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Hyperkalemia associated trends in cardiac arrest and cardiac arrhythmias a CDC wonder analysis 1999-2020

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Abstract

BACKGROUND:

Cardiac arrest and cardiac arrhythmias are potentially lethal heart conditions the symptoms of which are exacerbated by hyperkalemia. This study evaluates mortality trends of hyperkalemia related cardiac arrest and cardiac arrhythmia deaths in the United States from 1999 to 2020 using CDC WONDER data.

METHODS:

CDC WONDER Multiple Cause of Death database was used to get data for adults aged 25 and older. ICD-10 code Hyperkalemia was identified using ICD-10 code E87.5. Cardiac arrest and cardiac arrhythmias were identified using ICD-10 codes I46–I49, including I46.0, I46.1, I46.9 ,I47.0, I47.1, I47.2, I47.9,I48 and I49.0–I49.5, I49.8, I49.9).AAMRs per 100,000 were stratified by sex, race and ethnicity, region, state and urbanization level. A p value < 0.05 was considered statistically significant.

RESULTS:

A total of 53,399 deaths were recorded among individuals aged ≥25 years in which the majority of these deaths occurred in medical facilities (85.91%). Overall mortality rate decreased from 1999 (1.13) to 2011 (1.01) followed by rapid increase (1.64) in 2020. AAMRs were consistently higher in males than females throughout the study period (males: 1.34 vs. females: 0.96).Mortality varied by race and ethnicity and geographical region and urbanization with the highest overall AAMR observed among Black or African American individuals followed by Hispanics.Highest mortality was observed in the West, Rhode Island(1.97) and non metropolitan areas

CONCLUSION

Hyperkalemia-related cardiac arrhythmias and cardiac arrest deaths showed temporal variation from 1999 to 2020. . These findings highlight the need for effective potassium serum level management, and improved access to timely care.

Introduction

Cardiac arrest is the cessation of all electrical activity in the heart which stops the heart from pumping blood to the tissues of the body. It is most often due cardiac arrhythmias that cause electrical malfunctioning of the heart and impair effective circulation[1] Cardiac arrhythmia is the beating of the heart varying from the normal heart rate and/or rhythm that is not physiologically justified. [2] This disturbance in heart rate or rhythm may be caused by electrolyte imbalances like hyperkalemia. Hyperkalemia disturbs the resting membrane potential of excitable cells, particularly cardiac myocytes, predisposing to life-threatening arrhythmias.[3]Hyperkalemia is marked by a serum potassium level of > 5.2 mmol/L.

Potassium plays an important role in maintaining the heart's electrical activity, and high potassium levels can reduce cardiac excitability, slow conduction, and eventually lead to arrhythmias and cardiac arrest.[4] Hyperkalemia may be genetic or it can result from medications or supplements containing potassium, excessive intake of potassium-rich foods or salt substitutes, and medical conditions such as Chronic Kidney Disease, Diabetes Mellitus, and Heart Failure that impair the body's ability to regulate or excrete potassium.

In particular, kidney dysfunction reduces potassium elimination further increasing potassium accumulation in the blood.[5] Severe elevations in potassium levels can precipitate symptoms of sudden cardiac arrest leading to death if not promptly managed [3] However, despite its clinical relevance, population-level data evaluating long-term trends in hyperkalemia-associated cardiac arrhythmias and cardiac arrest remain unexplored. It is important to understand these trends in order to identify the changes in disease prevalence, evaluate potential shifts in risk factors, and provide insights to public health strategists to curb mortality risk.

Therefore, with this study we aim to evaluate temporal trends in hyperkalemia-associated cardiac arrest and cardiac arrhythmia mortality in the United States from 1999 to 2020 using the CDC WONDER database.

Materials and Methods

Study design and Population

An observational analysis was conducted using death records from the CDC WONDER Multiple Cause of Death database for the period 1999-2020 [6], focusing on individuals aged 25-85+ years in the United States. The methodological approach was informed by previously a published CDC WONDER–based study Siddiqi et al. , 2022[7]. All descriptions have been independently written and adapted to align with the objectives of the present analysis. Mortality records were reviewed for cases in which hyperkalemia, cardiac arrest and cardiac arrhythmias were listed among the causes of death. The 10th edition of the International Classification of Diseases (ICD-10) was used to identify relevant cases. Hyperkalemia was classified under E87.5 code. Cardiac arrest and cardiac arrhythmias were classified under I46-I49 codes as I46.0(cardiac arrest with successful resuscitation) I46.1(sudden cardiac death as described) I46.9(cardiac arrest unspecified) I47.0(Re-entry ventricular arrythmia) I47.1(supraventricular tachycardia) I47.2(ventricular tachycardia) I47.9(paroxysmal tachycardia unspecified) I48(Atrial fibrillation and flutter) I49.0(ventricular fibrillation and flutter) I49.1(Atrial premature depolarisation) I49.2(Junctional premature depolarisation) I49.3(ventricular premature depolarisation) I49.4(other and unspecified premature depolarisation) I49.5(sick sinus syndrome) I49.8(other specified cardiac arrythmias) I49.9(cardiac arrythmias unspecified)[8]. We included mortality data only if both hyperkalemia and cardiac arrest/ arrhythmias codes appeared; those without both codes were excluded. Because this study used publicly available, de-identified government data, Institutional Review or any ethical board approval was not required or necessary.

Data abstraction

The CDC WONDER dataset includes information on sex, race/ethnicity, urban-rural classification, region, state, age group, and place of death [6]. Sex was classified as male or female based on death certificate records. Race/ethnicity followed the Office of Management and Budget (1997) standards: Hispanic or Latino, non-Hispanic (NH) White, NH Black or African American, NH American Indian or Alaska Native, and NH Asian or Pacific Islander. Urban-rural status was defined according to the National Center for Health Statistics (2013) scheme, which classifies urban areas as large metropolitan regions (≥1 million population) or medium/small metropolitan regions (50,000-999,999 population). Rural areas are defined as non-metropolitan regions with <50,000 population. Geographic regions were categorized by the US Census Bureau (2013) as West, Midwest, South, or Northeast. Place of death was grouped into healthcare settings (including outpatient, emergency department, inpatient, dead on arrival, or unknown status), home, hospice/palliative care, and nursing/extended care facilities. Data covered all 50 states and Washington, D.C. The mortality variables available through CDC WONDER have been widely used in prior epidemiologic studies and form the basis of the present analysis.

Statistical analysis

National trends were evaluated using age-adjusted mortality rates (AAMRs) per 100,000 individuals for Ischemic heart disease and Infectious triggers (influenza and pneumonia), adjusted for population age structure using the 2000 U.S. standard population as the reference. Mortality rates were analyzed for 1999-2020 by sex, race/ethnicity, urban-rural status, state, census region,place of death and year. Temporal patterns in AAMRs were assessed using the Joinpoint Regression Program (Version 5.3.0.0) [9], which applies log-linear regression models to identify statistically significant changes in trends. Annual percent changes (APCs) with 95% confidence intervals (CIs) were calculated, and trends were classified as increasing or decreasing when the slope significantly differed from zero. A p-value <0.05 was considered statistically significant.

Results

Age-adjusted mortality rates (AAMRs) for hyperkalemia-associated cardiac arrest and cardiac arrhythmias among older adults were calculated and expressed as deaths per 100,000 population. Between 1999 and 2020, a total of 53,399 deaths were recorded among individuals aged ≥25 years in which hyperkalemia was associated with cardiac arrest or cardiac arrhythmias (Supplementary Table 1). The majority of these deaths occurred in medical facilities (85.91%), followed by the decedent's home (6.56%) and nursing homes or long-term care facilities (5.77%). Smaller proportions of deaths were reported in hospice settings (0.70%) and other locations (1.07%).

Overall trend in mortality from 1999 to 2020:

From 1999 to 2020, mortality trends demonstrated distinct temporal patterns. Initially, there was a gradual and consistent decline in mortality rates from 1.13 in 1999 to 1.01 in 2011 (APC: −1.01; 95% CI:

−1.84 to −0.18; p = 0.02). This period was followed by a marked and rapid increase in mortality, reaching 1.64 in 2020 (APC: 5.14; 95% CI: 3.98 to 6.30; p < 0.001). These findings suggest a reversal of the earlier improving trend and highlight the need for targeted interventions to improve health outcomes. (supplementary table 2 and 3)(fig.1 and supplementary fig 1)

Overall, the average annual percent change (AAPC) from 1999 to 2020 indicates a significant upward trend in mortality (AAPC: 1.58; 95% CI: 0.95 to 2.21; p < 0.001), underscoring the necessity for improvements in clinical management and preventive strategies.

Gender wise stratification:

Throughout the study period, males consistently exhibited higher age-adjusted mortality rates (AAMRs) compared with females [overall AAMR: males 1.34 (95% CI: 1.32–1.36) vs. females 0.96 (95% CI: 0.94–0.97)].(fig 2)

Among males, mortality rates initially showed a steady decline from 1.35 in 1999 to 1.14 in 2009 (APC: −1.71; 95% CI: −2.46 to −0.96; p < 0.001). This was followed by a gradual increase, reaching 1.60 in 2018 (APC: 3.70; 95% CI: 2.65 to 4.76; p < 0.001). Subsequently, a sharp rise in mortality was observed, with rates increasing to 2.06 in 2020 (APC: 14.49; 95% CI: 7.10 to 22.38; p < 0.001).

In contrast, females experienced a slower but steady decline in mortality from 0.97 in 1999 to 0.81 in 2009 (APC: −1.99; 95% CI: −3.16 to −0.80; p < 0.01). This was followed by a notable increase in mortality, reaching 1.29 in 2020 (APC: 4.02; 95% CI: 3.08 to 4.97; p < 0.001).(supplementary 2 and 3)(supplementary fig 2)

These findings highlight a persistent gender disparity in mortality trends, emphasizing the need for improved and targeted management strategies to address these differences and enhance overall health outcomes.

Race/Ethnicity wise stratification:

When stratified by ethnicity, Hispanics exhibited a higher overall age-adjusted mortality rate (AAMR) compared with non-Hispanics [Hispanics: 1.32 (95% CI: 1.28–1.36) vs. non-Hispanics: 1.10 (95% CI: 1.09–1.11)].

Across racial groups, the highest overall AAMR was consistently observed among Black or African American individuals (overall AAMR: 1.95; 95% CI: 1.91–1.99), followed by Hispanics or Latinos (overall AAMR: 1.32; 95% CI: 1.28–1.36), Asians and Pacific Islanders (overall AAMR: 1.08; 95% CI: 1.03–1.13), and Whites (overall AAMR: 1.03; 95% CI: 1.02–1.04).(fig 3)

Among Black or African American individuals, mortality initially declined steadily from 2.14 in 1999 to 1.61 in 2009 (APC: −2.14; 95% CI: −3.38 to −0.88; p < 0.01). This was followed by a gradual increase,

reaching 2.10 in 2018 (APC: 2.90; 95% CI: 1.42–4.39; $p < 0.01$). Subsequently, a marked rise in mortality was observed from 2.10 in 2018 to 3.10 in 2020 (APC: 17.97; 95% CI: 6.11–31.15; $p < 0.01$).

Hispanic or Latino individuals demonstrated a steady decline in mortality from 1.36 in 1999 to 0.98 in 2012 (APC: −2.29; 95% CI: −4.31 to −0.23; $p = 0.03$), followed by a significant upward trend, with mortality increasing to 2.00 in 2020 (APC: 6.57; 95% CI: 3.49–9.75; $p < 0.001$).

Similarly, Asians and Pacific Islanders experienced an initial decline in mortality from 1.48 in 1999 to 0.80 in 2015 (APC: −2.62; 95% CI: −4.10 to −1.20; $p < 0.01$). This trend was followed by a notable increase, with mortality rising to 1.42 in 2020 (APC: 12.14; 95% CI: 5.68–18.99; $p < 0.001$).

Among White individuals, mortality decreased from 1.02 in 1999 to 0.87 in 2008 (APC: −2.26; 95% CI: −3.84 to −0.65; $p < 0.01$). However, this decline was followed by a sustained upward trend, with mortality increasing to 1.47 in 2020 (APC: 4.10; 95% CI: 3.22–4.99; $p < 0.001$).

Racial and ethnic disparities in mortality, particularly among Black and Hispanic populations, underscore the need for targeted interventions, including improved access to early detection, timely management of electrolyte disorders, and standardized treatment protocols to reduce these gaps.(supplementary table 2and 4)(supplementary figure 3)

Limitation: Mortality estimates for American Indian or Alaska Native populations contained multiple unreliable values in the CDC WONDER database; therefore, this group was not analyzed in detail.

Urbanization wise stratification:

Throughout the study period, mortality rates were consistently higher in nonmetropolitan areas compared with metropolitan regions, highlighting a clear geographic disparity. Within nonmetropolitan areas, micropolitan regions exhibited the highest overall age-adjusted mortality rate (AAMR: 1.32; 95% CI: 1.29–1.35), slightly above noncore areas (1.30; 95% CI: 1.26–1.33). Among metropolitan areas, small metropolitan regions had the highest AAMR (1.19; 95% CI: 1.16–1.22), followed by medium metropolitan (1.17; 95% CI: 1.15–1.19), large central metropolitan (1.13; 95% CI: 1.11–1.14), and large fringe metropolitan areas (0.89; 95% CI: 0.87–0.90).

Across metropolitan areas, large central metropolitan regions initially showed a decline in mortality from 1.21 in 1999 to 0.91 in 2010 (APC: −2.75; 95% CI: −4.02 to −1.46; $p < 0.001$), followed by a sharp increase to 1.68 in 2020 (APC: 5.30; 95% CI: 3.99–6.62; $p < 0.001$). Large fringe metropolitan areas declined from 0.93 in 1999 to 0.77 in 2010 (APC: −1.72; 95% CI: −3.15 to −0.26; $p = 0.02$), then rose to 1.25 in 2020 (APC: 5.12; 95% CI: 3.75–6.51; $p < 0.001$). Medium metropolitan areas declined modestly from 1.08 in 1999 to 1.04 in 2008 (APC: −1.53; 95% CI: −3.34 to 0.31; $p = 0.10$), followed by an increase to 1.59 in 2020 (APC: 3.43; 95% CI: 2.44–4.44; $p < 0.001$). Small metropolitan areas showed a slight decline from 1.23 in 1999 to 1.10 in 2014 (APC: 0.54; 95% CI: −0.64 to 1.73; $p = 0.35$), then increased steadily to 1.97 in 2020 (APC: 9.04; 95% CI: 5.20–13.02; $p < 0.001$).

In nonmetropolitan areas, micropolitan regions exhibited a steady increase in mortality from 1.24 in 1999 to 1.36 in 2016 (APC: 1.10; 95% CI: 0.34–1.86; $p < 0.01$), followed by a sharp rise to 1.99 in 2020 (APC: 9.94; 95% CI: 4.09–16.10; $p < 0.01$). Noncore areas initially declined from 1.26 in 1999 to 1.11 in 2011 (APC: −0.61; 95% CI: −2.55–1.37; $p = 0.52$), then experienced a steep rise to 2.24 in 2020 (APC: 7.00; 95% CI: 4.27–9.79; $p < 0.001$).(supplementary table 2 and 7)(figure 4 and supplementary fig 4)

These findings highlight a persistent geographic disparity, with rural and micropolitan communities consistently experiencing higher mortality than urban populations. Contributing factors may include limited healthcare access, delayed diagnosis and treatment, fewer preventive services, and socioeconomic barriers. Targeted interventions, such as expanding rural healthcare services, telemedicine, and timely management of high-risk conditions, are needed to reduce these excess mortality rates.

Geographic region wise stratification:

Throughout the study period, the highest overall age-adjusted mortality rate (AAMR) was observed in the West (1.33; 95% CI: 1.31–1.35), followed by the Northeast (1.14; 95% CI: 1.11–1.16), the South (1.08; 95% CI: 1.07–1.10), and the Midwest (0.95; 95% CI: 0.93–0.96).(fig 5 and supplementary fig 5)

Within the Northeast, Rhode Island (1.97), Connecticut (1.28), New York (1.26), Massachusetts (1.24), and Vermont (1.23) reported the highest mortality rates, whereas Maine (0.92) and New Jersey (0.87) had the lowest. In the Midwest, North Dakota (1.63), Nebraska (1.46), and South Dakota (1.40) were at the upper end, compared with Minnesota (0.69) and Illinois (0.60) at the lower end.

In the South, South Carolina (1.64), Mississippi (1.63), and West Virginia (1.60) were in the upper 90th percentile, while Delaware (0.77), Louisiana (0.72), and Florida (0.65) fell in the lowest 10th percentile. The West also displayed substantial variation, with Nevada (1.79), Washington (1.58), and California (1.46) having the highest rates, compared to New Mexico (0.89), Alaska (0.87), and Colorado (0.87), which had the lowest mortality rates.(supplementary table 5 and 6)

Discussion

The present study provides a national assessment of hyperkalemia-associated mortality in the United States from 1999 to 2020, highlighting its growing clinical and public health relevance. During this period, 53 399 deaths among adults aged ≥25 years were attributed to hyperkalemia-associated cardiac arrest and arrhythmias, most occurring in medical facilities. Mortality trends demonstrated a biphasic pattern, with declining age-adjusted rates from 1999 to 2011 followed by a sustained increase through 2020. Substantial disparities were observed across demographic and geographic groups, with higher mortality among males, Black and Hispanic individuals, and residents of rural or micropolitan areas. (fig 6)

These findings likely reflect the interaction between hyperkalemia and prevalent comorbidities, including chronic kidney disease, heart failure, diabetes, and cardiovascular disease, which increase susceptibility to malignant arrhythmias and death. Together, these results underscore the clinical severity of hyperkalemia and persistent challenges in its detection and management across diverse populations.

Hyperkalemia is a potentially life-threatening condition that can precipitate fatal cardiac arrhythmias, emphasizing the critical importance of early recognition and prompt treatment. Evidence from a comprehensive review of multiple studies highlights both the prevalence of hyperkalemia in high-risk populations and the effectiveness of timely interventions in preventing severe cardiac outcomes. These insights support the trends observed in the present CDC WONDER analysis, reinforcing the link between hyperkalemia and rising mortality from cardiac arrest and arrhythmias.[]

Hyperkalemia is strongly associated with increased morbidity and mortality, particularly among patients with renal disease and heart failure, where impaired potassium regulation and cardiovascular vulnerability amplify risk. Clinical context plays a critical role in determining outcomes, as underlying comorbidities, medication use, and disease severity influence both the development of hyperkalemia and its consequences. Evidence derived from reviews of clinical data and existing literature consistently supports this association, reinforcing the importance of early identification and management in high-risk populations. These observations align with the increasing mortality trends related to hyperkalemia-associated cardiac arrest and arrhythmias demonstrated in the present population-based analysis.[10]

Hyperkalemia is a common and clinically significant electrolyte disorder that is strongly associated with cardiac dysrhythmias and increased mortality. However, current management strategies are largely informed by small studies, limited clinical trials, and experiential evidence rather than large randomized data, resulting in variability in practice. The relative lack of high-quality evidence to guide optimal treatment approaches underscores the need for further research to improve standardized care. These gaps in evidence-based management may contribute to persistent adverse outcomes, consistent with the rising mortality trends from hyperkalemia-associated cardiac arrest and arrhythmias observed in the present study.[11]

Previous epidemiological studies have highlighted the substantial healthcare burden associated with hyperkalemia. In an analysis of emergency department utilization in the United States, approximately 814,181 annual emergency department visits were reported, in which hyperkalemia was listed as any diagnosis, with 66,989 visits where it was the primary diagnosis. The majority of affected patients were older adults, particularly those aged 45–64 years (36.04%) and 65–84 years (39.44%), and Medicare accounted for nearly 68% of cases, reflecting the high prevalence of hyperkalemia among older individuals with chronic comorbidities. Several clinical conditions were identified as common contributors, including missed dialysis in patients with end-stage renal disease, acute renal failure, severe metabolic acidosis, trauma, burns, and rhabdomyolysis. These findings illustrate the widespread occurrence of hyperkalemia in acute care settings and underscore its strong association with underlying renal and systemic illnesses. In the context of the present analysis, which demonstrated a significant

increase in mortality from hyperkalemia-associated cardiac arrest and arrhythmias in recent years, the high frequency of hyperkalemia-related emergency encounters further emphasizes the growing clinical burden of this electrolyte disturbance and its potential progression to severe cardiovascular complications.[12]

A body of literature has established a clear correlation between elevated serum potassium levels and characteristic electrocardiographic (ECG) changes, forming the physiologic basis for hyperkalemia-related cardiac arrhythmias. Progressive potassium elevation is associated with sequential ECG abnormalities, including peaked T waves, PR prolongation, widening of the QRS complex, and eventual sine-wave patterns leading to cardiac arrest. Evidence derived from clinical studies and literature reviews consistently demonstrates that these electrical disturbances precede or accompany malignant arrhythmias, reinforcing the importance of early ECG monitoring in at-risk patients. This mechanistic relationship supports the population-level association between hyperkalemia and increased mortality from cardiac arrest and arrhythmias observed in the present analysis.[13]

Hyperkalemia represents a major and clinically significant complication in patients with chronic kidney disease (CKD) and is associated with increased mortality risk. Evidence from a large retrospective analysis of 2,103,422 medical records from 245,808 veterans demonstrated the strong association between elevated potassium levels and adverse outcomes in this high-risk population. The large cohort size strengthens the reliability of these findings and underscores the substantial burden of hyperkalemia among patients with impaired renal function. These data align with population-level mortality trends showing persistent and rising deaths related to hyperkalemia-associated cardiac events, particularly in groups with underlying kidney disease.[14]

Prior clinical studies have also demonstrated the severe outcomes associated with hyperkalemia. An et al. analyzed 923 patients with severe hyperkalemia (≥6.5 mEq/L) and reported that 20.3% presented with cardiac arrest at diagnosis, while in-hospital mortality reached 30.7%. Among symptomatic patients, cardiac arrest was the most common presentation, and 50.4% exhibited electrocardiographic changes typical of hyperkalemia. These findings highlight the life-threatening cardiac complications associated with severe hyperkalemia and support the association between hyperkalemia and fatal cardiac arrest and arrhythmias observed in the present study.[15]

Hyperkalemia has also been linked to an increased risk of fatal arrhythmic events. A previous study showed that in patients with chronic kidney disease and coronary artery disease, serum potassium levels >5.0 mEq/L were associated with more than a twofold increase in the risk of sudden cardiac death (OR: 2.37; 95% CI: 1.33–4.23). Hyperkalemia was present in 16.7% of proximate laboratory measurements, underscoring its frequent occurrence in high-risk cardiovascular populations. These findings reinforce the strong mechanistic and clinical connection between elevated potassium levels and malignant arrhythmias, aligning with the increasing mortality trends observed in the present population-based analysis. [16]

Delayed recognition of hyperkalemia remains a critical concern in clinical practice. A median time of 117 minutes has been reported from triage to treatment, even though 83% of patients had abnormal ECGs. Classic hyperkalemia ECG changes, including peaked T-waves (34%), first-degree AV block (17%), and interventricular conduction delays (12%), often did not trigger timely intervention. Notably, two patients died from cardiac arrhythmias despite receiving treatment, highlighting the challenges in promptly identifying and managing hyperkalemia. These findings provide context for the rising mortality trends observed in the present study, emphasizing that delays in recognition and treatment can contribute to fatal cardiac events. [17]Hyperkalemia exerts significant cardiovascular effects, particularly in high-risk populations. It has been emphasized that elevated serum potassium is strongly associated with life-threatening cardiac arrhythmias and increased mortality, with the risk being especially pronounced in patients with diabetes or impaired renal function. These findings align with the present analysis, which demonstrates rising mortality from hyperkalemia-associated cardiac arrest and arrhythmias, and underscore the need for vigilant monitoring and management in vulnerable populations.[18]Management of hyperkalemia in acute settings relies on prompt pharmacologic interventions. A systematic review done in the past, identified nebulized beta-agonists and intravenous insulin with glucose as first-line therapies, with combination therapy proving more effective than either alone at lowering serum potassium. However, the review noted that most studies focused on potassium reduction rather than hard clinical outcomes, such as mortality or cardiac arrhythmias. This underscores a gap between biochemical correction and the prevention of fatal cardiac events, which is reflected in the persistent and increasing mortality trends observed in the present population-level analysis. [19]

Guidelines and resuscitation literature emphasize the acute danger of electrolyte disturbances in cardiac arrest. The related resuscitation guidance highlights that electrolyte abnormalities, particularly hyperkalemia, are frequently associated with life-threatening arrhythmias and cardiopulmonary arrest, necessitating empiric treatment even before laboratory confirmation is available. This reinforces the clinical urgency of rapid recognition and immediate intervention, consistent with the high proportion of deaths occurring in acute care settings and the increasing mortality from hyperkalemia-associated cardiac arrest observed in the present study. [20]Effective management of hyperkalemia is essential to prevent fatal cardiac complications. In a prior study, a stepwise approach has been outlined, including membrane stabilization with calcium, intracellular potassium shift using beta-agonists and insulin, and enhanced potassium excretion, with dialysis being the most efficient method for potassium removal. These interventions underscore the critical importance of timely and aggressive treatment in preventing life-threatening arrhythmias. In the context of the present CDC WONDER analysis, this evidence supports the observed rising trends in hyperkalemia-associated cardiac arrest and arrhythmia mortality from 1999 to 2020, highlighting both the clinical severity of hyperkalemia and the need for improved recognition and management strategies.[21]Large-scale database analyses further demonstrate the population-level burden of hyperkalemia. A retrospective study of 2,270,635 patients from a large U.S. commercial claims database reported an increased prevalence of hyperkalemia, particularly among individuals with chronic kidney disease and heart failure, underscoring the concentration of risk within populations with underlying cardiovascular and renal comorbidities. These data reinforce that hyperkalemia is not limited

to isolated clinical encounters but represents a widespread condition in high-risk groups, consistent with the persistent mortality burden and rising trends in hyperkalemia-associated cardiac arrest and arrhythmias observed in the present analysis.[22]Hyperkalemia is particularly prevalent among patients with cardiovascular disease and is associated with increased mortality and hospitalization rates. A study of 15,803 patients using logistic regression identified key predictors, including advanced chronic kidney disease, diabetes, coronary artery disease, and peripheral vascular disease. These findings highlight the elevated risk in patients with multiple comorbidities and align with the present CDC WONDER analysis, which demonstrates rising mortality from hyperkalemia-associated cardiac arrest and arrhythmias, particularly in populations with underlying cardiovascular and renal disease.[23]Abnormal serum potassium levels are strongly linked to adverse cardiovascular outcomes. A meta-analysis of 24 studies including 310,825 participants demonstrated that hypokalemia is associated with supraventricular arrhythmias, while hyperkalemia is linked to increased cardiovascular mortality and ventricular arrhythmias. These findings underscore the dose-dependent relationship between potassium abnormalities and fatal cardiac events, supporting the observed increase in hyperkalemia-associated cardiac arrest and arrhythmia mortality in the present CDC

WONDER analysis.[24]

Clinical implications

Our findings show that there is a significant role hyperkalemia in precipitating cardiac arrest and arrhythmia related deaths. Therefore, it is necessary to monitor serum potassium levels in individuals having these heart conditions to prevent worsening of symptoms and deaths. Timely access to effective potassium-lowering therapies may help reduce preventable mortality. Additionally, expanding access to emergency and specialty care in rural and underserved communities may further mitigate disparities in outcomes.

Limitations

This study has several limitations. Mortality data derived from CDC WONDER rely on death certificate coding and are subject to misclassification or variability in reporting of AMI and infectious conditions. The database lacks clinical details, including onset of disease, severity of illness, comorbid conditions, and treatment received, limiting causal interpretation. Despite these limitations, the large national sample and extended study period provide valuable insight into long term mortality patterns.

Conclusion

Hyperkalemia remains a significant and rising contributor to mortality from cardiac arrest and arrhythmias, particularly among high-risk populations defined by age, comorbidities, sex, race, and geographic location. Despite advances in pharmacologic therapies, guideline-directed interventions, and awareness of ECG-based recognition, timely identification and treatment remain inconsistent, contributing to preventable deaths. The observed upward trends in mortality since 2011, coupled with

persistent disparities, highlight the urgent need for targeted strategies, including improved surveillance, standardized treatment protocols, enhanced access to care in rural and underserved regions, and continued research to define evidence-based management approaches. Addressing these gaps is essential to reduce the burden of hyperkalemia-related cardiac complications and improve outcomes across vulnerable populations.

Declarations

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Conflict of interest:

The authors declare no conflict of interest.

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Author Contributions:Inam Ur Rehman Khan and Javeria Gul conceptualized the idea. Saqib Muhammad and Aleena Shehzadi conducted the literature search. Eishal Khan, Muhammad Awais Khan, Faizan Ahmad, Ibadullah, Muhammad Armaghan Saddozai, Umama Khan, and Maria Campwala contributed to writing the original draft. Anam Rafique, Shawail Alam, and Areeba Zia edited and improved the manuscript. Nasrin Ghafoor and Kamil Ahmad Kamil finalized the final version of the manuscript.

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Data Availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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Figures

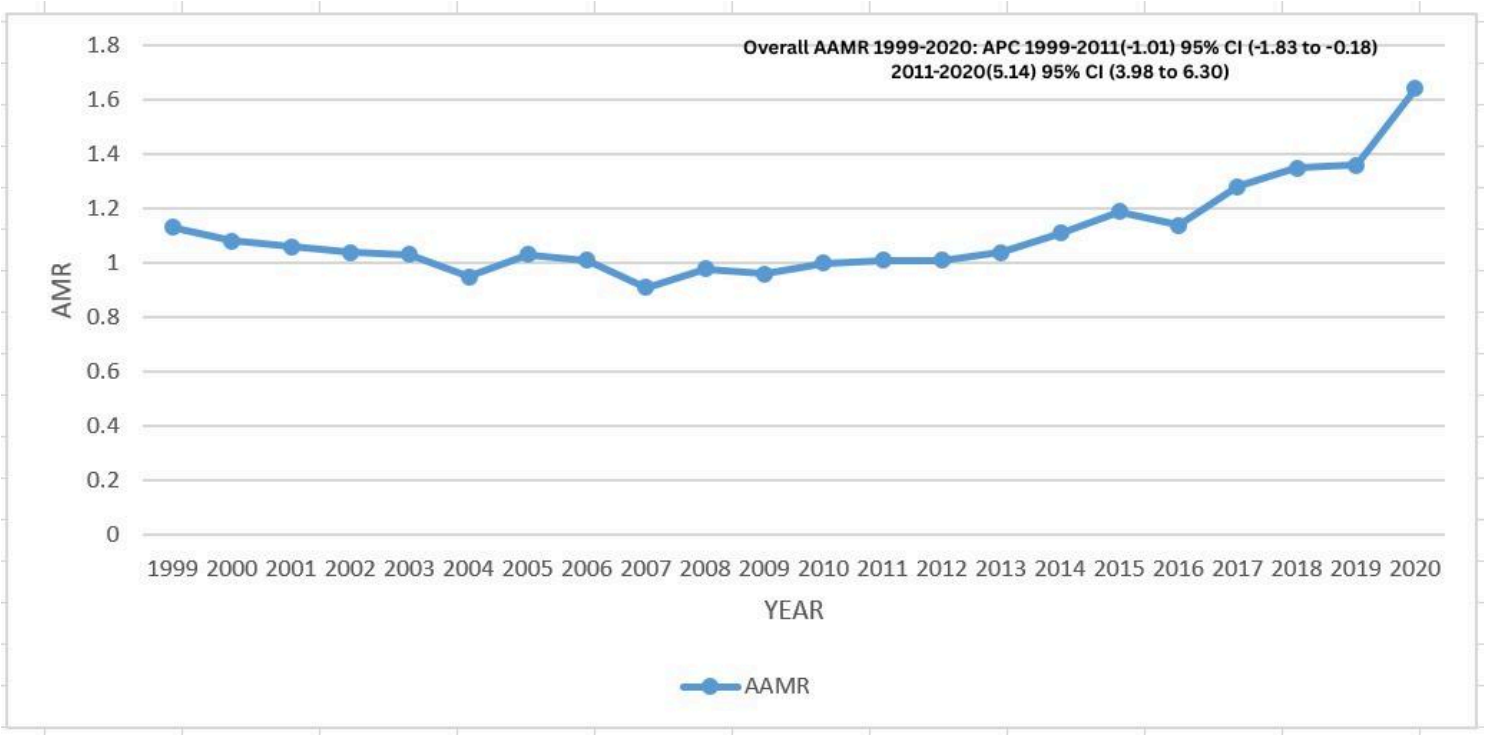


Figure 1

Overall trends in AAMRs for hyperkalemia and cardiac arrest + cardiac arrhythmias.

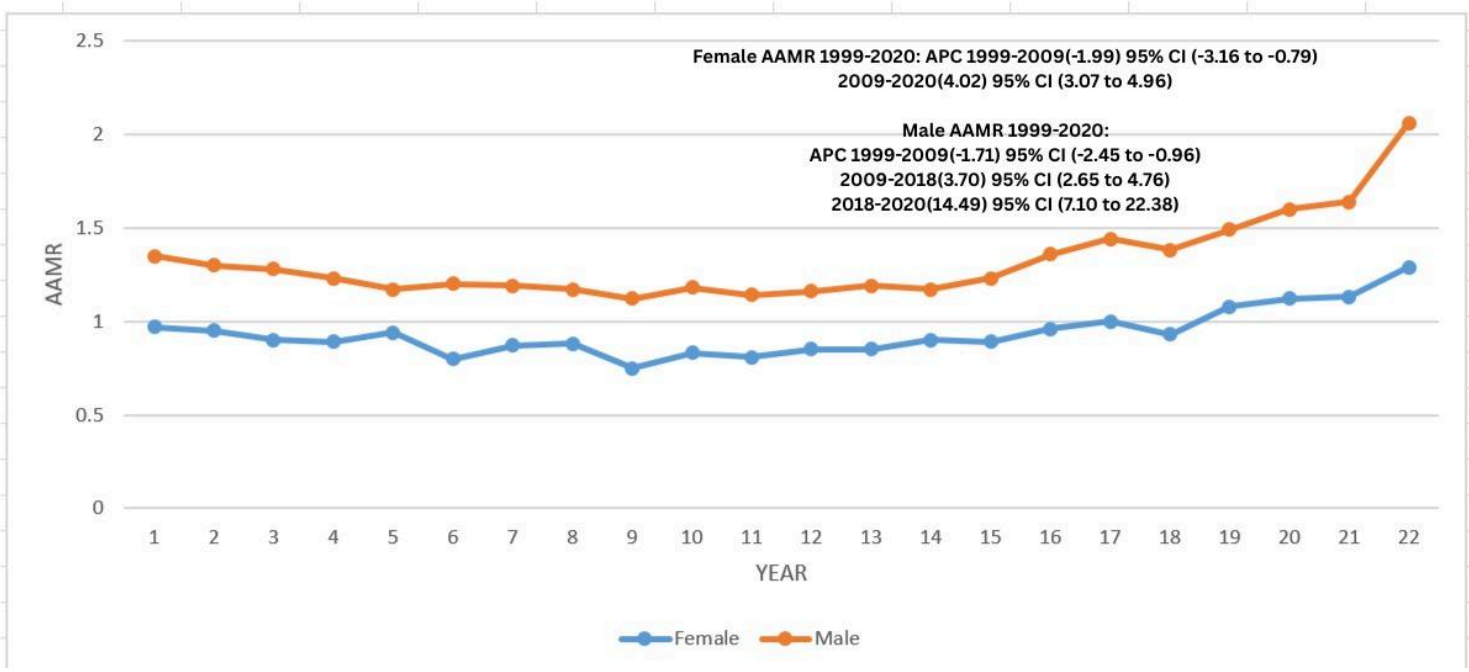


Figure 2

Sex-specific trends in AAMRs for hyperkalemia and cardiac arrest + cardiac arrhythmia

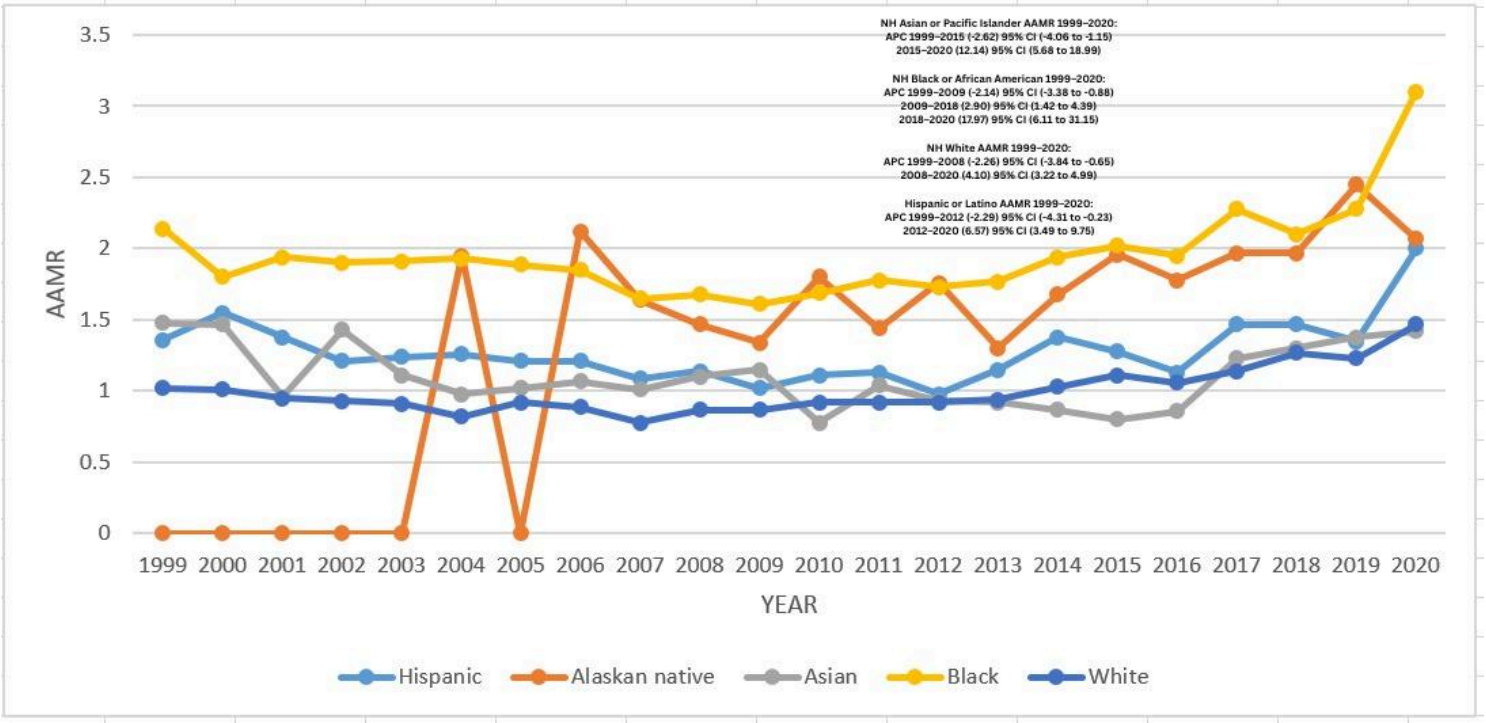


Figure 3

Race stratified trends in AAMRs for hyperkalemia and cardiac arrest + cardiac arrhythmia

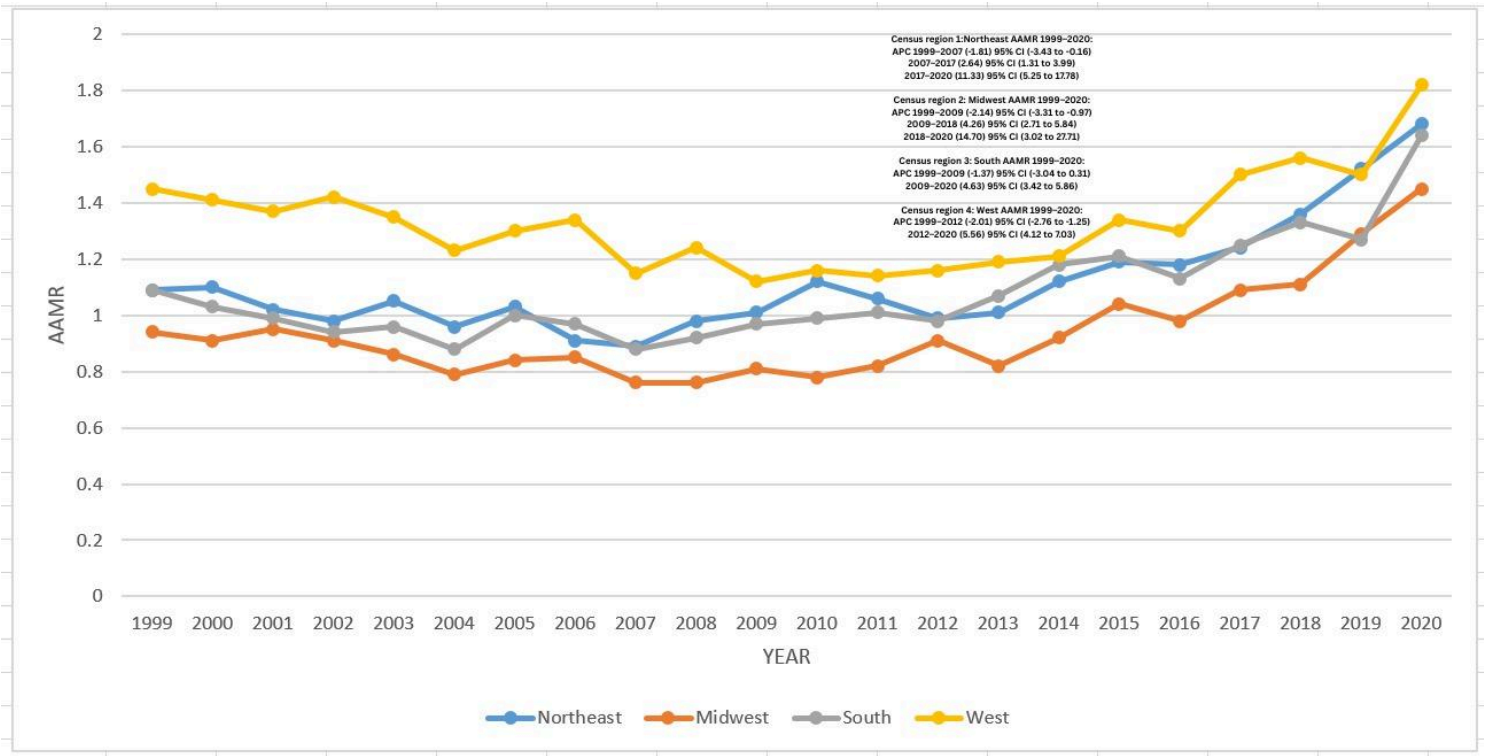


Figure 4

AAMRs trends by urbanization in for hyperkalemia and cardiac arrest + cardiac arrhythmia

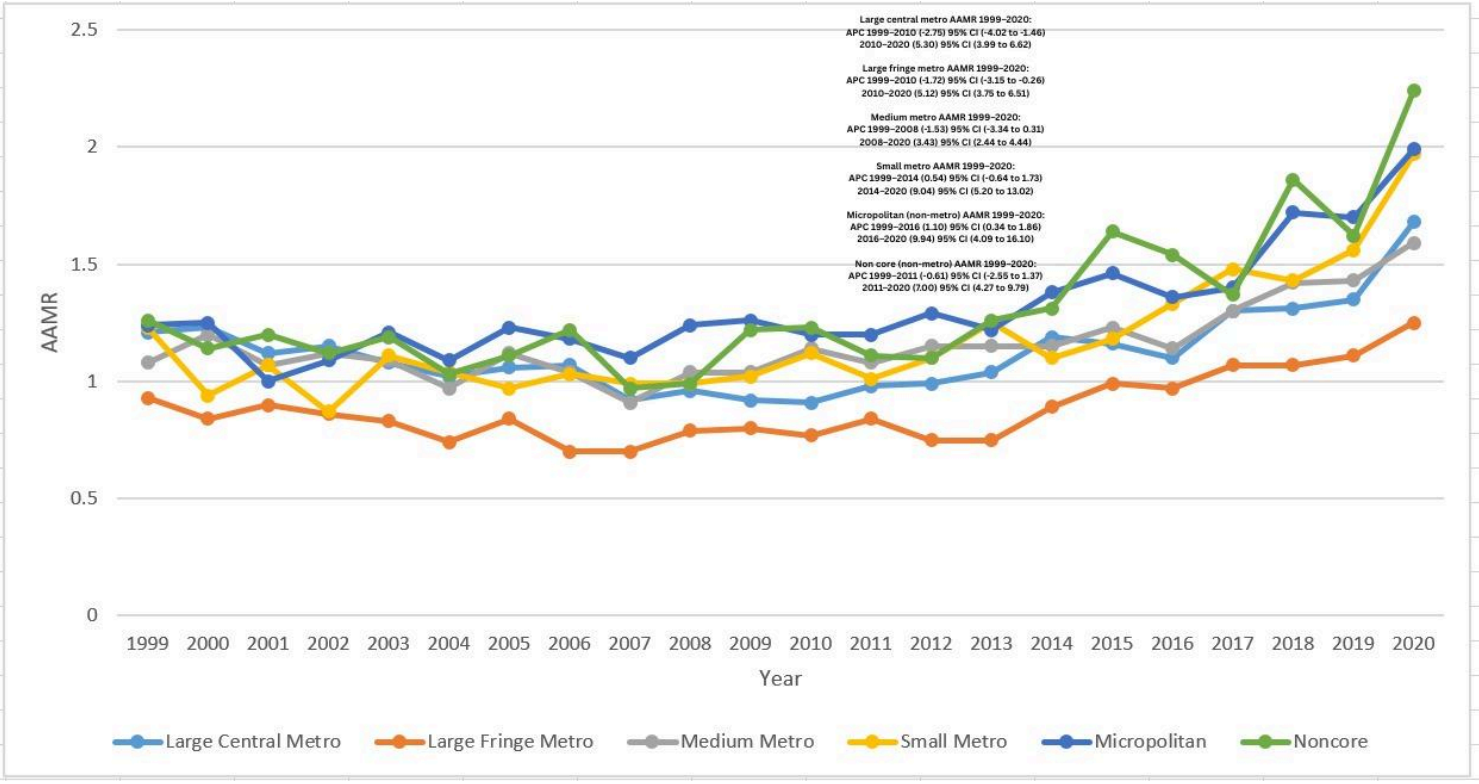


Figure 5

Trends in AAMRs by census region for hyperkalemia and cardiac arrest + cardiac arrhythmia

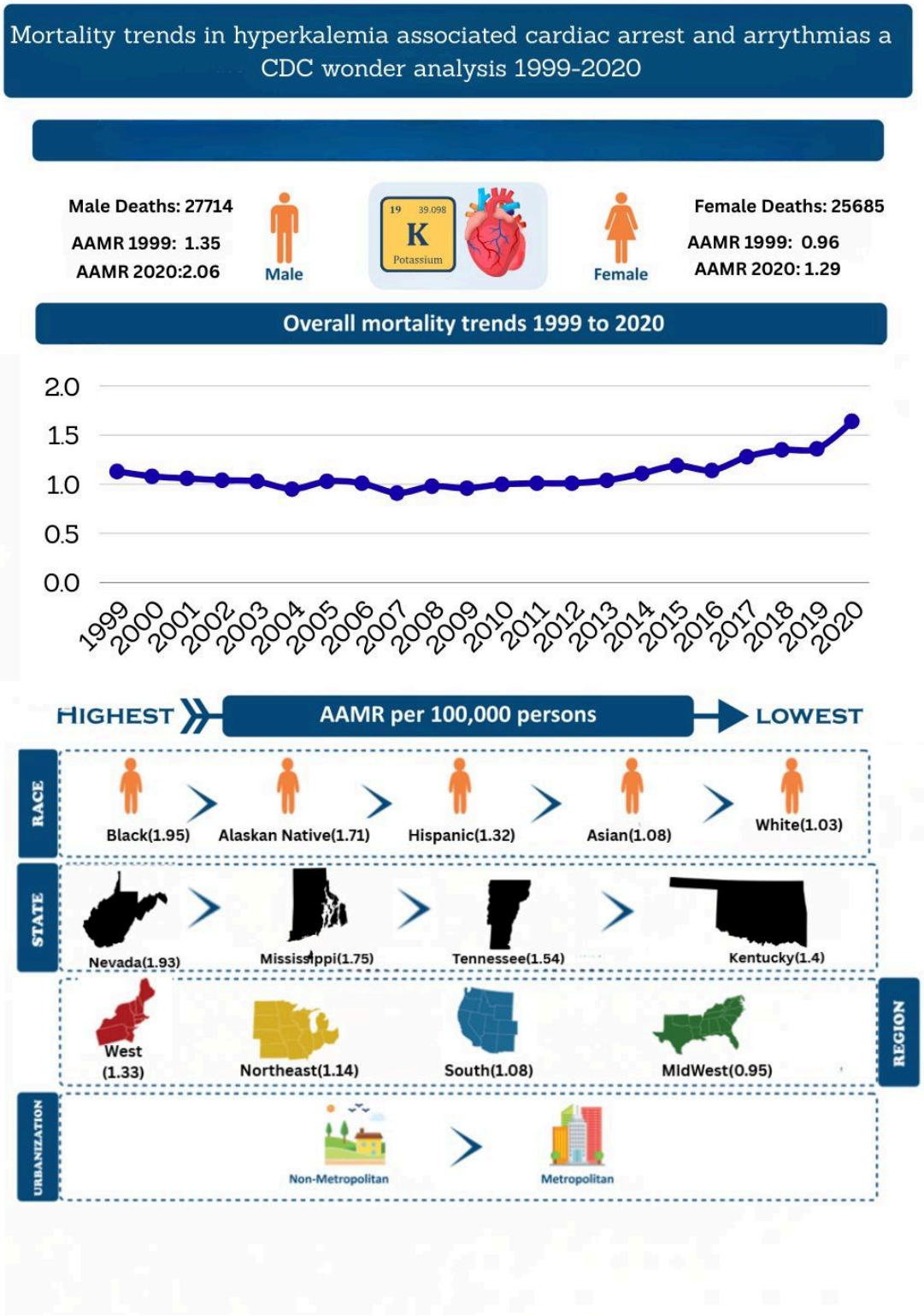


Figure 6

Central illustration showing mortality trends of hyperkalemia associated cardiac arrest and cardiac arrhythmias among US adults aged ≥25 years

AAMR: age-adjusted mortality rate.

Supplementary Files

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

- tablesandfigures.xlsx
- jphyperkalemiacaandca.docx