Rural–Urban Differences in Cancer Incidence and Trends in the United States

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Abstract

Background: Cancer incidence and mortality rates in the United States are declining, but this decrease may not be observed in rural areas where residents are more likely to live in poverty, smoke, and forego cancer screening. However, there is limited research exploring national rural–urban differences in cancer incidence and trends.

Methods: We analyzed data from the North American Association of Central Cancer Registries' public use dataset, which includes population-based cancer incidence data from 46 states. We calculated age-adjusted incidence rates, rate ratios, and annual percentage change (APC) for: all cancers combined, selected individual cancers, and cancers associated with tobacco use and human papillomavirus (HPV). Rural–urban comparisons were made by demographic, geographic, and socioeconomic characteristics for 2009 to 2013. Trends were analyzed for 1995 to 2013.

Results: Combined cancers incidence rates were generally higher in urban populations, except for the South, although the urban decline in incidence rate was greater than in rural populations (10.2% vs. 4.8%, respectively). Rural cancer disparities included higher rates of tobacco-associated, HPV-associated, lung and bronchus, cervical, and colorectal cancers across most population groups. Furthermore, HPV-associated cancer incidence rates increased in rural areas (APC = 0.724, $P < 0.05$), while temporal trends remained stable in urban areas.

Conclusions: Cancer rates associated with modifiable risks—tobacco, HPV, and some preventive screening modalities (e.g., colorectal and cervical cancers)—were higher in rural compared with urban populations.

Impact: Population-based, clinical, and/or policy strategies and interventions that address these modifiable risk factors could help reduce cancer disparities experienced in rural populations. *Cancer Epidemiol Biomarkers Prev; 27(11); 1265–74. ©2017 AACR.*

Introduction

Cancer mortality rates across the United States have been decreasing, but this decline has not been experienced equally across demographic groups. For some racial/ethnic minorities, incidence and mortality rates have declined more slowly than for whites, which is also the case for rural areas (1). For many rural populations, cancer mortality is not decreasing; it is steady and, in some cases, rising. Several studies have documented persistently elevated cancer incidence and mortality in rural communities compared with urban areas (2–5). As nearly 1 in 5 Americans lives in a rural area, disparities among this population can have a broad impact on the nation's health (6).

The reasons for these cancer health disparities are complex. In 2010 to 2012, the highest rates of poverty and uninsured status in the nation were found in small rural counties and in large inner cities (7). Although the Affordable Care Act increased insurance coverage, many states with large rural populations did not expand Medicaid, leaving millions of people still without health insurance (8). Furthermore, there are documented barriers to health care access in rural communities. Many rural residents live in health care provider–shortage areas, may have fewer choices in care, and may need to travel long distances just to see a primary care physician. Thus, it is not surprising that studies have found that rural residents have lower rates of cancer screening and experience lower quality cancer care (2, 3). Furthermore, numerous studies have identified higher rates of cancer-risk behaviors among rural residents, which can contribute to the elevated incidence rates. Higher rates of tobacco use and obesity in rural populations are consistently reported (9–13). In addition, human papillomavirus (HPV) vaccination rates are lagging in rural areas, with lower rates associated with increasing rurality (14).

The preponderance of evidence shows that rural residents may be at greater risk for cancer, and there has been an increasing call for further research efforts and funding investments in cancer control based upon geographic location, broadly, and rural locations, specifically (15, 16). However, there is a paucity of research that has comprehensively characterized the rural cancer burden. Previous investigations have been limited to examining specific

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Note: Supplementary data for this article are available at Cancer Epidemiology, Biomarkers & Prevention Online (http://cebp.aacrjournals.org/).

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doi: 10.1158/1055-9965.EPI-17-0430

rural regions (e.g., Appalachia), data from only Surveillance Epidemiology and End Results (SEER) registries, or national data of single or limited cancer types (5, 17–26). Therefore, our objective is to describe the national rural cancer burden by assessing rural–urban differences in incidence rates and trends by overall cancer, individual cancers, and by subgroups of cancers (tobacco- and HPV-associated).

Materials and Methods

We analyzed data from the North American Association of Central Cancer Registries (NAACCR) Cancer in North America public use dataset, which contains data from population-based cancer registries in the United States and Canada who authorized inclusion in the dataset and whose registry was certified as meeting gold or silver data quality standards by NAACCR (27). Gold and silver quality standards are based on level of data completeness (95+% for gold certification and 90+% for silver certification), accuracy, and timeliness of submission of data to NAACCR (28). This dataset included 46 states in the United States and the District of Columbia, representing 93% of the United States population. Four states (Kansas, Maryland, Minnesota, and Vermont) did not consent for their data to be included. The dataset includes variables on demographics, registry, county-level characteristics (i.e., rural and poverty status), and tumor characteristics (e.g., site, histology, stage).

Rural and urban were defined using the 2013 Beale codes (also known as Rural-Urban Continuum Codes or RUCCs), which categorize counties based upon their population size and proximity to metropolitan areas. A Beale code or RUCC of one to three indicates a metro (urban) county whereas a code of four to nine indicates a non-metro (rural) county as outlined in the map in Supplementary Fig. S1 (29).

Changes in cancer case reporting requirements occurred in 2001 in response to the shift from International Classification of Disease Oncology-2 (ICD-O-2) to ICD-O-3 histology and behavior codes. Our analysis only included cases that were malignant in both ICD-O-2 and ICD-O-3 to allow for congruency in analysis over time. Primary site of cancer diagnosis was defined by the ICD-O-3 classification. We also categorized cancer groups associated with two different carcinogenic exposures—tobacco and HPV. Tobacco-associated cancers were those identified by the 2014 Surgeon General's Report, including oral cavity and pharynx, larynx, esophagus, trachea, lung and bronchus, acute myeloid leukemia, stomach, liver, pancreas, kidney and ureter, cervix, bladder, and colorectal (30). HPV-associated cancers were determined by ICD-O-3 code for primary site and relevant histology, that is cervical carcinomas and squamous cell carcinomas of the oropharynx, vagina, vulva, penis, anus, and rectum (31).

We used SEER*Stat 8.3.2 to calculate age-adjusted incidence rates and rate ratios utilizing Tiwari modifications and to determine annual percentage change (APC) for selected individual cancer sites and groups (32). Rate ratios with p-values less than 0.05 indicated statistically significant rural–urban differences in rates. Rural–urban incidence rate comparisons were made by sex, race/ethnicity, U.S. census division, and county-level poverty rate for 2009 to 2013. Race/ethnic groups were defined as non-Hispanic (NH) white, NH black, and Hispanic. U.S. Census Division include the Northeast, South, Midwest, and West as outlined in the map in Supplementary Figure S1. APC and overall percentage change in cancer rates were analyzed for 1995 to 2013.

Table 1. Demographic characteristics of invasive cancer cases in rural and urban areas, 2009–2013

	Rural *N* (%)	Urban *N* (%)
Total cases	1,215,260 (16.7%)	6,073,283 (83.3%)
U.S. Census region		
Northeast	134,197 (11.0%)	1,411,055 (23.2%)
Midwest	373,953 (30.8%)	1,157,272 (19.1%)
South	546,632 (45.0%)	2,130,224 (35.1%)
West	160,478 (13.2%)	1,374,732 (22.6%)
Sex		
Male	646,302 (53.1%)	3,069,294 (50.5%)
Female	568,866 (46.9%)	3,003,288 (49.5%)
Race/ethnicity		
Non-Hispanic white	1,066,639 (87.8%)	4,571,767 (75.3%)
Non-Hispanic black	84,207 (6.9%)	688,268 (11.3%)
Hispanic	31,675 (2.6%)	507,150 (8.4%)
Other	22,784 (1.9%)	223,674 (3.7%)
Unknown	9,955 (0.8%)	82,424 (1.4%)
Age		
0–19	9,384 (0.8%)	59,312 (1.0%)
20–44	70,405 (5.8%)	464,105 (7.6%)
45–64	441,423 (36.3%)	2,316,831 (38.1%)
65+	694,048 (57.1%)	3,233,035 (53.2%)
County poverty level		
0–9.99%	69,566 (5.7%)	1,019,614 (16.8%)
10–19.99%	744,946 (61.3%)	4,403,852 (72.5%)
20+%	400,748 (33.0%)	649,817 (10.7%)

APCs with P values less than 0.05 indicated a statistically significant percentage change in rates. This study was determined to be nonhuman subjects research by the Springfield Committee for Research Involving Human Subjects.

Results

Between 2009 and 2013, 1,215,260 invasive cancer cases were diagnosed in rural populations, comprising 16.7% of all cancer cases (Table 1). More than three-fourths (75.8%) of rural cancer cases were diagnosed in the Midwest and the South. Most cases in rural areas were NH white (87.8%), compared with 75.3% of urban cases. More than half of both rural and urban cancer cases were diagnosed in individuals 65 years of age or older (57.1% and 53.2%, respectively). One third of rural cancer cases were diagnosed in counties with greater than 20% of the population living in poverty compared with 10.7% of urban cases.

Primary site by sex

The incidence rates for all sites combined were higher in urban populations for both sexes combined and for females (Table 2). The all sites combined incidence rate in rural and urban populations was 446.4 and 448.7 per 100,000, respectively. The rate of tobacco-associated cancers were higher in both sexes combined and individually, with a rural rate in both sexes combined of 205.8 per 100,000 compared with a rate of 192.0 in urban populations. Rates of HPV-associated cancer were higher in rural females compared with urban (15.2 vs. 13.4 per 100,000, respectively). In addition, for both sexes combined and for males and females analyzed separately, oral and pharynx, esophagus, colon and rectum, lung and bronchus, larynx, and kidney and renal pelvis cancers each were higher in rural populations compared with urban. Urban populations had higher rates of breast (female), prostate, stomach, liver and intrahepatic duct, pancreas, melanoma, thyroid, non-Hodgkin lymphoma, and endometrial cancer.

Table 2. Invasive cancer incidence rates by primary site, rural and urban, all races, 2009–2013

	Rural[a]			Urban[a]		
	All rates	**Male rates**	**Female rates**	**All rates**	**Male rates**	**Female rates**
All sites	446.4[b]	502.1	405.4[b]	448.7	501.1	412.5
Tobacco-associated	205.8[b]	266.0[b]	155.8[b]	192.0	248.3	147.9
HPV-associated	12.6[b]	9.9	15.2[b]	11.7	10.0	13.4
Oral cavity and pharynx	12.2[b]	18.3[b]	6.7[b]	11.2	16.9	6.2
Esophagus	5.1[b]	8.9[b]	1.7[b]	4.6	8.0	1.8
Stomach	5.8[b]	8.1[b]	3.8[b]	6.9	9.5	4.8
Colon and rectum	43.9[b]	50.5[b]	38.2[b]	40.1	46.2	35.1
Liver and intrahepatic duct	6.3[b]	9.6[b]	3.4[b]	7.9	12.3	4.2
Pancreas	11.9[b]	13.7[b]	10.4[b]	12.5	14.2	11.0
Larynx	4.4[b]	7.3[b]	1.8[b]	3.4	6.0	1.3
Lung and bronchus	70.2[b]	86.7[b]	57.1[b]	61.2	72.5	52.8
Melanoma	19.9[b]	24.1[b]	16.9[b]	20.1	26.1	15.9
Breast	—	—	113.4[b]	—	—	124.8
Cervical	—	—	8.4[b]	—	—	7.6
Endometrial	—	—	25.0b	—	—	25.7
Ovary	—	—	11.3[b]	—	—	11.7
Prostate	—	114.1[b]	—	—	124.5	—
Testis	—	5.5	—	—	5.5	—
Urinary bladder	20.9[b]	36.0	8.8	20.6	36.1	8.9
Kidney and renal pelvis	16.9[b]	21.9[b]	12.3[b]	15.9	21.6	11.1
Brain and other nervous system	6.7[b]	7.8	5.6	6.6	7.7	5.6
Thyroid	12.0[b]	5.8[b]	18.2[b]	14.4	7.2	21.2
Hodgkin lymphoma	2.6	3.0	2.3	2.7	3.1	2.4
Non-Hodgkin lymphoma	18.2[b]	21.8[b]	15.3[b]	19.2	23.2	16.0
Myeloma	5.9[b]	7.4[b]	4.8[b]	6.5	8.1	5.3
Leukemia	13.5[b]	17.1	10.5	13.3	17.1	10.4

[a]Rates are expressed per 100,000 people and age-adjusted to the 2000 U.S. standard population.
[b]The rate ratio indicates that the rural rate is statistically significantly different than the urban rate ($P < 0.05$).

Race/ethnicity

Urban populations had higher all cancer combined incidence rates across sexes and racial/ethnic groups with the exception of NH black males, where there was no rural–urban difference (Table 3). Tobacco-associated cancer rates were higher in rural males across NH racial groups. For women, rates were higher in rural NH whites and Hispanics, but no rural–urban differences in rates among NH blacks. Elevated HPV-associated cancers were found in rural areas amongst all sex and race/ethnic groupings except NH black males and Hispanic females, where there were no rural–urban differences. Lung and bronchus cancer rates were higher in rural areas for all sex and race/ethnic groupings except for NH black women amongst whom rates are higher in urban populations. Colorectal cancer rates were higher in rural NH white and black men and women, but there was no rural–urban difference in rates among Hispanics. Cervical cancer rates were higher among rural NH whites and blacks than their urban peers, but there was no difference in Hispanics. Higher rates of breast, prostate, and thyroid cancers were seen in urban populations across sex and racial/ethnic groupings.

Geographic census region

All cancer combined incidence rates were higher in urban populations across census regions, except the South where rates were higher in rural areas (449.1 vs. 440.9 per 100,000 in rural and urban areas, respectively; Table 4). Tobacco-associated, HPV-associated, and lung and bronchus cancers were highest in rural areas across regions, except for the Midwest where there were no rural–urban differences. Colorectal cancer incidence rates were higher in rural areas, except for the West where there was no rural–urban difference. Oral cavity and pharynx, esophagus, and larynx cancers were higher in rural areas across regions. Cervical cancer rates were higher in rural areas of the Midwest and South, but no differences were seen in other regions. Breast, prostate, and thyroid cancers incidence rates were higher in urban areas across all regions. Stratifications by race/ethnicity showed some different dynamics for colorectal cancer. Rates were higher in urban blacks in the Northeast, Midwest, and West compared with their rural peers, but the rate in the black South was higher in rural populations (Supplementary Table S1). Hispanics in the rural West also had a higher colorectal cancer rate than their urban peers.

County poverty level

Among populations where less than 10% live in poverty, colorectal cancer rates were higher in rural populations, but rates for all cancers combined, tobacco-associated, prostate, breast, and five other cancers were higher in urban populations (Table 5). In populations where the county poverty rate was 10% to 19.99%, the all cancer combined rate was higher in rural populations (447.6 vs. 445.6 per 100,000, respectively). Tobacco-associated, HPV-associated, lung and bronchus, colorectal, and six other cancers were higher in rural areas with between 10% and 19.99% of the population living below poverty. In populations where 20+% of the population lives in poverty, the all cancer combined rate was higher in urban areas, but the tobacco-associated, HPV-associated, lung and bronchus, colorectal, and five other cancers had higher rates in rural areas.

Trends

Between 1995 and 2013, the all cancers combined incidence rate decreased for both rural and urban populations (a decrease of 4.84% and 10.22%, respectively), with average annual decreases of 0.27% and 0.56% (Fig. 1A). Lung cancer incidence rates decreased by 7.0% and 18.4% in rural and urban populations,

Table 3. Cancer incidence rates by primary site by race/ethnicity

	Rural[a]			Urban[a]		
	All rates	Male rates	Female rates	All rates	Male rates	Female rates
All cancers						
NH white	449.5[b]	501.5[b]	410.8[b]	464.4	510.1	433.1
NH black	458.7[b]	567.8	384.6[b]	471.4	570.7	404.9
Hispanic	322.7[b]	349.5[b]	306.3[b]	350.9	393.5	325.2
Tobacco-associated cancers						
NH white	206.6[b]	266.8[b]	156.3[b]	197.0	253.7	151.5
NH black	216.1[b]	292.3[b]	159.5[b]	209.9	276.8	163.7
Hispanic	152.4	189.2[b]	119.6[b]	150.0	195.5	116.0
HPV-associated cancers						
NH white	12.8[b]	10.3[b]	15.2[b]	12.3	11.0	13.6
NH black	13.1[b]	10.2	16.0[b]	12.4	9.6	14.7
Hispanic	8.9[b]	5.2[b]	13.1	10.1	6.3	13.7
Selected individual cancers						
Prostate						
NH white	—	108.1[b]	—	—	116.2	—
NH black	—	190.5[b]	—	—	199.0	—
Hispanic	—	78.1[b]	—	—	106.7	—
Breast						
NH white	—	—	114.3[b]	—	—	131.4
NH black	—	—	118.2[b]	—	—	125.6
Hispanic	—	—	81.6[b]	—	—	92.5
Lung and bronchus						
NH white	71.7[b]	87.3[b]	59.2[b]	65.4	75.4	58.0
NH black	70.1[b]	104.5[b]	45.0[b]	67.0	89.7	51.9
Hispanic	36.7[b]	45.7[b]	29.2[b]	32.3	41.9	25.4
Colorectal						
NH white	43.2[b]	49.7[b]	37.6[b]	39.5	45.2	34.7
NH black	53.8[b]	63.7[b]	46.8[b]	48.8	58.0	42.5
Hispanic	36.6	42.5	31.1	35.6	43.0	29.9
Urinary bladder						
NH white	22.1[b]	38.0[b]	9.2[b]	23.3	40.5	10.0
NH black	10.5[b]	16.9[b]	6.1[b]	12.1	20.2	6.8
Hispanic	10.3[b]	16.8[b]	4.7	11.4	20.1	5.2
Melanoma						
NH white	22.1[b]	26.5[b]	18.9[b]	26.2	33.0	21.3
NH black	1.3[b]	1.3	1.3[b]	1.0	1.1	0.9
Hispanic	5.5[b]	6.1[b]	5.3[b]	4.5	5.0	4.2
Kidney and renal pelvis						
NH white	16.8c	21.9	12.2[b]	16.1	21.9	11.1
NH black	17.5	22.4[b]	13.5	18.0	24.7	12.9
Hispanic	16.6	20.2	13.2[b]	15.8	20.7	11.9
Non-Hodgkin lymphoma						
NH white	18.7[b]	22.4[b]	15.6[b]	20.1	24.3	16.7
NH black	12.5[b]	14.5[b]	10.7[b]	14.6	17.7	12.2
Hispanic	14.9	16.8[b]	13.3	17.4	20.1	15.2
Leukemia						
NH white	13.8[b]	17.4[b]	10.7	14.0	18.0	10.8
NH black	10.1	13.0	8.1	10.5	13.3	8.6
Hispanic	10.0[b]	12.0	8.1[b]	10.7	13.1	8.9
Oral cavity and pharynx						
NH white	12.5[b]	18.7[b]	6.8	12.2	18.4	6.7
NH black	11.3[b]	17.7[b]	5.8[b]	9.3	14.7	5.2
Hispanic	6.6[b]	9.3[b]	3.9	7.2	10.9	4.1
Endometrial						
NH white	—	—	25.3[b]	—	—	26.5
NH black	—	—	23.3[b]	—	—	25.2
Hispanic	—	—	19.0[b]	—	—	21.8
Thyroid						
NH white	12.8[b]	6.3[b]	19.3[b]	15.7	8.2	23.0
NH black	6.7[b]	2.7[b]	10.7[b]	9.2	3.8	13.6
Hispanic	9.0[b]	4.2[b]	14.7[b]	12.8	5.3	20.0
Pancreas						
NH white	11.8[b]	13.6[b]	10.1[b]	12.4	14.2	10.8
NH black	15.1[b]	16.5	13.8	15.8	17.3	14.6
Hispanic	10.7	11.1	10.3	11.2	12.2	10.3

(Continued on the following page)

Table 3. Cancer incidence rates by primary site by race/ethnicity (Cont'd)

	Rural[a]			Urban[a]		
	All rates	Male rates	Female rates	All rates	Male rates	Female rates
Esophagus						
NH white	5.1[b]	9.0[b]	1.7[b]	5.0	8.7	1.9
NH black	5.9[b]	10.1[b]	2.4	4.5	7.3	2.4
Hispanic	3.0	4.9	1.1	2.8	5.0	1.1
Larynx						
NH white	4.3[b]	7.2[b]	1.8[b]	3.5	6.0	1.4
NH black	5.8[b]	11.5[b]	1.9	4.5	8.6	1.8
Hispanic	2.6	4.4	0.8	2.6	5.1	0.7
Brain and other nervous system						
NH white	7.2[b]	8.4[b]	6.0[b]	7.5	8.8	6.4
NH black	3.8	4.4[b]	3.3	4.2	4.9	3.7
Hispanic	4.7[b]	5.2[b]	4.0	5.2	6.0	4.5
Cervix						
NH white	—	—	8.0[b]	—	—	6.9
NH black	—	—	10.8[b]	—	—	9.8
Hispanic	—	—	9.4	—	—	9.9

[a]Rates are expressed per 100,000 people and age-adjusted to the 2000 U.S. standard population.
[b]The rate ratio indicates that the rural rate is statistically significantly different than the urban rate ($P < 0.05$).

respectively, corresponding to −0.34% and −1.08% APCs (Fig. 1B). Breast cancer rates in rural and urban areas decreased at nearly equal rates, with APCs of −0.52% and −0.51%, respectively (Fig. 1C). Colorectal cancer rates decreased 21.78% and 32.22% in rural and urban areas, respectively Fig. 1D). Rural and urban populations experienced 28.05% and 35.04% decreases in cervical cancer incidence rates between 1995 and 2013 (Fig. 1E). Trends in prostate cancer incidence rates were similar between rural and urban populations; 37.99% and 38.18% decreases, respectively (Fig. 1F). Rural populations experienced a statistically significant 0.79% APC increase in HPV-associated cancers between 1995 and 2013, whereas rates remained stable in urban areas (Fig. 1G). The decrease in tobacco-associated cancer incidence rates were steeper in urban compared with rural populations, with decreases of 13.8% and 3.4%, respectively (Fig. 1H).

Discussion

We evaluated rural–urban differences in cancer incidence rates and trends in the United States. In general, urban populations had higher all sites combined incidence rates regardless of sex or race/ethnic groupings. However, rural populations often had higher rates of tobacco-associated and HPV-associated cancer rates. For individual cancers, rural populations, had higher rates of lung and bronchus, colorectal, oral and pharynx, larynx, and cervical cancers than their urban peers, whereas urban populations had higher rates of breast (female), prostate, and thyroid cancers. For most regions, cancer incidence rates were higher in urban populations, except for the South. Lung and bronchus, colorectal, and oral cavity and pharynx cancers tended to be higher in rural areas across most regions. The rate of all cancers combined was higher in rural populations in areas with 10% to 19.99% of the population living in poverty. Higher rates of lung and bronchus, colorectal,

Table 4. Cancer incidence rates by U.S. Census region

	Northeast[a]		Midwest[a]		South[a]		West[a]	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
All cancers	476.6[b]	482.9	447.0[b]	462.4	449.1[b]	440.9	415.7[b]	419.8
Tobacco-associated	208.5[b]	201.8	204.5	203.6	215.8[b]	194.3	175.3[b]	170.4
HPV-associated	12.3[b]	11.5	11.9	11.8	13.7[b]	12.7	10.9[b]	10.5
Prostate	121.3[b]	136.9	110.3[b]	125.4	116.1[b]	122.5	111.4[b]	116.3
Breast (female)	122.0[b]	131.5	114.8[b]	127.1	110.6[b]	121.0	113.6[b]	122.8
Lung and bronchus	69.1[b]	63.1	68.9	68.5	77.0[b]	64.6	53.0[b]	48.7
Colorectal	43.2[b]	41.8	44.6[b]	41.9	45.5[b]	39.7	37.7	37.4
Urinary bladder	27.1[b]	24.3	22.0[b]	21.6	18.8	18.9	20.6[b]	18.8
Melanoma	22.6[b]	20.2	20.1[b]	19.0	18.2[b]	19.5	23.3[b]	21.9
Kidney and renal pelvis	16.1	16.0	17.2	16.9	17.5[b]	16.3	14.7	14.5
Non-Hodgkin lymphoma	20.6[b]	21.3	19.5	19.7	17.1	18.1	17.3[b]	18.6
Leukemia	15.5[b]	14.6	13.8[b]	13.4	12.9	12.8	13.3[b]	12.9
Oral cavity and pharynx	11.5[b]	11.0	11.9[b]	11.4	13.0[b]	11.8	11.1[b]	10.3
Endometrial	31.2	30.8	27.8	28.3	22.1	22.1	23.7	24.2
Thyroid	16.1[b]	19.6	12.4[b]	13.6	10.7[b]	12.2	12.2[b]	13.7
Pancreas	12.7[b]	13.4	11.7[b]	13.0	12.2	12.1	11.0[b]	11.7
Esophagus	5.9[b]	4.9	5.4[b]	5.2	4.7[b]	4.4	4.9[b]	4.1
Larynx	4.0[b]	3.5	4.2[b]	3.9	5.1[b]	3.9	2.7[b]	2.3
Brain and other nervous system	7.4[b]	6.8	6.9	6.7	6.4	6.5	6.7[b]	6.3
Cervix	7.3	7.2	7.7[b]	7.2	9.4[b]	8.3	7.3	7.0

[a]Rates are expressed per 100,000 people and age-adjusted to the 2000 U.S. standard population.
[b]The rate ratio indicates that the rural rate is statistically significantly different than the urban rate ($P < 0.05$).

Table 5. Cancer incidence rates by county-level poverty rates

	0–9.99% Below poverty[a]		10–19.99% Below poverty[a]		20+% Below poverty[a]	
	Rural	Urban	Rural	Urban	Rural	Urban
All cancers	441.7[b]	463.7	447.6[b]	445.6	445.2[b]	448.2
Tobacco-associated	183.5[b]	188.8	203.2[b]	191.6	214.4[b]	200.5
HPV-associated	10.2	10.4	12.3[b]	11.9	13.5[b]	12.7
Prostate	120.9[b]	127.7	112.9[b]	122.6	115.3[b]	132.7
Breast (female)	120.4[b]	134.6	114.8[b]	123.6	109.8[b]	117.6
Lung and bronchus	55.5[b]	58.9	68.5[b]	61.2	76.0[b]	64.6
Colorectal	41.7[b]	39.2	43.1[b]	40.0	45.8[b]	41.9
Urinary bladder	23.0	23.0	22.0[b]	20.4	18.4[b]	17.9
Melanoma	25.2[b]	23.7	21.0[b]	20.2	17.0[b]	14.1
Kidney and renal pelvis	15.6	15.8	16.7[b]	15.8	17.4[b]	17.0
Non-Hodgkin lymphoma	18.8[b]	20.6	18.9	19.0	16.9[b]	18.2
Leukemia	14.7	14.2	13.7b	13.2	12.8	12.8
Oral cavity and pharynx	10.8	10.9	12.2[b]	11.3	12.5[b]	11.2
Endometrial	26.6[b]	27.9	26.2[b]	25.2	22.4[b]	25.0
Thyroid	14.0[b]	17.8	12.5[b]	13.8	10.6[b]	13.0
Pancreas	11.6[b]	12.9	11.8[b]	12.3	12.2[b]	13.0
Esophagus	5.0	4.6	5.2[b]	4.5	4.9	4.8
Larynx	3.0	2.9	4.1[b]	3.4	5.0[b]	4.1
Brain and central nervous	7.0	7.1	6.9[b]	6.5	6.3	6.0
Cervix	5.9	6.1	8.0[b]	7.7	9.4	9.2

[a]Rates are expressed per 100,000 people and age-adjusted to the 2000 U.S. standard population.
[b]The rate ratio indicates that the rural rate is statistically significantly different than the urban rate ($P < 0.05$).

kidney and renal pelvis, and oral cavity and pharynx cancers were found in rural areas with at least 10% of the population living in poverty compared with urban areas. Rates of lung, breast, and colorectal, cervical, prostate, and tobacco-associated cancers decreased in both rural and urban populations, but the rate of decrease was more pronounced in urban population. The rate of HPV-associated cancers increased in rural population, but remained stable in urban populations.

As many individual cancer rates are higher in rural areas, the higher combined cancer rate in urban areas may be largely driven by higher rates of breast and prostate cancer, the two most common cancers. Of particular note, however, is the dynamic of

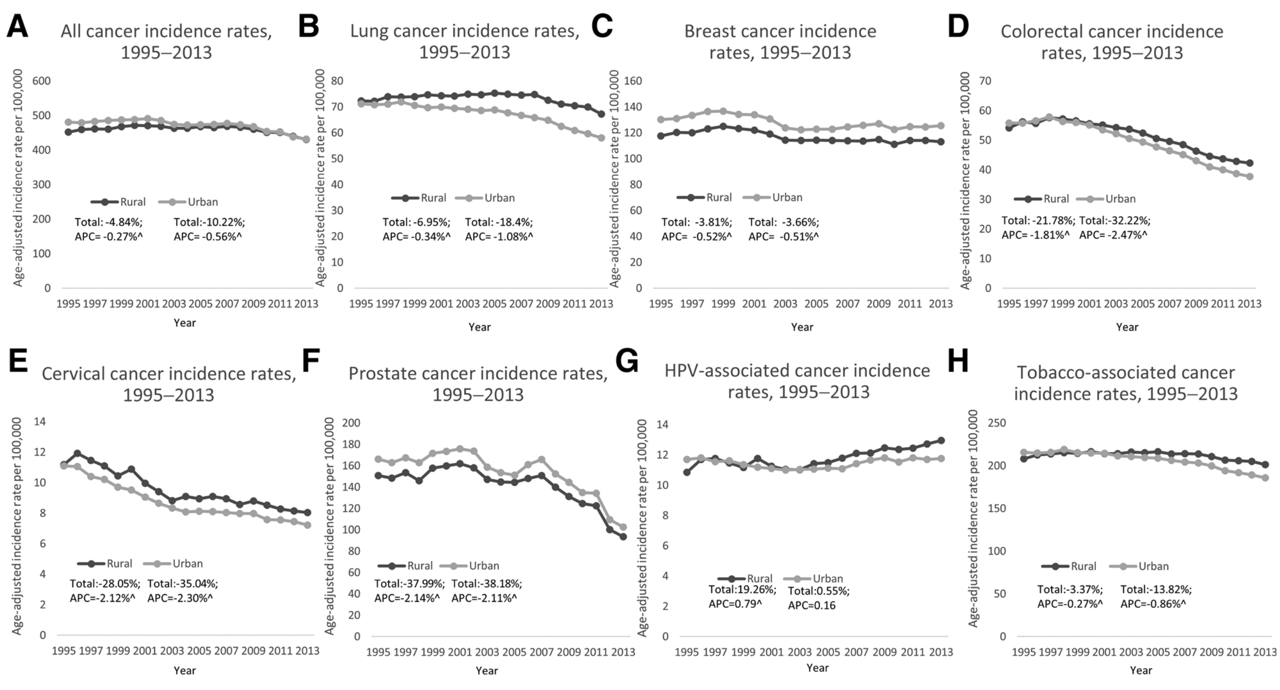

Figure 1.

Temporal trends in rural and urban cancer incidence, 1995–2013; rates are per 100,000 and age-adjusted to the 2000 U.S. standard population. "Total" indicates the percent change in incidence between 1995 and 2013, and "APC" indicates the APC in rates during this interval. ^ notes an APC that is statistically significantly different than zero ($P < 0.05$). Figure 1 contains multiple panels displaying the trends, total percent change, and APC (1995–2013) for eight cancer groups. **A**, all cancer; **B**, lung cancer; **C**, breast cancer; **D**, colorectal cancer; **E**, cervical cancer; **F**, prostate cancer; **G**, HPV-associated cancer; **H**, tobacco-associated cancer.

rural *incidence* rates and trends relative to *mortality* rates and trends. We found that incidence rates for all cancers combined are decreasing in rural areas, but other studies have shown that the rural mortality rates are not decreasing at such rates. In 1999, cancer mortality rates for those residing in urban and rural were similar, but by 2014 there was a marked disparity with higher cancer mortality in rural populations (33). Less access to cancer screening and oncology care in rural areas due to poorer spatial access to care, cost burdens, and greater uninsured rates among rural populations may contribute to this incidence/mortality dynamic (34, 35). These access barriers may mean that rural residents are diagnosed at a more advanced stage of disease which can affect prognosis and treatment options (36, 37). Social and behavioral factors like higher poverty, greater social isolation, and higher levels of smoking, obesity, and physical inactivity may also contribute to poorer cancer outcomes (38, 39). Future research should examine this dynamic by assessing rural–urban differences in cancer stage at diagnosis and treatment to elucidate the contributing factors to higher mortality in rural areas despite lower incidence rates.

HPV-associated cancers were significantly higher among NH white rural females and NH black rural males; among rural individuals in the Northeast, South, and West regions; and among communities where 10% or more of the population lived below the poverty level. These findings complement a recent study that showed elevated oral pharyngeal cancer rates among males and those living in rural areas (40). Furthermore, other studies have shown that sexually transmitted disease risk is associated with lower income and that rural males engage in more risky sexual behaviors (41, 42). Identifying patterns of HPV-associated cancer is important as there are vaccines for HPV subtypes most commonly associated with cancer (i.e., 16 and 18). A multistate survey found no rural–urban difference in HPV vaccination initiations overall, but some rural subgroups were less likely than their urban counterparts to initiate vaccination, including girls whose mothers indicated cost as a barrier (43). A statewide analysis of clinic visits among adolescents in Utah found that rural adolescents were less likely to receive a HPV vaccination when receiving other adolescent vaccinations compared with their urban counterparts (44). As HPV-associated cancers are the only cancer type where rates are increasing in rural areas, there is an opportunity to reduce and change the trending trajectory of these rates through HPV vaccination interventions.

We also found a decreasing trend in cervical cancer incidence rates for both rural and urban women, although the decrease was greater in urban. However, incidence rates were higher for rural compared with urban women, particularly in the South. Furthermore, incidence rates were higher for both rural NH white and NH black women. These findings are consistent with studies indicating higher rates in rural women, especially among Southern black women (45, 46). Rural women are less likely than their urban counterparts to have had a pap smear, which paradoxically may contribute to higher rates in rural areas due to lack of detection at a precancerous stage and may underestimate already high rates due to lack of detection (17, 47, 48). Our findings of rural–urban and geographic disparities in incidence among both white and black women in the rural South correspond with elevated mortality rates in these populations as well (46, 49, 50).

Our analysis found that tobacco-associated cancers were significantly higher among rural males (NH white and NH black) and females (NH white and Hispanic); among rural populations in the Northeast, South, and West; and among rural populations experiencing greater poverty. The rate of tobacco-associated cancers was especially high in the rural South, likely the key contributor to the higher overall cancer incidence rates in rural vs. urban south. A 2006 study indicated that smoking rates in the rural areas of 10 states (including the southern states of Alabama, Georgia, Mississippi, Oklahoma, South Carolina, and Texas) increased between the mid-1990s and the early 2000s, which may latently contribute to higher tobacco-associated cancer rates in the rural South (51). Furthermore, although tobacco-associated cancer incidence rates have decreased in both rural and urban populations, the decrease has been more pronounced in urban areas. These findings complement studies consistently indicating higher smoking rates and higher rates of smokeless tobacco in rural areas (10–12, 52, 53). Doogan and colleagues suggest that rural–urban differences in smoking in past studies were due to demographic or psychosocial differences, whereas more recent differences may be due to the disproportionately positive effects of tobacco control policies in urban areas (11). There are opportunities to ensure that policies are broadly relevant and enforceable. Furthermore, although our findings mirror differences in smoking prevalence, they also might suggest population groups among whom tobacco cessation interventions might best be implemented and may inform the development for more context-specific (e.g., rural Hispanic females) programs. Our findings also underscore the importance of interventions aimed at preventing smoking initiation in rural adolescents, among whom tobacco use is more pervasive (53, 54). In addition to rurally relevant tobacco initiatives, continued efforts could address policies and interventions that promote healthy lifestyles more broadly (13, 55, 56).

Our results indicated rural–urban differences in lung cancer incidence across most racial/ethnic groups and regions, with these disparities widening in recent years. This corroborate previous studies showing higher rates in rural areas, which may be due in part to higher poverty and smoking rates in rural areas (19). Primary and secondary prevention strategies can help reduce the lung cancer disparity in rural areas. The continued rural disparity for lung cancer specifically provides an opportunity to implement low-dose computed tomography (LDCT) screening to reduce lung cancer mortality in high risk, rural areas. Although radiologist capacity for LDCT is a concern in rural areas, efforts to increase knowledge and awareness of LDCT in rural areas like Appalachian Kentucky have shown preliminary success (57, 58). Similar campaigns could be implemented in other rural areas to reach high-risk populations as implementation of LDCT screening programs continues to expand.

Most rural populations had higher colorectal cancer incidence rates than urban populations across sexes, race/ethnic groups, regions, and poverty levels. In addition, although colorectal cancer rates have decreased in both rural and urban populations, rates in rural populations have decreased more slowly. The increased incidence in rural areas is consistent with studies indicating lower colorectal cancer screening rates in rural populations, with disparities seen also between rural and urban minorities (59–61). Other studies have shown that high rates of colorectal cancer mortality have clustered in largely rural areas of the United States, like the Lower Mississippi Delta Region and Appalachia (49, 62). The confluence of high incidence and mortality and low colorectal cancer screening rates make rural populations important areas for preventive and screening interventions.

Although most cancer incidence rates are higher in rural areas, there are a few notable exceptions, namely breast, prostate, and thyroid cancers. These high urban rates persist regardless of race, ethnicity, and region. For breast cancer, our findings corroborate previous studies showing higher incidence rates in urban areas, which may be due to increased early detection and utilization of mammography services (63–67). Our findings also corroborate previous studies showing higher rates of prostate cancer in urban areas (63, 68, 69). Even when stratifying by racial/ethnic groupings (NH whites, NH blacks, or Hispanics), rates were higher in urban populations across all groups. As with breast cancer, elevated incidence of prostate cancer among urban men may be due to higher screening rates and greater availability of healthcare services, especially as the majority of our study period was prior to the 2012 United States Preventive Services Task Force (USPSTF) discontinuation of recommending PSA testing (70). Higher rates of thyroid cancer in urban areas is consistent with previous studies (71). Likewise, this may be due to greater access to healthcare services utilization of imaging services among urban residents, especially as previous studies show urban residents have higher and increasing incidence of small tumors that may be indicative of incidentally detected cancers (71). Despite the elevated incidence rates of these cancers in urban areas, studies have either shown no rural–urban differences in mortality or elevated mortality in rural areas. Although there continues to be debate regarding overdiagnosis of both breast and thyroid cancers and as the USPSTF recently revisited prostate cancer screening recommendations, it is important for rural populations to have adequate access and utilization of screening services and cancer treatment to reduce rural mortality disparities.

Strengths and limitations

Our study is the first, to our knowledge, to comprehensively describe rural–urban differences in cancer incidence across sexes, racial/ethnic groups, regions, and poverty levels and to assess trends. Previous studies were limited to single-state cancer registries, multi-registry data sources like SEER, mortality data, or only considered one or a few cancer types. Assessing rural–urban differences across demographic and geographic designations and categorizing cancers by associations with carcinogenic agents like tobacco and HPV provides useful information to better understand disparities and inform population-based interventions. Furthermore, our assessment of rural–urban incidence trends will be useful for future research and interventions.

Our study was not without limitation. The only rural–urban metric available in the dataset was a dichotomous rural–urban measure, which limits how we could make comparisons. Analyses that use different measures and/or categorizations of rural–urban status may yield different results. Furthermore, the NAACCR dataset categorized counties into a small number of poverty groupings with the most impoverished grouping being 20+%. However, because poverty is more pervasive in rural areas (e.g., 21.7% of the entire rural South lives below poverty), residual confounding may have occurred when stratifying by only a small number of predefined poverty levels (72). The dataset did not include data from four states. This may particularly have affected analysis performed by U.S. Census region, as one state in the Northeast region (Vermont) and South region (Maryland) and two states in the Midwest region (Minnesota and Kansas) were not included. In addition, a few states were not certified for the entirety of the study period, thus their data were only included for years when they achieved silver or gold certification (73). This year-to-year variability may minimally impact findings, but to fully utilize the robustness of this dataset, we included all registries that were certified for each given year in our analysis.

Conclusions

We found that overall cancer incidence rates were higher in urban areas, but there were some areas where rural populations experience cancer disparity. Cancers associated with modifiable factors (i.e., tobacco and HPV) were higher in rural areas, as were cancers with either new or established screening modalities like lung, cervical, and colorectal cancers. Thus, these cancers, are ready for population-based, clinical, and/or policy strategies and interventions that will reduce risk and ultimately reduce incidence (and mortality). Our findings further underscore the importance of greater research investment in rural cancer control. In addition, as more geographically precise data become more readily available, more specific analysis could consider cancer incidence differences along a rural–urban gradient, beyond the dichotomous rural–urban designations used in our study and could look more finely at differences across census regions. This will be important for identifying areas and populations who would benefit the most from interventions known to be effective at reducing smoking, increasing HPV vaccination, and increasing access to and utilization of cancer screening tests. Future research should explore differences in cancer stage distribution, receipt of treatment, and survival to help further characterize rural-urban cancer disparities and to subsequently develop population and clinically based strategies and interventions to close gaps in rural–urban cancer outcomes.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Disclaimer

The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH, the North American Association of Central Cancer Registries, nor any individual cancer registry.

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Acknowledgments

The authors acknowledge the efforts of cancer registrars and state cancer registries in collecting and maintaining the data used in this study.

W.D. Jenkins, A.J. Fogleman, D.E. Steward, and L. Brard (P20CA192987) and A.S. James, S.R. Izadi, and G.A. Colditz (P20CA192966) are supported by grants from the National Cancer Institute.

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Received May 17, 2017; revised June 27, 2017; accepted July 18, 2017; published first July 27, 2017.

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