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Temporal trends, gender, and ethnoracial disparities in mortality from pulmonary emphysema

A retrospective nationwide analysis

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Abstract

Emphysema, a significant global health issue, involves abnormal lung enlargement and wall destruction, affecting 9% to 12% of people worldwide. In the United States (US), 2 million people live with emphysema, with numbers expected to rise. Data on mortality trends and disparities associated with demographic factors is limited, underscoring our study's focus on analyzing these patterns in US adults. This study examined death certificates from the CDC WONDER database for individuals aged 25 and older who died with emphysema (J43) between 1999 and 2020. Age-adjusted mortality rates (AAMRs) and annual percent change were calculated by year, gender, age group, race/ethnicity, geographic region, and urbanization status. Between 1999 and 2020, there were 484,095 reported deaths among emphysema patients. The overall AAMR decreased from 18.5 to 7.2 per 100,000 population, with an annual decrease of 8% from 2008 to 2015, followed by a slight recent increase. Analyzing by age groups, older adults had the highest AAMR of 42. Men had significantly higher AAMRs than women (13.4 vs 7.8). By race, non-Hispanic (NH) White patients had the highest AAMRs (11.3), followed by NH American Indian or Alaska Native (8.2), NH Black (7.7), Hispanic (3.9), and NH Asian or Pacific Islander patients (3.1). Nonmetropolitan areas had higher AAMRs compared to metropolitan areas (11.7 vs 9.8). Emphysema mortality has decreased overall but recently increased slightly. Higher rates are seen among older adults, men, NH White patients, and nonmetropolitan residents. Policies are needed to continue reducing these death rates and to address these disparities.

Abbreviations: AAMR = age-adjusted mortality rates, APC = annual percentage change, COPD = chronic obstructive pulmonary disease, NH = non-Hispanic.

Keywords: emphysema, epidemiology, gender disparity, mortality, pulmonology, racial disparity, trends

1. Introduction

Emphysema is a condition of the lung characterized by abnormal, permanent enlargement of the airspaces distal to the terminal bronchiole, accompanied by destruction of their walls and without obvious fibrosis.[1] It is a major public health problem that imposes a substantial economic burden worldwide. Global prevalence using the global initiative for chronic obstructive lung disease (GOLD) definition of chronic obstructive pulmonary disease (COPD), which includes emphysema, is estimated to be around 9% to 12%, translating to 300 to 400 million individuals.[2–4] According to the American Lung Association, 11.7 million of those reside in the United States (US), of which 2 million live with emphysema and account for 1.6% of the adult population.[5] These figures are projected to rise by 23% by the year 2050, with the incidence among females experiencing the most substantial increase, estimated at 47.1%.[6] COPD is believed to be an under-diagnosed condition, as a significantly higher number of American individuals exhibit signs of impaired lung function consistent with COPD than those who receive an official diagnosis.[5] The financial burden of COPD in the US is over $20 billion each year in individuals 45 years of age and older, and this is projected to nearly double over the next 20 years.[7,8] On average, a patient

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The datasets generated during and/or analyzed during the current study are publicly available.

No ethical approval was required for this study design, as all data were obtained from publicly available sources.

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with the disease spends more than $4000 in medical bills every year, and COPD is considered an irreversible change, for the rest of their lives.[7]

Causes of mortality in COPD vary with severity of disease. In mild to moderate disease, two-third of the deaths are caused by lung cancer or cardiovascular complications, while in COPD with severe airflow limitation respiratory failure becomes the primary cause.[9] Patients with emphysema are at risk of developing respiratory infections, which may lead to severe exacerbation of symptoms. These events significantly worsen lung function, eventually causing acute respiratory failure and death.[10,11] In a relatively recent study in England with a large cohort, 23.3% of patients with COPD died due to cardiovascular disease, while 25.7% died due to COPD related causes.[12] Previous hospitalization for acute exacerbation, hospital readmission in the last month, and cardiovascular comorbidity are the strongest predictors of mortality, followed by sex, age, and long-term oxygen therapy.[13]

Within the field of COPD, research on the mortality trends of emphysema in relation to demographic factors such as age, gender, and race is limited. This underscores the need for our study, which specifically addresses this gap. Our research aimed to examine the demographic and regional patterns of mortality among US adults aged 25 and older with emphysema from 1999 to 2020. Ultimately, this analysis is a vital resource for identifying high-risk populations and implementing interventions to reduce the disease burden.

2. Methodology

2.1. Study setting and population

The mortality data was obtained from the Centers for Disease Control and Prevention wide-ranging online data for epidemiologic research (WONDER) database.[14] Using this database, we analyzed mortality rates in individuals diagnosed with emphysema between 1999 and 2020. International statistical classification of diseases and related health problems, 10th revision code J43 was applied to identify cases of emphysema.[15] Our study focused on death certificates within the multiple cause of death public-use dataset.[16] This enabled us to investigate mortality within emphysema patients aged ≥ 25 years. This method and database have been utilized in previously published studies to analyze mortality trends.[17–21] Institutional review board approval was not required, as we utilized a de-identified government-provided public-use dataset following strengthening the reporting of observational studies in epidemiology (STROBE) guidelines.[22]

2.2. Data abstraction

The data were categorized based on different demographic variables, which included population size, age distribution, gender composition, racial/ethnic background, geographic location, urbanization level, and place of death. Places of death encompassed inpatient settings, outpatient facilities, emergency rooms, cases of death upon arrival, residences, hospice/nursing homes/long-term care facilities, or cases where the location was unspecified. Ethnoracial categories included Hispanic or Latino, non-Hispanic (NH) White, NH Black/African American, NH American Indian/Alaskan Native, and NH Asian.

The patients were divided into ten-year intervals based on whether they were young adults (25–44 years), middle-aged adults (45–64 years), or older adults (65–85 + years) in line with the previously published studies.[23] Geographically, we categorized our study population using the urban–rural classification scheme of the National Center for Health Statistics. Urban areas were defined as populations of 50,000 or more, while rural areas included populations of fewer than 50,000 residents. Moreover, we divided the United States into 4 regions in accordance with the US Census Bureau classification: Northeast, Midwest, South, and West.[24]

2.3. Statistical analysis

We assessed gender, race, age, urbanization, and census-related patterns by calculating both crude and age-adjusted mortality rates (AAMR) per 100,000 individuals, using the 2000 US population as the baseline for AAMR standardization.[25] To examine trends in AAMR of emphysema-related mortality, the Joinpoint regression program (Version 5.0.2, National Cancer Institute) was employed.[26] Temporal trends in AAMR were evaluated by fitting log-linear regression models. Joinpoint regression was used to detect inflection points in the temporal trends of AAMR for emphysema from 1999 to 2020, following established methodological guidelines. For datasets spanning 17 to 21 time-points, the guidelines suggest identifying a maximum of 3 inflection points within the study period. Given that this study encompasses 22 years, the Joinpoint regression software was configured to detect up to 4 joinpoints where significant shifts in the trend were present. However, fewer than the maximum allowed inflection points could be identified if the greatest variation between trends was achieved with fewer joinpoints. Thus, the analysis permitted the identification of between 0 and 4 joinpoints. The grid search method (2, 2, 0), along with a permutation test and parametric method, was utilized to calculate the annual percent change (APC) and corresponding 95% confidence intervals (CIs). APC quantifies the rate of change in AAMR over time, indicating whether mortality rates are rising or falling each year. A positive APC signifies an increase, while a negative APC indicates a decrease in mortality rates. APC values were deemed significant if their CIs excluded zero, based on 2-tailed *t*-tests, with statistical significance set at $P \leq .05$.

3. Results

Between 1999 and 2020, there were 484,095 total deaths where emphysema was either the underlying or a contributing cause (Table S1, Supplemental Digital Content, http://links.lww.com/MD/O227). The place of death was recorded for 460,714 cases: 45% occurred in medical facilities, 37.8% at the decedents' homes, 14.7% in nursing home/long-term care facilities, and 2.4% in hospices (Table S2, Supplemental Digital Content, http://links.lww.com/MD/O227).

3.1. Demographic trends in mortality

The AAMR was 18.5 in 1999, decreasing to 7.2 by 2020. From 1999 to 2001, the overall AAMR significantly declined (APC: −8.92*; 95% CI: −10.94 to −5.57). This was followed by a significant reduction from 2001 to 2008 (APC: −3.82*; 95% CI: −4.65 to −1.09), and another significant decline from 2008 to 2015 (APC: −8.28*; 95% CI: −11.74 to −6.91). However, from 2015 to 2020, there was an increasing trend (APC: 2.15; 95% CI: −0.78 to 8.60) (Fig. 1, Tables S3 and S4, Supplemental Digital Content, http://links.lww.com/MD/O227).

3.2. Gender stratification

During the study period, men's AAMRs were higher than women's (13.4 vs 7.8). In 1999, the average AAMR for men was 26, which significantly decreased to 21.2 in 2001 (APC: −10.34*; 95% CI: −13.98 to −4.73). It further declined to 15.6 in 2008 (APC: −4.27; 95% CI: −9.92 to 0.29), then sharply decreased to 8.6 in 2015 (APC: −8.32*; 95% CI: −12.01 to −3.47), followed by an increase to 9.5 in 2020 (APC: 2.07; 95% CI: −1.04 to 9.34). For women, the AAMR was 13.7 in 1999, significantly dropping to 11 in 2002 (APC: −6.71*; 95% CI: −9.16 to −4.83).

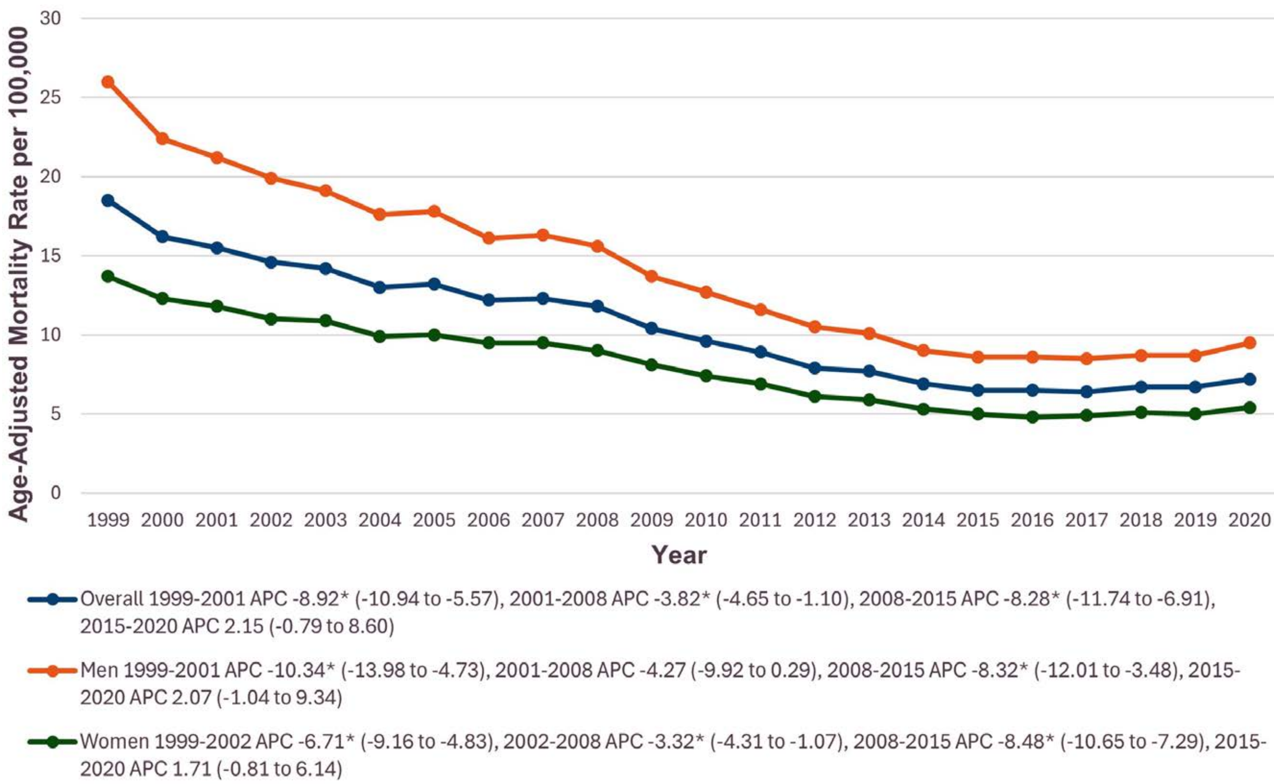

Figure 1. Overall and sex-stratified pulmonary emphysema-related age-adjusted mortality rates per 100,000 in adults in the United States, 1999 to 2020. *Indicates that the annual percentage change is significantly different from zero at $\alpha = 0.05$. AAMR = age-adjusted mortality rate, APC = annual percentage change.

It then significantly decreased to 9 in 2008 (APC: −3.33*; 95% CI: −4.31 to −1.07), followed by a similar decrease to 5 in 2015 (APC: −8.48*; 95% CI: −10.65 to −7.29), and rose to 5.4 in 2020 (APC: 1.71; 95% CI: −0.81 to 6.14) (Fig. 1, Tables S3 and S4, Supplemental Digital Content, http://links.lww.com/MD/O227).

3.3. Stratification by age groups

When stratified by age groups, older adults had the highest AAMRs (42), followed by middle-aged adults (5.2) and young adults (0.3; 95% CI: 0.3–0.3). Among young adults, AAMRs significantly increased from 1999 to 2001 (APC: 20.51*; 95% CI: 1.63 to 40.40), followed by a significant decrease until 2020 (APC: −1.90*; 95% CI: −3.21 to −1.24). Middle-aged adults experienced a significant decrease from 1999 to 2001 (APC: −9.30*; 95% CI: −12.58 to −4.47), followed by a decrease from 2001 to 2008 (APC: −1.96; 95% CI: −2.77 to 2.26), a significant decline from 2008 to 2015 (APC: −4.49*; 95% CI: −8.99 to −3.46), and an increase from 2015 to 2020 (APC: 0.83; 95% CI: −1.74 to 7.90). Similarly, older adults showed a significant decrease from 1999 to 2001 (APC: −8.72*; 95% CI: −11.53 to −4.46), followed by a decrease from 2001 to 2008 (APC: −4.25*; 95% CI: −12.32 to −0.75), a steep decline from 2008 to 2015 (APC: −9.20*; 95% CI: −12.05 to −0.24), and a significant upward trend from 2015 to 2020 (APC: 2.48*; 95% CI: 0.09 to 7.68) (Fig. 2, Tables S3 and S5, Supplemental Digital Content, http://links.lww.com/MD/O227).

3.4. Racial stratification

When stratified by race or ethnicity, AAMRs were highest among NH White individuals (11.3), followed by NH American Indian or Alaska Native individuals (8.2), NH Black or African American individuals (7.7), Hispanic or Latino individuals (3.9), and NH Asian or Pacific Islander individuals (3.1).

From 1999 to 2004, AAMRs among NH Black or African American patients decreased (APC: −5.39*; 95% CI: −10.22 to −3.28), followed by a continued decrease from 2004 to 2007 (APC: −0.72; 95% CI: −9.12 to 1.60). There was a significant rise from 2007 to 2015 (APC: −6.89*; 95% CI: −10.22 to −0.61) and an increasing trend from 2015 to 2020 (APC: 2.81; 95% CI: −0.12 to 9.43). Among NH White patients, a significant downward trend was observed from 1999 to 2001 (APC: −8.71*; 95% CI: −10.58 to −5.70), followed by a continued decrease from 2001 to 2008 (APC: −3.55*; 95% CI: −4.25 to −1.34). There was a sharp decline from 2008 to 2015 (APC: −8.04*; 95% CI: −10.36 to −6.92), followed by an upward trend from 2015 to 2020 (APC: 2.22; 95% CI: −0.24 to 6.33). Among NH American Indian or Alaska Native patients, AAMRs significantly decreased from 1999 to 2020 (APC: −3.65*; 95% CI: −4.47 to −2.76). AAMRs among Hispanic patients significantly decreased from 1999 to 2018 (APC: −5.66*; 95% CI: −6.76 to −4.90), followed by an upward trend from 2018 to 2020 (APC: 16.82; 95% CI: −0.26 to 24.45). Lastly, AAMRs for NH Asian or Pacific Islander patients significantly decreased from 1999 to 2017 (APC: −6.25*; 95% CI: −7.38 to −5.58), followed by an increase from 2017 to 2020 (APC: 4.84; 95% CI: −2.19 to 15.08) (Fig. 3, Tables S3 and S6, Supplemental Digital Content, http://links.lww.com/MD/O227).

3.5. State-wise distribution

AAMR values varied significantly by state, ranging from 6.5 in North Dakota to 18.6 in Vermont. States in the top 90th percentile (New Mexico, Oregon, Michigan, Ohio, Indiana, and Vermont) had AAMRs approximately 3 times higher than those

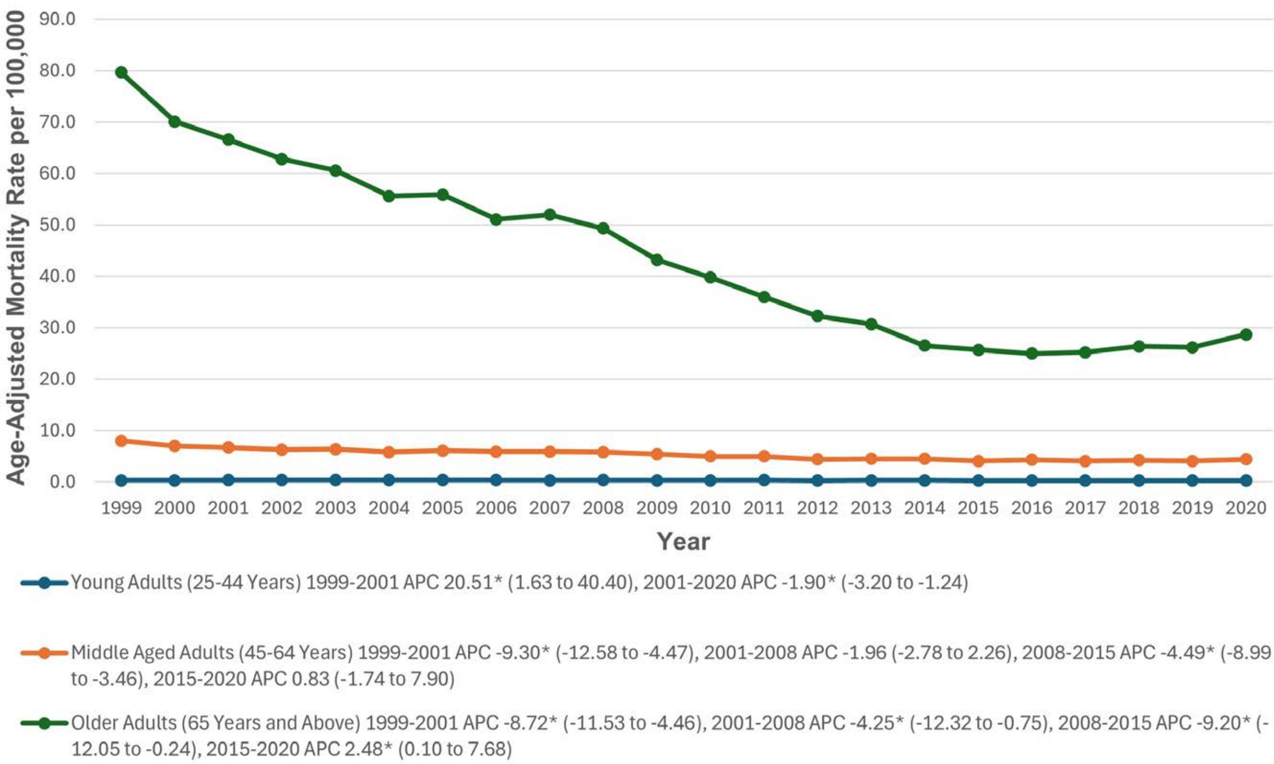

Figure 2. Pulmonary emphysema-related age-adjusted mortality rates per 100,000, stratified by age groups in adults in the United States, 1999 to 2020. *Indicates that the annual percentage change is significantly different from zero at α = 0.05. AAMR = age-adjusted mortality rate, APC = annual percentage change.

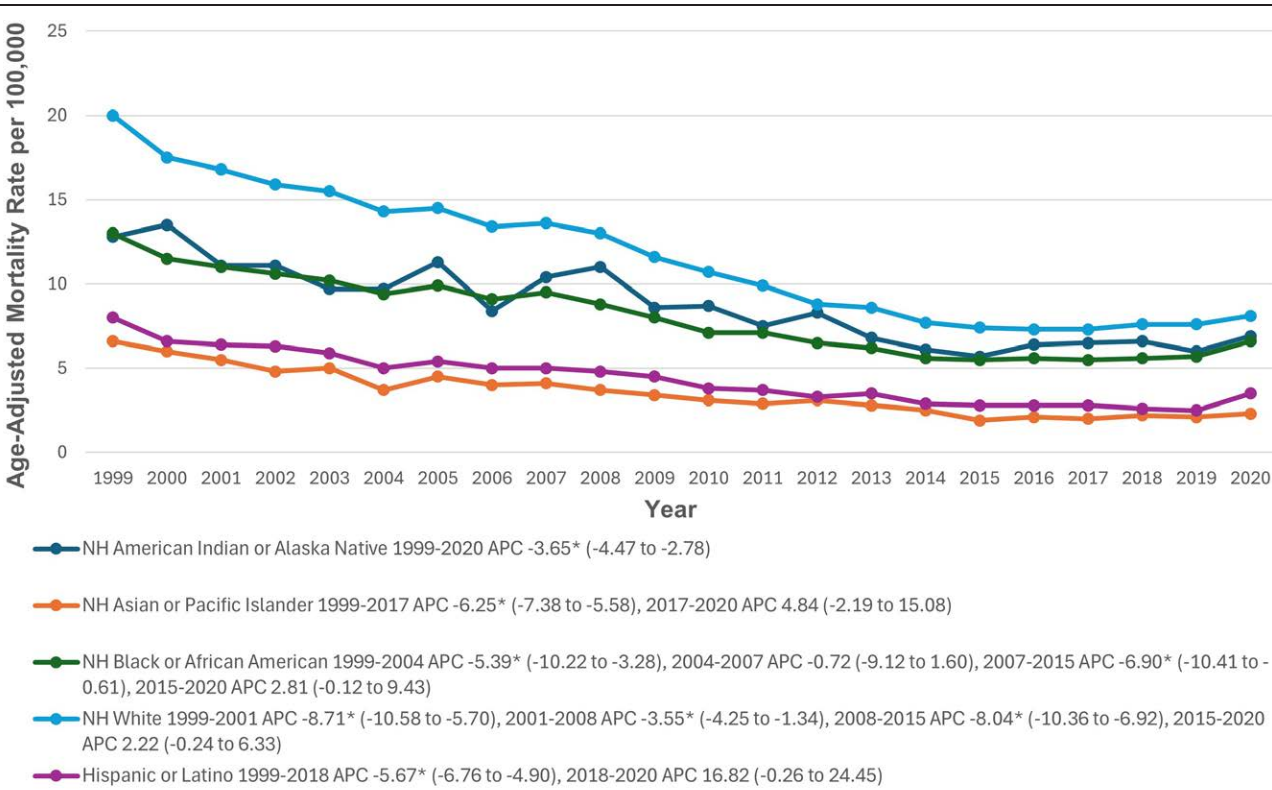

Figure 3. Pulmonary emphysema-related age-adjusted mortality rates per 100,000, stratified by race in adults in the United States, 1999 to 2020. *Indicates that the annual percentage change is significantly different from zero at α = 0.05. AAMR = age-adjusted mortality rate, APC = annual percentage change.

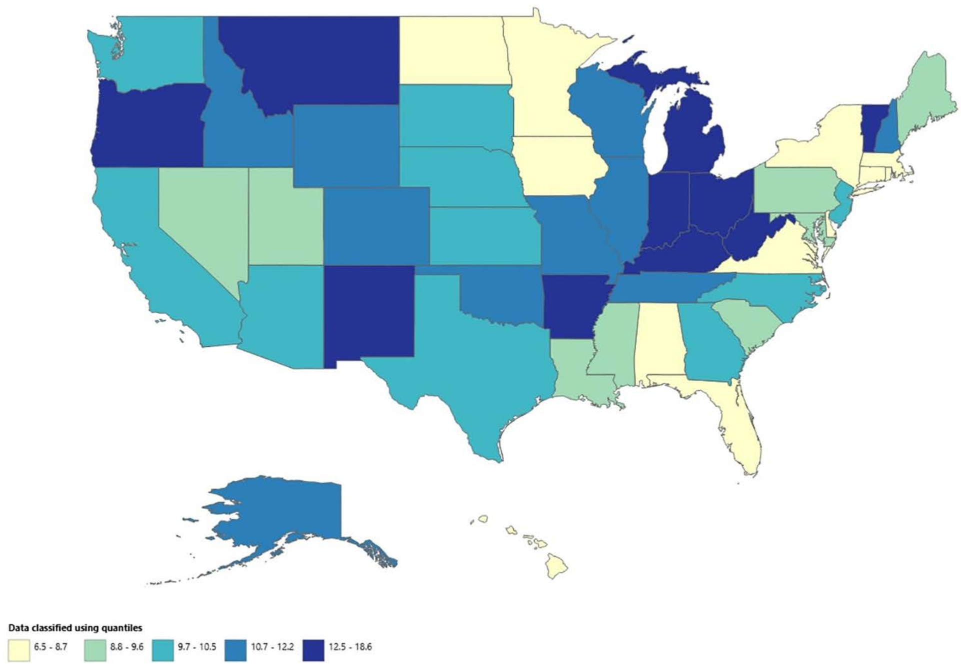

Figure 4. Pulmonary emphysema-related age-adjusted mortality rates per 100,000, stratified by state in adults in the United States, 1999 to 2020. AAMR = age-adjusted mortality rate.

in the bottom 10th percentile (North Dakota, Rhode Island, Delaware, District of Columbia, Hawaii, and Minnesota) (Fig. 4, Table S7, Supplemental Digital Content, http://links.lww.com/MD/O227).

3.6. Census region

During the study period, the highest AAMRs were observed in the Midwestern (11.7) and Western regions (10.3), followed by the Southern (9.7) and Northeastern regions (9.0). From 1999 to 2015, AAMRs decreased significantly in the Western region (APC: −6.12*; 95% CI: −6.75 to −5.70), followed by a slight increase from 2015 to 2020 (APC: 0.08; 95% CI: −2.85 to 8.63). In the Midwestern region, there was a decrease from 1999 to 2008 (APC: −3.74; 95% CI: −4.70 to 0.12), followed by a sharp decline from 2008 to 2015 (APC: −6.85*; 95% CI: −12.25 to −5.24). The Southern region saw a significant decrease from 1999 to 2004 (APC: −6.85*; 95% CI: −10.33 to −4.99), followed by a decline from 2004 to 2007 (APC: −1.33; 95% CI: −4.91 to 0.16), and a significant decrease from 2007 to 2015 (APC: −9.45*; 95% CI: −11.48 to −8.32). From 2015 to 2020, an upward trend was observed in the Midwestern region (APC: 2.46; 95% CI: −0.49 to 10.16) and the Southern region (APC: 3.10; 95% CI: −0.11 to 9.12). In the Northeastern region, there was a significant decrease from 1999 to 2001 (APC: −9.91*; 95% CI: −12.86 to −5.28), followed by a decline from 2001 to 2007 (APC: −2.68; 95% CI: −4.24 to 1.03), a sharp decrease from 2007 to 2016 (APC: −7.31*; 95% CI: −8.64 to −6.45), and an increase from 2016 to 2020 (APC: 2.23; 95% CI: −0.31 to 6.76) (Figure 5, Tables S3 and S8, Supplemental Digital Content, http://links.lww.com/MD/O227).

3.7. Urbanization

Throughout the study period, nonmetropolitan areas exhibited slightly higher AAMRs for emphysema than metropolitan areas, with overall AAMRs of 11.7 and 9.8, respectively. In nonmetropolitan areas, AAMRs significantly decreased from 1999 to 2002 (APC: −7.39*; 95% CI: −12.25 to −3.55), followed by a continued decrease from 2002 to 2008 (APC: −0.63; 95% CI: −2.35 to 4.19), a significant decrease from 2008 to 2015 (APC: −7.46*; 95% CI: −11.99 to −5.99), and a significant upward trend from 2015 to 2020 (APC: 2.87*; 95% CI: 0.38 to 7.50). In metropolitan areas, a significant decrease in AAMRs was observed from 1999 to 2001 (APC: −8.73*; 95% CI: −10.56 to −5.59), followed by an increasing trend from 2001 to 2008 (APC: −4.37*; 95% CI: −5.23 to −1.87), a significant decline from 2008 to 2015 (APC: −8.48*; 95% CI: −11.67 to −7.08), and a rise from 2015 to 2020 (APC: 1.85; 95% CI: −0.97 to 7.77) (Fig. 6, Tables S3 and S9, Supplemental Digital Content, http://links.lww.com/MD/O227).

Note: APC values marked with an asterisk (*) are statistically significant at $P \leq .05$.

4. Discussion

COPD, including emphysema, is the third leading cause of death worldwide and the fourth leading cause of death in the US.[27] These statistics underscore the critical need for effective strategies to mitigate this significant health burden. In our study, we observed a significant reduction in AAMR due to emphysema from 1999 to 2020. These findings align with global trends where AAMR for COPD has consistently decreased in the 21st century across countries.[28–30] The decrease in emphysema-related AAMR in the US can be attributed to various state-level initiatives. In 1995, the American Thoracic Society published its first COPD guidelines,[31] followed by comprehensive guidelines for COPD management and prevention published by the US National Heart, Lung, and Blood Institute (NHLBI) and World Health Organization (WHO) in 2001.[32] These efforts likely contributed to decreased emphysema morbidity and mortality in our analysis. The healthy people initiative, launched in 1979 to promote health and prevent disease in the U.S, achieved its goal of reducing COPD deaths, which may have also contributed to lower emphysema-related AAMR.

Furthermore, the 2005 WHO Framework Convention on Tobacco Control led to widespread smoking cessation programs, reducing smoking prevalence and secondhand smoke exposure, the primary risk factors for emphysema.[33–35] Improvements in

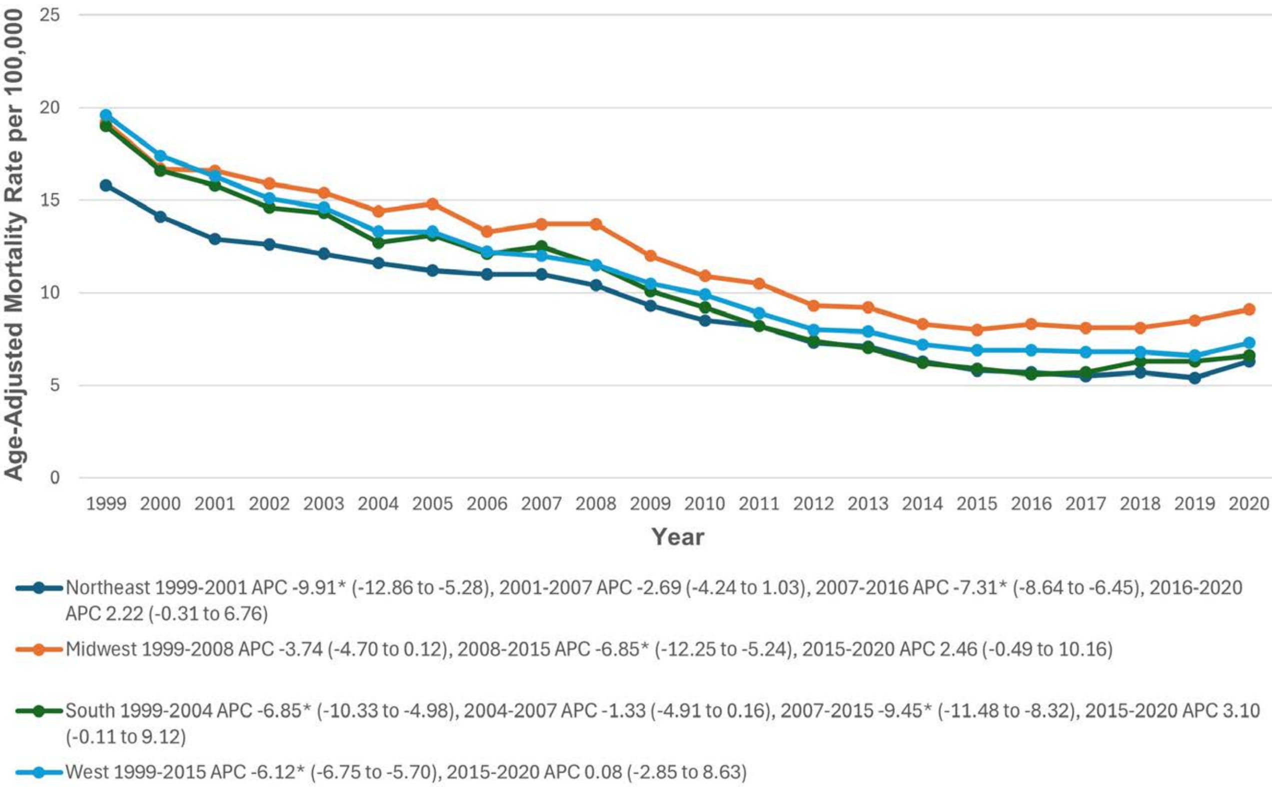

Figure 5. Pulmonary emphysema-related age-adjusted mortality rates per 100,000, stratified by census regions in adults in the United States, 1999 to 2020. *Indicates that the annual percentage change is significantly different from zero at $\alpha = 0.05$. AAMR = age-adjusted mortality rate, APC = annual percentage change.

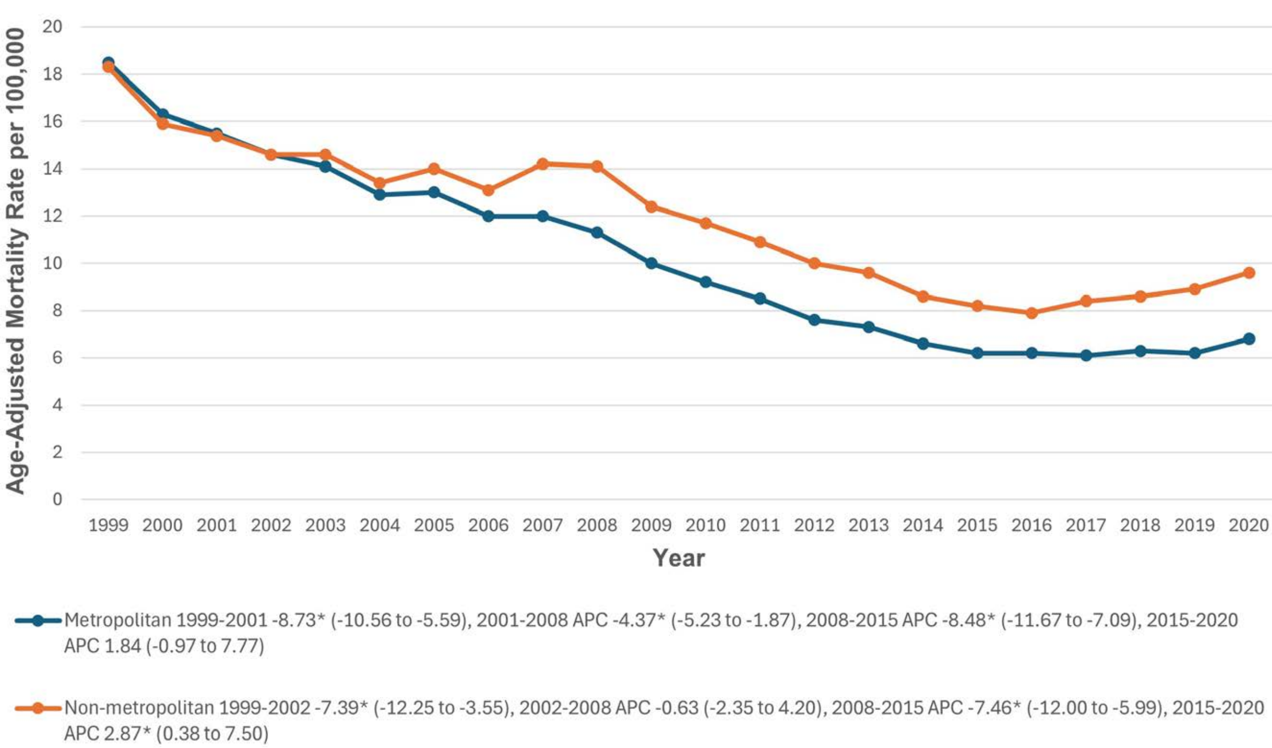

Figure 6. Pulmonary emphysema-related age-adjusted mortality rates per 100,000 in adults in the metropolitan and nonmetropolitan areas in the United States, 1999 to 2020. *Indicates that the annual percentage change is significantly different from zero at $\alpha = 0.05$. AAMR = age-adjusted mortality rate, APC = annual percentage change.

air quality, largely due to the Clean Air Act, have reduced pollutant exposure, which may have mitigated emphysema severity.[36] Advancements in medical treatments, such as long-acting bronchodilators, inhaled corticosteroids, and combination therapies, have also enhanced disease management and quality of life for patients with COPD, including emphysema.[37] Together, these factors – COPD guidelines, smoking reduction, improved air quality, and medical advancements – have likely contributed to the observed decline in emphysema-related AAMR in the US.

However, from 2015 onwards, a concerning trend of increasing emphysema-related AAMR emerged. Multiple factors may explain this reversal. The growing aging population in the U.S has increasing susceptibility to chronic diseases like emphysema, with older individuals more prone to comorbidities such as cardiovascular diseases that can exacerbate emphysema outcomes.[38] Secondly, smoking rates among older adults in the US increased from 13.0% in 2011 to 15.8% in 2022, contributing to rising emphysema mortality.[39] Persistent environmental exposures to air pollutants and occupational hazards have also played a role in increasing mortality rates.[40,41] Additionally, the onset of the COVID-19 pandemic in 2019 introduced substantial challenges for emphysema patients. While emphysema was not highly prevalent among COVID-19 cases, its presence correlated with increased disease severity and higher mortality rates in affected individuals.[42]

Our study indicates a significant decrease in overall AAMR trends since 1999 for both genders, with a recent uptick from 2015 onwards. However, the gap between men's and women's rates is narrowing, though men's rates remain consistently higher throughout the study period. Historically, women were considered less prone to emphysema, remained under-diagnosed, and were often overlooked in clinical settings.[43] Research from North America and Spain suggests female smokers were significantly under-diagnosed compared to males, with fewer receiving spirometry testing or pulmonologist referrals.[44] However, recent data highlight a rising prevalence of emphysema among women compared to men. From 1998 to 2009, COPD rates increased among women in the U.S but decreased among men, a pattern observed in other countries like Canada, the Netherlands, and Austria as well.[45] Since 2011, more American women have been diagnosed with emphysema than men, reflecting a significant shift. Over recent decades, emphysema prevalence and mortality in women have risen markedly, approaching parity with men,[46] and in 2000, emphysema deaths among women surpassed those in men for the first time.[47] Our data supports these trends, revealing a significant shift in the gender distribution of emphysema mortality. This shifting landscape between genders can be attributed to several factors. The increasing prevalence of AAMR among women is linked in part to rising tobacco use and exposure to biomass fuels.[45] Current smoking trends among women now mirror those of men after a lag of nearly a century.[48] The WHO highlights that tobacco advertising now increasingly targets young girls.[49] Despite similar levels of tobacco exposure, women face a heightened risk of developing emphysema, often with less cigarette exposure, and tend to experience more severe disease at younger ages compared to men.[50,51] Women also exhibit a faster decline in FEV1 and earlier onset of disease, contributing to increasing mortality trends in emphysema.[46,52] While AAMR increased for both genders after 2015, indicating an overall upward trend, the narrowing mortality gap between men and women, with women approaching men's rates, poses a new public health challenge that requires intervention.

Despite an overall decline in AAMR across various age groups, our study identifies a concerning uptick in emphysema-related deaths among middle-aged and older adults since 2015. Emphysema, classified as a noncommunicable disease (NCD), reflects the broader increase in NCDs nationwide.[53] Major contributors to NCDs include tobacco use, alcohol misuse, poor diet, and physical inactivity, all directly linked to emphysema mortality. Recent decades have seen a rise in obesity and unhealthy lifestyles among Americans, particularly impacting vulnerable adults and seniors.[54] The COVID-19 pandemic exacerbated these trends, with studies reporting increased food intake, reduced physical activity, weight gain, disrupted sleep, and heightened smoking rates globally.[55–57] Moreover, environmental factors like air pollution significantly influence emphysema mortality.[58] These factors collectively contribute to the severity and mortality of emphysema, especially in older vulnerable populations.

Ethnoracial disparities were also observed, with NH White individuals consistently exhibiting the highest and NH Asians had the lowest AAMRs throughout the study period, aligning with existing literature on cardio-respiratory pathologies.[59] These differences may stem partly from factors such as survival bias, given the social construct of race and competing risks of death before reaching age 75. However, a concerning trend emerged: a steady increase in mortality rates among NH Black or African American individuals since 2007. Studies also highlight stable COPD mortality among White males from 1980 to 2004, contrasting with an upward trend among Black patients during the same period.[60] This disparity may relate to poorer lung function among African Americans.[61,62] Additionally, COPD, including emphysema, leads to higher hospitalization rates among NH Black individuals.[63] Similarly, Black women with COPD face a heightened risk of cardio-respiratory disease-related mortality compared to White women.[64] Despite conflicting trends in recent years between NH White and NH Black individuals, addressing these underlying causes becomes crucial. Implementing targeted interventions and culturally tailored approaches are essential steps towards reducing racial disparities in emphysema-related mortality.

State-by-state trends illustrate that throughout the 21–year study period, Vermont had the highest change in AAMR, while North Dakota had the lowest overall mortality, with top percentile states showing rates 3 times higher than bottom percentile states. Regional analyses revealed consistently higher AAMRs in the Midwestern and Western regions, with significant declines observed over time, albeit with recent fluctuations suggesting ongoing challenges. Furthermore, our findings highlight that nonmetropolitan areas bear a disproportionate burden of emphysema-related mortality compared to metropolitan areas. Over the past decade, both settings have seen an increase in AAMRs, with a more pronounced rise observed in nonmetropolitan regions. This disparity may stem from lower socioeconomic status, limited access to primary care physicians in rural areas, and a notable scarcity of pulmonologists – only 34.5% of rural residents had access to a pulmonologist within 10 miles, while the majority of pulmonologists were concentrated in urban areas.[65] This, combined with substantial hospital reductions over the past decade, likely exacerbated these health inequities.[66]

Based on the comprehensive analysis of emphysema-related mortality trends across demographics and regions, our study highlights the necessity for targeted interventions and ongoing surveillance. Efforts should prioritize addressing socioeconomic disparities, enhancing healthcare access in rural and underserved areas, and promoting smoking cessation programs. Additionally, there is a critical need for continued research to monitor and understand the evolving trends in emphysema mortality, especially in light of recent increases observed after 2015. These efforts are essential for mitigating the impact of emphysema and improving health outcomes across diverse populations in the US.

4.1. Limitations

There are several limitations that need to be considered in our analysis using CDC WONDER data for emphysema mortality trends. First, the reliance on ICD codes and death certificates poses a risk of underreporting or misclassification of emphysema-related deaths, potentially leading to inaccurate mortality estimates. Second, the database lacks detailed clinical variables that could enhance our understanding of emphysema phenotypes, such as pulmonary function tests, imaging results like CT scans, or smoking history, which are crucial for a comprehensive characterization of the disease burden. Third, our analysis was constrained by the lack of differentiation in emphysema subtypes on death certificates, which typically report only broad categories such as "emphysema" or "COPD." This limited our ability to conduct reliable subgroup analyses by specific emphysema types, potentially underestimating subtype-specific mortality trends. Fourth, our study was also limited by the absence of data on confounding factors and specific comorbidities, which prevented the application of multivariable analyses to further explore their effects on emphysema mortality trends. While multivariable analyses could provide additional insights, the CDC WONDER database does not capture information on comorbid conditions or other potential confounders that could affect outcomes in emphysema patients. Information on specific medical therapies and treatments for emphysema is also not captured in the dataset, limiting insights into treatment patterns and their impact on mortality trends. Lastly, important variables such as income, education, and access to healthcare, which are significant determinants of health outcomes, are not reported in the CDC WONDER database or on death certificates. The absence of these variables restricts our ability to fully understand the context surrounding emphysema-related mortality. Addressing these limitations is essential for more nuanced interpretations and targeted public health interventions aimed at reducing emphysema-related mortality.

5. Conclusion

In conclusion, our study provides a comprehensive analysis of emphysema-related mortality trends among US adults aged 25 and older from 1999 to 2020, revealing notable demographic disparities and temporal shifts. We observed a significant overall decline in AAMR from emphysema over the past 2 decades, attributable to public health interventions, improved clinical management, and declining smoking rates. However, recent trends indicate an emerging reversal, particularly among certain demographic groups such as women and middle-aged adults, coupled with persistent disparities among ethnoracial minorities. These findings underscore the ongoing challenges in managing and preventing emphysema, necessitating targeted interventions to mitigate risk factors, improve access to healthcare, and address the specific needs of vulnerable populations to sustain the gains achieved and curb the resurgence in mortality rates observed in recent years.

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References

[1] The definition of emphysema. Report of a national heart, lung, and blood institute, division of lung diseases workshop. Am Rev Respir Dis. 1985;132:182–5.
[2] 2024 GOLD Report. Global initiative for chronic obstructive lung disease: GOLD. Available at: https://goldcopd.org/2024-gold-report/. Accessed November 10, 2024.
[3] Ntritsos G, Franek J, Belbasis L, et al. Gender-specific estimates of COPD prevalence: a systematic review and meta-analysis. Int J Chron Obstruct Pulmon Dis. 2018;13:1507–14.
[4] Varmaghani M, Dehghani M, Heidari E, Sharifi F, Moghaddam SS, Farzadfar F. Global prevalence of chronic obstructive pulmonary disease: systematic review and meta-analysis. East Mediterr Health J. 2019;25:47–57.
[5] Association AL. COPD trends brief: prevalence. Available at: https://www.lung.org/research/trends-in-lung-disease/copd-trends-brief/copd-prevalence. Accessed November 10, 2024.
[6] Boers E, Barrett M, Su JG, et al. Global burden of chronic obstructive pulmonary disease through 2050. JAMA Netw Open. 2023;6:e2346598.
[7] Association AL. COPD trends brief: burden. Available at: https://www.lung.org/research/trends-in-lung-disease/copd-trends-brief/copd-burden. Accessed November 10, 2024.
[8] GBD Chronic Respiratory Disease Collaborators. Prevalence and attributable health burden of chronic respiratory diseases, 1990-2017: a systematic analysis for the global burden of disease study 2017. Lancet Respir Med. 2020;8:585–96.
[9] Sin DD, Anthonisen NR, Soriano JB, Agusti AG. Mortality in COPD: role of comorbidities. Eur Respir J. 2006;28:1245–57.
[10] Yu Y, Liu W, Jiang HL, Mao B. Pneumonia is associated with increased mortality in hospitalized COPD patients: a systematic review and meta-analysis. Respiration. 2021;100:64–76.
[11] Abi Abdallah G, Diop S, Jamme M, Legriel S, Ferré A. Respiratory infection triggering severe acute exacerbations of chronic obstructive pulmonary disease. Int J Chron Obstruct Pulmon Dis. 2024;19:555–65.
[12] Whittaker H, Rothnie KJ, Quint JK. Cause-specific mortality in COPD subpopulations: a cohort study of 339 647 people in England. Thorax. 2024;79:202–8.
[13] Owusuaa C, Dijkland SA, Nieboer D, van der Rijt CCD, van der Heide A. Predictors of mortality in chronic obstructive pulmonary disease: a systematic review and meta-analysis. BMC Pulm Med. 2022;22:125.
[14] CDC WONDER. Available at: https://wonder.cdc.gov/. Accessed August 24, 2024.
[15] 2025 ICD-10-CM diagnosis code J43: emphysema. Available at: https://www.icd10data.com/ICD10CM/Codes/J00-J99/J40-J4A/J43-/J43. Accessed November 10, 2024.
[16] Multiple cause of death data on CDC WONDER. Available at: https://wonder.cdc.gov/mcd.html. Accessed August 24, 2024.
[17] Goyal A, Saeed H, Shahnoor S, Arshad MK, Wasay A. Mortality trends, gender, and racial disparities in older adults due to abdominal aortic aneurysm: a nationwide cross-sectional analysis. Int J Surg. 2024.
[18] Sohail AH, Flesner SL, Quazi MA, et al. Emerging trends and demographic disparities in anal cancer mortality across the United States census regions: an analysis of National Center for Health Statistics mortality data. Colorectal Dis. 2024;26:1913–21.
[19] Alim Ur Rahman H, Moeed A, Hotwani P, et al. Abstract 4143756: demographic characteristics and geographic patterns of atrial fibrillation-associated mortality among older adults with heart failure in the United States (1999–2020). Circulation. 2024;150(Suppl_1):A4143756–A4143756.
[20] Saeed H, Abdullah, Hameed H, et al. Mortality trends and disparities in adults with Huntington's disease in the United States. J Huntington's Dis. 2024:18796397241287399.
[21] Ullah I, Farooqi H, Ahmad O, et al. TCT-781 trends of acute myocardial infarction related deaths in US patients from 1999 to 2020. J Am Coll Cardiol. 2024;84(18, Supplement):B315.
[22] Cuschieri S. The STROBE guidelines. Saudi J Anaesth. 2019;13(Suppl 1):S31–4.
[23] Maqsood MH, Talha KM, Minhas AMK, et al. CDC-WONDER database analysis of COVID-19 and cardiovascular disease-related mortality. J Am Coll Cardiol. 2023;81:1743–5.
[24] Ingram DD, Franco SJ. 2013 NCHS urban-rural classification scheme for counties. Vital Health Stat 2. 2014:1–73.
[25] Anderson RN, Rosenberg HM. Age standardization of death rates: implementation of the year 2000 standard. Natl Vital Stat Rep. 1998;47:1–16, 20.
[26] Joinpoint regression program. Available at: https://surveillance.cancer.gov/joinpoint/. Accessed July 10, 2024.

[27] Sullivan J, Pravosud V, Mannino DM, Siegel K, Choate R, Sullivan T. National and state estimates of COPD morbidity and mortality: United States, 2014–2015. Chronic Obstr Pulm Dis. 2018;5:324–33.

[28] Alqahtani JS. Prevalence, incidence, morbidity and mortality rates of COPD in Saudi Arabia: trends in burden of COPD from 1990 to 2019. PLoS One. 2022;17:e0268772.

[29] Marshall DC, Al Omari O, Goodall R, et al. Trends in prevalence, mortality, and disability-adjusted life-years relating to chronic obstructive pulmonary disease in Europe: an observational study of the global burden of disease database, 2001–2019. BMC Pulm Med. 2022;22:289.

[30] Mei F, Dalmartello M, Bonifazi M, et al. Chronic obstructive pulmonary disease (COPD) mortality trends worldwide: an update to 2019. Respirology. 2022;27:941–50.

[31] Standards for the diagnosis and care of patients with chronic obstructive pulmonary disease. American Thoracic Society. Am J Respir Crit Care Med. 1995;152(5 Pt 2):S77–121.

[32] Pauwels RA, Buist AS, Calverley PM, Jenkins CR, Hurd SS; GOLD Scientific Committee. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease. NHLBI/WHO global initiative for chronic obstructive lung disease (GOLD) workshop summary. Am J Respir Crit Care Med. 2001;163:1256–76.

[33] Peruga A, López MJ, Martinez C, Fernández E. Tobacco control policies in the 21st century: achievements and open challenges. Mol Oncol. 2021;15:744–52.

[34] Husten CG, Deyton LR. Understanding the tobacco control act: efforts by the US food and drug administration to make tobacco-related morbidity and mortality part of the USA's past, not its future. Lancet. 2013;381:1570–80.

[35] Celli BR, Wedzicha JA. Update on clinical aspects of chronic obstructive pulmonary disease. N Engl J Med. 2019;381:1257–66.

[36] Pope CA, Ezzati M, Dockery DW. Fine-particulate air pollution and life expectancy in the United States. N Engl J Med. 2009;360:376–86.

[37] Rabe KF, Hurd S, Anzueto A, et al; Global Initiative for Chronic Obstructive Lung Disease. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary. Am J Respir Crit Care Med. 2007;176:532–55.

[38] Bureau UC. U.S. Older population grew from 2010 to 2020 at fastest rate since 1880 to 1890. Census.gov. Available at: https://www.census.gov/library/stories/2023/05/2020-census-united-states-older-population-grew.html. Accessed November 10, 2024.

[39] Meza R, Cao P, Jeon J, Warner KE, Levy DT. Trends in US adult smoking prevalence, 2011 to 2022. JAMA Health Forum. 2023;4:e234213.

[40] Syamlal G, Kurth LM, Dodd KE, Blackley DJ, Hall NB, Mazurek JM. Chronic obstructive pulmonary disease mortality by industry and occupation: United States, 2020. MMWR Morb Mortal Wkly Rep. 2022;71:1550–4.

[41] Tanrıverdi E, Doğan D, Turan D, et al. The impact of co-existing comorbid diseases on long-term mortality in bronchoscopic lung volume reduction. Med Glas (Zenica). 2020;17:73–8.

[42] Alqahtani JS, Oyelade T, Aldhahir AM, et al. Prevalence, severity and mortality associated with COPD and smoking in patients with COVID-19: a rapid systematic review and meta-analysis. PLoS One. 2020;15:e0233147.

[43] Ancochea J, Miravitlles M, García-Río F, et al. Underdiagnosis of chronic obstructive pulmonary disease in women: quantification of the problem, determinants and proposed actions. Arch Bronconeumol. 2013;49:223–9.

[44] Miravitlles M, de la Roza C, Naberan K, et al. [Attitudes toward the diagnosis of chronic obstructive pulmonary disease in primary care]. Arch Bronconeumol. 2006;42:3–8.

[45] Gut-Gobert C, Cavaillès A, Dixmier A, et al. Women and COPD: do we need more evidence? Eur Respir Rev. 2019;28:180055.

[46] Aryal S, Diaz-Guzman E, Mannino DM. Influence of sex on chronic obstructive pulmonary disease risk and treatment outcomes. Int J Chron Obstruct Pulmon Dis. 2014;9:1145–54.

[47] Mannino DM, Homa DM, Akinbami LJ, Ford ES, Redd SC. Chronic obstructive pulmonary disease surveillance: United States, 1971–2000. MMWR Surveill Summ. 2002;51:1–16.

[48] Lopez AD, Collishaw NE, Piha T. A descriptive model of the cigarette epidemic in developed countries. Tob Control. 1994;3:242–7.

[49] Haglund M. Women and tobacco: a fatal attraction. Bull World Health Organ. 2010;88:563.

[50] Sørheim IC, Johannessen A, Gulsvik A, Bakke PS, Silverman EK, DeMeo DL. Gender differences in COPD: are women more susceptible to smoking effects than men? Thorax. 2010;65:480–5.

[51] Hardin M, Foreman M, Dransfield MT, et al; COPD Gene Investigators. Sex-specific features of emphysema among current and former smokers with COPD. Eur Respir J. 2016;47:104–12.

[52] Aryal S, Diaz-Guzman E, Mannino DM. COPD and gender differences: an update. Transl Res. 2013;162:208–18.

[53] Luciani S, Agurto I, Caixeta R, Hennis A. Prioritizing noncommunicable diseases in the Americas region in the era of COVID-19. Rev Panam Salud Publica. 2022;46:e83.

[54] Koliaki C, Dalamaga M, Liatis S. Update on the obesity epidemic: after the sudden rise, is the upward trajectory beginning to flatten? Curr Obes Rep. 2023;12:514–27.

[55] Di Renzo L, Gualtieri P, Pivari F, et al. Eating habits and lifestyle changes during COVID-19 lockdown: an Italian survey. J Transl Med. 2020;18:229.

[56] Adult physical activity falls by a quarter since lockdown. The Independent. 2020. Available at: https://www.independent.co.uk/life-style/health-and-families/coronavirus-lockdown-physical-activity-reduced-exercise-weight-a9505411.html. Accessed November 10, 2024.

[57] Radwan H, Al Kitbi M, Hasan H, et al. Indirect health effects of COVID-19: unhealthy lifestyle behaviors during the lockdown in the United Arab Emirates. Int J Environ Res Public Health. 2021;18:1964.

[58] State of Global Air Report 2020. State of global air. Available at: https://www.stateofglobalair.org/resources/archived/state-global-air-report-2020. Accessed November 10, 2024.

[59] Siddiqi TJ, Khan Minhas AM, Greene SJ, et al. Trends in heart failure-related mortality among older adults in the United States from 1999–2019. JACC. 2022;10:851–9.

[60] Charette MF, Oh YS, Maric-Bilkan C, et al. Shifting demographics among research project grant awardees at the National Heart, Lung, and Blood Institute (NHLBI). PLoS One. 2016;11:e0168511.

[61] Gilkes A, Ashworth M, Schofield P, et al. Does COPD risk vary by ethnicity? A retrospective cross-sectional study. Int J Chron Obstruct Pulmon Dis. 2016;11:739–46.

[62] Sood A, Petersen H, Liu C, et al. Racial and ethnic minorities have a lower prevalence of airflow obstruction than non-Hispanic whites. COPD. 2022;19:61–8.

[63] Jørgensen TSH, Allore H, Elman MR, Nagel C, Quiñones AR. The importance of chronic conditions for potentially avoidable hospitalizations among non-Hispanic Black and non-Hispanic White older adults in the US: a cross-sectional observational study. BMC Health Serv Res. 2022;22:468.

[64] Krishnan JK, Rajan M, Banerjee S, et al. Race and sex differences in mortality in individuals with chronic obstructive pulmonary disease. Ann Am Thorac Soc. 2022;19:1661–8.

[65] Croft JB, Lu H, Zhang X, Holt JB. Geographic accessibility of pulmonologists for adults with COPD: United States, 2013. Chest. 2016;150:544–53.

[66] Basu S, Berkowitz SA, Phillips RL, Bitton A, Landon BE, Phillips RS. Association of primary care physician supply with population mortality in the United States, 2005–2015. JAMA Intern Med. 2019;179:506–14.