ORIGINAL ARTICLE

Epidemiological burden of female genital tract cancers in the United States, 1999–2024

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ABSTRACT

Background: Female genital tract cancers (FGTCs) remain a leading contributor to women's cancer mortality in the United States. This study provides the first comprehensive, population-level assessment of temporal, demographic, and geographic patterns in FGTC mortality from 1999 through 2024.

Methodology: We extracted death certificate data from the CDC WONDER database (ICD-10 codes C51-C58 listed as the underlying or a contributing cause of death) and calculated crude and age-adjusted mortality rates (AAMRs) per 100,000 women using the 2000 U.S. standard population. Trends were examined with Joinpoint regression to estimate annual percent change (APC). Analyses were stratified by age, race/ethnicity, census region, state, and NCHS urban–rural classification.

Results: From 1999 to 2024, 850,404 FGTC-related deaths were recorded. The overall AAMR was 10.6 per 100,000. Mortality declined from 1999 to 2018 (APC: –1.35, p = 0.0396), but a marked increase occurred between 2018 and 2021 (AAMR rising from 8.8 to 16.8 per 100,000), followed by stabilization through 2024. Pronounced disparities were observed: non-Hispanic Black women experienced the highest average AAMR (21.6), followed by non-Hispanic White (17.1) and American Indian/Alaska Native women (14.0). Regional and urban–rural heterogeneity was evident, with the Northeast and Midwest showing higher AAMRs and nonmetropolitan areas demonstrating persistently elevated rates; state-level burdens peaked in the District of Columbia and several Appalachian states. The 2018-2021 increase overlapped temporally with the COVID-19 pandemic; however, the present data do not permit causal attribution.

Conclusion: Although FGTC mortality declined through 2018, progress has since stalled. Persistent racial, geographic, and rural–urban inequities underscore the need for equity-focused interventions, such as reinforcing screening and vaccination programs, expanding access to specialty oncology care (including teleoncology and regional referral pathways), and prioritizing policies that mitigate social determinants driving excess mortality.

Keywords: Epidemiology, female genital tract cancers, CDC WONDER, United States.

Introduction

Female genital neoplasms are cancers that affect the female genital tract (FGT), including cervical, endometrial, and ovarian cancers, which have been estimated to account for approximately 40% of newly diagnosed cancers among women worldwide [1]. Female genital tract cancer (FGTC) can have a negative impact on patient quality of life with associated complications such as cervical insufficiency, sexual dysfunction, and psychological distress [2]. Moreover, late-stage disease is well recognized to be more aggressive and often results in life-threatening outcomes. As such, early diagnosis and treatment of FGTC are of great importance.

In 2025, an estimated 13,860 deaths are expected to occur from uterine cancers and 12,730 deaths from ovarian cancer, making these the leading causes of

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gynecologic cancer mortality in the United States [3,4]. Cervical cancer accounts for approximately 4,320 deaths annually, reflecting progress achieved through screening and HPV vaccination but still underscoring persistent disparities in access to preventive care [5]. Globally, cervical cancer remains the most commonly diagnosed cancer and the leading cause of cancer death in 23 and 36 countries, respectively [1]. In contrast, vulvar cancer contributes roughly 1,770 deaths per year, with a relatively stable mortality rate of 0.6 per 100,000 women [6]. The mortality rate for uterine cancers has been rising by about 1.5% annually over the past decade, while ovarian cancer continues to exhibit poor survival outcomes, with a 5-year relative survival rate of about 50% [3,4]. Collectively, these malignancies remain a significant contributor to female cancer mortality, which overall stands at approximately 145 deaths per 100,000 women per year across all cancer types in the United States [7].

Despite advances in screening, vaccination, and therapeutic strategies, no previous study has comprehensively evaluated long-term national mortality trends associated with FGTC in the United States. Much of the existing literature focuses on individual cancer types, regional registries, or limited time frames, leaving important gaps in understanding population-level patterns across all major gynecologic malignancies. To address this, the present study analyzes U.S. mortality data from 1999 to 2024, offering the first extensive assessment of geographic, demographic, and temporal variations in mortality from cancers of the female genital tract. In accordance with the TITAN Guideline (2025) for transparent use of AI in scholarly communication, no AI tools were used in the research design, data collection, analysis, or interpretation; AI assistance was limited solely to language refinement during manuscript preparation [8].

Methods

Study population and selection criteria

The Centers for Disease Control and Prevention (CDC) Wide-Ranging Online Data for Epidemiologic Research (WONDER) system provided the mortality data used in this population-based analysis [9,10]. The International Classification of Diseases, 10th Revision (ICD-10) codes C51–C58 were used to identify deaths among women from 1999 to 2024 in which a malignant neoplasm of the female genital organs was recorded on the death certificate. The dataset includes death certificate data from the Multiple Cause of Death Public Use Files for all 50 U.S. states and the District of Columbia. Deaths were included when FGTC was listed either as the underlying cause of death or as a contributing (multiple) cause of death; therefore, the analysis captures FGTC-related deaths rather than only deaths in which FGTC was the underlying cause. Each death was counted once, regardless of the number of FGTC codes listed. The standard CDC groupings for age at death ranged from less than 1 year to more than 85 years. Informed consent and institutional review board (IRB) approval were not necessary because all data were deidentified and made publicly available. For cross-sectional and trend analyses, the study was carried out in compliance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [11].

Data extraction

Place of death, population counts, and demographic, geographic, and temporal characteristics were among the variables taken from the CDC WONDER database. The places of death were classified as private homes, hospices, long-term care facilities, nursing homes, and hospitals. Age, race, and ethnicity were among the demographic factors; sex was not included because the analysis was restricted to female decedents. White, Black or African American, American Indian or Alaska Native, Asian or Pacific Islander, and Hispanic or Latino were the racial and ethnic categories. The National Center for Health Statistics (NCHS) Urban–Rural Classification Scheme was used to define urban–rural status. Based on 2013 U.S. census data, large metropolitan areas had populations of ≥1 million, medium/small metropolitan areas ranged from 50,000 to 999,999, and nonmetropolitan (rural) areas included counties with <50,000 residents [12]. According to U.S. Census Bureau guidelines, the United States was separated into four census regions: Northeast, Midwest, South, and West [13].

Statistical analysis

Crude mortality rates (CMRs) and age-adjusted mortality rates (AAMRs), both expressed per 100,000 female population, along with corresponding 95% confidence intervals (CIs), were used to assess mortality trends from 1999 to 2024. The 2000 U.S. standard population was used for age adjustment in order to enable reliable comparisons across years, demographic subgroups, and geographical areas [14]. The rates were categorized by urban/rural classification, census region or state, race/ethnicity, and year of death. Joinpoint regression modeling (Joinpoint Regression Program, Version 5.4.0; National Cancer Institute) [15], which finds statistically significant turning points in mortality trajectories, was used to examine temporal trends. For each subgroup, the annual percent change (APC) and associated 95% CIs were computed. Trends were considered statistically significant if $p < 0.05$ and the 95% CI excluded zero. All graphical and descriptive analyses were performed using Microsoft Excel.

Results

A total of 850,404 female deaths attributable to genital tract cancers were recorded in the United States from 1999 to 2024. All decedents were women (100%). Regarding place of death, 41.1% of deaths occurred at home (n = 349,778), followed by medical facilities (28.9%, n = 245,888), nursing homes or long-term care facilities (14.4%, n = 122,807), and hospice facilities (9.5%, n = 81,158) (Supplementary Tables 1 and 2).

Age-specific crude mortality rates increased markedly with advancing age. The lowest rate was observed

among women aged 15-24 years (0.2 per 100,000; 95% CI: 0.2-0.2), followed by 1.7 (95% CI: 1.6-1.7) among those aged 25-34 years and 5.8 (95% CI: 5.7-5.9) among women aged 35-44 years. Rates rose sharply thereafter, reaching 15.5 (95% CI: 15.4-15.6) in the 45-54-year group, 34.8 (95% CI: 34.6-35.1) in the 55-64-year group, and 64.7 (95% CI: 64.3-65.0) among those aged 65-74 years. The highest mortality burden occurred among the oldest women, with crude rates of 98.7 (95% CI: 98.1-99.2) for ages 75-84 years and 126.4 (95% CI: 125.5-127.3) for ages ≥85 years (Table 1).

Female

Between 1999 and 2024, the overall AAMR for FGTC was 10.6 per 100,000 population (95% CI: 10.5-10.7). From 1999 to 2018, mortality rates declined gradually from 10.5 (95% CI: 10.4-10.7) to 8.8 (95% CI: 8.7-8.8) per 100,000, reflecting a significant downward trend (APC: –1.35, 95% CI: –2.63 to –0.25, p = 0.0396). However, this trend reversed between 2018 and 2021, during which the AAMR nearly doubled from 8.8 (95% CI: 8.7-8.8) in 2018 to 16.8 (95% CI: 16.7-17.0) in 2021, indicating a sharp but statistically nonsignificant increase (APC: 23.52, 95% CI: –3.20 to 29.55, p = 0.0852). From 2021 to 2024, rates stabilized, with a slight decline from 16.8 (95% CI: 16.7-17.0) to 16.4 (95% CI: 16.3-16.6) per 100,000 (APC: 1.74, 95% CI: –9.65 to 10.61, p = 0.3799). These temporal patterns are illustrated in Figure 1 and detailed in Supplementary Tables 3 and 4.

Race and ethnicity

Between 1999 and 2024, pronounced racial and ethnic disparities were observed in AAMR for FGTC. Average mortality rates were highest among non-Hispanic (NH) Black women (21.6 per 100,000; 95% CI: 20.9-22.2), followed by NH White women (17.1; 95% CI: 16.8-17.3), NH American Indian/Alaska Native women (14.0; 95% CI: 11.7-16.3), Hispanic or Latino women (13.8; 95% CI: 13.2-14.4), and lowest among NH Asian or Pacific Islander women (10.8; 95% CI: 10.1-11.5).

Among NH White women, AAMRs declined steadily from 18.5 (95% CI: 18.2-18.7) in 1999 to 16.1 (15.9-16.3) in 2018, reflecting a significant long-term decrease from 1999–2014 (APC: –0.90, 95% CI: –1.12 to –0.75, p < 0.000001). Rates then stabilized, remaining near 16.2 (16.0-16.5) by 2024 (APC: –0.00, 95% CI: –0.29 to 0.58, p = 0.9698).

For NH Black women, AAMRs fell from 23.3 (22.5-24.1) in 1999 to 20.7 (20.0-21.4) in 2008, indicating a significant early decline (APC: –1.44, 95% CI: –2.25 to –0.63, p = 0.0308). However, this improvement plateaued and later reversed, with rates increasing modestly to 21.9 (21.4-22.5) in 2024 (APC: 0.71, 95% CI: 0.20 to 1.67, p = 0.0372).

NH Asian or Pacific Islander women consistently exhibited the lowest mortality burden, with AAMRs declining from 10.9 (9.9-11.9) in 1999 to 9.6 (9.0-10.2) in 2014 (APC: –0.58, 95% CI: –2.04 to –0.03, p = 0.0376), followed by a modest but significant rise to 11.5 (10.9-12.1) in 2024 (APC: 1.28, 95% CI: 0.56 to 3.38, p < 0.000001).

Among NH American Indian/Alaska Native women, mortality rates fluctuated widely over the study period, ranging from 11.2 (8.8-14.1) in 1999 to 12.5 (10.6-14.4) in 2024, without a statistically significant overall change (APC: –0.03, 95% CI: –0.72 to 0.76, p = 0.933).

Table 1. *Demographic characteristics of female genital tract cancer–related deaths in the United States, 1999-2024.*

Variable	Deaths	AAMRs / CMRs (95% CI) per 100,000
Women	*850404 (100%)*	*10.6(10.5–10.7)*
Types of cancer[a]		
External genital tract cancers	*46023*	*0.5 (0.5-0.6)*
Uterine cancers	*397640*	*4.4 (4.3-4.6)*
Ovarian and adnexal cancers	*411753*	*4.5 (4.5-4.5)*
Census region[a]		
Northeast	*172,249 (20.3%)*	*17.7(17.2–18.1)*
Midwest	*194,671 (22.9%)*	*17.6(17.2–18.0)*
South	*306,493 (36.0%)*	*16.7(16.3–17.0)*
West	*176,991 (20.8%)*	*16.5(16.1–17.0)*
Race/Ethnicity [a]		
American Indian or Alaska native	*4,132 (0.5%)*	*14.0(11.7–16.3)*
Asian or Pacific Islander	*24,512 (2.9%)*	*10.8(10.1–11.5)*
Black or African American	*111,629 (13.1%)*	*21.6(20.9–22.2)*
White	*645,478 (75.9%)*	*17.1(16.8–17.3)*
Hispanic or Latino	*62,099 (7.3%)*	*13.8(13.2–14.4)*
Urbanization[a]		
Metropolitan	*705,559 (83.0%)*	*17.0(16.8–17.2)*
Non-metropolitan	*144,845 (17.0%)*	*17.6(17.1–18.0)*
Age groups[b]		
15-24 years	*1,073 (0.1%)*	*0.2 (0.2-0.2)*
25-34 years	*8,982 (1.1%)*	*1.7 (1.6-1.7)*
35-44 years	*32,147 (3.8%)*	*5.8 (5.7-5.9)*
45-54 years	*85,484 (10.1%)*	*15.5 (15.4-15.6)*
55-64 years	*168,005 (19.8%)*	*34.8 (34.6-35.1)*
65-74 years	*223,583 (26.3%)*	*64.7 (64.3-65.0)*
75-84 years	*209,616 (24.7%)*	*98.7 (98.1-99.2)*
85+ years	*121,421 (14.3%)*	*126.4 (125.5-127.3)*
Place of death [c]		
Medical facility	*245,888 (28.9%)*	-
Decedent's home	*349,778 (41.1%)*	-
Hospice facility	*81,158 (9.5%)*	-
Nursing home/long-term care facility	*122,807 (14.4%)*	-

Note.

[a] Age-adjusted mortality rates (AAMRs) are utilized.

[b] Crude Mortality Rates (CMRs) are used for all age-specific analyses.

[c] Age-adjusted mortality rates (AAMRs) are not applicable to place of death.

For Hispanic or Latino women, rates declined from 14.1 (13.3-14.9) in 1999 to 13.0 (12.6-13.5) in 2018, representing a significant long-term reduction (APC: –0.63, 95% CI: –0.98 to –0.33, $p < 0.000001$). However, mortality subsequently increased to 14.6 (14.1-15.1) in 2024 (APC: 1.80, 95% CI: 0.91 to 4.09, $p = 0.0004$).

These racial and ethnic variations are illustrated in Figure 2 and summarized in Supplementary Tables 3 and 5.

Census region

Between 1999 and 2024, distinct regional variations were observed in FGTC mortality across the United States. The highest average AAMRs were recorded in the Northeast (17.7 per 100,000; 95% CI: 17.2-18.1) and Midwest (17.6; 95% CI: 17.2-18.0), followed by the South (16.7; 95% CI: 16.3-17.0) and West (16.5; 95% CI: 16.1-17.0).

In the Northeast, AAMRs declined steadily from 19.5 (95% CI: 19.0-19.9) in 1999 to 15.9 (95% CI: 15.5-16.3) in 2024, indicating a significant long-term reduction (APC: –0.83, 95% CI: –0.93 to –0.74, $p < 0.000001$).

In the Midwest, rates decreased significantly from 19.1 (95% CI: 18.6-19.5) in 1999 to 16.8 (95% CI: 16.4-17.2) in 2014 (APC: –0.93, 95% CI: –1.32 to –0.75, $p < 0.000001$), after which they stabilized through 2024 (APC: –0.04, 95% CI: –0.41 to 0.93, $p = 0.9286$).

In the South, mortality declined from 18.0 (95% CI: 17.6-18.4) in 1999 to 15.7 (95% CI: 15.4-16.0) in 2015, showing a significant downward trend (APC: –0.85, 95% CI: –1.16 to –0.66, $p < 0.000001$). However, this pattern reversed thereafter, with rates slightly increasing to 16.6 (95% CI: 16.3-16.9) in 2024 (APC: 0.59, 95% CI: 0.31 to 1.02, $p = 0.0008$).

In the West, rates decreased notably from 17.8 (95% CI: 17.3-18.3) in 1999 to 15.9 (95% CI: 15.5-16.3) in 2011 (APC: –1.11, 95% CI: –1.45 to –0.87, $p < 0.000001$), followed by a prolonged period of stability through 2024 (APC: 0.03, 95% CI: –0.21 to 0.38, $p = 0.775$).

Overall, while mortality rates declined across all regions over the 26-year period, the Northeast and Midwest had the highest average levels of FGTC mortality, whereas the West had the lowest average AAMR. These regional trends are illustrated in Figure 3 and detailed in Supplementary Tables 3 and 6.

Urbanization

Across the study period (1999-2024), women residing in nonmetropolitan areas consistently exhibited slightly higher AAMRs from genital tract cancers compared with those in metropolitan regions. The overall AAMR was 17.6 (95% CI: 17.1-18.0) deaths per 100,000 in nonmetropolitan areas versus 17.0 (95% CI: 16.8-17.2) in metropolitan areas.

From 1999 to 2009, mortality rates in metropolitan areas declined significantly from 18.5 (95% CI: 18.3-18.7) to 16.7 (95% CI: 16.5-16.9) (APC: –1.08, 95% CI: –1.81 to –0.88, $p = 0.0096$). Between 2009 and 2019, the decline slowed and became statistically nonsignificant (APC: –0.54, 95% CI: –0.82 to 0.04, $p = 0.0612$), followed by a significant rebound increase from 2019 to 2024 (APC: 0.97, 95% CI: 0.36 to 2.46, $p = 0.0092$).

In contrast, nonmetropolitan areas demonstrated a significant decline in mortality from 1999 to 2012 (APC: –0.93, 95% CI: –1.81 to –0.57, $p = 0.0012$), after which the trend plateaued (APC: 0.12, 95% CI: –0.21 to 1.02, $p = 0.4115$). By 2024, AAMRs reached 17.2 (95% CI: 17.0-17.5) in nonmetropolitan and 16.7 (95% CI: 16.3-16.9) in metropolitan areas, reflecting a persistent yet narrowing rural–urban mortality gap (Figure 4, Supplementary Tables 3 and 7).

State

Substantial geographic variation in AAMR for FGTC was observed across U.S. states. The highest AAMRs were reported in the District of Columbia (21.7, 95% CI: 20.5-23.0), West Virginia (19.2, 95% CI: 18.6-19.8), Delaware (18.1, 95% CI: 17.1-18.9), Pennsylvania (18.3, 95% CI: 18.1-18.6), and Indiana (18.3, 95% CI: 18.0-18.7). In contrast, the lowest AAMRs were observed in Alaska (13.8, 95% CI: 12.7-15.0), Hawaii (13.8, 95% CI: 13.2-14.5), Arizona (15.0, 95% CI: 14.6-15.3), Utah (15.0, 95% CI: 14.4-15.6), and Nevada (15.3, 95% CI: 14.8-15.9). State-level variation is illustrated in Figure 5 and detailed in Supplementary Table 8.

Discussion

Significant demographic, geographic, and temporal differences in FGTC mortality were found in this nationwide analysis of U.S. mortality data from 1999 to 2024. A total of 850,404 FGTC-related deaths were recorded, and mortality rates increased markedly with age. While the overall AAMR decreased gradually until 2018, there was a marked, although statistically nonsignificant, increase from 2018 to 2021, after which it stabilized until 2024. NH Black women and those living in nonmetropolitan areas had the highest mortality rates, indicating persistent racial, regional, and urban–rural disparities. There was also significant state-level variation, with the highest mortality burdens found in the District of Columbia and a number of Appalachian states. Overall, despite earlier declines, progress in reducing FGTC mortality has plateaued in recent years, with persistent inequities across population subgroups (Figure 6).

FGTC mortality declined through 2018. Although our data cannot establish the reasons for this decline, it coincided with advances in screening, targeted therapy, and surgical technique during this period. A noticeable shift toward surgical de-escalation, with an emphasis on less drastic and more customized procedures, took place in the early 2010s. The LAP2 trial's results supported a wider shift toward less invasive procedures by showing that laparoscopic surgical staging for early-stage endometrial cancer was a safe and efficient substitute for open surgery [16]. Sentinel lymph node mapping for cervical, endometrial, and vulvar cancers became widely used during this time as well, successfully lowering the need for extensive lymphadenectomy and the morbidity that goes along with it. Concurrently, the development

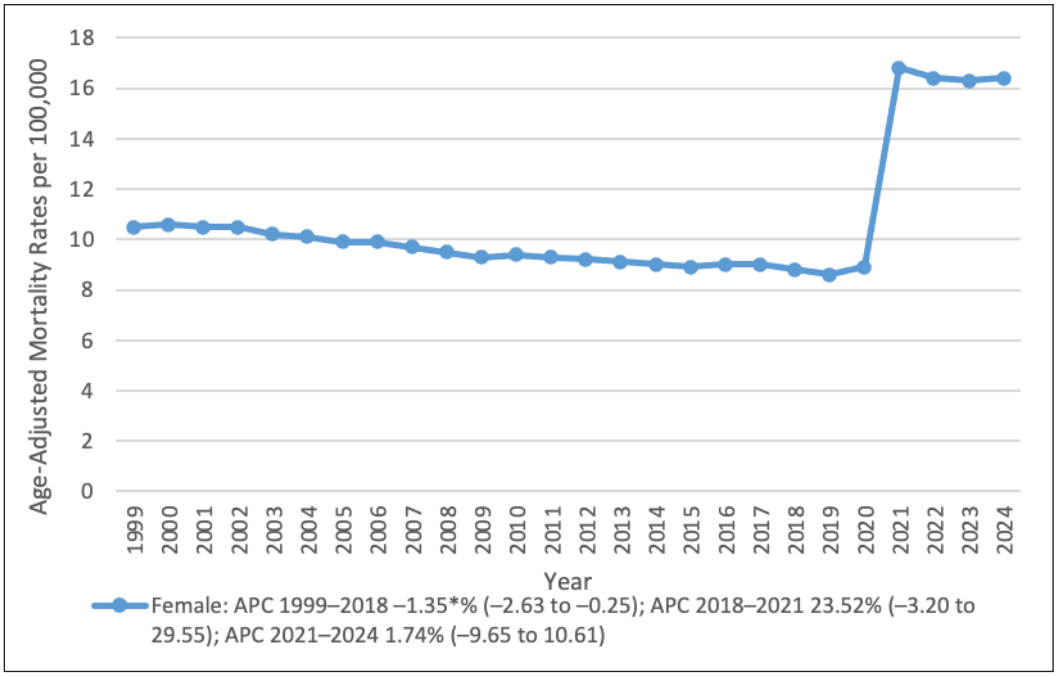


Figure 1. *Age-adjusted mortality rates (AAMRs) for female genital tract cancers in the United States, 1999–2024.*

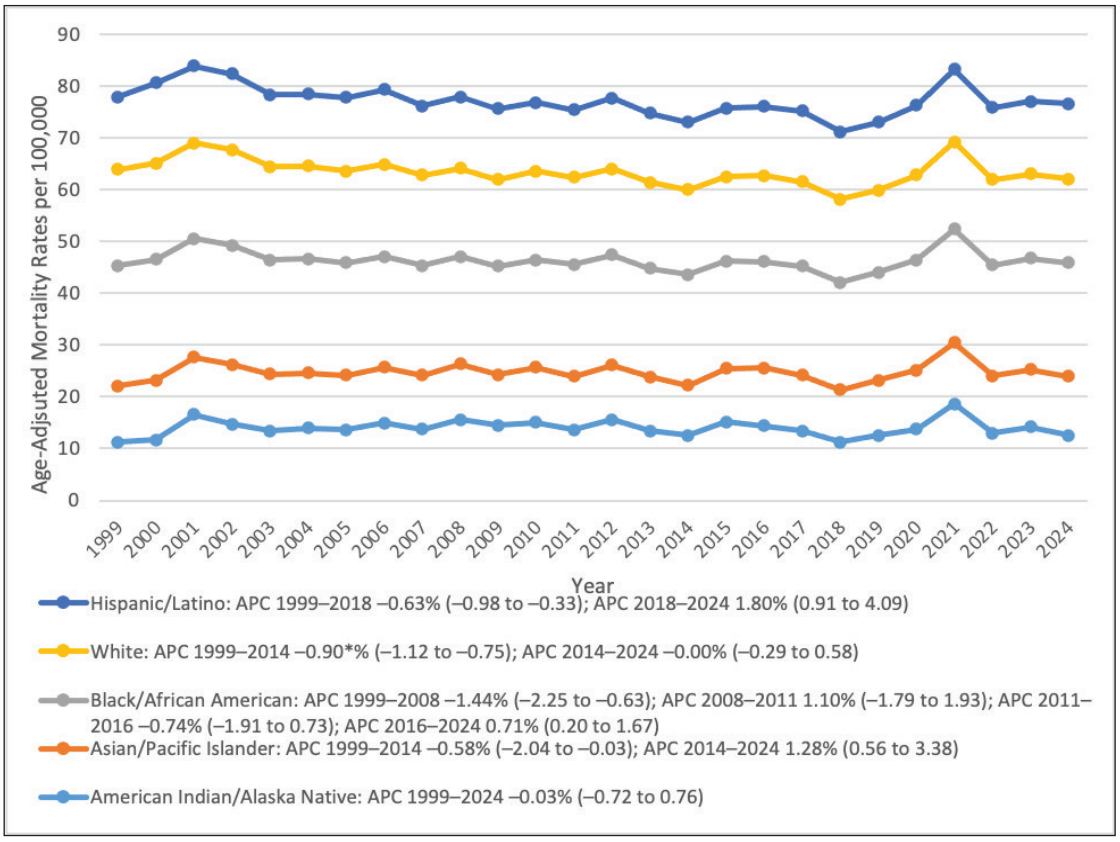


Figure 2. *AAMRs for female genital tract cancers in the United States, 1999-2024, stratified by race/ethnicity.*

of targeted treatments, such as bevacizumab, an antiangiogenic drug authorized in 2014 for platinum-resistant recurrent ovarian cancer, provided better results with less toxicity [17]. Screening and risk-assessment techniques also improved: combined HPV testing and cytology enhanced the detection of cervical cancer, and algorithms such as the Risk of Ovarian Cancer Algorithm showed promise for early detection [18,19].

The COVID-19 pandemic has been associated with reported delays in the diagnosis, treatment, and follow-

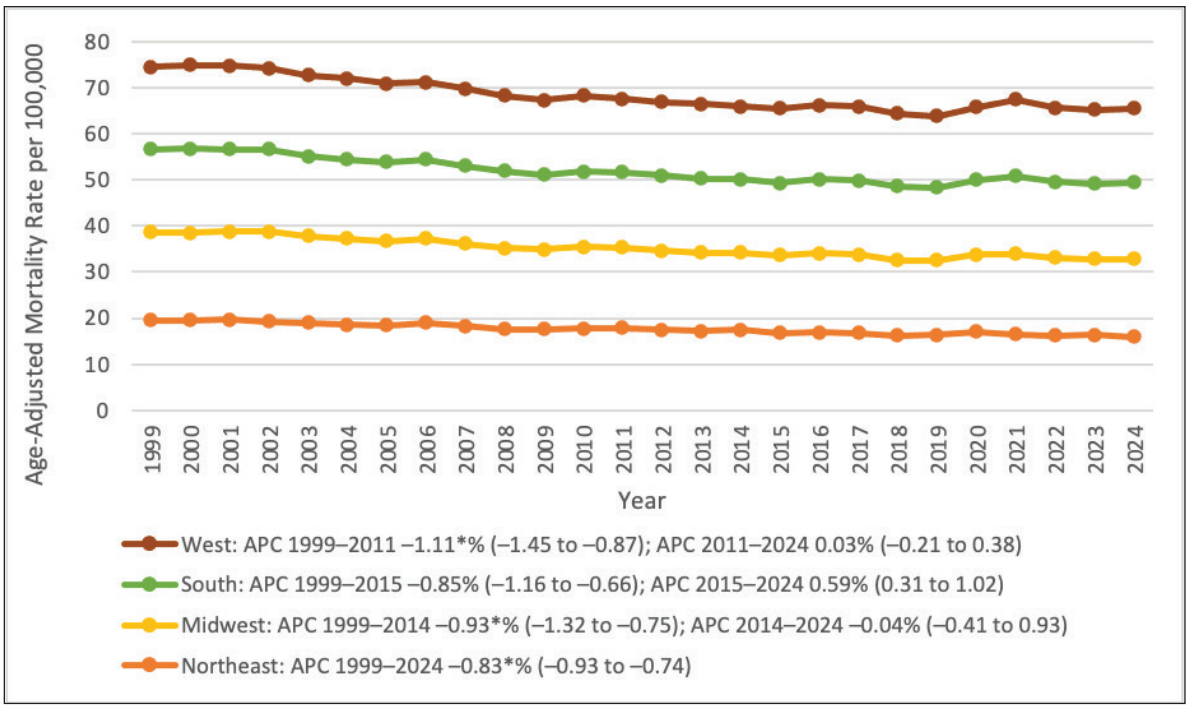


Figure 3. *AAMRs for female genital tract cancers in the United States, 1999-2024, stratified by census region.*

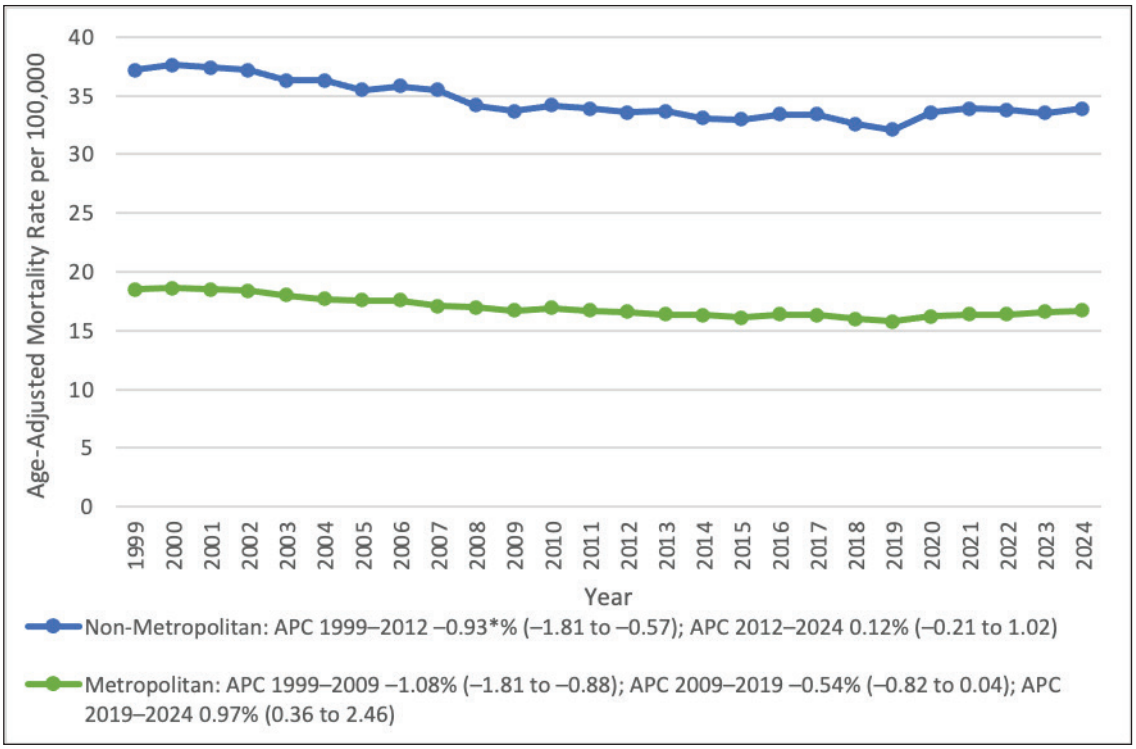


Figure 4. *AAMRs for female genital tract cancers in the United States, 1999-2024, stratified by urbanization.*

up care of patients with FGTC. Previous studies suggest that, beyond COVID-19 infection itself, disruptions in cancer treatment and the reallocation of medical resources to the pandemic response may have contributed to excess mortality among patients with cancer [20,21]. In our analysis, the increase in FGTC-related mortality overlapped temporally with the pandemic period; however, because death certificate data do not capture treatment delays, stage at diagnosis, or individual-level COVID-19 infection, this association should not be interpreted as causal. Strengthening healthcare resilience, guaranteeing oncologic care continuity, and resolving the backlog in screening and surgical services are important to sustain the progress made before 2020 [22].

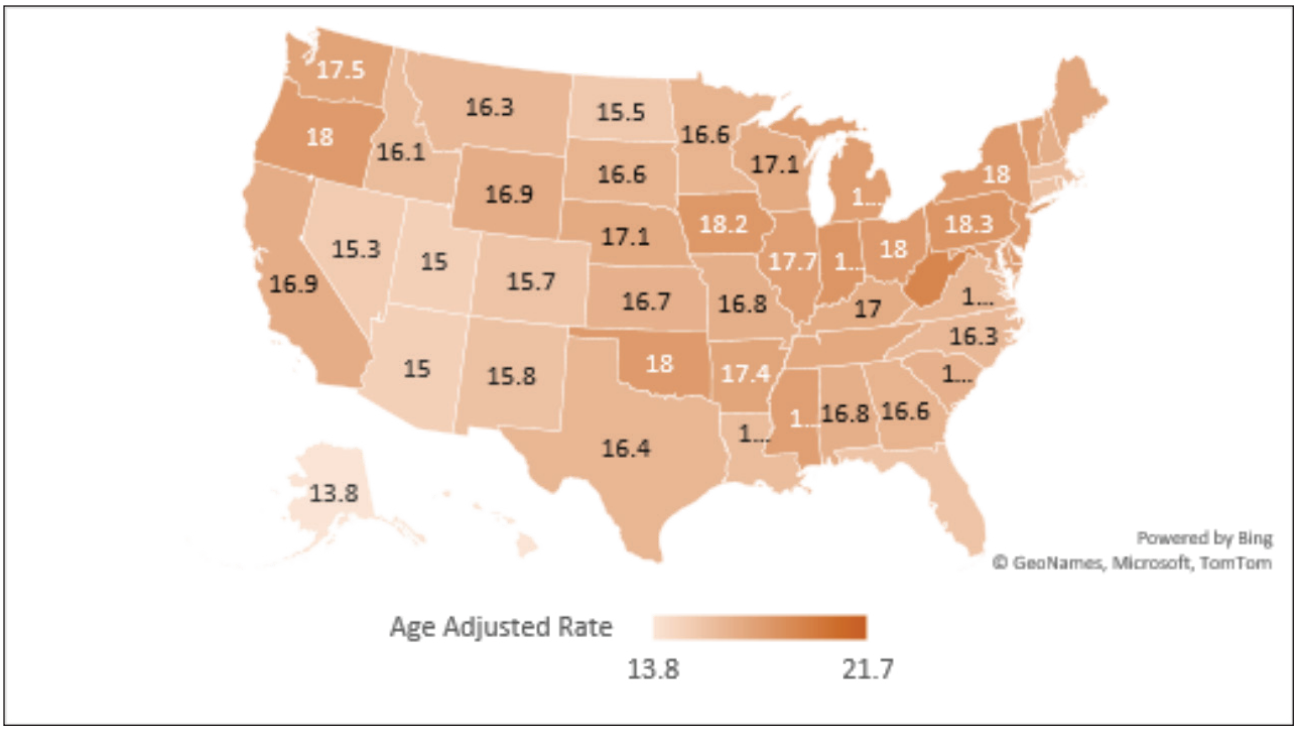


Figure 5. *AAMRs for female genital tract cancers in the United States, 1999-2024, stratified by state.*

In the United States, there are still notable racial and ethnic differences in the mortality rate of FGTC, especially between NH Black and NH White women. Differences in cervical and uterine cancer outcomes, where NH Black and NH American Indian or Alaska Native women have disproportionately higher mortality rates, are a major contributing factor to the observed mortality gap. Previous studies have reported that this gap widened during the COVID-19 pandemic [23]. Younger age at diagnosis, a higher chance of presenting with localized disease, and a higher prevalence of ovarian cancer subtypes linked to favorable prognoses could all contribute to NH Asian women's low mortality rate [24]. On the other hand, compared to their White counterparts, NH Black women with ovarian cancer typically have a higher burden of comorbidities at the start of treatment and a worse overall survival [25,26].

Remarkably, the mortality difference between NH Black and NH White women decreased during the pandemic, mostly as a result of a dramatic drop in the incidence of ovarian cancer in NH White women [27]. In addition to having a higher diagnosis rate of aggressive, non-endometrioid histologic subtypes, NH Black women are still twice as likely as NH White women to die from uterine corpus cancer [28]. The 5-year survival gap - 64% for NH Black women versus 86% for NH White women - and more general data indicating that NH Black Americans have a 33% higher risk of dying from cancer overall, which reflects ongoing disparities in treatment quality and access to healthcare, further highlight this racial disparity [29].

The literature indicates distinct census region patterns in FGTC mortality, with women in Southern states consistently having higher death rates from cervical, endometrial, and ovarian cancers than those in the Northeast and West [30]. In contrast, we found broadly similar mortality rates across census regions. Previous studies suggest that racial and ethnic disparities amplify regional gaps, which persist after age adjustment. The mortality rate is higher for Black and American Indian/ Alaska Native women in many high-mortality areas [31]. Many of the regional differences can be explained by structural factors, such as lower screening coverage, less access to gynecologic oncology specialists, lower Medicaid expansion rates, and higher socioeconomic deprivation [32,33]. Policy levers to reduce these disparities include expanding Medicaid and screening programs, improving rural oncology workforce and referral networks, and targeted public health interventions in high-mortality census regions [34].

In the United States, rural–urban disparities have a major impact on the outcomes of FGTC, with rural women experiencing higher incidence and mortality rates for the majority of cancer types [35]. Rural populations experience delayed detection of cervical cancer due to a number of obstacles, including lower HPV vaccination coverage, fewer colposcopy services, and restricted access to Pap and HPV screening programs [36]. Due to factors such as delayed symptom recognition, longer travel times to gynecologic oncologists, and fewer high-volume surgical centers - all of which are associated with suboptimal cytoreductive surgery and a lower survival rate - ovarian cancer outcomes are worse in rural areas [37]. Due in part to delayed specialist referrals, lack of knowledge about abnormal uterine bleeding, and restricted access to diagnostic imaging, endometrial cancer frequently manifests in rural women at an advanced stage [38,39]. These disparities are made worse

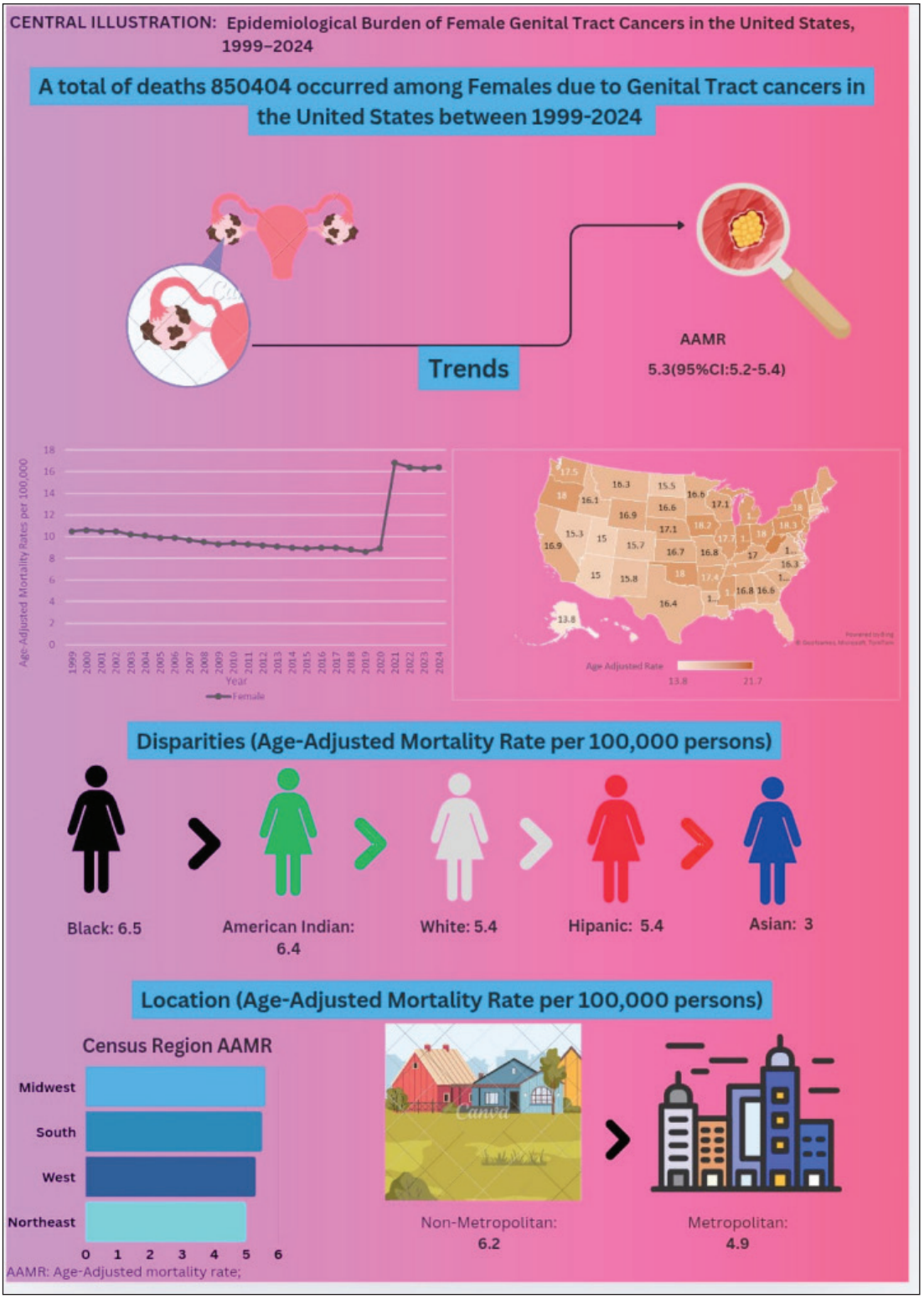


Figure 6. *Central illustration: demographic characteristics of female genital tract cancer mortality in the United States, 1999-2024.*

by structural factors such as a lack of healthcare workers, transportation issues, inadequate insurance coverage, and socioeconomic deprivation. Targeted interventions, such as regional referral networks, teleoncology services, and mobile screening units, are crucial to reducing mortality gaps by enhancing rural communities' access to prompt, evidence-based care.

Limitations

This study has several limitations. First, as an analysis of population-level data from the CDC WONDER database, it relies on death certificate data, which may be subject to underreporting or misclassification of specific gynecologic cancer subtypes. Second, the database does not include comprehensive clinical variables like

socioeconomic status, stage at diagnosis, or treatment modality, which makes it more difficult to account for confounding variables. Third, variations in reporting accuracy or coding standards over time may have affected temporal trends. Fourth, because deaths were identified when FGTC was listed as either the underlying or a contributing cause, our estimates reflect FGTC-related mortality rather than deaths caused exclusively by FGTC. Finally, given the descriptive, population-level design, the observed trends cannot be causally attributed to specific factors such as the COVID-19 pandemic or changes in screening and treatment. Notwithstanding these limitations [40], CDC WONDER provides comprehensive, nationally representative mortality data that enable a detailed evaluation of regional and demographic differences in FGTC.

Conclusion

In conclusion, this analysis shows both notable advancements and ongoing difficulties in lowering the death rate from FGTC in the United States. Despite advances in targeted therapies, screening technologies, and minimally invasive surgery, persistent racial, geographic, and socioeconomic disparities still impede equitable outcomes. Earlier gains have stalled in recent years, and the reasons for this warrant further investigation. To maintain long-term mortality reductions and guarantee that progress benefits all populations, it is imperative to strengthen healthcare access, enhance early detection, and put equity-focused policies into place.

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List of Abbreviations

AAMRs	Age-adjusted mortality rates
APC	Annual percent change
CDC	Centers for Disease Control and Prevention
CIs	Confidence intervals
CMRs	Crude mortality rates
FGT	Female genital tract
FGTC	Female genital tract cancer
NCHS	National Center for Health Statistics
NH	Non-Hispanic
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
WONDER	Wide-Ranging Online Data for Epidemiologic Research

Conflict of interest
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Supplementary content, if any, is available online.

REFERENCES

1. Ferlay J, Colombet M, Soerjomataram I, Dyba T, Randi G, Bettio M, et al. Cancer incidence and mortality patterns in Europe: estimates for 40 countries and 25 major cancers in 2018. Eur J Cancer. 2018;103:356–87. https://doi.org/10.1016/j.ejca.2018.07.005
2. Membrilla-Beltran L, Cardona D, Camara-Roca L, Aparicio-Mota A, Roman P, Rueda-Ruzafa L. Impact of cervical cancer on quality of life and sexuality in female survivors. Int J Environ Res Public Health. 2023;20(4):3751. https://doi.org/10.3390/ijerph20043751
3. Giaquinto AN, Miller KD, Tossas KY, Winn RA, Jemal A, Siegel RL. Cancer statistics for African American/Black people 2022. CA Cancer J Clin. 2022;72(3):202–29. https://doi.org/10.3322/caac.21718
4. Ovarian Cancer | American Cancer Society [Internet]. [cited 2025 Oct 31]. Available from: https://www.cancer.org/cancer/types/ovarian-cancer.html
5. Gopalkrishnan K, Karim R. Addressing global disparities in cervical cancer burden: a narrative review of emerging strategies. Curr HIV/AIDS Rep. 2025;22(1):18. https://doi.org/10.1007/s11904-025-00727-2
6. Key Statistics for Vulvar Cancer | American Cancer Society [Internet]. [cited 2025 Oct 31]. Available from: https://www.cancer.org/cancer/types/vulvar-cancer/about/key-statistics.html
7. Siegel RL, Kratzer TB, Giaquinto AN, Sung H, Jemal A. Cancer statistics, 2025. CA Cancer J Clin. 2025;75(1):10–45. https://doi.org/10.3322/caac.21871

8. Agha RA, Mathew G, Rashid R, Kerwan A, Al-Jabir A, Sohrabi C, et al. Transparency in the reporting of artificial intelligence-the TITAN guideline. Rev Premier J Sci. https://doi.org/10.70389/PJS.100082

9. Multiple cause of death data on CDC WONDER [Internet]. [cited 2025 Oct 31]. Available from: https://wonder.cdc.gov/mcd.html

10. Kumar S, Zulfiqar R, Khan S, Malik W, Rehman A, Arshia F, et al. Twenty-six-year trends in U.S. mortality among older adults with coexisting chronic kidney disease and atrial fibrillation/flutter. Ann Med Surg (Lond). 2026;88(6):3325–34. https://doi.org/10.1097/MS9.0000000000004960

11. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol. 2008;61(4):344–9. https://doi.org/10.1016/j.jclinepi.2007.11.008

12. Aggarwal R, Chiu N, Loccoh EC, Kazi DS, Yeh RW, Wadhera RK. Rural-urban disparities: diabetes, hypertension, heart disease, and stroke mortality among black and white adults, 1999–2018. J Am Coll Cardiol. 2021;77(11):1480–1. https://doi.org/10.1016/j.jacc.2021.01.032

13. Center for Health Statistics N. 2013 NCHS urban-rural classification scheme for counties series 2. 2013;166

14. Sorlie PD, Thom TJ, Manolio T, Rosenberg HM, Anderson RN, Burke GL. Age-adjusted death rates: consequences of the Year 2000 standard. Ann Epidemiol. 1999;9(2):93–100. https://doi.org/10.1016/S1047-2797(98)00061-1

15. Joinpoint regression program [Internet]. [cited 2025 Oct 31]. Available from: https://surveillance.cancer.gov/joinpoint/

16. Walker JL, Piedmonte MR, Spirtos NM, Eisenkop SM, Schlaerth JB, Mannel RS, et al. Recurrence and survival after random assignment to laparoscopy versus laparotomy for comprehensive surgical staging of uterine cancer: gynecologic oncology group LAP2 study. J Clin Oncol. 2012;30(7):695–700. https://doi.org/10.1200/JCO.2011.38.8645

17. Vilches JC, Santía MC, Yates EM, Pareja R, Lozano M, Ramirez PT. Notable surgical trials in gynecologic oncology: a 10-year overview. Int J Gynecol Cancer. 2024;34(8):1273–82. https://doi.org/10.1136/ijgc-2024-005471

18. Eun TJ, Perkins RB. Screening for cervical cancer. Med Clin North Am. 2020;104(6):1063–78. https://doi.org/10.1016/j.mcna.2020.08.006

19. Charkhchi P, Cybulski C, Gronwald J, Wong FO, Narod SA, Akbari MR. CA125 and ovarian cancer: a comprehensive review. Cancers (Basel). 2020;12(12):3730. https://doi.org/10.3390/cancers12123730

20. Lara OD, Smith M, Wang Y, O'Cearbhaill RE, Blank SV, Kolev V, et al. COVID-19 outcomes of patients with gynecologic cancer in New York City: an updated analysis from the initial surge of the pandemic. Gynecol Oncol. 2022 Feb;164(2):304–10. https://doi.org/10.1016/j.ygyno.2021.12.004

21. Henley SJ, Dowling NF, Ahmad FB, Ellington TD, Wu M, Richardson LC. COVID-19 and other underlying causes of cancer deaths - United States, January 2018-July 2022. MMWR Morb Mortal Wkly Rep. 2022;71(50):1583–8. https://doi.org/10.15585/mmwr.mm7150a3

22. Alyahya A, Albegamy Y, Albalawi MA, Elkarouri A, Alanazi S, Alshehri L, et al. Trends in mortality from high-risk surgical procedures: national burden of transplants, implants, and organ removal from 1999 to 2024 in United States. Am J Surg. 2026;254:116825. https://doi.org/10.1016/j.amjsurg.2026.116825

23. Jambunathan B, Lang J, Mays M, Ekwenna O. Quantifying mortality burden in patients with cancer due to COVID-19 in the US: A national cross-sectional analysis. Cancer Med. 2023;12(16):17413–7. https://doi.org/10.1002/cam4.6364

24. Karia PS, Tehranifar P, Visvanathan K, Wright JD, Genkinger JM. Cancer-specific mortality in asian american women diagnosed with gynecologic cancer: a nationwide population-based analysis. Cancer Epidemiol Biomarkers Prev. 2022;31(3):578–87. https://doi.org/10.1158/1055-9965.EPI-21-0829

25. Taylor JS, He W, Harrison R, Zhao H, Sun CC, Lu KH, et al. Disparities in treatment and survival among elderly ovarian cancer patients. Gynecol Oncol. 2018;151(2):269–74. https://doi.org/10.1016/j.ygyno.2018.08.041

26. Kumar L, Ali T, Iqbal F, Ahmed M, Azeem B. Unveiling trends in urinary tract cancer mortality among older adults in the United States (1999–2022): a CDC WONDER perspective. Int Urol Nephrol. 2025;57(10):3151–61. https://doi.org/10.1007/s11255-025-04490-6

27. Xi Y, Guo Y, Qiu S, Lv F, Deng Y, Xie J, et al. Trends in gynaecologic cancer mortality and the impact of the COVID-19 pandemic in the United States. Infect Agent Cancer. 2024;19(1):4. https://doi.org/10.1186/s13027-024-00567-6

28. Cote ML, Ruterbusch JJ, Olson SH, Lu K, Ali-Fehmi R. The growing burden of endometrial cancer: A major racial disparity affecting black women. Cancer Epidemiol Biomarkers Prev. 2015;24(9):1407–15. https://doi.org/10.1158/1055-9965.EPI-15-0316

29. Shavers VL, Brown ML. Racial and ethnic disparities in the receipt of cancer treatment. J Natl Cancer Inst. 2002;94(5):334–57. https://doi.org/10.1093/jnci/94.5.334

30. Ovarian Cancer - Cancer Stat Facts [Internet]. [cited 2025 Oct 31]. Available from: https://seer.cancer.gov/statfacts/html/ovary.html

31. Collins Y, Holcomb K, Chapman-Davis E, Khabele D, Farley JH. Gynecologic cancer disparities: a report from the health disparities taskforce of the society of gynecologic oncology. Gynecol Oncol. 2014;133(2):353–61. https://doi.org/10.1016/j.ygyno.2013.12.039

32. Alarid-Escudero F, Gracia V, Wolf M, Zhao R, Easterly CW, Kim JJ, et al. State-level disparities in cervical cancer prevention and outcomes in the U.S.: a modeling study. medRxiv. 2024 Jun 12. https://doi.org/10.1101/2024.06.11.24308795

33. Raja A, Raja S, Amin S. Bin, Salman M, Azeem B, Kumar L. Temporal trends in hypertension related end stage renal disease mortality rates: an analysis of gender, race/ethnicity, and geographic disparities in the United States. Front Nephrol. 2024;3. https://doi.org/10.3389/fneph.2023.1339312

34. Lent AB, Derksen D, Jacobs ET, Barraza L, Calhoun EA. Policy Recommendations for improving rural cancer services in the United States. JCO Oncol Pract. 2023;19(5):288–94. https://doi.org/10.1200/OP.22.00704

35. Lee NK, Tiro JA, Odunsi K. Disparities in gynecologic cancers. Cancer J. 2023;29(6):343–53. https://doi.org/10.1097/PPO.0000000000000678

36. (PDF) Barriers to cervical cancer awareness in rural communities [Internet]. [cited 2025 Oct 31]. Available from: https://www.researchgate.net/publication/391497557_Barriers_to_Cervical_Cancer_Awareness_in_Rural_Communities

37. Ulmer KK, Greteman B, Cardillo N, Schneider A, McDonald M, Bender D, et al. Disparity of ovarian cancer survival between urban and rural settings. Int J Gynecol Cancer. 2022;32(4):540–6. https://doi.org/10.1136/ijgc-2021-003096

38. Farzaneh F, Jafari Ashtiani A, Hashemi M, Hosseini MS, Arab M, Ashrafganjoei T, et al. Endometrial cancer in women with abnormal uterine bleeding: data mining classification methods. Caspian J Intern Med. 2023;14(3):526–33.

39. Rani S, Kumar L, Ali SM, Ashraf S, Bhimani S, Kumar S, et al. Trends in United States mortality among patients with atrial fibrillation/flutter related heart failure (1999-2024): disparities by gender, race/ethnicity and region. BMC Cardiovasc Disord. 2025;25(1):558. https://doi.org/10.1186/s12872-025-05036-5

40. Mahmood A, Latif F, Latif S, Smith DN, Ayalew BD, Raja A, et al. Heart failure and tobacco use disorder: mortality trends and disparities in the United States. Ann Med Surg (Lond). 2026;88(2):1639–47. https://doi.org/10.1097/MS9.0000000000004729