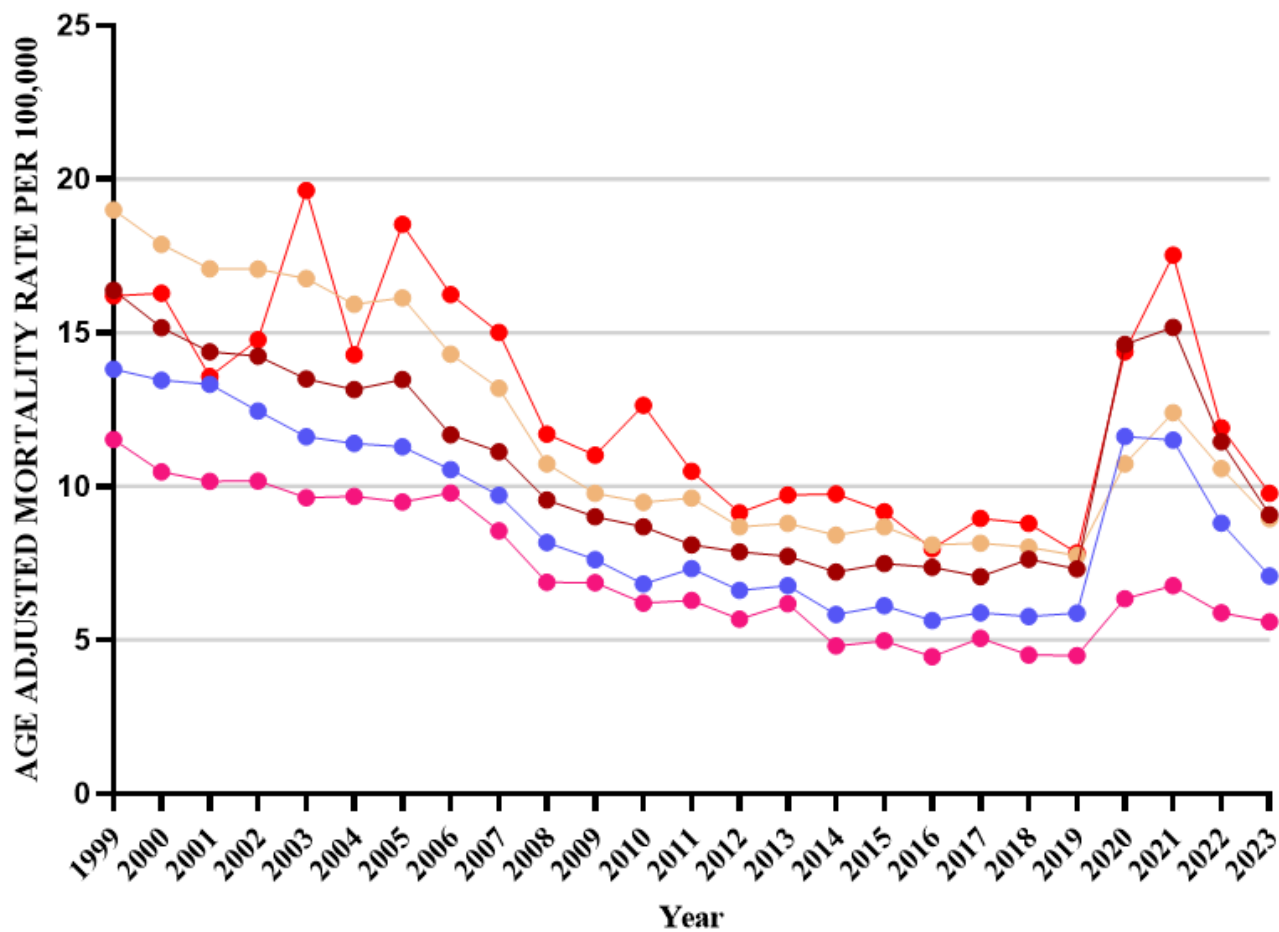


- **Younger Adults (25-44):** 1999-2018: APC 0.23 (-0.55 to 0.93), 2018-2021: APC 60.07 (41.28 to 68.22), 2021-2023: APC -28.79 (-34.96 to -20.73)
- **Middle-Aged Adults (45-64):** 1999-2011: APC -3.93 (-9.64 to -2.48), 2011-2018: APC 2.32 (-2.02 to 9.39), 2018-2021: APC 41.69 (32.32 to 49.63), 2021-2023: APC -27.14 (-34.63 to -20.20)
- **Older Adults (65-85+):** 1999-2005: APC -2.64 (-4.10 to 0.01), 2005-2009: APC -11.28 (-15.10 to -8.00), 2009-2018: APC -3.24 (-5.01 to -0.70), 2018-2021: APC 16.60 (10.61 to 20.34), 2021-2023: APC -15.35 (-21.93 to -9.05)

Figure 2

See image above for figure legend

## Heart Failure with Pneumonia associated AAMR Stratified by Race per 100,000 Population



- **Hispanic:** 1999-2018: APC -5.15 (-6.31 to -4.25), 2018-2021: APC 34.39 (20.84 to 43.20), 2021-2023: APC -26.38 (-36.04 to -15.14)
- **NH Black:** 1999-2017: APC -5.14 (-6.31 to -4.25), 2017-2021: APC 25.27 (17.84 to 40.93), 2021-2023: APC -24.57 (-35.11 to -9.54)
- **NH White:** 1999-2005: APC -2.40 (-3.81 to -0.04), 2005-2009: APC -11.35 (-15.12 to -8.05), 2009-2018: APC -2.73 (-4.54 to -0.44), 2018-2021: APC 16.80 (11.10 to 20.35), 2021-2023: APC -14.22 (-21.01 to -7.82)
- **NH American Indian or Alaska Native:** 1999-2018: APC -4.36 (-5.93 to -3.19), 2018-2021: APC 28.59 (14.26 to 38.41), 2021-2023: APC -25.93 (-37.85 to -11.15)
- **NH Asian or Pacific Islander:** 1999-2018: APC -5.22 (-6.40 to -4.00), 2018-2021: APC 16.17 (-7.30 to 21.57), 2021-2023: APC -10.33 (-20.20 to 5.52)

Figure 3

See image above for figure legend

## Heart Failure with Pneumonia associated AAMR Stratified by the U.S Census Region per 100,000 Population

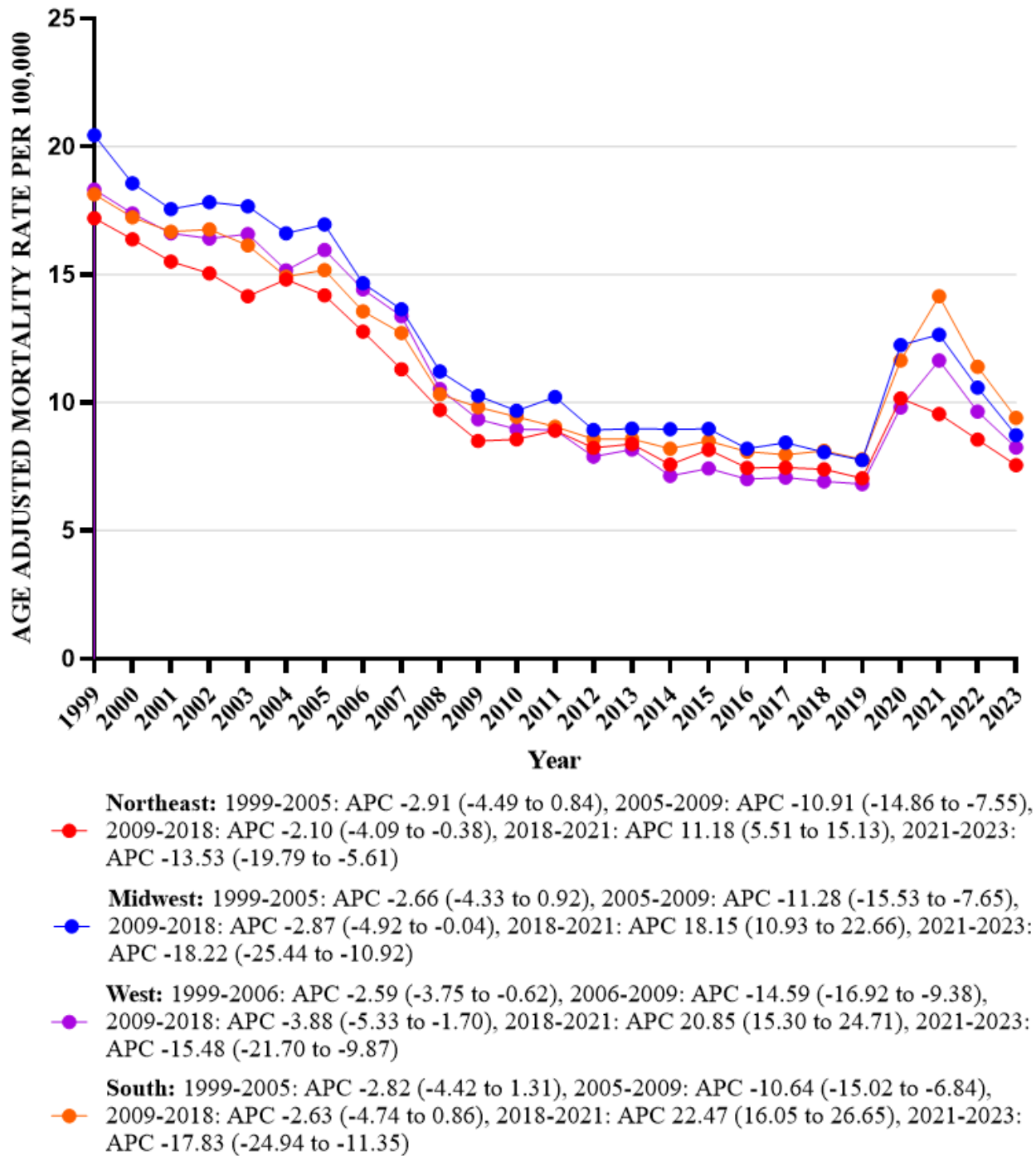


**Figure 4**

See image above for figure legend

## Heart Failure with Pneumonia associated AAMR Stratified by Urbanization per 100,000 Population

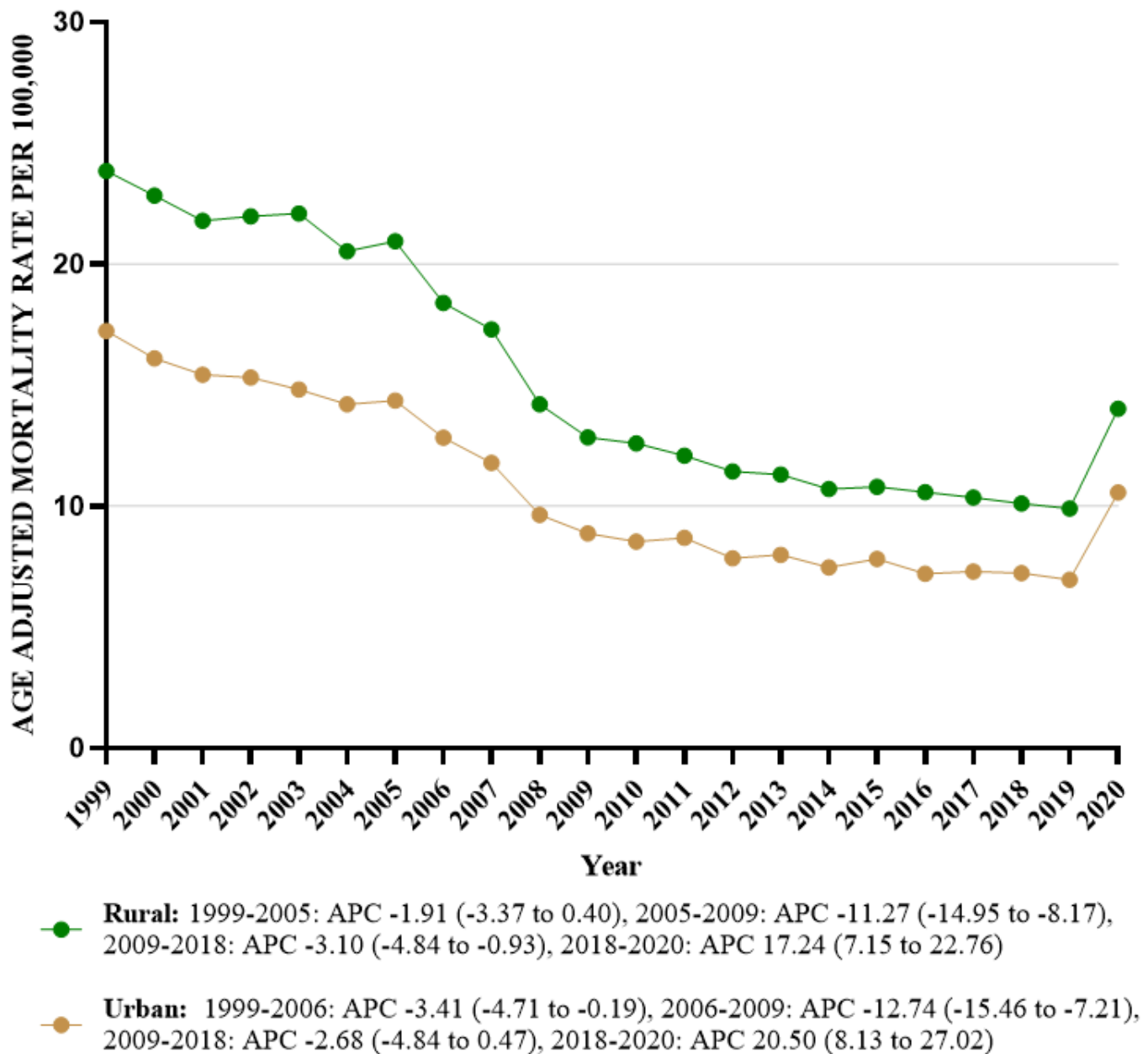


**Figure 5**

See image above for figure legend

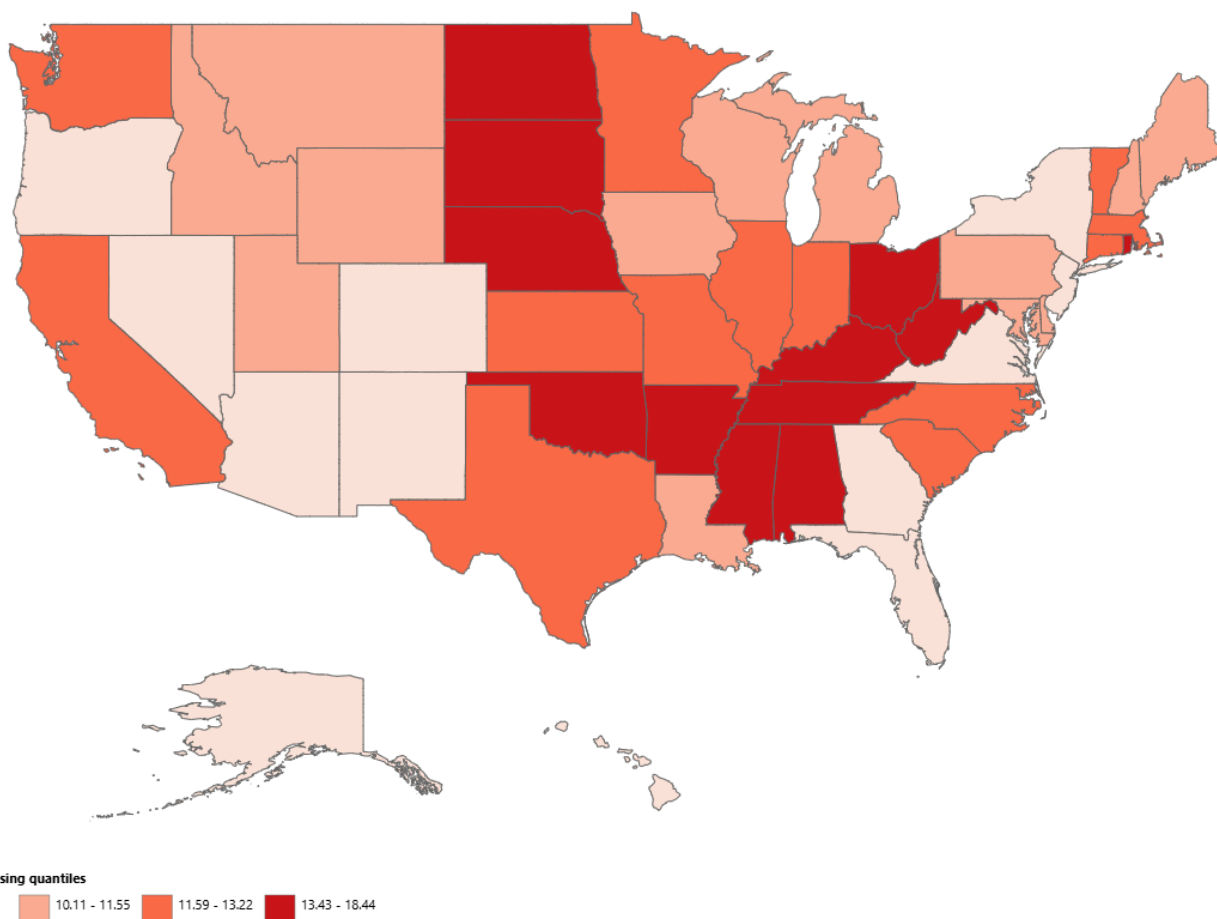


**Figure 6**

Heart Failure with Pneumonia AAMR Stratified by State per 100,000 Population

Temporal Trends in Heart Failure associated with Pneumonia in US Adults, from 1999 to 2023:  
A CDC Wonder Database Analysis

A total of 619,729 deaths occurred among adults aged 25 years and older in the United States between 1999 and 2023 due to Heart Failure associated with Pneumonia.

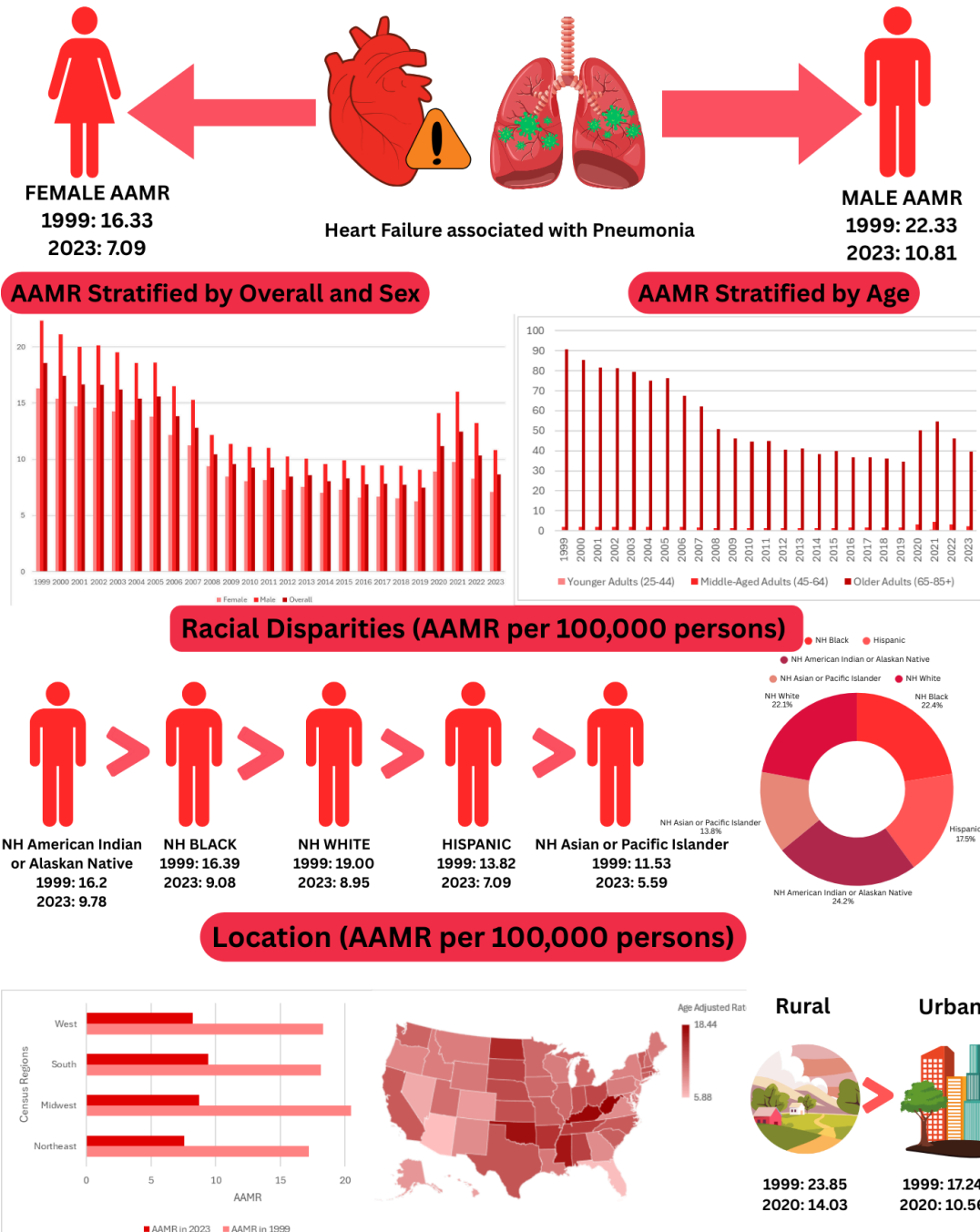


Figure 7

Central Illustration

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [HFPneumoniasupplementarytables.docx](#)