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Trends in Mortality Involving Coexisting Lung Cancer and Chronic Kidney Disease in the United States: A CDC WONDER Analysis, 1999–2024

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Research Article

Keywords: lung cancer, chronic kidney disease, CDC WONDER, mortality trends, age-adjusted mortality rate, Joinpoint regression, health disparities, geographic disparities

Posted Date: July 27th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10284876/v1

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Additional Declarations: No competing interests reported.

Abstract

Background

Lung cancer remains the leading cause of cancer-related mortality worldwide (1–3), while chronic kidney disease (CKD) is a major contributor to morbidity, mortality, and healthcare utilization. The coexistence of these conditions may complicate clinical management and adversely affect outcomes; however, long-term national mortality trends and demographic disparities among individuals with coexisting lung cancer and CKD remain incompletely characterized. We evaluated temporal trends in mortality involving coexisting lung cancer and CKD among U.S. adults aged ≥ 45 years between 1999 and 2024.

Methods

We conducted a retrospective, population-based serial cross-sectional analysis using the Centers for Disease Control and Prevention (CDC) WONDER Multiple Cause of Death database (4). Deaths involving coexisting lung cancer (ICD-10 code C34) and chronic kidney disease (ICD-10 code N18) were identified when both conditions were listed anywhere on the death certificate as underlying or contributing causes of death. Age-adjusted mortality rates (AAMRs) per 100,000 population were calculated using the 2000 U.S. standard population. Mortality trends were evaluated using Joinpoint Regression Program version 6.0.1. Annual percent changes (APCs) and average annual percent changes (AAPCs) with 95% confidence intervals (CIs) were estimated overall and according to age group, sex, race and ethnicity, census region, state, and metropolitan status.

Results

Between 1999 and 2024, 37,851 deaths involving coexisting lung cancer and chronic kidney disease were identified among U.S. adults aged ≥ 45 years. The overall AAMR increased from 0.70 to 1.50 per 100,000 population, corresponding to an AAPC of 1.29% (95% CI, 0.52–2.20). Mortality was consistently highest among older adults, men, and non-Hispanic Black individuals. Geographic disparities were evident, with the highest regional mortality observed in the Midwest and persistently higher mortality in non-metropolitan than metropolitan areas. Joinpoint analysis demonstrated a marked increase during 2008–2011, followed by a transient decline and renewed increase through 2024.

Conclusions

Mortality involving coexisting lung cancer and chronic kidney disease increased nationally over the study period, with substantial demographic and geographic disparities. These findings support continued surveillance, earlier recognition of high-risk populations, equitable access to multidisciplinary care, and targeted public health strategies to reduce the burden of coexisting lung cancer and CKD.

1. Introduction

Lung cancer remains the leading cause of cancer-related mortality worldwide and continues to represent a major public health challenge despite advances in early detection and treatment. Chronic kidney disease (CKD) is a progressive disorder characterized by persistent abnormalities in kidney structure or function for at least three months and is associated with substantial morbidity, premature mortality, and healthcare utilization. According to the kidney disease: Improving Global Outcomes (KDIGO) guidelines, CKD is defined by a reduced estimated glomerular filtration rate (< 60 mL/min/1.73 m^2), markers of kidney damage, or both. The coexistence of lung cancer and CKD is clinically important because impaired renal function may complicate cancer management through altered drug metabolism, increased treatment-related toxicity, reduced eligibility for systemic therapies, and a greater burden of comorbidities (5, 6). Consequently, patients with both conditions often experience poorer clinical outcomes and reduced survival compared with those without CKD (5, 6).

Both lung cancer and CKD impose a substantial health burden in the United States (3, 6, 7). Lung cancer remains the leading cause of cancer-related death, accounting for more deaths than any other malignancy (8, 9), while CKD is associated with considerable healthcare expenditures, cardiovascular complications, and premature mortality (3, 6, 7). The burden of these conditions is not equally distributed across the population (3, 7). Previous studies have demonstrated important disparities according to age, sex, race and ethnicity, socioeconomic status, and geographic location. Older adults are particularly vulnerable because the incidence and mortality of both lung cancer and CKD increase substantially with advancing age (3, 7). In addition, individuals living in rural and underserved communities frequently experience delayed diagnosis, reduced access to specialized oncology and nephrology services, and poorer health outcomes, emphasizing the need to evaluate demographic and geographic disparities at a national level (9, 10).

Previous studies have examined mortality related to lung cancer or chronic kidney disease individually using national databases, including the Centers for Disease Control and Prevention (CDC) WONDER database (4). However, national studies specifically evaluating mortality involving the coexistence of lung cancer and CKD remain limited. Most published investigations have focused on disease-specific mortality or clinical outcomes among selected patient populations rather than long-term national mortality trends involving both conditions (5, 11). Furthermore, comprehensive evaluations of demographic and geographic disparities, including differences according to age group, sex, race and ethnicity, census region, state, and metropolitan status, are lacking. An updated national analysis incorporating mortality data through 2024 is therefore needed to better characterize temporal trends and identify populations at greatest risk.

Therefore, we used the Centers for Disease Control and Prevention (CDC) WONDER Multiple Cause of Death database to evaluate national mortality trends involving coexisting lung cancer and chronic kidney disease among U.S. adults aged ≥ 45 years between 1999 and 2024. We examined differences according to age group, sex, race and ethnicity, census region, state, and metropolitan status and assessed temporal trends using Joinpoint regression analysis. By providing a comprehensive evaluation of long-term mortality patterns and demographic disparities, this study aims to improve understanding of the

national burden of coexisting lung cancer and CKD and to inform future public health strategies and clinical management of high-risk populations.

2. Methods

2.1 Study Design and Reporting Framework

This study was conducted as a retrospective, population-based, serial cross-sectional analysis of national mortality data obtained from the Centers for Disease Control and Prevention (CDC) Wide-ranging Online Data for Epidemiologic Research (WONDER) Multiple Cause of Death database (4). The analysis evaluated temporal trends in mortality involving the coexistence of lung cancer and chronic kidney disease among U.S. adults aged ≥ 45 years between 1999 and 2024. The study utilized publicly available, de-identified, aggregate mortality data and was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines, where applicable (12).

2.2 Data Source

Mortality data were obtained from the Centers for Disease Control and Prevention (CDC) Wide-ranging Online Data for Epidemiologic Research (WONDER) Multiple Cause of Death database, which compiles information from death certificates filed in all 50 U.S. states and the District of Columbia through the National Vital Statistics System (NVSS) (4). The database includes demographic characteristics, underlying and contributing causes of death, and population estimates derived from the U.S. Census Bureau, enabling calculation of national mortality rates.

To obtain complete mortality data from 1999 through 2024, two CDC WONDER datasets were used because a single database covering the entire study period was not available. Mortality data for 1999–2020 were extracted from the Multiple Cause of Death, 1999–2020 database, while mortality data for 2021–2024 were obtained from the Multiple Cause of Death, 2018–2024 database. Data from the overlapping years (2018–2020) were used only to facilitate extraction of the newer dataset, and the final analyses incorporated a continuous mortality series spanning 1999–2024.

Deaths were identified when lung cancer (ICD-10 code C34) and chronic kidney disease (ICD-10 code N18) were both listed anywhere on the death certificate as either the underlying cause of death or contributing causes of death. Thus, records were retained only when both conditions co-occurred on the same death certificate, consistent with a multiple-cause-of-death analysis.

2.3 Case Definition and ICD-10 Codes

Deaths involving coexisting lung cancer and chronic kidney disease were identified using the International Classification of Diseases, Tenth Revision (ICD-10). Lung cancer was identified using ICD-10 code C34, which includes all malignant neoplasms of the bronchus and lung (C34.0–C34.9). Chronic kidney disease was identified using ICD-10 code N18, encompassing all stages of chronic kidney disease (N18.1–N18.9). ICD-10 codes were queried within the multiple-cause-of-death fields, and

records were included only when both C34 and N18 appeared on the same death certificate, regardless of whether either condition was listed as the underlying or a contributing cause of death. No restriction was placed on the underlying cause of death. A detailed CDC WONDER query, including database selection, ICD-10 codes, grouping variables, and analysis parameters, is provided in Supplementary Table S1 to ensure reproducibility.

2.4 Study Population

The study included U.S. residents aged ≥ 45 years whose death certificates met the prespecified ICD-10 criteria for coexisting lung cancer and chronic kidney disease between January 1, 1999, and December 31, 2024. Individuals younger than 45 years were excluded because deaths involving the coexistence of lung cancer and chronic kidney disease were uncommon in these age groups, resulting in unstable mortality estimates and frequent data suppression or unreliable rates in CDC WONDER. Restricting the analysis to adults aged ≥ 45 years improved the reliability and interpretability of temporal trend analyses. All available deaths meeting the inclusion criteria were included, regardless of sex, race and ethnicity, geographic region, or place of death.

2.5 Demographic and Geographic Variables

Demographic and geographic characteristics were obtained directly from the CDC WONDER Multiple Cause of Death database. Mortality data were stratified according to age group, sex, race and ethnicity, census region, state, metropolitan status, and place of death using the classifications provided by the National Center for Health Statistics (NCHS).

Sex was classified as male or female, as recorded on death certificates in the CDC WONDER database. Because the database records biological sex rather than gender identity, the term sex is used throughout this study.

Age was categorized into middle-aged adults (45–64 years) and older adults (≥ 65 years). These age groups were selected because the burden of both lung cancer and chronic kidney disease increases substantially with advancing age and because mortality estimates in younger age groups were unstable owing to small numbers of deaths.

Race and ethnicity were classified according to the CDC WONDER categories as non-Hispanic White, non-Hispanic Black or African American, Hispanic or Latino, non-Hispanic American Indian or Alaska Native, and non-Hispanic Asian or Pacific Islander. Race and ethnicity analyses were restricted to years in which comparable data were available across the selected CDC WONDER datasets.

Geographic analyses were performed according to the four U.S. Census regions: Northeast, Midwest, South, and West, based on the U.S. Census Bureau regional classification. State-level mortality rates were calculated using pooled mortality data across the study period to evaluate geographic variation in disease burden.

Urbanization was classified according to the 2013 National Center for Health Statistics Urban–Rural Classification Scheme for Counties and grouped into metropolitan and non-metropolitan areas. Because urbanization variables were unavailable in the CDC WONDER dataset for 2021–2024, analyses of metropolitan status were restricted to 1999–2020.

Place of death was categorized according to the CDC WONDER classifications, including medical facility, decedent's home, hospice facility, nursing home or long-term care facility, and other or unknown locations.

2.6 Outcome Measures

The primary outcome was the age-adjusted mortality rate (AAMR) per 100,000 population for deaths involving coexisting lung cancer and chronic kidney disease. AAMRs were calculated by direct standardization to the 2000 U.S. standard population, as reported by the CDC WONDER database (13).

Secondary outcomes included annual death counts, sex-specific AAMRs, age group-specific AAMRs, race and ethnicity-specific AAMRs, census region-specific AAMRs, pooled state-level AAMRs, metropolitan and non-metropolitan AAMRs, place-of-death distributions, and temporal trends quantified using annual percent changes (APCs) and average annual percent changes (AAPCs). Corresponding 95% confidence intervals (CIs) for mortality rates were obtained directly from the CDC WONDER database.

2.7 Data Suppression and Reliability

In accordance with CDC WONDER confidentiality and data reliability policies, death counts fewer than 10 were suppressed to protect individual privacy. Suppressed values were not imputed or estimated. Mortality rates designated as unreliable by the CDC WONDER database because of small numbers of deaths or statistical instability were interpreted cautiously and excluded from Joinpoint trend analyses when appropriate. Consequently, some subgroup analyses, particularly among younger age groups and certain racial and ethnic populations, were unavailable or restricted because of data suppression or unreliable estimates.

2.8 Statistical Analysis

Descriptive statistics were used to summarize annual death counts and mortality rates overall and across demographic and geographic subgroups. Age-adjusted mortality rates (AAMRs) and corresponding 95% confidence intervals (CIs) were obtained directly from the CDC WONDER database. Annual mortality trends were evaluated overall and according to age group, sex, race and ethnicity, census region, metropolitan status, and individual disease categories.

Temporal trends were analyzed using the Joinpoint Regression Program (Version 6.0.1; National Cancer Institute, Surveillance Research Program, Statistical Research and Applications Branch, Bethesda, MD, USA) (14). Log-linear regression models were fitted to annual mortality rates to identify statistically significant changes in temporal trends. Annual percent changes (APCs) with 95% confidence intervals

(CIs) were calculated for each trend segment, and average annual percent changes (AAPCs) were estimated to summarize trends across the overall study period. Trends were considered statistically significant when the corresponding 95% confidence interval did not include zero. Statistical significance was defined as a two-sided *P* value < 0.05.

Comparisons of temporal trends between subgroups were descriptive and based on APCs and AAPCs. Formal statistical comparisons between subgroup-specific trends (e.g., tests of parallelism or coincidence) were not performed.

2.9 Ethical Considerations

This study utilized publicly available, de-identified, aggregate mortality data obtained from the Centers for Disease Control and Prevention (CDC) WONDER database. Because the database contains no individually identifiable information, institutional review board approval and informed consent were not required in accordance with applicable regulations governing research involving publicly available data.

3. Results

Between 1999 and 2024, a total of 37,851 deaths were recorded among adults aged ≥ 45 years in whom both lung cancer and chronic kidney disease were listed as underlying or contributing causes (Supplementary Table 1). Place-of-death information was available for 36,410 cases (Supplementary Table 2). Among these, most deaths occurred in medical facilities (43.5%), followed by decedents' homes (33.3%), nursing homes or long-term care facilities (14.8%), and hospice facilities (8.4%).

3.1 Demographic trends in mortality

Adults aged ≥ 45 years with both lung cancer and chronic kidney disease had an overall age-adjusted mortality rate (AAMR) of 0.70 (95% CI, 0.70–0.80) per 100,000 population in 1999, which increased to 1.50 (95% CI, 1.50–1.60) in 2024. Joinpoint regression identified four temporal trend segments over the study period. Mortality remained stable between 1999 and 2008 (APC, 0.55%; 95% CI, − 10.32 to 5.02; P = 0.964), followed by a significant increase from 2008 to 2011 (APC, 28.92%; 95% CI, 11.35 to 40.58; P = 0.027). This was followed by a significant decline between 2011 and 2014 (APC, − 12.79%; 95% CI, − 18.17 to − 2.15; P = 0.030), before mortality increased significantly again from 2014 to 2024 (APC, 3.01%; 95% CI, 0.77 to 9.70; P = 0.022) (Fig. 1, Supplementary Tables 4 and 5).

Age-stratified analysis demonstrated that older adults consistently experienced substantially higher mortality rates than middle-aged adults throughout the study period. Among adults aged 45–64 years, the AAMR increased from 0.40 (95% CI, 0.40–0.50) in 1999 to 0.90 (95% CI, 0.90–1.00) in 2024. Joinpoint regression showed a non-significant increase between 1999 and 2008 (APC, 0.80%; 95% CI, − 1.94 to 3.62), followed by a significant increase from 2008 to 2011 (APC, 21.49%; 95% CI, 10.61 to 36.49), a non-significant decline between 2011 and 2014 (APC, − 11.31%; 95% CI, − 22.25 to 1.16), and a significant increase from 2014 to 2024 (APC, 3.18%; 95% CI, 1.15 to 8.09). In contrast, adults aged ≥ 65

years experienced a substantially higher mortality burden, with the AAMR increasing from 2.80 (95% CI, 2.70–2.90) in 1999 to 5.70 (95% CI, 5.60–5.90) in 2024. Mortality remained relatively stable between 1999 and 2008 (APC, 0.46%; 95% CI, − 1.83 to 2.80), increased significantly between 2008 and 2011 (APC, 29.93%; 95% CI, 13.39 to 40.88), declined significantly from 2011 to 2014 (APC, − 12.97%; 95% CI, − 18.17 to − 2.63), and subsequently increased significantly between 2014 and 2024 (APC, 3.00%; 95% CI, 0.80 to 9.47) (Supplementary Table 3).

3.2 Sex-Specific Trends

Throughout the study period, men consistently exhibited higher age-adjusted mortality rates (AAMRs) than women. In 1999, the AAMR for men was 1.20 (95% CI, 1.10–1.30), compared with 0.30 (95% CI, 0.30–0.40) for women. By 2024, these rates had increased to 1.90 (95% CI, 1.80–2.00) in men and 1.20 (95% CI, 1.20–1.30) in women (Supplementary Table 5).

Joinpoint regression demonstrated distinct temporal patterns between the sexes. Among men, mortality remained stable between 1999 and 2008 (APC, 0.36%; 95% CI, − 1.65 to 2.41), followed by a significant increase from 2008 to 2011 (APC, 28.67%; 95% CI, 13.76 to 40.82), a significant decline between 2011 and 2014 (APC, − 12.88%; 95% CI, − 18.20 to − 2.64), and a subsequent significant increase from 2014 to 2024 (APC, 2.73%; 95% CI, 0.44 to 9.22). In contrast, women experienced a stable trend from 1999 to 2008 (APC, 0.87%; 95% CI, − 2.52 to 4.39), followed by a significant increase between 2008 and 2011 (APC, 30.42%; 95% CI, 11.27 to 45.66), a non-significant decline from 2011 to 2014 (APC, − 11.82%; 95% CI, − 22.64 to 1.42), and a significant increase from 2014 to 2024 (APC, 3.69%; 95% CI, 1.32 to 10.26) (Supplementary Table 4).

Overall, mortality rates remained consistently higher among men throughout the study period. Although both sexes demonstrated similar temporal patterns characterized by an early period of stability, followed by a marked increase, a transient decline, and a subsequent increase, the increase during the most recent period was numerically greater among women than men.

3.3 Racial and Ethnic Trends

Age-adjusted mortality rates (AAMRs) varied substantially across racial and ethnic groups throughout the study period. In 2020, the highest AAMR was observed among non-Hispanic Black individuals (2.30; 95% CI, 2.20–2.50), followed by non-Hispanic White individuals (1.50; 95% CI, 1.40–1.50), non-Hispanic American Indian or Alaska Native individuals (1.30; 95% CI, 0.90–1.80), non-Hispanic Asian or Pacific Islander individuals (1.00; 95% CI, 0.90–1.20), and Hispanic individuals (0.90; 95% CI, 0.80–1.00) (Supplementary Table 6).

Joinpoint regression demonstrated heterogeneous temporal patterns among racial and ethnic groups. Mortality remained relatively stable during the early study period in most populations, followed by significant increases during the late 2000s and early 2010s. Non-Hispanic Black individuals consistently experienced the highest mortality burden throughout the study period. Non-Hispanic White individuals also demonstrated a sustained increase in mortality after 2014. Despite a significant increase during

recent years, mortality among Hispanic individuals remained the lowest throughout the study period. Trends among non-Hispanic American Indian or Alaska Native and non-Hispanic Asian or Pacific Islander populations exhibited greater year-to-year variability because of smaller numbers of deaths, although both groups demonstrated an overall upward trend (Fig. 2).

Overall, substantial racial and ethnic disparities persisted throughout the study period, with non-Hispanic Black individuals experiencing the greatest mortality burden, whereas Hispanic individuals consistently exhibited the lowest mortality rates.

3.4 State-Level Trends

Substantial geographic variation in age-adjusted mortality rates (AAMRs) was observed across U.S. states during the study period (Supplementary Table 7). State-level AAMRs ranged from 0.75 (95% CI, 0.51–1.01) in Utah to 2.58 (95% CI, 2.31–2.86) in Kentucky. Other states with among the highest pooled age-adjusted mortality rates included West Virginia, Mississippi, Arkansas, and Alabama, whereas Wyoming, Arizona, Hawaii, and New Mexico had among the lowest pooled age-adjusted mortality rates (Fig. 3). Overall, the highest mortality burden was concentrated in the southeastern United States, whereas the lowest mortality rates were generally observed in the western United States.

3.5 Census Region Trends

Age-adjusted mortality rates (AAMRs) varied across the four U.S. census regions throughout the study period. In 2024, the highest AAMR was observed in the Midwest (2.00; 95% CI, 1.90–2.10), followed by the South (1.70; 95% CI, 1.70–1.80), Northeast (1.40; 95% CI, 1.30–1.50), and West (1.20; 95% CI, 1.20–1.30) (Supplementary Table 8). Joinpoint regression demonstrated heterogeneous temporal trends across regions. Mortality remained relatively stable during the early study period, followed by a marked increase during the late 2000s and early 2010s. The Midwest consistently experienced the greatest mortality burden throughout most of the study period, whereas the West maintained the lowest mortality rates (Fig. 4).

3.6 Urbanization Trends

Mortality involving coexisting lung cancer and chronic kidney disease differed between metropolitan and non-metropolitan areas throughout the study period (Supplementary Table 9). In metropolitan areas, the age-adjusted mortality rate (AAMR) increased from 0.70 (95% CI, 0.60–0.70) per 100,000 population in 1999 to 1.50 (95% CI, 1.40–1.50) per 100,000 population in 2020. Joinpoint regression demonstrated a stable trend between 1999 and 2008 (APC, 0.51%; 95% CI, − 0.95 to 2.00), followed by a significant increase from 2008 to 2011 (APC, 29.14%; 95% CI, 13.06 to 40.98), a significant decline between 2011 and 2014 (APC, − 12.83%; 95% CI, − 18.17 to − 2.39), and a subsequent significant increase from 2014 to 2020 (APC, 3.14%; 95% CI, 1.12 to 8.58).

In non-metropolitan areas, the AAMR increased from 0.80 (95% CI, 0.70–0.90) per 100,000 population in 1999 to 1.90 (95% CI, 1.80–2.00) per 100,000 population in 2020. Mortality remained relatively stable between 1999 and 2008 (APC, 0.64%; 95% CI, − 1.52 to 2.85), followed by a significant increase from

2008 to 2011 (APC, 28.47%; 95% CI, 11.48 to 40.37), a significant decline between 2011 and 2014 (APC, − 12.62%; 95% CI, − 17.86 to − 2.42), and a significant increase from 2014 to 2020 (APC, 2.94%; 95% CI, 0.74 to 9.24). Throughout the study period, mortality rates remained consistently higher in non-metropolitan than metropolitan areas (Fig. 5).

3.7 Place of Death

Between 1999 and 2024, place-of-death information was available for 36,410 deaths involving coexisting lung cancer and chronic kidney disease (Supplementary Table 2). Most deaths occurred in medical facilities (43.5%), followed by decedents' homes (33.3%), nursing homes or long-term care facilities (14.8%), and hospice facilities (8.4%). Place-of-death information was unavailable for a small proportion of deaths because some place-of-death categories were suppressed or unavailable during portions of the study period.

3.8 Trends in Mortality by Individual Disease

3.8.1 Lung Cancer

Overall lung cancer mortality declined substantially during the study period. The age-adjusted mortality rate (AAMR) decreased from 166.6 (95% CI, 165.7–167.4) per 100,000 population in 1999 to 88.0 (95% CI, 87.5–88.4) in 2024 (Supplementary Table 10). Joinpoint regression demonstrated multiple temporal changes, with an overall decline in mortality throughout the study period despite variation in the magnitude of decline across individual trend segments.

3.8.2 Chronic Kidney Disease

In contrast, mortality involving chronic kidney disease increased during the study period. The overall AAMR rose from 60.2 (95% CI, 59.7–60.7) per 100,000 population in 1999 to 81.4 (95% CI, 81.0–81.9) in 2024 (Supplementary Table 11). Joinpoint regression demonstrated significant temporal variation, with an overall upward trend in CKD-related mortality over the 26-year study period.

3.8.3 Sex-Specific Lung Cancer Trends

Lung cancer mortality declined among both sexes, although men consistently experienced higher mortality rates than women. Among women, the AAMR declined from 119.6 per 100,000 population in 1999 to 74.9 in 2024. Among men, the AAMR declined from 206.9 to 96.8 per 100,000 population during the same period, although mortality remained consistently higher than among women (Supplementary Table 10). Joinpoint regression demonstrated declining mortality trends in both sexes, with differences in the magnitude of decline across study periods.

3.8.4 Sex-Specific Chronic Kidney Disease Trends

Chronic kidney disease mortality increased among both men and women throughout the study period. Among women, the AAMR increased from 49.3 per 100,000 population in 1999 to 65.2 in 2024. Among men, the AAMR increased from 78.6 to 107.8 per 100,000 population during the same period, with men

consistently experiencing higher mortality than women (Supplementary Table 11). Temporal trend analysis demonstrated sustained increases in mortality for both sexes.

3.8.5 Racial and Ethnic Lung Cancer Trends

Lung cancer mortality differed across racial and ethnic groups throughout the study period. Although mortality declined in all racial and ethnic groups, non-Hispanic White and non-Hispanic Black individuals consistently experienced the highest mortality rates, whereas Hispanic individuals consistently experienced the lowest mortality rates (Fig. 6A; Supplementary Table 12).

3.8.6 Racial and Ethnic Chronic Kidney Disease Trends

Marked racial and ethnic disparities were also observed for chronic kidney disease mortality. Non-Hispanic American Indian or Alaska Native and non-Hispanic Black individuals experienced the highest mortality rates throughout much of the study period, whereas Hispanic individuals consistently experienced the lowest mortality rates despite increasing trends over time (Fig. 6B; Supplementary Table 13).

4. Discussion

In this national mortality analysis of 37,851 deaths involving coexisting lung cancer and chronic kidney disease among U.S. adults aged ≥ 45 years, mortality increased between 1999 and 2024, with the most pronounced rise occurring during 2008–2011. Mortality remained consistently higher among men, older adults, non-Hispanic Black individuals, residents of the Midwest, and residents of non-metropolitan areas. Considerable geographic variation was observed across the United States, with the highest mortality rates concentrated in Kentucky and several southeastern states. Collectively, these findings demonstrate persistent demographic and geographic disparities in mortality involving coexisting lung cancer and chronic kidney disease and underscore the substantial public health burden associated with this combination of conditions. The increasing mortality involving coexisting lung cancer and chronic kidney disease observed in this study likely reflects multiple interacting factors rather than a single underlying mechanism. Previous investigations have independently described the growing burden of chronic kidney disease and the persistently high mortality associated with lung cancer using national registries and population-based datasets (3, 6). Chronic kidney disease affects approximately 15% of U.S. adults and is increasingly recognized as an important determinant of adverse outcomes among patients with malignancy (5, 7). Likewise, despite advances in early detection and treatment, lung cancer remains the leading cause of cancer-related death worldwide. However, few studies have comprehensively evaluated long-term national mortality involving the coexistence of lung cancer and chronic kidney disease using a multiple-cause-of-death approach. By analyzing 26 years of nationwide mortality data, our study extends existing evidence by characterizing temporal trends and demographic and geographic disparities across age groups, sex, race and ethnicity, census region, state, and urbanization status. These findings provide contemporary national estimates that may serve as a benchmark for future epidemiologic and health policy research.

The observed increase in mortality involving coexisting lung cancer and chronic kidney disease likely reflects multiple interacting factors rather than a single underlying mechanism. Population aging and improvements in lung cancer diagnosis and treatment have increased survival, thereby increasing the likelihood of developing chronic comorbidities such as CKD. In addition, the growing prevalence of diabetes mellitus, hypertension, obesity, and cardiovascular disease has contributed substantially to the national burden of chronic kidney disease. Cancer therapies, including platinum-based chemotherapy, targeted therapies, immune checkpoint inhibitors, radiographic contrast agents, and supportive medications, may also contribute to kidney injury or accelerate progression of pre-existing renal dysfunction, thereby increasing the complexity of cancer management (15–18). Furthermore, greater recognition of chronic kidney disease on death certificates, evolving coding practices, and disruptions in healthcare delivery during the COVID-19 pandemic may have influenced mortality patterns during the later years of the study. Although the present analysis cannot establish causal relationships, these factors may collectively explain the observed increase in mortality involving coexisting lung cancer and chronic kidney disease over time.

Marked demographic disparities were identified throughout the study period. Mortality remained consistently higher among men than women, which may reflect historical differences in tobacco exposure, occupational risk factors, comorbidity burden, and healthcare utilization (1, 3). Older adults experienced substantially greater mortality than middle-aged adults, likely owing to declining physiological reserve, frailty, multimorbidity, and reduced tolerance of cancer-directed therapies with advancing age (6, 11). Persistent racial and ethnic disparities were also observed, with non-Hispanic Black individuals experiencing the highest mortality burden throughout much of the study period (1, 3). Because the CDC WONDER database does not contain individual-level clinical, behavioral, or socioeconomic information, these explanations should be interpreted as biologically and epidemiologically plausible hypotheses rather than direct causal inferences.

Geographic and urban–rural disparities were also prominent in the present study. The highest mortality rates were observed in the Midwest and several southeastern states, while individuals residing in non-metropolitan areas consistently experienced greater mortality than those living in metropolitan areas. Differences in healthcare infrastructure, availability of multidisciplinary oncology and nephrology services, access to comprehensive cancer centers, socioeconomic conditions, insurance coverage, and healthcare utilization may also contribute to these geographic disparities. Individuals living in rural communities frequently encounter longer travel distances, delayed diagnosis, reduced access to specialist care, and fewer opportunities to participate in multidisciplinary treatment programs (9, 10, 19). Nevertheless, because the present study was based on aggregate mortality data, the observed geographic variation should not be interpreted as evidence of causal relationships with any specific environmental, healthcare, or socioeconomic factor.

The findings of this study have important clinical and public health implications. Given the increasing mortality involving coexisting lung cancer and chronic kidney disease, clinicians should recognize chronic kidney disease as a major comorbidity when evaluating patients with lung cancer. Early

identification of renal dysfunction, optimization of cardiovascular and metabolic risk factors, careful monitoring of kidney function during cancer therapy, and appropriate dose adjustment of potentially nephrotoxic medications may improve clinical outcomes (6, 11, 20). From a public health perspective, interventions aimed at reducing disparities in access to cancer care and chronic kidney disease management, particularly among older adults, racial and ethnic minority populations, and residents of underserved communities, may help reduce the growing mortality burden observed in this study.

From a health-system perspective, these findings support strengthening integrated models of cancer and kidney care across the United States. Expansion of multidisciplinary clinics, coordinated referral pathways, telemedicine services, and regional networks linking community hospitals with tertiary oncology and nephrology centers may improve access to specialized care, particularly in rural and underserved areas. Continued investment in national mortality surveillance, standardized death-certificate reporting, and linkage of mortality data with clinical registries may further enhance understanding of disease burden and support the development of targeted strategies to reduce demographic and geographic disparities.

This study has several important strengths. It represents a comprehensive national analysis of mortality involving coexisting lung cancer and chronic kidney disease using the CDC WONDER Multiple Cause of Death database over a 26-year period. The large number of deaths, nationally representative dataset, standardized mortality reporting, and inclusion of demographic and geographic subgroup analyses provide a robust assessment of long-term mortality trends. The application of Joinpoint regression enabled objective evaluation of temporal changes in mortality, while the use of standardized ICD-10 definitions enhances the reproducibility of the study. Despite these limitations, the present study provides comprehensive national evidence regarding long-term mortality trends and disparities involving coexisting lung cancer and chronic kidney disease and establishes an important foundation for future clinical and epidemiological investigations.

4.1 Future Directions

These findings emphasize the need for targeted strategies to reduce mortality involving coexisting lung cancer and chronic kidney disease, particularly among populations with the greatest disease burden. Future efforts should focus on improving early recognition and management of chronic kidney disease in patients with lung cancer, reducing demographic, geographic, and urban–rural disparities in access to multidisciplinary care, and optimizing coordination between oncology and nephrology services. Further research integrating clinical, laboratory, and treatment data with population-based mortality records is warranted to better understand the mechanisms underlying the observed mortality trends and to develop interventions aimed at improving outcomes among individuals with coexisting lung cancer and chronic kidney disease.

5. Limitations

This study has several limitations. First, reliance on death certificate data and ICD-10 coding may result in misclassification or underreporting of lung cancer and chronic kidney disease. Because death certificates may contain multiple underlying and contributing causes of death, the presence of both lung cancer and chronic kidney disease on a death certificate does not establish that either condition directly caused death. Therefore, the findings should be interpreted as mortality involving coexisting lung cancer and chronic kidney disease rather than mortality directly attributable to either condition.

Second, temporal changes in diagnostic practices, increased recognition and documentation of chronic kidney disease, and evolving death certificate coding practices may have influenced observed mortality trends independent of true changes in disease burden. Third, the CDC WONDER database lacks detailed clinical information, including lung cancer stage, histological subtype, chronic kidney disease stage, laboratory findings, treatment modalities, kidney function, and comorbid conditions that may influence mortality estimates.

Additionally, important patient-level characteristics, including smoking history, obesity, diabetes mellitus, hypertension, cardiovascular disease, socioeconomic status, health insurance coverage, and healthcare utilization, were unavailable and therefore could not be evaluated. The database also does not permit assessment of treatment-related nephrotoxicity, medication exposure, or adherence to guideline-directed therapies. Furthermore, although mortality patterns changed during the COVID-19 pandemic period, the direct contribution of SARS-CoV-2 infection to mortality involving coexisting lung cancer and chronic kidney disease could not be determined using the available data. Finally, death certificate reporting practices may vary across geographic regions and over time, and suppression of small cell counts may have limited analyses in selected subgroups.

6. Conclusions

Mortality involving coexisting lung cancer and chronic kidney disease among U.S. adults aged ≥ 45 years increased between 1999 and 2024, with distinct temporal changes identified by Joinpoint regression. Higher mortality rates were consistently observed among men, older adults, non-Hispanic Black individuals, residents of the Midwest, and residents of non-metropolitan areas, with substantial geographic variation across U.S. states.

These findings highlight persistent demographic and geographic disparities in mortality involving coexisting lung cancer and chronic kidney disease and underscore the need for targeted public health interventions, equitable access to multidisciplinary care, and optimized management of high-risk populations. Because this study was based on multiple-cause-of-death data, the findings should be interpreted as mortality involving coexisting lung cancer and chronic kidney disease rather than evidence that either condition directly caused the observed mortality.

Abbreviations

AAMR

Age-adjusted mortality rate
APC
Annual percent change
CDC
Centers for Disease Control and Prevention
CI
Confidence interval
ICD-10
International Classification of Diseases, 10th Revision
NH
Non-Hispanic
AIAN
American Indian or Alaska Native
API
Asian or Pacific Islander
CKD
Chronic Kidney disease
AAPC
Average Annual Percent change

Declarations

Ethics approval and consent to participate

This study used publicly available, de-identified data from the Centers for Disease Control and Prevention (CDC) WONDER database. Therefore, ethical approval and informed consent were not required.

Consent for publication

Not applicable as this study does not involve human participants or identifiable data.

Competing interests

The author declares that there are no competing interests.

Clinical trial number

Not applicable

Rasheeda Shehroz

Rasheeda Shehroz is an international medical graduate with a background in clinical medicine and an interest in epidemiological research and public health outcomes.

Funding

The author received no financial support for this study.

Author Contribution

Rasheeda Shehroz: Conceptualization, methodology, data curation, formal analysis, investigation, visualization, writing—original draft, writing—review and editing. The author read and approved the final manuscript.

Acknowledgements

The author has no acknowledgements to declare.

Data Availability

The datasets analyzed during the current study are publicly available from the Centers for Disease Control and Prevention (CDC) Wide-ranging Online Data for Epidemiologic Research (WONDER) Multiple Cause of Death database at https://wonder.cdc.gov/. The data are publicly accessible, de-identified, and can be obtained by applying the search parameters described in the Methods section of this manuscript.

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Figures

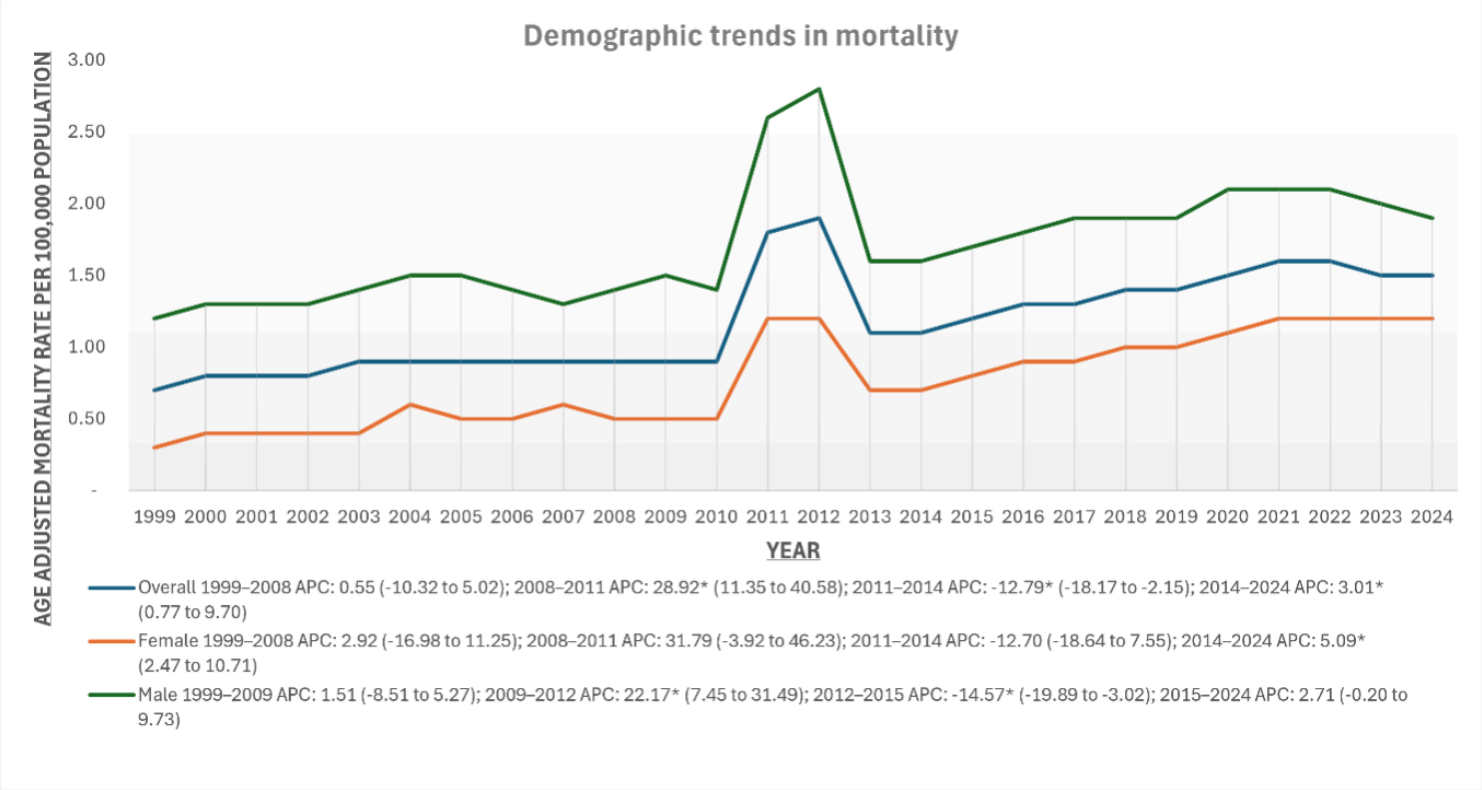

Figure 1

Age-Adjusted Mortality Rates for Coexisting Lung Cancer and Chronic Kidney Disease, Overall and by Sex, Among U.S. Adults Aged ≥45 Years, 1999–2024.

Indicates that the annual percent change (APC) is significantly different from zero at α = 0.05. AAMR = age-adjusted mortality rate; APC = annual percent change; CI = confidence interval.

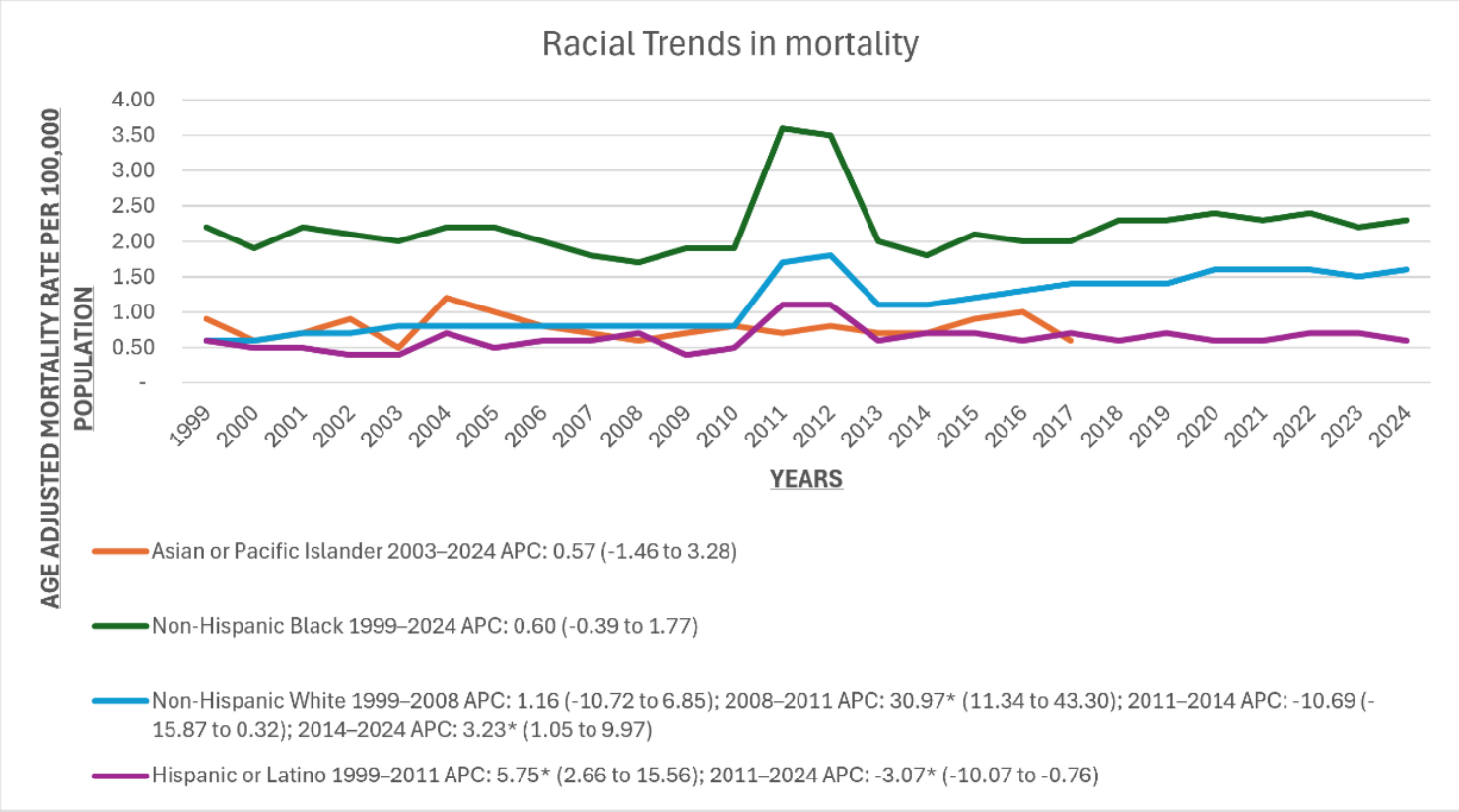

Figure 2

Lung Cancer and Chronic Kidney Disease–Related Age-Adjusted Mortality Rates per 100,000, Stratified by Race and Ethnicity in Adults Aged ≥45 Years in the United States, 1999–2024.

Indicates that the annual percent change (APC) is significantly different from zero at α = 0.05. Abbreviations as in Fig. 1.

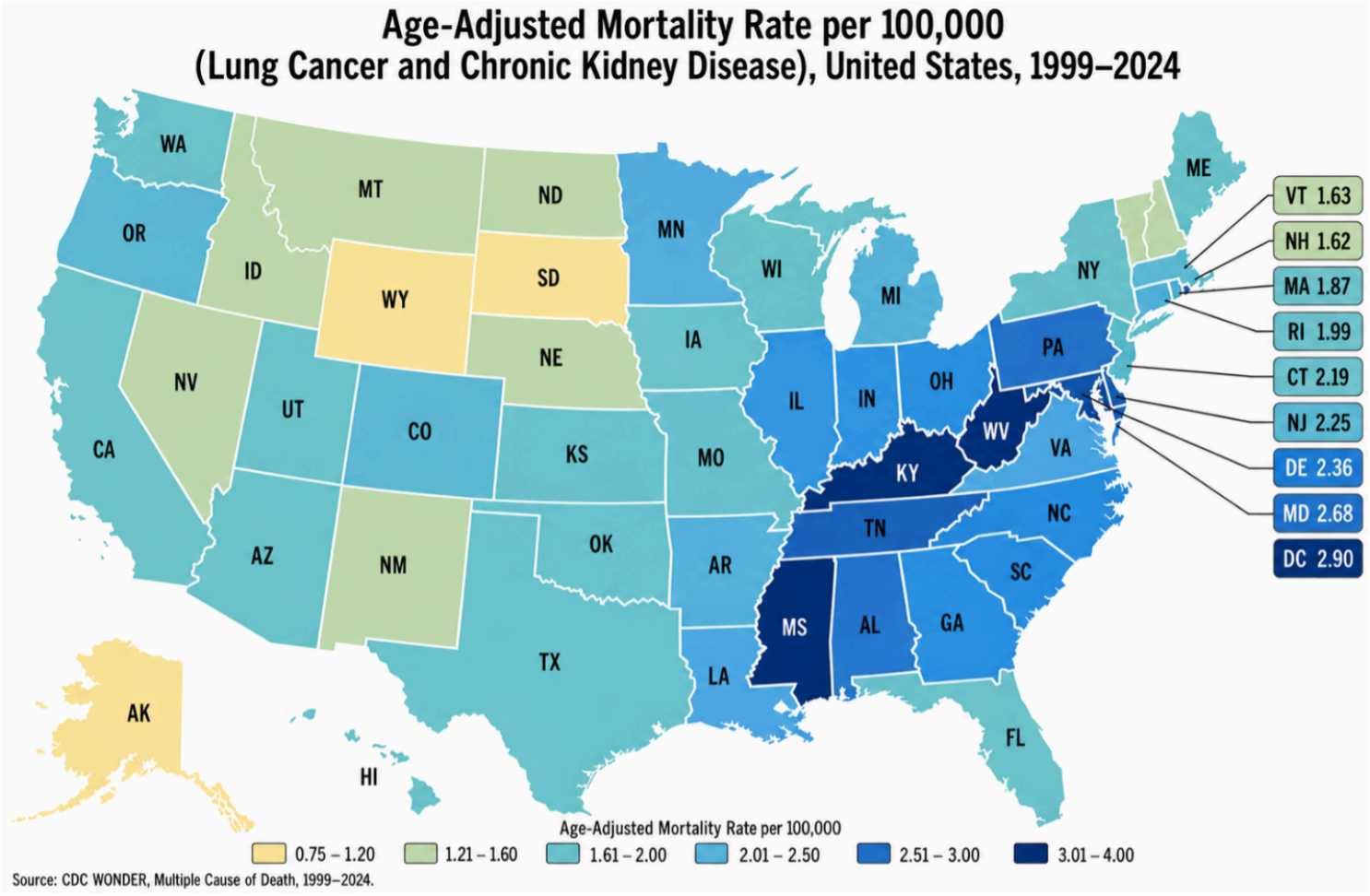

Figure 3

Lung Cancer and Chronic Kidney Disease–Related Age-Adjusted Mortality Rates per 100,000, Stratified by State in Adults Aged ≥45 Years in the United States, 1999–2024.

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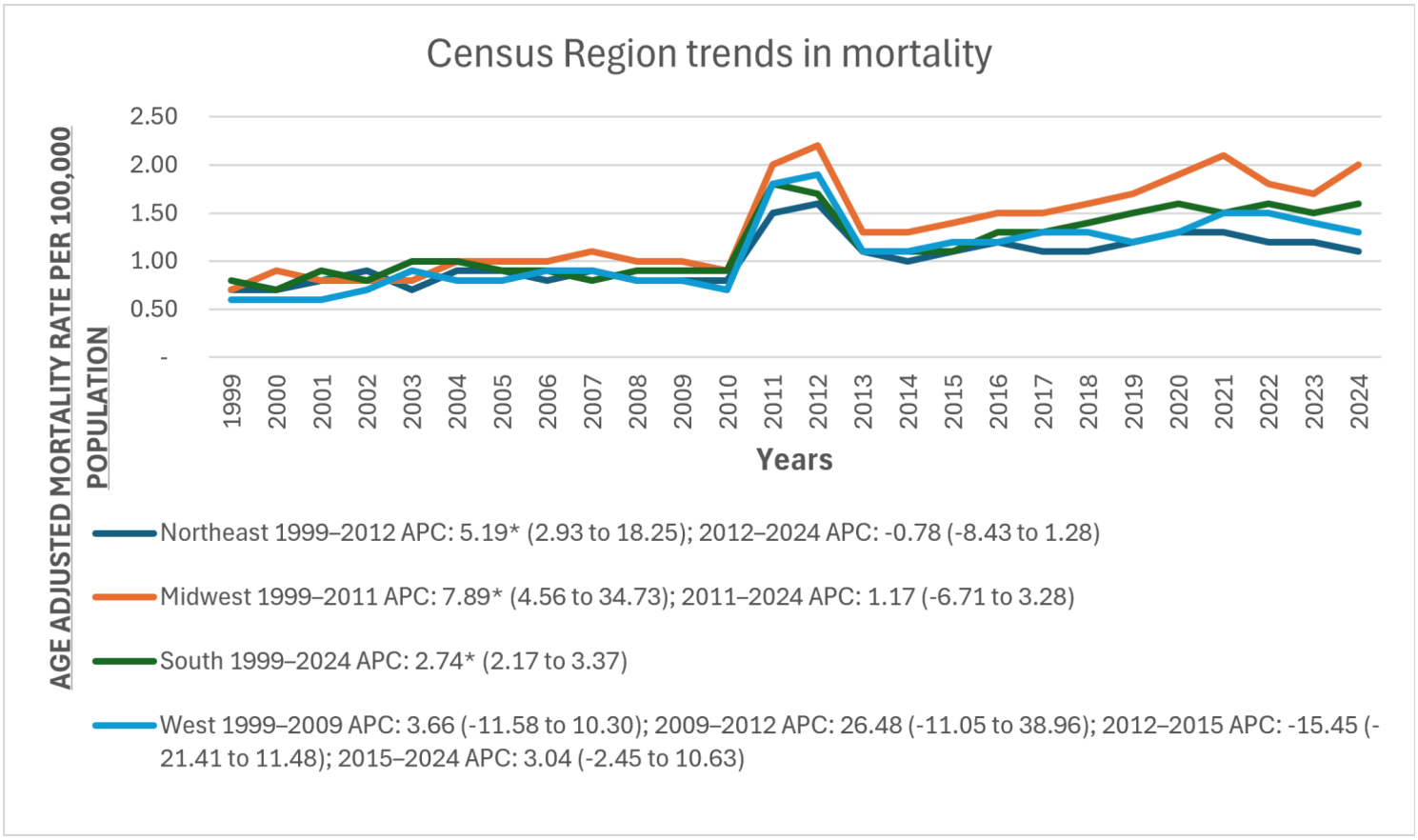

Figure 4

Lung Cancer and Chronic Kidney Disease–Related Age-Adjusted Mortality Rates per 100,000, Stratified by Census Regions in Adults Aged ≥45 Years in the United States, 1999–2024.

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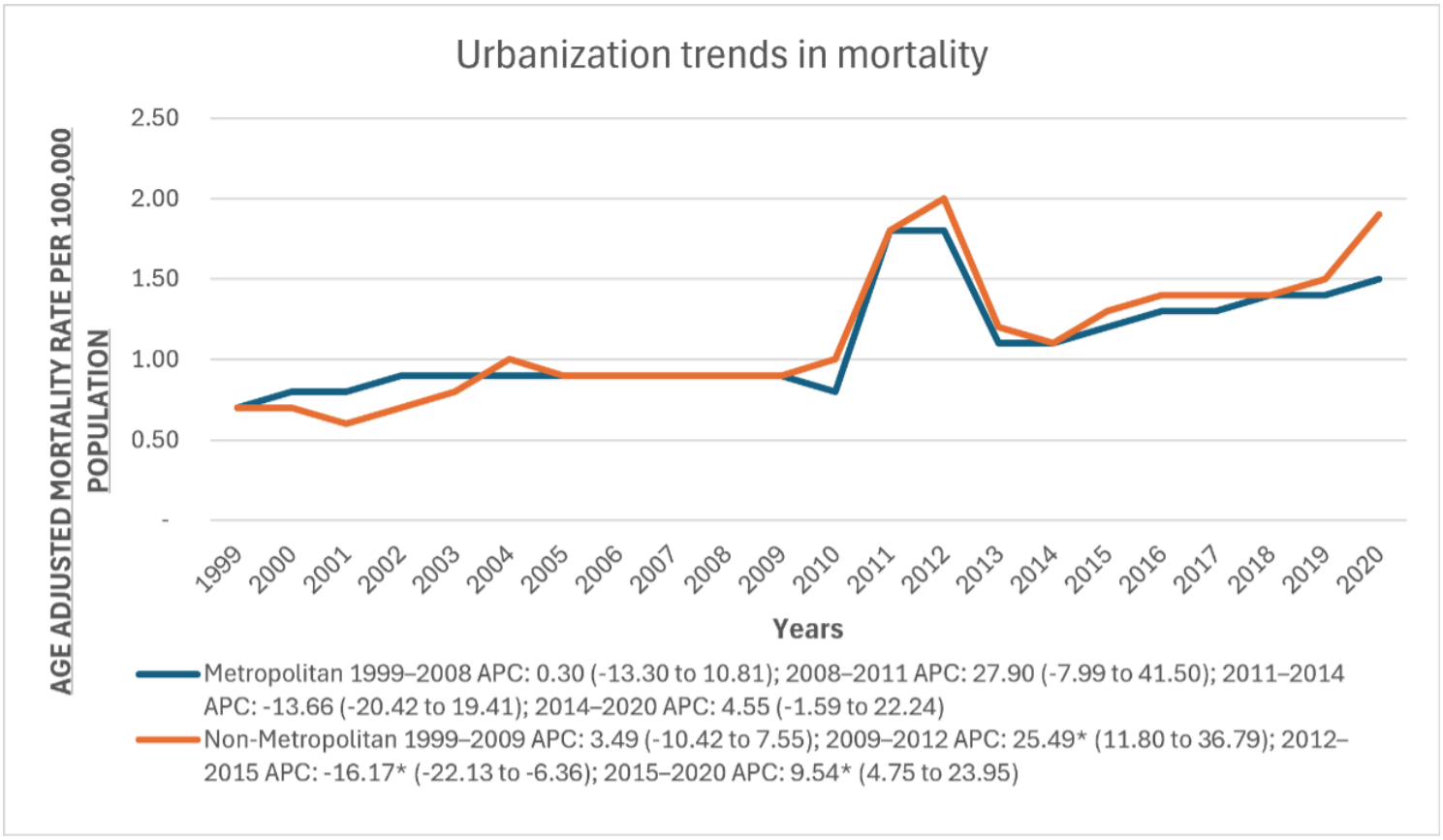

Figure 5

Lung Cancer and Chronic Kidney Disease–Related Age-Adjusted Mortality Rates per 100,000 in Adults Aged ≥45 Years in Metropolitan and Non-Metropolitan Areas in the United States, 1999–2024.

Indicates that the annual percent change (APC) is significantly different from zero at α = 0.05. Abbreviations as in Fig. 1.

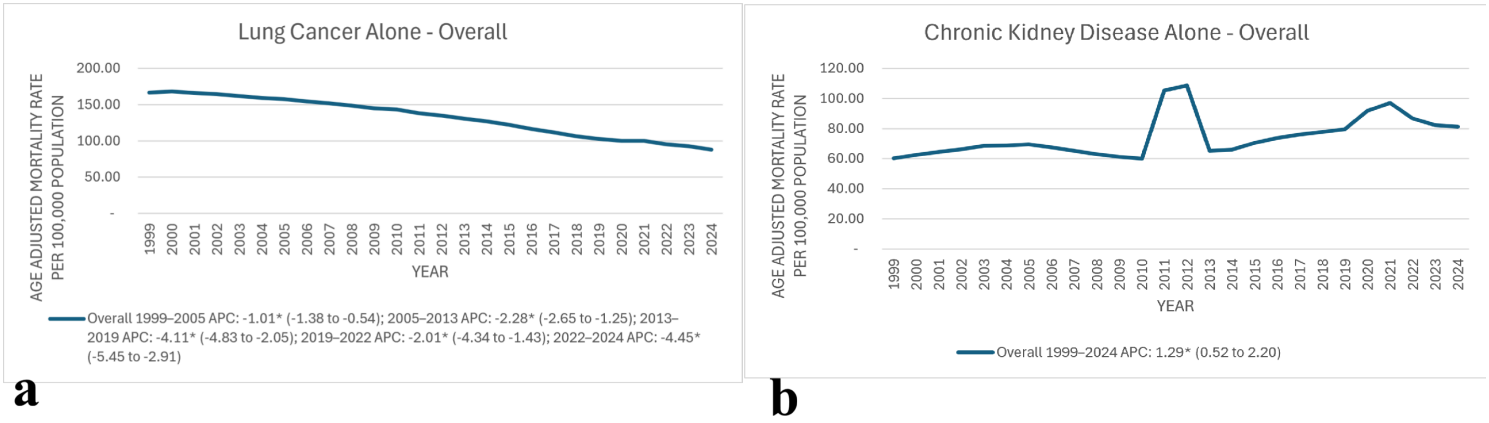

Figure 6

Age-adjusted mortality rates per 100,000 population in the United States among adults aged ≥45 years, 1999–2024. (A) Lung cancer-related mortality. (B) Chronic kidney disease-related mortality.

Indicates that the annual percent change (APC) is significantly different from zero at α = 0.05. Abbreviations as in Fig. 1.

Supplementary Files

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