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Cervical cancer incidence and trends among women aged 15–29 years by county-level economic status and rurality – United States, 2007–2020

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Abstract

Introduction: Variations in cervical cancer incidence rates and trends have been reported by sociodemographic characteristics. However, research on economic characteristics is limited especially among younger women in the United States.

Methods: We analyzed United States Cancer Statistics data to examine age-standardized cervical cancer incidence rates among women aged 15–29 years during 2007–2020. We used an index-based county-level economic classification to rank counties in the top 25 %, middle 25 %–75 %, and bottom 25 %. We assessed differences in incidence using rate ratios and trends using annual percent changes (APCs) from joinpoint regression. Due to impact from the COVID-19 pandemic, trend analysis excluded 2020 data. Analyses were conducted during August–October 2023.

Results: During 2007–2020, incidence rates were lower in the top 25 % counties economically than the bottom 25 % or middle 25 %–75 % (1.6 vs 2.1 vs 1.9 per 100,000, respectively). Rates were higher in nonmetropolitan than metropolitan counties across economic groups. Overall, rates declined in all county-level economic strata, especially in the bottom 25 % during 2015–2019 (APC –10.6 %). Rates appeared to decrease in metropolitan counties and women of all races across economic categories. decreases were most evident in the top 25 % of non-Hispanic White women during 2016–2019 and nonmetropolitan counties during 2017–2019.

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Sameer V. Gopalani: Writing – review & editing, Methodology, Formal analysis. **Virginia Senkomago:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization. **Radhika Agarwal:** Writing – original draft, Methodology, Formal analysis, Conceptualization. **Jessica B. King:** Writing – review & editing, Methodology, Formal analysis.

Declaration of competing interest

The authors report no conflict of interest. The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Conclusions: In women aged 15–29 years, declining rates of cervical cancer during 2007–2019 across county-level economic strata may partly reflect effects of human papillomavirus vaccination and cervical cancer screening. Further observed differences by race and rurality may help inform efforts to increase implementation of preventive measures in populations with the highest burden.

Keywords

Cervical cancer; HPV vaccination; Cervical cancer screening; Cervical cancer incidence; Cervical cancer trends

1. Introduction

Variations in cervical cancer incidence rates and trends have been reported by race and ethnicity [1,2], rural-urban status [3,4], and county-level income and socioeconomic status [5–7]. These differences are less characterized among women who may have received the human papillomavirus (HPV) vaccination during childhood and cervical cancer screening beginning at 21 years old. Focusing on this population could inform whether disparities in incidence persist despite the availability of many preventive measures. Here we assessed cervical cancer incidence rates and trends by county-level economic status and other sociodemographic characteristics among U.S. women aged 15–29 years during 2007–2020.

2. Methods

2.1. Data source

We analyzed incidence data from the U.S. Cancer Statistics database, which combines population-based cancer registry data from the Centers for Disease Control and Prevention's (CDC) National Program of Cancer Registries and the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) Program [8]. During 2007–2020, 49 registries met publication criteria (excluding Indiana, Nevada). Three additional registries (Kansas, Minnesota, Virginia) were excluded due to unpublished county data. Our analytic dataset covers 91.8 % of the U.S. population.

2.2. Cancer definition

Histologically confirmed cases of invasive cervical cancer were defined using the International Classification of Diseases for Oncology, Third Edition (ICD-O-3) site (C53.0–C53.9) and histology (8010–8671, 8940–8941) codes. ICD-O-3 histology codes were used to define cervical squamous cell carcinoma (SCC(8050–8084) and adenocarcinoma (AC) (8140–8575).

2.3. Measures

Incidence rates and trends were analyzed by county-level economic status, rural-urban county classification, and individual-level age, race and ethnicity, disease stage, and histology. An index-based county economic classification from the Appalachian Regional Commission (ARC) [9] was used to rank each county in bottom 25 % (distressed, at-risk), middle 25 %–75 %, and top 25 % (competitive, attainment) strata. Rural-Urban Continuum

codes [9] were used to classify counties as metropolitan (codes 1–3) or nonmetropolitan (4–9).

2.4. Statistical analysis

Age-standardized incidence rates were calculated for women aged 15–29 years per 100,000. Either rate ratios (RR) or chi-square tests were used to assess differences across county-level economic status. Incidence rate trends were calculated using joinpoint regression and quantified using annual percent change (APC); a maximum of two joinpoint (three line segments) were allowed. The weighted Bayesian information criterion method was used for model selection, and the empirical quantile method was used to calculate 95 % confidence interval (CI) for APC. Statistical significance was $p < 0.05$. Rates for 2020 were excluded from trend calculations due to reduced diagnoses during the COVID-19 pandemic [10].

Data were analyzed from August to October 2023. Rates were calculated using SEER*Stat software (version 8.4.2) [11]. Trends were calculated using Joinpoint Regression Program (version 5.0.2) [12]. This study did not require institutional review board approval; it involved secondary analyses of publicly available, deidentified data.

3. Results

3.1. Incidence rates

During 2007–2020, 7997 cases of cervical cancer were reported among women aged 15–29 years (Table 1). Incidence was lower in counties ranked in the top 25 % economically (1.6 per 100,000, 95 % CI: 1.5, 1.7) than those ranked middle 25 %–75 % (1.9, 95 % CI: 1.9, 2.0) or bottom 25 % (2.1, 95 % CI: 2.0, 2.3). Compared to non-Hispanic White women, incidence rates were lower among non-Hispanic Black women in the top 25 % (RR: 0.8, 95 % CI: 0.7, 0.9), middle 25 %–75 % (RR: 0.9, 95 % CI: 0.8, 1.0), and bottom 25 % (RR: 0.8, 95 % CI: 0.6, 0.9) and among non-Hispanic Asian or Pacific Islander women (RR: 0.4 for all three economic strata). Women in nonmetropolitan counties had higher incidence rates compared to women in metropolitan counties in all county-level economic strata. As county-level economic status decreased, the proportion of cases diagnosed at localized stage slightly decreased and those diagnosed at later stage slightly increased (Appendix Tables 1–2).

3.2. Incidence rate trends

Cervical cancer incidence rates decreased during 2007–2019 in the top 25 % (APC: –2.8, 95 % CI: –4.7, –1.3) and middle 25 %–75 % (APC: –2.9, 95 % CI: –4.3, –1.4) groups. Incidence decreased steeply during 2015–2019 in the bottom 25 % (APC: –10.6 [95 % CI: –32.1, –2.6]) but modest decreases were noted during 2007–2015 (–1.1 [95 % CI: –5.0, 18.4]) (Fig. 1, Table 2).

Incidence rates decreased among women aged 15–24 years in the top 25 % (APC: –7.8, 95 % CI: –15.1, –2.7) and middle 25 %–75 % (APC: –8.0, 95 % CI: –10.5, –5.6) (trends were not assessed in the bottom 25 % because of low case counts). Among women in nonmetropolitan counties, rates decreased in counties ranked top 25 % during 2017–2019

(APC: -24.1, 95 % CI: -39.6, -3.6) and bottom 25 % (APC: -6.0, 95 % CI: -11.5, -0.7). Rates appeared to decrease in metropolitan counties and among women of all races in each economic category; the decrease was most evident in non-Hispanic White women and nonmetropolitan counties in the top 25 % during 2016–2019 and 2017–2019, respectively.

4. Discussion

In this assessment of cervical cancer incidence rates and trends among younger women age 15–29 years by county-level economic status, rates were higher in the bottom 25 % of counties economically. Incidence rates decreased among counties ranked in the top 25 % and middle 25 %–75 % during the study period and, more recently, among counties in the bottom 25 %. The decline in incidence rates among the youngest women is encouraging and aligns with previous research [13]. As HPV vaccination coverage increases among adolescents [14] and young adults [15], cervical cancer incidence is expected to decline.

In a recent study using 22 SEER registries, cervical cancer incidence rates plateaued during 2006–2019 among women in the lowest quartile of household income [7]. Our results indicate a sharp decline during 2015–2019 in the lower 25 % of counties per the ARC index. This decline was greater in nonmetropolitan counties versus metropolitan counties in the bottom 25 % category. Using an alternate classification of county-level rurality, the 2020 National Immunization Survey-Teen found that adolescents from households with incomes under the poverty level in nonmetropolitan statistical areas had higher HPV vaccine initiation and completion than adolescents from households with incomes above the poverty level [16]. This may be due to increased vaccine uptake in lower economic status rural counties, enabled through programs such as the CDC's Vaccines for Children [17].

A slightly higher proportion of cancers diagnosed at an advanced stage in the bottom 25 % of counties economically may indicate differential access to screening and early detection.

Limitations include using county-level economic status, which approximates but does not fully represent individual-level economic status. While the prevalence of hysterectomy in younger women is low (0.6 % among women aged 18–29 years) [18], cervical cancer incidence rates were not adjusted for hysterectomy status. Some analyses were limited by counts fewer than 6. Trend analysis for metropolitan and nonmetropolitan counties started in 2009 due to low counts in 2008. Rates for 2020 were excluded from trend calculations due to reduced diagnoses during the COVID-19 pandemic [10]. In assessing racial variations, we acknowledge the role of social and structural determinants of health and the need for better data to quantify these factors. Future studies can explore the interplay between economic status, county rurality, and cervical cancer mortality rates, and between economic status and HPV vaccination or cervical cancer screening rates.

5. Conclusion

In women aged 15–29 years, declining cervical cancer incidence rates across county-level economic strata, especially in the bottom 25 % recently, may reflect the effect of HPV vaccination and screening. Further observed differences by race and rurality may help

inform efforts to increase implementation of preventive measures in populations with the highest burden.

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Appendix

Table A1

Cervical Cancer Incidence Among Women Aged 15–29 Years, by County-Level Economic Status and Tumor Characteristics—United States, 2007–2020^a

County-level economic status ^b											
	Total		Upper 25 %			Middle 25 %–75 %				Bottom 25 %	
	No.	Rate (95 % CI) ^c	No.	Rate (95 % CI) ^c	Proportion	No.	Rate (95 % CI) ^c	Proportion	No.	Rate (95 % CI) ^c	Proportion
Stage ^{d,e}											
Local	5100	1.2 (1.1, 1.2)	1546	1.1 (1.0, 1.1)	67.3 %	2948	1.2 (1.2, 1.2)	62.8 %	606	1.3 (1.2, 1.4)	60.1 %
Regional	2073	0.5 (0.5, 0.5)	532	0.4 (0.3, 0.4)	23.2 %	1261	0.5 (0.5, 0.5)	26.9 %	280	0.6 (0.5, 0.7)	27.8 %
Distant	419	0.1 (0.1, 0.1)	108	0.1 (0.1, 0.1)	4.7 %	241	0.1 (0.1, 0.1)	5.1 %	70	0.1 (0.1, 0.2)	6.9 %
Unknown or unstaged	405	0.1 (0.1, 0.1)	111 (27.4)	0.1 (0.1, 0.1)	4.8 %	242 (59.8)	0.1 (0.1, 0.1)	5.2 %	52 (12.8)	0.1 (0.1, 0.1)	5.2 %
Histology ^{e,f,g}											
SCC	5616	1.3 (1.3, 1.3)	1558 (27.7)	1.1 (1.0, 1.1)	71.7 %	3328 (59.3)	1.4 (1.3, 1.4)	75.1 %	730 (13.0)	1.6 (1.4, 1.7)	78.0 %
AC	1924	0.4 (0.4, 0.5)	614 (31.9)	0.4 (0.4, 0.5)	28.3 %	1104 (57.4)	0.5 (0.4, 0.5)	24.9 %	206 (10.7)	0.4 (0.4, 0.5)	22.0 %

AC, adenocarcinoma; CI, confidence interval; SCC, squamous cell carcinoma.

Notes:

^aData source: Centers for Disease Control and Prevention's National Program of Cancer Registries and the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) Program. Incidence data were compiled from cancer registries that met data quality standards from 2007 to 2020. Indiana and Nevada were excluded because cases reported in 2020 were not available. Virginia, Minnesota, and Kansas were excluded due to missing county data.

^bIndex-based county economic classification developed by the Appalachian Regional Commission based on 3 economic indicators: 3-year average unemployment rate, per capita market income, and poverty rate.

^cIncidence rates were standardized to the 2000 United States standard population using the direct method. Rates expressed per 100,000 women.

^dCancer stage derived using SEER Summary Stage guidelines.

^eChi-square significant at $p < 0.05$.

^fThe International Classification of Disease for Oncology, Third Edition, histology codes were used to define cervical squamous cell carcinoma (8050–8084 and 8120–8131) and adenocarcinoma (8140–8575).

^gOther histologic subtypes are not displayed in this table ($n = 457$).

Table A2

Trends in Cervical Cancer Incidence Among Women Aged 15–29 Years by County-Level Economic Status and Tumor Characteristics —United States, 2007–2019^{a,b}

County-level economic status ^c						
	Upper 25 %		Middle 25 %–75 %		Bottom 25 %	
	Years	APC (95 % CI) ^d	Years	APC (95 % CI) ^d	Years	APC (95 % CI) ^d
Stage						
Local	2007–2019	–3.2 (–5.4, –1.4)	2007–2016 2016–2019	–2.4 (–3.4, 0.6) –10.0 (–17.5, –5.0)	2007–2019	–3.3 (–6.2, –0.6)
Regional	2007–2019	–2.7 (–5.8, –0.1)	2007–2019	–1.0 (–3.7, 1.9)	2007–2014 2014–2019	4.4 (–9.6, 93.3) –13.6 (–63.8, 4.4)
Distant	^e	^e	2007–2010 2010–2016 2016–2019	–12.3 (–32.2, 2.7) 14.1 (8.2, 33.8) –27.3 (–43.8, –14.7)	^e	^e
Histology						
SCC	2007–2016 2016–2019	–0.7 (–5.0, 12.8) –11.1 (–27.9, –1.1)	2007–2019	–2.5 (–3.8, –1.1)	2007–2019	–2.8 (–5.9, 0.3)
AC	2007–2019	–3.8 (–5.8, –2.1)	2007–2019	–3.2 (–5.0, –1.2)	2007–2019	–4.9 (–10.9, 0.6)

AC, adenocarcinoma; APC, annual percent change; CI, confidence interval; SCC, squamous cell carcinoma.

Notes:

^aData source: Centers for Disease Control and Prevention's National Program of Cancer Registries and the National Cancer Institute's Surveillance, Epidemiology, and End Results Program. Incidence data were compiled from cancer registries that met data quality standards from 2007 to 2020. Indiana and Nevada were excluded because cases reported in 2020 were not available. Virginia, Minnesota, and Kansas were excluded due to missing county data.

^b2020 data were excluded from trend analysis to limit bias from the impact of the COVID-19 pandemic regarding access to healthcare and cancer diagnoses. Data can be visualized as a detached datapoint in Fig. 1.

^cIndex-based county economic classification developed by the Appalachian Regional Commission based on 3 economic indicators: 3-year average unemployment rate, per capita market income, and poverty rate.

^dBoldface indicates $p < 0.05$.

^eTrends not presented due to some years having fewer than 6 cases.

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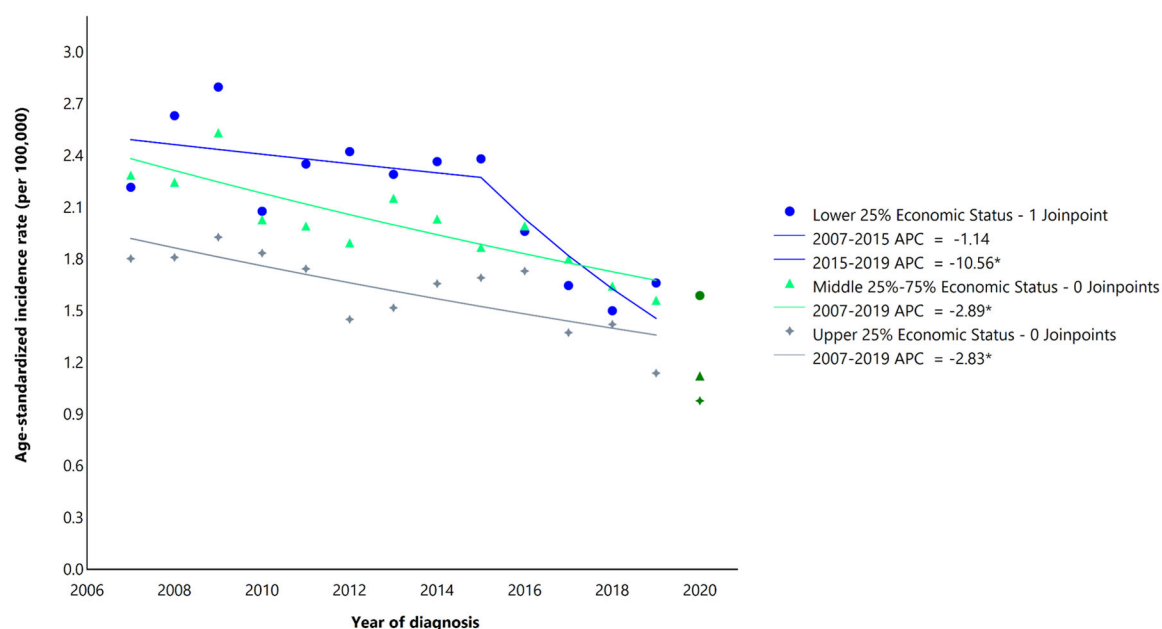


Fig. 1.

Trends in cervical cancer incidence rate among women aged 15–29 years, by county-level economic status — United States, 2007–2019.^{a-f} APC, annual percent change. ^aData source: Centers for Disease Control and Prevention's National Program of Cancer Registries and the National Cancer Institute's Surveillance, Epidemiology, and End Results Program. Incidence data were compiled from cancer registries that met data quality standards from 2007 to 2020. Indiana and Nevada were excluded because cases reported in 2020 were not available. Virginia, Minnesota, and Kansas were excluded due to missing county data. ^b2020 data were excluded from trend analysis to limit bias from the impact of the COVID-19 pandemic regarding access to healthcare and cancer diagnoses. Data can be visualized as a detached datapoint. ^cIndex-based county economic classification developed by the Appalachian Regional Commission based on 3 economic indicators: 3-year average unemployment rate, per capita market income, and poverty rate. ^dCases per 100,000 persons; age-standardized to the 2000 U.S. standard population. ^e* Indicates $p < .05$. ^fTrends calculated using Joinpoint Regression Program (version 5.0.2).

Table 1

Cervical Cancer Incidence Rate Among Women Aged 15–29 Years, by County-Level Economic Status and Sociodemographic Characteristics—United States, 2007–2020^a.

County-level economic status ^b									
Total		Top 25 %			Middle 25 %–75 %			Bottom 25 %	
No.	Rate (95 % CI) ^c	No. (%)	Rate (95 % CI) ^c	Rate ratio (95 % CI) ^d	No. (%)	Rate (95 % CI) ^c	Rate ratio (95 % CI) ^d	No. (%)	Rate ratio (95 % CI) ^d
Overall	7997	1.8 (1.8, 1.9)	2297	1.6 (1.5, 1.7)	–	4692	1.9 (1.9, 2.0)	1008	2.1 (2.0, 2.3)
Age at diagnosis (years)									
15–24	1300 (16.3)	0.5 (0.4, 0.5)	385 (16.8)	0.4 (0.4, 0.5)	REF	736 (15.7)	0.5 (0.4, 0.5)	179 (17.8)	0.6 (0.5, 0.6)
25–29	6697 (83.7)	4.8 (4.7, 4.9)	1912 (83.2)	4.1 (3.9, 4.3)	9.9 (8.9, 11.1)	3956 (84.3)	5.0 (4.9, 5.2)	829 (82.2)	11 (10.1, 11.9)
Race and ethnicity^e									
Non-Hispanic White	4629 (57.9)	1.9 (1.9, 2.0)	1429 (62.2)	1.7 (1.6, 1.8)	REF	2678 (57.1)	2.0 (1.9, 2.1)	522 (51.8)	2.4 (2.2, 2.6)
Non-Hispanic Black	1092 (13.7)	1.7 (1.6, 1.8)	208 (9.1)	1.3 (1.2, 1.5)	0.8 (0.7, 0.9)	703 (15)	1.8 (1.7, 1.9)	181 (18)	0.9 (0.8, 1.0)
Non-Hispanic American Indian or Alaska Native	104 (1.3)	2.6 (2.1, 3.2)	20 (0.9)	2.2 (1.4, 3.4)	1.3 (0.8, 2.1)	61 (1.3)	3.1 (2.4, 3.9)	23 (2.3)	2.1 (1.3, 3.2)
Non-Hispanic Asian or Pacific Islander	209 (2.6)	0.7 (0.6, 0.8)	88 (3.8)	0.6 (0.5, 0.8)	0.4 (0.3, 0.5)	107 (2.3)	0.7 (0.6, 0.9)	14 (1.4)	0.4 (0.3, 0.6)
Hispanic (all races)	1703 (21.3)	1.9 (1.8, 2.0)	429 (18.7)	1.8 (1.6, 2.0)	1.1 (1.0, 1.2)	1012 (21.6)	1.9 (1.8, 2.0)	262 (26)	2.1 (1.9, 2.4)
Rural-urban county classification^f									
Metropolitan	6760 (84.5)	1.8 (1.7, 1.8)	2163 (94.2)	1.6 (1.5, 1.6)	REF	4042 (86.1)	1.9 (1.8, 1.9)	555 (55.1)	1.9 (1.7, 2.1)
Nonmetropolitan	1237 (15.5)	2.4 (2.3, 2.5)	134 (5.8)	2.0 (1.7, 2.4)	1.2 (1.1, 1.5)	650 (13.9)	2.4 (2.2, 2.6)	453 (44.9)	1.3 (1.2, 1.4)

CI, confidence interval; REF, referent.

^aData source: Centers for Disease Control and Prevention's National Program of Cancer Registries and the National Cancer Institute's Surveillance, Epidemiology, and End Results Program. Incidence data were compiled from cancer registries that met data quality standards from 2007 to 2020. Indiana and Nevada were excluded because cases reported in 2020 were not available. Virginia, Minnesota, and Kansas were excluded due to missing county data.

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^b Index-based county economic classification developed by the Appalachian Regional Commission based on 3 economic indicators: 3-year average unemployment rate, per capita market income, and poverty rate.

^c Except for rates stratified by age, incidence rates were standardized to the 2000 United States standard population using the direct method. Rates expressed per 100,000 women.

^d Boldface indicates $p < 0.05$.

^e Rates by race and ethnicity did not include data from North Dakota and Wisconsin due to limited information from these registries.

^f Based on the United States Department of Agriculture's 2013 rural-urban continuum code definitions: metropolitan (rural-urban continuum code 1–3) and nonmetropolitan (rural-urban continuum code 4–9) counties.

Table 2

Trends in Cervical Cancer Incidence Among Women Aged 15–29 Years by County-Level Economic Status and Sociodemographic Characteristics—United States, 2007–2019^{a,b}.

County-level economic status ^c						
Top 25 %		Middle 25 %–75 %		Bottom 25 %		
Years	APC (95 % CI) ^d	Years	APC (95 % CI) ^d	Years	APC (95 % CI) ^d	
Overall	2007–2019 –2.8 (–4.7, –1.3)	2007–2019	–2.9 (–4.3, –1.4)	2007–2015 2015–2019	–1.1 (–5.0, 18.4) –10.6 (–32.1, –2.6)	
Age at diagnosis (years)						
15–24	2007–2019 –7.8 (–15.1, –2.7)	2007–2019	–8.0 (–10.5, –5.6)	<i>e</i>	<i>e</i>	
25–29	2007–2019 –1.7 (–3.7, 0.0)	2007–2019	–1.8 (–3.1, –0.4)	2007–2015 2015–2019	0.4 (–5.4, 27.9) –9.1 (–34.4, 0.3)	
Race and ethnicity ^f						
Non-Hispanic White	2007–2016 –0.3 (–1.6, 1.5)	2007–2019	–2.6 (–3.9, –1.2)	2007–2019	–4.1 (–6.7, –1.6)	
	2016–2019 –14.4 (–25.9, –8.1)					
Non-Hispanic Black	2007–2019 –2.6 (–7.7, 1.6)	2007–2019	–2.5 (–4.0, –0.7)	2007–2019	–0.3 (–3.4, 2.8)	
Hispanic (all races)	2007–2019 –3.4 (–7.2, –0.1)	2007–2019	–3.5 (–5.0, –2.0)	2007–2019	–4.3 (–11.1, 2.1)	
Rural-urban county classification ^{g,h}						
Metropolitan	2009–2019 –3.5 (–6.0, –1.3)	2009–2019	–3.6 (–6.4, –0.6)	2009–2019	–3.4 (–5.9, –0.9)	
Nonmetropolitan	2009–2017 –1.4 (–6.5, 13.1)	2009–2019	–0.4 (–3.5, 2.8)	2009–2019	–6.0 (–11.5, –0.7)	
	2017–2019 –24.1 (–39.6, –3.6)					

APC, annual percent change; CI, confidence interval.

^aData source: Centers for Disease Control and Prevention’s National Program of Cancer Registries and the National Cancer Institute’s Surveillance, Epidemiology, and End Results Program. Incidence data were compiled from cancer registries that met data quality standards from 2007 to 2020. Indiana and Nevada were excluded because cases reported in 2020 were not available. Virginia, Minnesota, and Kansas were excluded due to missing county data.

^b2020 data were excluded from trend analysis to limit bias from the impact of the COVID-19 pandemic regarding access to healthcare and cancer diagnoses. Data can be visualized as a detached datapoint in Fig. 1.

^cIndex-based county economic classification developed by the Appalachian Regional Commission based on 3 economic indicators: 3-year average unemployment rate, per capita market income, and poverty rate.

^dBoldface indicates $p < 0.05$.

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^eTrends suppressed due to some years having fewer than 6 cases.

^fTrends for non-Hispanic American Indian or Alaska Native and non-Hispanic Asian or Pacific Islander were not presented due to some years having fewer than 6 cases. Trends by race and ethnicity did not include data from North Dakota and Wisconsin due to limited information from these registries.

^gBased on the United States Department of Agriculture's 2013 rural-urban continuum code definitions: metropolitan (rural-urban continuum code 1–3) and nonmetropolitan (rural-urban continuum code 4–9) counties.

^hTrend analysis was conducted from 2009 onwards for rural-urban county classification due to limited counts in 2008.