ORIGINAL ARTICLE

Histologic Lung Cancer Incidence Rates and Trends Vary by Race/Ethnicity and Residential County

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Received 14 August 2017; revised 30 November 2017; accepted 21 December 2017
Available online - 19 January 2018

ABSTRACT

Introduction: Lung cancer incidence is higher among non-Hispanic (NH) blacks than among the NH white and Hispanic populations in the United States. However, national cancer estimates may not always reflect the cancer burden in terms of disparities and incidence in small geographic areas, especially urban-rural disparities. Moreover, there is a gap in the literature regarding rural-urban disparities in terms of cancer histologic type.

Methods: Using population-based cancer registry data—Surveillance, Epidemiology and End Results and National Program of Cancer Registries data—we present age-adjusted histologic rates and trends by race/ethnicity and residential county location at the time of first cancer diagnosis. Rate ratios were calculated to examine racial/ethnic differences in rates. Annual percent change was calculated to measure changes in rates over time.

Results: We found that declines in squamous cell carcinoma are occurring fastest in metropolitan counties, whereas rates of adenocarcinoma increased fastest in counties nonadjacent to metropolitan areas. Further, although NH black men have increased lung cancer incidence compared with NH white and Hispanic men in all geographic locations, we found that the degree of the disparity increases with increasing rurality of residence. Finally, we discovered that among women whose lung cancer was diagnosed when they were younger than 55 years, the incidence of squamous cell carcinoma and adenocarcinoma was higher for NH blacks than for NH whites.

Conclusions: Our results highlight disparities among NH blacks in nonadjacent rural areas. These findings may have significant impact for the implementation of smoking cessation and lung cancer screening programs.

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Keywords: Lung cancer; Histology; Incidence; Surveillance; Health disparities; Registry

Introduction

Although cigarette smoking has decreased significantly over the past few decades, disparities in tobacco use and lung cancer incidence in terms of race, ethnicity, education, and socioeconomic status remain in the United States.[1–4] The main types of lung cancer include SCLC and NSCLC (adenocarcinoma, squamous cell carcinoma, and large cell carcinoma). Approximately 80% to 85% of lung cancers are NSCLC and 10% to 15% are SCLC. Most lung cancers are due to smoking; however, the strength of association varies by histologic subtype.[5] Evidence suggests that cigarette smoking is more strongly associated with SCLC and squamous cell carcinoma and less associated with adenocarcinoma and large call carcinoma.[6–8] Public health campaigns around the negative health consequences of smoking initiated a decline in smoking prevalence and a decrease in lung cancer incidence toward the end of the last century. Squamous cell carcinoma and SCLC declined, but the adenocarcinoma subtype increased. Although some of these histologic changes are attributable to the global decline in smoking prevalence,[4] changes in the design

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

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Published by Elsevier Inc. on behalf of International Association for the Study of Lung Cancer.

ISSN: 1556-0864

https://doi.org/10.1016/j.jtho.2017.12.010

and composition of cigarettes—both of which modified inhalation and patterns of use—are also attributable causes.[4, 9–11] Racial and ethnic differences in smoking behaviors and lung carcinogenesis[12] suggest that some racial/ethnic groups are more susceptible to lung cancer.[2] For instance, despite lower smoking prevalence rates,[2] later age of smoking initiation,[13–15] and lower number of cigarettes smoked per day,[13] non-Hispanic (NH) blacks are disproportionately affected by lung cancer compared with NH whites.[13,16–19] Furthermore, among Hispanic populations, the incidence of lung cancer is lower than among NH whites[20]—a trend that is also observed among first-generation U.S. Hispanics[21]—whereas the prevalence of smoking in the aggregate is approximately 40% to 50% lower than in NH whites, though it is worth noting that there are marked differences in smoking patterns according to country of origin.[13,20] Collectively, cigarette smoking patterns appear to contribute to, but not fully explain racial/ethnic disparities in lung cancer incidence.[22–26] Thus, some aspects of racial/ethnic disparities in lung cancer incidence may be associated with modifiable exposures or other unmeasured facets of tobacco use.[27]

Geographical residence—and associated environmental exposures such as smoking, radon, pollution, and other unknown factors—is one potential cofactor that mediates racial/ethnic disparities in lung cancer incidence.[28] Smoking rates and unhealthy behaviors, for example, are higher in rural areas.[29–31] A recent comprehensive description of histologic lung cancer incidence rates and trends in the United States demonstrated that lung cancer rates overall are highest in the South, whereas lung adenocarcinoma rates are highest in the Northeast region.[3,19] Moreover, recent work has suggested that higher altitude is associated with reduced incidence of lung cancer.[32–34] Few studies have examined differences in lung cancer incidence by using small or well-defined geographic regions. These studies are important, as they may help to identify regions with patients at high risk for lung cancer that can be targeted for outreach and implementation of low-dose computed tomography (LDCT) screening. Efforts are also needed to reduce disparities in rural and urban lung cancer rates; to do so, however, one first needs to identify and characterize these disparities. In this study, we have examined county-level lung cancer incidence rates by histologic subtype, with an emphasis on racial/ethnic and geographical differences.

Materials and Methods

Data Sources

Data on incident lung and bronchus cancer cases diagnosed between 2004 and 2013 were obtained from the Centers for Disease Control and Prevention National Programs of Cancer Registries (NPCR) and the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) registries. Together, these two registries provide cancer incidence data for 100% of the U.S population without duplication of individual registries. NPCR and SEER are required to have fewer than two unresolved duplicates per 1000 cases to meet USCS publication criteria. The Registry Plus Link Plus system was used to detect duplicate records. All registries that met the United States Cancer Statistics data quality standards were included. Minnesota and Kansas were excluded from the study because of missing county-level data, and Nevada was excluded because statewide data did not meet high-quality standards for all study years, resulting in 96.5% coverage of the U.S. population.

Because the influence of cigarette smoke on the risk of lung cancer histologic subtypes is not equal,[8] we examined incidence rates and trends for all major histologic lung cancer subtypes. Lung cancer histologic groups were defined by using International Classification of Diseases for Oncology, Version 3, codes as follows: SCLC (8002–8005 and 8041–8045); NSCLC (8046); squamous (8052, 8070–8076, 8078, 8083–8084, 8094, 8120, and 8123); adenocarcinoma (8050, 8140–8141, 8144, 8201, 8250–8255, 8260, 8290, 8310, 8320, 8323, 8333, 8470, 8480, 8481, 8490, 8507, 8550, 8570, 8572, 8574, and 8576); large cell (8012–8014, 8021, and 8082); carcinoma, NOS (8000, 8001, 8010, 8020, and 8230); other specified types (8022, 8030, 8031–8033, 8200, 8240, 8241, 8244–8246, 8249, 8430, 8560, 8562, and 8575); sarcoma (8800–8805, 8810, 8811, 8815, 8830, 8890, 8900, 8940, 9040, 9041, 9043, 9120, 9133, 9220, 9231, 9473, and 9540) (Supplementary Table 1). Cases were restricted to non-Hispanic (NH) white, NH black, and Hispanic adults (≥18 years), with Hispanic ethnicity being mutually exclusive from race categories. Cases verified by autopsy only or death certificate only and not microscopically confirmed were excluded from the study.

Using state-county American National Standards Institute codes, which are also referred to as Federal Information Processing Standards codes, we coded incidence data by assigning 2003 county-level Rural-Urban Continuum Codes (RUCCs) on the basis of county of residence at the time of first diagnosis. RUCC is a system for county-level assessment of rurality and urbanization with codes ranging from 1 to 9 that was developed by the United States Department of Agriculture.[35] For metropolitan-nonmetropolitan variation analysis, counties were categorized as metropolitan (RUCC codes 1–3), adjacent to metropolitan (RUCC codes 4, 6, and 8), or nonadjacent to metropolitan (RUCC codes 5, 7, and 9).[28] RUCC codes 1 to 3 correspond to counties

in metropolitan areas with a population of 250,000 or more; codes 4, 6, and 8 correspond to counties in urban and rural counties adjacent to metropolitan areas; and codes 5, 7, and 9 correspond to urban and rural counties not adjacent to a metropolitan area.

Statistical Analysis

Age-adjusted incidence rates were calculated for each year and by histologic subtype, sex, race/ethnicity, and county residence (rural versus urban status). Racial versus ethnic incidence rate ratios were calculated by using NH white age-adjusted rate as the referent group compared with rates for NH black and Hispanic adults. Rates were calculated per 100,000 persons and 95% confidence intervals were calculated for rates and rate ratios. Rate ratios were calculated to examine differences in rates between racial/ethnic groups. Annual percent change (APC) was calculated to measure rate trends over time. Differences between racial/ethnic groups within each region were considered significant at p less than 0.05. All data analyses were performed with SEER*Stat software, version 8.2.1. The Tiwari method was used to calculate confidence intervals for rate ratios and rates.[36]

Results

Lung cancer was diagnosed in 1,491,055 NH whites, 190,060 NH blacks, and 70,613 Hispanics between 2004 and 2013. The majority of patients resided in metropolitan counties at the time of first cancer diagnosis (Table 1). The rates for NH black and NH white men living in metropolitan counties were similar (61.1 and 60.2 per 100, 00, respectively), whereas the rates for NH white men living in counties adjacent to metropolitan counties were higher than those for NH blacks (63.3 and 60.5 per 100,000, respectively), and the rates for NH blacks living in counties not adjacent to metropolitan counties were higher than those for NH whites (61.2 and 60.9 per 100,000, respectively). The overall rates of lung cancer among adults age 45 to 54 and 55 to 64 years were higher for NH blacks (54.4 and 154.0 per 100,000, respectively) and lower for Hispanics (15.5 and 55.3 per 100,000, respectively) than the rates for NH whites (43.4 and 131.3 per 100,000, respectively) (see Table 1). Adenocarcinoma had the highest incidence, followed by squamous cell carcinomas, among all racial/ethnic groups. Incidence of late-stage disease was higher among NH blacks (33.4 per 100,000) than among NH white (30.8 per 100,000) and Hispanic adults (15.9 per 100,000).

As shown in Table 2, among U.S. adult males younger than 55 years, NH blacks have the highest incidence rates for squamous cell (2.3 per 100,000), adenocarcinoma (5.3 per 100,000), and large cell (0.5 per 100,000) lung cancers. Historically, NH black women have had a lower incidence of lung cancer than NH white women.[10,37,38] However, our analysis demonstrated that among women younger than 55 years, squamous cell (rate ratio 1.19), adenocarcinoma (rate ratio 1.10), and large cell carcinoma (rate ratio 1.15) incidence rates are significantly higher than those among NH white women (see Table 2). The incidence for SCLCs was significantly lower for Hispanic (rate ratio 0.45) and NH black (rate ratio 0.80) men than for NH white men (see Table 2). We further analyzed these data by looking at APCs during the period from 2004 to 2013. Interestingly, our study found that for most age groups ($\geq$55 years), the APC of lung adenocarcinoma is higher among NH black women than among NH white women. Similar observations were made among men (see Table 2).

Table 3 shows sex-specific incidence rates for different histologic types of lung cancer and trends by regional location and race. Rates of squamous cell among men were significantly higher in adjacent metropolitan (rate ratio 1.25) and nonadjacent (rate ratio 1.19) counties than the rates for men living in metropolitan counties. Similar observations were observed for women (see Table 3). We noted that the racial disparity in incidence persisted among men regardless of residential location. However, we observed that degree of disparity in incidence of lung squamous cell carcinoma between NH black men and NH white men increased linearly with decreasing proximity to metropolitan counties, rising from 24% to 29% to 45% in metropolitan, adjacent metropolitan, and nonadjacent metropolitan locations, respectively.

We observed declining rate trends for SCLC and squamous cell lung cancer in both men and women, with greater significant rate declines occurring in men and women living in metropolitan counties (see Table 3). For SCLCs, there was evidence that greater declines occur among NH Black men and women living in metropolitan counties (APC for men –3.6% and APC for women –2.3%).

The incidences of lung adenocarcinoma in metropolitan counties and counties not adjacent to metropolitan counties were significantly higher among NH black men than among NH white men (see Table 3). The degree of disparity between NH white and NH black men with regard to lung adenocarcinoma was greater with increasing rurality of county, with rates increasing more rapidly among NH black men living in metropolitan counties (APC2.0%) and counties not adjacent to metropolitan counties (APC 4.6%) (see Table 3). Although lung adenocarcinoma rates for NH black women are significantly lower than those for NH white women for all geographic locations, rate increases were greater among NH black women (see Table 3).

The incidence of large cell lung cancer was significantly higher in nonmetropolitan counties than in

Table 1. Racial/Ethnic Incidence Rates of Lung Cancer, by Select Demographic Characteristics, Histologic Type, and Diagnosis Stage: United States, 2004-2013

Demographic and Clinical Characteristics	Total (N = 1,751,728)		NH White (n = 1,491,055)		NH Black (n = 190,060)		Hispanic (n = 70,613)	
	n (%)[a]	Rate (CI)	n (%)[a]	Rate (CI)	n (%)[a]	Rate (CI)	n (%)[a]	Rate (CI)
County of residence[b]								
Metropolitan	1,419,987 (81.1%)	57.5 (57.4-57.6)	1,185,705 (79.5%)	60.2 (60.1-60.3)	168,651 (88.7%)	61.1 (60.8-61.4)	65,631 (92.9%)	29.4 (29.2-29.6)
Adjacent to metropolitan	223,295 (12.7%)	62.4 (62.1-62.7)	204,531 (13.7%)	63.6 (63.3-63.8)	15,564 (8.2%)	60.5 (59.6-61.5)	3200 (4.5%)	31.4 (30.3-32.6)
Nonadjacent to metropolitan	107,444 (6.1%)	59.7 (59.3-60.1)	99,936 (6.7%)	60.9 (60.5-61.3)	5753 (3.0%)	61.2 (59.6-62.9)	1755 (2.5%)	27.6 (26.3-29)
Region[c]								
Northeast	359,607 (20.5%)	59.5 (59.3-59.7)	314,246 (21.1%)	61.6 (61.4-61.8)	31,871 (16.8%)	57.4 (56.7-58)	13,490 (19.1%)	34.8 (34.2-35.4)
Midwest	396,877 (22.7%)	62.8 (62.6-63)	352,539 (23.6%)	62.7 (62.5-62.9)	39,750 (20.9%)	73.3 (72.6-74)	4588 (6.5%)	30.9 (29.9-31.9)
South	724,236 (41.3%)	61.4 (61.3-61.6)	591,838 (39.7%)	65.2 (65-65.3)	103,504 (54.5%)	59 (58.6-59.3)	28,894 (40.9%)	30.5 (30.2-30.9)
West	271,008 (15.5%)	45.7 (45.6-45.9)	232,432 (15.6%)	49 (48.8-49.2)	149,35 (7.9%)	57 (56.1-58)	23,641 (33.5%)	26 (25.7-26.4)
Sex								
Male	942,116 (53.8%)	70.2 (70-70.3)	795,011 (53.3%)	71.7 (71.5-71.8)	107,635 (56.6%)	83.4 (82.9-83.9)	39,470 (55.9%)	38.6 (38.2-39)
Female	809,612 (46.2%)	49.1 (49-49.3)	696,044 (46.7%)	52.4 (52.2-52.5)	82,425 (43.4%)	45.9 (45.5-46.2)	31,143 (44.1%)	22.9 (22.6-23.2)
Age, y								
<45	30,496 (1.7%)	2.0 (1.9-2.0)	23,101 (1.5%)	2.2 (2.2-2.2)	4794 (2.4%)	2.2 (2.1-,2.3)	2601 (3.7%)	0.9 (0.9-,0.9)
45-54	167,974 (9.6%)	41.3 (41.1-41.5)	131,642 (8.8%)	43.3 (43.1-43.5)	28,689 (15.1%)	54.4 (53.7-55)	7643 (10.8%)	15.5 (15.2-15.8)
55-64	404,644 (23.1%)	126.8 (126.4-127.2)	333,449 (22.4%)	131.1 (130.7-131.6)	55,133 (29.0%)	154 (152.7-155.3)	16,062 (22.7%)	55.3 (54.4-56.1)
65-74	592,230 (33.8%)	307.2 (306.4-308)	509,985 (34.2%)	322.1 (321.2-323)	59,222 (31.2%)	308.2 (305.7-310.7)	23,023 (32.6%)	151.1 (149.1-153.1)
≥75	556,384 (31.8%)	330.8 (329.9-331.7)	492,878 (33.1%)	343.5 (342.5-344.4)	42,222 (22.2%)	305.9 (303-308.8)	21,284 (30.1%)	198.6 (195.9-201.3)
Histologic type								
SCLC	256,549 (14.6%)	8.4 (8.4-8.5)	228,054 (15.3%)	9.2 (9.2-9.3)	20,053 (10.6%)	6.5 (6.4-6.5)	8442 (12.0%)	3.5 (3.4-3.5)
NSCLC	233,268 (13.3%)	7.8 (7.7-7.8)	195,226 (13.1%)	8 (7.9-8)	28,935 (15.2%)	9.2 (9.1-9.3)	9,107 (12.9%1)	3.8 (3.7-3.9)
Squamous cell	402,483 (23.0%)	13.5 (13.4-13.5)	343,312 (23.0%)	14 (13.9-14)	45,623 (24.0%)	15.3 (15.2-15.4)	13,548 (19.2%)	6 (5.9-6.1)
Adenocarcinoma	673,810 (38.5%)	22.3 (22.3-22.4)	568,326 (38.1%)	23.1 (23.1-23.2)	75,480 (39.7%5)	23.7 (23.6-23.9)	30,004 (42.5%)	12.4 (12.2-12.5)
Large cell	46,876 (2.7%)	1.6 (1.5-1.6)	39,775 (2.7%)	1.6 (1.6-1.6)	5520 (2.9%)	1.7 (1.7-1.8)	1581 (2.2%)	0.7 (0.6-0.7)
Carcinoma, NOS	56,596 (3.2%)	1.9 (1.9-1.9)	46,256 (3.1%)	1.9 (1.9-1.9)	6848 (3.6%)	2.3 (2.2-2.3)	3492 (4.9%)	1.5 (1.5-1.6)
Sarcoma	2631 (0.2%)	0.1 (0.1-0.1)	2140 (0.1%)	0.1 (0.1-0.1)	288 (0.2%)	0.1 (0.1-0.1)	203 (0.3%)	0.1 (0.1-0.1)
Other specified types	77,797 (4.4%)	2.6 (2.6-2.6)	66,553 (4.5%)	2.8 (2.7-2.8)	7134 (3.8%)	2.2 (2.2-2.3)	4110 (5.8%)	1.6 (1.5-1.6)

(continued)

Table 1. Continued

Demographic and Clinical Characteristics	Total (N = 1,751,728)		NH White (n = 1,491,055)		NH Black (n = 190,060)		Hispanic (n = 70,613)	
	n (%)[a]	Rate (CI)	n (%)[a]	Rate (CI)	n (%)[a]	Rate (CI)	n (%)[a]	Rate (CI)
Stage at diagnosis								
Localized	340,956 (19.5%)	11.4 (11.4-11.5)	298,219 (20.0%)	12.2 (12.2-12.3)	30,759 (16.2%)	10.2 (10.1-10.3)	11,978 (17.0%)	5.1 (5-5.2)
Regional	430,528 (24.6%)	14.3 (14.3-14.3)	369,030 (24.7%)	15 (15-15.1)	45,913 (24.2%)	14.7 (14.5-14.8)	15,585 (22.1%)	6.5 (6.4-6.6)
Distant	902,941 (51.5%)	29.8 (29.8-29.9)	758,755 (50.9%)	30.8 (30.7-30.9)	105,337 (55.4%)	33.4 (33.2-33.6)	38,849 (55.0%)	15.9 (15.8-16.1)
Unknown	77,303 (4.4%)	2.6 (2.6-2.6)	65,051 (4.4%)	2.6 (2.6-2.7)	8051 (4.2%)	2.7 (2.7-2.8)	4201 (5.9%)	1.9 (1.8-1.9)

Note: Cases diagnosed by death certificate only or autopsy only are excluded from all analyses. Rates are per 100,000 and age-adjusted to the 2000 U.S. standard population (19 age groups, Census P25-1130) standard; confidence intervals (Tiwari method) are 95% for rates and ratios. Lung cancer histologic groups were defined by using the International Classification of Diseases for Oncology, Version 3 (see Supplementary Table 1). Data are from population-based registries that participate in the National Program of Cancer Registries and/or the Surveillance, Epidemiology, and End Results registry and meet high-quality data criteria. Nevada was excluded because it did not meet United States Cancer Statistics publication criteria, and Minnesota and Kansas were excluded because of missing county data. These registries cover 96.5% of the U.S. population in 2004-2013.

[a]Column percentages.

[b]Counties were categorized by Rural-Urban Continuum Codes (RUCC) into urban (RUCC 1-3), adjacent urban (RUCC 4, 6, and 8), and nonadjacent rural (RUCC 5, 7, and 9).

[c]Categorized by U.S. census region.

NH, non-Hispanic; CI, confidence interval; NOS, not otherwise specified.

metropolitan counties for both men and women. Compared with the rates for NH white men, the rates for NH black men in metropolitan counties and counties adjacent to metropolitan counties were significantly higher (rate ratios 1.22 and 1.33 per 100,000, respectively) and significantly lower for Hispanics in all regional locations (rate ratios 0.47, 0.53, and 0.47 per 100,000, respectively). Compared with the incidence among NH white women, the incidence of large cell lung cancer was slightly lower among NH black (rate ratio 0.93) and Hispanic women (rate ratio 0.35), in metropolitan counties. The data also support a declining incidence of large cell lung cancer overall (see Table 3).

SCLC is the one histologic subtype with a lower incidence in NH blacks and Hispanic adults than in NH whites (see Table 3). Lower rates among NH black and Hispanic adults remained consistent across regional locations. Incidence rates significantly decreased among adults living in metropolitan counties and among women living in counties not adjacent to metropolitan areas (see Table 3).

Discussion

Recent comprehensive studies of the incidence rates of and trends in different histologic types of lung cancer in the United States demonstrated that rates vary by both race/ethnicity and geographic location.[3,19,39,40] However, these studies addressed geographic variance using topographical analyses at the census[19] or statewide[40] level. This study uses national data to provide up-to-date racial/ethnic rates and trends of histologic type of lung cancers by U.S. residential county.

In this study, our main research question was whether there was geographic variance in racial disparities at the county level. Our results show that the higher incidence of lung cancer in NH black men than in NH white men is observed in metropolitan and nonadjacent counties but the degree of disparity increases the further counties are situated from metropolitan areas. We also observed significantly higher rates of large cell lung cancer incidence in NH black women living in counties adjacent to metropolitan counties than in their NH white counterparts. To our knowledge, this is the first time that these trends have been reported.

Studies show rural-urban differences in smoking behaviors,[31] with the prevalence smoking higher in rural counties. Thus, it is possible that smoking contributes to the increased disparity in nonadjacent counties among NH black men. Studies that directly compare racial differences in smoking in rural areas are rare to our knowledge. One study, in adolescents, shows that cigarette smoking is higher among NH whites than among NH blacks.[41] However, given the

Table 2. Incidence Rates of Invasive Squamous Cell, Adenocarcinoma, Small Cell, and Large Cell Histologic Types of Lung Cancer for U.S. Men and Women by Race/Ethnicity and Age at Diagnosis, 2004 – 2013

Age and Race/Ethnicity	Squamous Cell						Adenocarcinoma					
	Men			Women			Men			Women		
	Rate (95% CI)	Rate Ratio	APC	Rate (95% CI)	Rate Ratio	APC	Rate (95% CI)	Rate Ratio	APC	Rate (95% CI)	Rate Ratio	APC
Total												
NH white	19.5 (19.5-19.6)	Ref	0.0	9.5 (9.5-9.6)	Ref	1.5[b]	24.9 (24.8-25)	Ref	1.2[b]	22.0 (22.0-22.1)	Ref	2.7[b]
NH black	24.1 (23.8-24.4)	1.23[a]	-2.0[b]	9.4 (9.3-9.5)	0.99	0.4	29.6 (29.2-29.9)	1.19[a]	2.0[b]	19.8 (19.6-20)	0.90[a]	3.3[b]
Hispanic	9.2 (9-9.4)	0.47[a]	-1.7[b]	3.6 (3.5-3.7)	0.37[a]	0.9	14.5 (14.2-14.7)	0.58[a]	0.6	10.9 (10.7-11.1)	0.49[a]	2.0[b]
<55 y												
NH white	1.9 (1.9-1.9)	Ref	-0.9[b]	0.9 (0.9-1.0)	Ref	0.1	3.3 (3.3-3.3)	Ref	0.7	4.3 (4.2-4.3)	Ref	2.7[b]
NH black	2.3 (2.2-2.4)	1.22[c]	-5.1[b]	1.1 (1.1-1.2)	1.19[c]	-5.1[b]	5.3 (5.2-5.4)	1.61[c]	-1.3[b]	4.7 (4.6-4.8)	1.10[c]	1.3
Hispanic	0.5 (0.5-0.5)	0.26[c]	-6.0[b]	0.3 (0.3-0.3)	0.33[c]	-4	1.5 (1.4-1.5)	0.44[c]	-2.4[b]	1.8 (1.7-1.8)	0.41[c]	0.3
55-64 y												
NH white	38.0 (37.6-38.3)	Ref	-1.4[b]	17.5 (17.2-17.7)	Ref	-1.1[b]	50 (49.6-50.4)	Ref	0.5[b]	49.7 (49.3-50.1)	Ref	0.9[b]
NH black	49.4 (48.3-50.5)	1.30[c]	-3.7[b]	19.0 (18.4-19.6)	1.09[c]	-1.8[b]	80.3 (78.9-81.7)	1.61[c]	1.7[b]	52.7 (51.7-53.7)	1.06[c]	3.4[b]
Hispanic	13.5 (12.9-14.1)	0.36[c]	-4.7[b]	5.6 (5.2-6)	0.32[c]	-1.9	26.0 (25.1-26.9)	0.52[c]	0.1	22.5 (21.8-23.3)	0.45[c]	1.9[b]
65-74 y												
NH white	106.1 (105.3-106.8)	Ref	-0.8[b]	56.9 (56.4-57.4)	Ref	0.8	127.3 (126.5-128.1)	Ref	0.4	113.4 (112.7-114.1)	Ref	2.2[b]
NH black	130.2 (127.7-132.7)	1.23[c]	-1.2	52.5 (51.1-53.8)	0.92[c]	1.3[b]	146.2 (143.5-148.8)	1.15[c]	2.4[b]	94.2 (92.4-96)	0.83[c]	3.5[b]
Hispanic	47.4 (45.7-49.1)	0.45[c]	-3.0[b]	19.7 (18.8-20.7)	0.35[c]	0.4	72.4 (70.4-74.5)	0.57[c]	0.2	53.2 (51.7-54.8)	0.47[c]	1.8[b]
≥75 y												
NH white	128.2 (127.3-129.2)	Ref	1.4[b]	57.9 (57.3-58.4)	Ref	3.8[b]	157.8 (156.7-158.8)	Ref	2.4[b]	113.7 (113-114.5)	Ref	4.4[b]
NH black	156.0 (152.5-159.6)	1.22[c]	-1.2	56.5 (54.9-58.1)	0.98	2.1[b]	144.4 (141.1-147.9)	0.92[c]	3.6[b]	87.3 (85.4-89.3)	0.77[c]	4.4[b]
Hispanic	75.4 (72.8-78.1)	0.59[c]	0.4	25.4 (24.2-26.7)	0.44[c]	3.1[b]	104.3 (101.2-107.5)	0.66[c]	1.6[b]	66.6 (64.6-68.6)	0.59[c]	2.7[b]

(continued)

Table 2. Continued

	Small cell						Large cell					
	Men			Women			Men			Women		
	Rate (95% CI)	Rate ratio	APC	Rate (95% CI)	Rate ratio	APC	Rate (95% CI)	Rate ratio	APC	Rate (95% CI)	Rate ratio	APC
Total												
NH white	10.0 (9.9-10.0)	Ref	-3.2[b]	8.7 (8.6-8.7)	Ref	-1.8[b]	2.0 (2.0-2.0)	Ref	-12.2[b]	1.3 (1.3-1.3)	Ref	-11.1[b]
NH black	8.0 (7.8-8.2)	0.80[a]	-3.5[b]	5.4 (5.3-5.5)	0.63[a]	-2.0[b]	2.4 (2.4-2.5)	1.21[a]	-11.3[b]	1.2 (1.1-1.3)	0.92[a]	-9.2[b]
Hispanic	4.5 (4.4-4.6)	0.45[a]	-3.8[b]	2.7 (2.6-2.8)	0.31[a]	-1.6[b]	0.9 (0.9-1.0)	0.46[a]	-14.6[b]	0.4 (0.4-0.5)	0.34[a]	-13.7[b]
<55 y												
NH white	1.5 (1.5-1.5)	Ref	-3.8[b]	1.6 (1.5-1.6)	Ref	-1.8[b]	0.3 (0.3-0.3)	Ref	-11.4[b]	0.3 (0.3-0.3)	Ref	-10.9[b]
NH black	1.1 (1.1-1.2)	0.76[c]	-5.3[b]	0.9 (0.9-1.0)	0.60[c]	-3.5[b]	0.5 (0.5-0.6)	1.67[c]	-11.3[b]	0.3 (0.3-0.3)	1.15[c]	-11.0[b]
Hispanic	0.4 (0.3-0.4)	0.24[c]	-8.1[b]	0.3 (0.3-0.4)	0.21[c]	-3.1	0.1 (0.1-0.1)	0.28[c]	[d]	0.1 (0.1-0.1)	0.26[c]	[d]
55-64 y												
NH white	24.3 (24.0-24.6)	Ref	-4.0[b]	23.1 (22.9-23.4)	Ref	-2.9[b]	4.4 (4.3-4.5)	Ref	-11.8[b]	3.1 (3.0-3.2)	Ref	-12.6[b]
NH black	19.7 (19.0-20.4)	0.81[c]	-4.5[b]	14.3 (13.7-14.8)	0.62[c]	-2.7[b]	6.6 (6.2-7.0)	1.51[c]	-11.5[b]	3.1 (2.9-3.4)	1.01	-10.7[b]
Hispanic	9.1 (8.6-9.7)	0.38[c]	-6.8[b]	6.5 (6.1-6.9)	0.28[c]	-1.6[b]	1.6 (1.4-1.8)	0.36[c]	[d]	1.0 (0.8-1.1)	0.31[c]	[d]
65-74 y												
NH white	53.2 (52.7-53.7)	Ref	-3.0[b]	48.5 (48.0-49.0)	Ref	-1.9[b]	10.3 (10.1-10.6)	Ref	-12.3[b]	6.8 (6.6-7.0)	Ref	-11.0[b]
NH black	41.4 (40.0-42.8)	0.78[c]	-3.1[b]	29.1 (28.1-30.1)	0.60[c]	-1.9[b]	11.6 (10.8-12.3)	1.12[c]	-11.5[b]	5.8 (5.4-6.3)	0.86[c]	-7.8[b]
Hispanic	24.9 (23.7-26.1)	0.47[c]	-2.5[b]	15.8 (14.9-16.6)	0.32[c]	-2.5	5.2 (4.7-5.8)	0.51[c]	-14.4[b]	2.1 (1.8-2.5)	0.31[c]	[d]
≥75 y												
NH white	52.4 (51.8-53.0)	Ref	-2.7[b]	36.7 (36.2-37.1)	Ref	-0.8[b]	11.6 (11.3-11.9)	Ref	-12. 6[b]	6.2 (6.0-6.4)	Ref	-10.1[b]
NH black	44.0 (42.1-45.9)	0.84[c]	-2.4[b]	25.2 (24.2-26.3)	0.69[c]	-0.6	11.2 (10.2-12.1)	0.96	-10.9[b]	4.9 (4.5-5.4)	0.80[c]	-8.3[b]
Hispanic	29.4 (27.8-31.1)	0.56[c]	-3.0[b]	13.8 (12.9-14.7)	0.38[c]	0.1	6.4 (5.6-7.2)	0.55[c]	-14.1[b]	2.8 (2.4-3.2)	0.45[c]	[d]

Note: Cases diagnosed by death certificate only or autopsy only are excluded from all analyses. Lung cancer histologic groups were defined by using the International Classification of Diseases for Oncology, Version 3 (see Supplementary Table 1). Rates are per 100,000 and age-adjusted to the 2000 U.S. standard population (19 age groups, Census P25-1130) standard; confidence intervals (Tiwari method) are 95% for rates and ratios. Data are from population-based registries that participate in the National Program of Cancer Registries and/or the Surveillance, Epidemiology, and End Results registry and meet high-quality data criteria. Nevada was excluded because it did not meet United States Cancer Statistics publication criteria, and Minnesota and Kansas were excluded because of missing county data. These registries cover 96.5% of the U.S. population in 2004-2013.

[a]Rate is significantly different from the rate for NH white (referent) ($p < 0.05$).

[b]The APC is significantly different from zero ($p < 0.05$).

[c]Rate is for the age category is significantly different from the rate for the NH white counterpart (referent) ($p < 0.05$).

[d]Statistic could not be calculated because of case count in 1 or more years fewer than 16.

CI, confidence interval; APC, annual percent change; NH, non-Hispanic; Ref, referent group.

later age at which NH blacks initiate smoking, this is not necessarily surprising.[15] We are not aware of studies among adults that break down these observations by race/ethnicity and sex. In addition, smoking is a very complex exposure to capture. In addition to status (i.e., current smoker, former smoker, and never-smoker), dose (cigarettes per day), duration, age at initiation, time to first cigarette, and daily versus nondaily use are key aspects of smoking relevant to its relationship with cancer. Moreover, depth of inhalation, smoking efficiency, type of tobacco (filtered, menthol, smokeless, etc.), are all factors that likely contribute to the complex relationship between smoking, lung cancer, and racial disparities.

Although several exposures have been linked to lung cancer, the effect size for smoking ranks highest by far. Other environmental and lifestyle exposures could contribute to this disparity, including radon exposure; ambient air quality; and exposure to asbestos, pesticides, diesel, and additional pollutants. Indeed, NH blacks are disproportionately employed in jobs in which they are exposed to these factors[42,43] and they often live in areas with higher sources of pollution.[44–51] Data are sparse regarding the relationship between

Table 3. Age-Adjusted Incidence Rates of Invasive Lung Cancer and APC Stratified by Histologic Type, Sex, Race, and County Designation, 2004 – 2013

	Male			Female		
Characteristic	Rate (95% CI)	APC	Rate Ratio	Rate (95% CI)	APC	Rate Ratio
Squamous cell						
Metropolitan	18.3 (18.3-18.4)	-0.5	Ref	8.8 (8.8-8.9)	1.0[a]	Ref
NH white	18.8 (18.7-18.9)	-0.1	Ref	9.4 (9.3-9.4)	1.3[a]	Ref
NH black	23.3 (23.0-23.6)	-2.2[a]	1.24[b]	9.5 (9.4-9.7)	0.4	1.02
Hispanic	9.2 (9.0-9.4)	-1.7[a]	0.49[b]	3.5 (3.4-3.6)	0.9	0.37[b]
Adjacent to metropolitan	22.9 (22.7-23.2)	0.0	1.25[b]	9.9 (9.7-10)	2.2[a]	1.11[b]
NH white	22.9 (22.7-23.2)	0.1	Ref	10.1 (10.0-10.3)	2.3[a]	Ref
NH black	29.5 (28.4-30.6)	-0.8	1.29[b]	8.3 (7.9-8.8)	0.7	0.82[b]
Hispanic	10.3 (9.4-11.3)	-3.1	0.45[b]	4.5 (4.0-5.2)	~	0.45[b]
Nonadjacent to metropolitan	21.8 (21.5-22.1)	0.1	1.19[b]	9.7 (9.5-9.9)	2.7[a]	1.09[b]
NH white	21.8 (21.5-22.2)	0.2	Ref	9.9 (9.7-10.1)	2.9[a]	Ref
NH black	31.7 (29.9-33.6)	0.0	1.45[b]	9.1 (8.3-10.0)	-0.2	0.91
Hispanic	8.1 (7.1-9.2)	~	0.37[b]	4.2 (3.5-5.0)	~	0.42[b]
Adenocarcinoma						
Metropolitan	24.7 (24.6-24.8)	1.0[a]	Ref	21.3 (21.2-21.4)	2.4[a]	Ref
NH white	25.1 (25.0-25.2)	1.0[a]	Ref	22.7 (22.6-22.8)	2.5[a]	Ref
NH black	29.6 (29.3-29.9)	2.0[a]	1.18[b]	20.4 (20.1-20.6)	3.1[a]	0.90[b]
Hispanic	14.7 (14.4-14.9)	0.7[a]	0.58[b]	11.0 (10.8-11.1)	1.9[a]	0.48[b]
Adjacent to metropolitan	24.5 (24.3-24.8)	1.8[a]	0.99	19 (18.8-19.2)	3.5[a]	0.89[b]
NH white	24.5 (24.3-24.8)	1.9[a]	Ref	19.6 (19.4-19.8)	3.5[a]	Ref
NH black	29.1 (28.1-30.2)	1.6	1.19[b]	15.0 (14.4-15.7)	4.4[a]	0.77[b]
Hispanic	13.1 (12.0-14.2)	0.3	0.53[b]	9.9 (9.0-10.8)	3.1	0.50[b]
Nonadjacent to metropolitan	23.2 (22.8-23.5)	1.9[a]	0.94[b]	18.2 (18-18.5)	3.7[a]	0.86[b]
NH white	23.3 (22.9-23.6)	1.9[a]	Ref	18.8 (18.5-19.1)	3.6[a]	Ref
NH black	29.2 (27.5-30.9)	4.6[a]	1.25[b]	14.9 (13.9-16.0)	5.9[a]	0.79[b]
Hispanic	11.2 (10.0-12.5)	-3.3	0.48[b]	9.6 (8.6-10.8)	0.6	0.51[b]
Small cell						
Metropolitan	8.9 (8.9-9)	-3.6[a]	Ref	7.5 (7.5-7.6)	-2.3[a]	Ref
NH white	9.6 (9.5-9.6)	-3.3[a]	Ref	8.4 (8.4-8.5)	-2.0[a]	Ref
NH black	7.9 (7.7-8.0)	-3.5[a]	0.82[b]	5.5 (5.4-5.6)	-2.2[a]	0.65[b]
Hispanic	4.5 (4.3-4.6)	-3.7[a]	0.47[b]	2.6 (2.5-2.7)	-1.7[a]	0.31[b]
Adjacent to metropolitan	11.4 (11.3-11.6)	-2.9[a]	1.29[b]	9.2 (9.1-9.3)	-1.0[a]	1.22[b]
NH white	11.9 (11.7-12.0)	-2.8[a]	Ref	9.7 (9.6-9.9)	-1.0[a]	Ref
NH black	8.9 (8.3-9.5)	-3.7[a]	0.75[b]	4.9 (4.5-5.3)	-0.8	0.50[b]
Hispanic	5.2 (4.6-5.9)	-6.5[a]	0.44[b]	4.1 (3.6-4.7)	-0.2	0.42[b]
Nonadjacent to metropolitan	10.9 (10.6-11.1)	-2.9[a]	1.22[b]	9 (8.8-9.2)	-1.5[a]	1.20[b]
NH white	11.2 (11.0-11.5)	-2.9[a]	Ref	9.5 (9.3-9.7)	-1.5[a]	Ref
NH black	9.5 (8.5-10.5)	-1.6	0.84[b]	4.4 (3.8-5.0)	[c]	0.46[b]
Hispanic	4.5 (3.7-5.3)	~	0.40[b]	3.8 (3.2-4.6)	[c]	0.40[b]

(continued)

Table 3. Continued

Characteristic	Male			Female		
	Rate (95% CI)	APC	Rate Ratio	Rate (95% CI)	APC	Rate Ratio
Large cell						
Metropolitan	1.9 (1.9-1.9)	-12.4[a]	Ref	1.2 (1.2-1.2)	-11.2[a]	Ref
NH white	1.9 (1.9-2.0)	-12.3[a]	Ref	1.3 (1.3-1.3)	-11.1[a]	Ref
NH black	2.4 (2.3-2.5)	-11.9[a]	1.22[b]	1.2 (1.1-1.2)	-9.9[a]	0.93[b]
Hispanic	0.9 (0.9-1.0)	-14.6[a]	0.47[b]	0.4 (0.4-0.5)	-14.0[a]	0.35[b]
Adjacent to metropolitan	2.5 (2.4-2.5)	-11.2[a]	1.29[b]	1.4 (1.4-1.5)	-10.0[a]	1.22[b]
NH white	2.4 (2.4-2.5)	-11.5[a]	Ref	1.5 (1.4-1.5)	-10.7[a]	Ref
NH black	3.2 (2.9-3.6)	-6.9[a]	1.33[b]	1.4 (1.2-1.6)	-0.7	0.92
Hispanic	1.3 (1.0-1.7)	[c]	0.53[b]	0.4 (0.3-0.7)	[c]	0.30[b]
Nonadjacent to metropolitan	2.1 (2-2.2)	-13.4[a]	1.11[b]	1.3 (1.2-1.4)	-11.6[a]	1.10[b]
NH white	2.2 (2.0-2.3)	-13.6[a]	Ref	1.3 (1.3-1.4)	-11.3[a]	Ref
NH black	2.3 (1.8-2.8)	[c]	1.06	1.3 (1.0-1.6)	[c]	0.96
Hispanic	1.0 (0.7-1.5)	[c]	0.47[b]	[c]	[c]	[c]

Cases diagnosed by death certificate only or autopsy only are excluded from all analyses. Rates are per 100,000 and age-adjusted to the 2000 U.S. standard population (19 age groups, Census P25-1130) standard; confidence intervals (Tiwari method) are 95% for rates and ratios. Lung cancer histologic groups were defined by using the International Classification of Diseases for Oncology version 3 (ICD-0-3) (see Supplementary Table 1). Counties were categorized by Rural-Urban Continuum Codes (RUCC) into urban (RUCC 1-3), adjacent urban (RUCC 4, 6, and 8), and nonadjacent rural (RUCC 5, 7, and 9). Data are from population-based registries that participate in the National Program of Cancer Registries and/or the Surveillance, Epidemiology, and End Results registry and meet high-quality data criteria. Nevada was excluded because it did not meet United States Cancer Statistics publication criteria, and Minnesota and Kansas were excluded because of missing county data. These registries cover 96.5% of the U.S. population 2004-2013.

[a]The APC is significantly different from zero ($p < 0.05$).

[b]The rate ratio indicates that the rate is significantly different than the rate for NH white ($p < 0.05$).

[c]Statistic could not be calculated because of case count in 1 or more years fewer than 16.

CI, confidence interval; APC, annual percent change; NH, non-Hispanic; Ref, referent group.

household radon levels with race and geographic location; thus, it is difficult to evaluate radon's potential contribution to lung cancer disparities in this context.[52,53] Interestingly, studies in which the association between exposure to carcinogens and lung cancer risk have been examined in different racial/ethnic groups show that the effect of the relationship was stronger in NH blacks than in NH whites and stronger in rural counties.[54]

We also examined how trends in lung cancer incidence are changing in the context of residential location. In accordance with the general literature and the most recent annual report,[55] we observed a decrease in squamous cell carcinoma, large cell carcinoma, and SCLC in both men and women. However, our analysis looked at these trends in greater detail and found that the greatest declines are generally observed in metropolitan counties—something that has not been described previously to the best of our knowledge. Interestingly, the one exception to this declining trend is adenocarcinoma, the incidence of which continues to rise.[4] Our data show that the increases, at least in recent years, appear to be occurring more so in nonadjacent counties in both men and women, with some of the largest increases also observed among NH black men. This observation is consistent with recent work using SEER 18 showing that cancer incidence is highest in rural counties.[56] Our work extends this by showing how rural and urban differences, defined by residence in a metropolitan county and residence in a country nonadjacent to a metropolitan country, are affected by sex and histologic and racial/ethnic factors.

Increases in adenocarcinoma have been documented for several decades,[4,10,38,55] though whether there is an absolute increase in lung adenocarcinoma among never-smokers remains controversial.[57–59] Many factors have contributed to these changes, including changes in smoking prevalence, and changes in cigarette design and composition.[4,60–62] For example, cigarette ventilation, which modifies the delivery of carcinogenic constituents,[63] gained market share because of the perception that it made smoking safer. It did not. Rather, the ventilation of cigarettes changed the histologic profiles of lung cancer. Possible explanations for the recent increases in lung adenocarcinoma include air pollution in the form of nitric oxides[64,65] and industrialization.[66,67]

One other key racial difference in smoking habits is the type of cigarette used; NH blacks preferentially use mentholated cigarettes. Because of its "cooling" properties, menthol counters the irritant effect of toxicants found in tobacco.[68,69] Mentholation can affect smoking behavior.[68,70–75] Indeed some studies have linked mentholated tobacco with reduced odds of quitting,[73–75] which could contribute to the lower quit rates among African Americans overall.[68] However, studies do not support the hypothesis that menthol cigarettes are associated with a greater risk of lung cancer compared with other tobacco types.[24–26,76]

In our study we tried to address whether changes in the histologic classification of lung cancer could drive the increases in adenocarcinoma that we observed (Supplementary Table 2). Recent years have seen a trend according to which nonspecific classification of lung cancer is avoided and more cases are designated as either adenocarcinoma and squamous cell carcinoma or other specific subtypes.[61] As already mentioned, we observed that increases in adenocarcinoma were occurring mostly in adjacent and nonadjacent counties. If this was driven primarily by differences in classification of other histologic subtypes—such as NSCLC, carcinoma not otherwise specified (NOS), and sarcoma—one might expect to see greater decreases in the same geographic areas for those subtypes. However, whereas decreases are observed for both carcinoma NOS and NSCLC, the greatest decreases are observed in metropolitan counties (see Supplementary Table 2). Similarly, the slight increases in adenocarcinoma in nonadjacent counties in men do not seem to be driven by better classification of carcinoma NOS or NSCLC (see Supplementary Table 2). Interestingly, a recent article by Patel et al. analyzing lung cancer incidence trends in California over a 28-year period found that increases in lung adenocarcinoma among women were more pronounced in areas of low neighborhood socioeconomic status. These data would appear to be congruent with our data regarding increases in lung adenocarcinoma in nonadjacent counties.[77]

Our analysis also highlighted a disparity among young NH black women compared with NH white women for squamous cell, adenocarcinoma, and large cell lung cancers. Overall, NH black women had lower rates of adenocarcinoma than NH white women. However, as noted earlier, this trend was reversed among women in whom lung cancer was diagnosed when they were younger than 55 years. Although this observation is not often discussed, previous studies have also highlighted a similar trend.[78–80] Moreover, a meta-analysis of never-smokers (without age stratification) also described increased incidence of lung cancer in NH black women compared with in NH white women. One possible explanation for this relates to the recent apparent rise of lung cancer in never-smokers.[81] Adenocarcinoma mostly occurs in never-smokers, and never-smokers tend to have their cancer diagnosed at an early age.[58,82] However, this is just speculative and will need to be addressed in future studies. We also noted that the recent increases in adenocarcinoma among women are primarily occurring among NH blacks.

As in previous work, we observed a lower lung cancer incidence of every histologic subtype in Hispanics than in NH black and white adults. These decreases in incidence did not appear to correlate with any specific geographic location. There is perhaps one exception in that the incidence of carcinoma NOS seemed to be higher in Hispanics than in NH whites. However, as the trend was not statistically significant, it is not possible to draw conclusions regarding what it might mean. Moreover, our data confirmed decreasing incidence of SCC in Hispanic men. Although rates of squamous cell lung cancer appeared to be rising in women, the increases were not statistically significant. The reasons for this observation are not clear, but they deserve further follow-up. Of note, the greatest changes in the incidence of carcinoma NOS, NSCLC, and other histologic types of lung cancer occurred among Hispanics (see Supplementary Table 2).

In 2015, LDCT screening was approved for Centers for Medicare and Medicaid Services reimbursement. However, studies show that the screening uptake remains low and is currently lower among NH blacks and that targeted intervention strategies may be needed, both to maximize the potential to reduce lung cancer mortality overall and to possibly reduce racial disparities and rural-urban disparities in lung cancer outcome.[83] Importantly, our data confirm the previously observed trend that lung cancer is diagnosed at a later stage in NH blacks, something that contributes to disparities in outcomes. To ensure that disparities in stage at presentation do not widen in the era of LDCT,[84] dedicated efforts should be made to ensure that the most vulnerable populations have access to screening. Our data show that disparities are highest in nonadjacent counties and that some of the main increases in lung adenocarcinoma are also occurring in these areas. As such, these counties could be targets for more intensive interventions. However, to plan for both smoking cessation and LDCT intervention programs, more extensive analyses are needed on smoking prevalence by race, sex, and urban versus rural residence.

Our study has several strengths and limitations. We are the first to assess lung cancer disparities at a small geographic county level across the main histologic subtypes. Second, our study covers more than 96% of the U.S. population. This was possible, as using NPCR and SEER data meant that we had greater population coverage than with use of SEER data alone. However, limitations include the possibility that the classification of rural populations into a single category is not optimal. By pooling counties, we did not have the ability to define discrete pockets of disparity—if any indeed exist. As noted,[28] the classification of rural or nonadjacent counties is not in itself a homogenous classification. Also, county-level associations do not reflect individual exposures. In addition, we cannot rule out the potential misclassification of Hispanic ethnicity, which could bias some of our findings. It is also possible that a delay in cancer reporting may result in underestimation of

incidence, but because we used data from multiple years, our estimated cases are likely to be only a slight underestimation. Moreover, important risk factor data, such as smoking behaviors, are not available within our cancer registry data set and therefore we were unable to directly examine the influence of these risk factors on our findings.

By using nationwide county-level data, our study demonstrates significant county-level differences in lung cancer rates and trends in NH white, NH black, and Hispanic U.S. adults. We observed significant and increasing disparities in adenocarcinoma in nonadjacent counties and among NH black men and women, suggesting the need for further study of this population. It is possible that factors confounding the increase of adenocarcinoma in the general population could also be responsible for the rural trends we observed.[4,10,38,55,60–62] The variations observed by race and geography, along with the continuing rise of adenocarcinoma, point to potential knowledge gaps in our understanding of all the risk factors—behavioral, social, and environmental—that drive lung cancer incidence in addition to, or in conjunction with, smoking in the United States. It will be important to implement primary prevention (smoking prevention and cessation and reduced exposure to other lung carcinogens) and lung cancer screening strategies that target specific population groups. Evidence already suggests both racial and urban-rural disparities in the uptake of screening programs for other cancer types.[85–87] Therefore, as the practice of LDCT screening becomes more widespread across the United States, it will also be important to continue monitoring such trends in lung cancer incidence across racial and geographic groups[84] by age so that appropriate resources can be put in place to reduce disparities in lung cancer incidence and death.

Supplementary Data

Note: To access the supplementary material accompanying this article, visit the online version of the *Journal of Thoracic Oncology* at www.jto.org and at https://doi.org/10.1016/j.jtho.2017.12.010.

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