The Effect of Provider Density on Lung Cancer Survival Among Blacks and Whites in the United States

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Introduction: Lung cancer mortality rates may vary with access to specialty providers and local resources. We sought to examine the effect of access to care, using density of lung cancer care providers, on lung cancer mortality among blacks and whites in the United States.

Methods: We examined U.S. county-level data for age-adjusted lung cancer mortality rates from 2003 to 2007. Our primary independent variable was per capita number of thoracic oncologic providers, adjusting for county-level smoking rates, socioeconomic status, and other geographic factors. Data were obtained from 2009 Area Resource File, National Center for Health Statistics, and the County Health Rankings Project.

Results: Providers of lung cancer care were unevenly distributed among the U.S. counties. For example, 41.4% of the U.S. population reside in counties with less than four thoracic surgeons per 100,000 people, 23.4% in counties with 4 to 15 surgeons per 100,000 people, and 35.3% in counties with more than 15 surgeons per 100,000 people. Geographically, 4.3% of whites compared with 11.2% of blacks lived in high lung cancer mortality zones. Lung cancer mortality did not vary by density of thoracic surgeons or oncology services; however, higher primary care provider density was associated with lung cancer mortality reduction of 4.1 per 100,000 for whites.

Conclusion: Variation in provider density for thoracic oncology in the United States was not associated with a difference in lung cancer mortality. Lower mortality associated with higher primary care provider density suggests that equitable access to primary care may lead to reduced cancer disparities.

Key Words: Lung cancer, Racial disparities, Provider density.

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Lung cancer remains the leading cause of cancer-related deaths and is tied as the third leading cause of death overall in industrialized countries. Within the United States, several groups identified by race, sex, and socioeconomic status have been linked to increased cancer mortality, suggesting a disparity because of these characteristics. The relationships are complicated by the fact that many of these characteristics may also be associated with areas of decreased access to care and local resources and not inherently based on implicit biases.[1–5]

Heterogeneity of local resources has been linked to timeliness of care and is thought to contribute to geographic variation in clinical outcomes. For lung cancer, access to thoracic surgeons and thus curative surgical resection is an important component of care, especially in early-stage disease when there is a realistic opportunity for long-term survival. Blacks have comparatively poorer access to specialty providers, which may contribute to disparities in cancer outcomes.[6] One potential measure of access to care for lung cancer patients is the relationship between opportunity and use of lung cancer services, including availability of thoracic surgeons and oncologic and primary care services. We sought to examine this relationship using provider density for delivery of thoracic oncologic care as a measure of access and to determine its influence on lung cancer mortality independent of major socioeconomic variables.

MATERIALS AND METHODS

Data Sources

County-level data were obtained from multiple sources, including the 2010 Area Resource File, the National Center for Health Statistics, the Population Health Center at the University of Michigan, and the County Health Rankings project from the Wisconsin Population Health Institute and Robert Wood Johnson Foundations, which aggregated data at the county level from multiple sources, including the Behavioral Risk Factor Surveillance System (BRFSS) and the 2000 Decennial Census and American Community Survey.[7]

Primary Outcome Measures

Primary outcome measures included lung cancer mortality rate from 2003 to 2007 in each county for the overall population, and the lung cancer mortality rate stratified by race in the county, obtained from National Center for Health Statistics estimates using age-adjusted calculations for the 2000 standard population performed through SEER-Stat

software.[8] Adult smoking rates in each county were estimated by County Health Ranking Project. This measure was based on the BRFSS 2007 question assessing the number of current adult smokers who have smoked at least 100 cigarettes in their lifetime. Similarly, adult obesity was assessed from self-reported body mass index and weight in the 2007 BRFSS. Food environment was ascertained using Geographic Information Systems methods from the County Health Rankings project. This measure assessed the percent of zip codes in a county with a *healthy food outlet*, which was defined as grocery stores with more than four employees or produce stands per farmers markets.

Primary Exposure

Access to clinical services was based on the 2007 American Medical Association Physician Master Files. Our primary independent variable was the density of specialty providers and oncology centers. This was assessed by the number of thoracic surgeons and number of hospitals offering oncology services per capita in each county stratified into tertiles for low, medium, and high number of providers per 100,000 people. In addition, we assessed the number of primary care physicians in each county by combining the number of internal medicine, family practice, and general practice physicians stratified accordingly.

Covariates

To adjust for socioeconomic status, we included, in the model, the median per capita income in 2007 in each county, obtained from the Regional Economic Information System from the Area Resource File. We included population density per square mile and indicators for whether a metropolitan area of more than 1 million residents was located in the county or in an adjacent county, and an indicator if the county was rural or included only small towns (<20,000 residents) and was only adjacent to other rural counties. Counties with small populations for which stable lung cancer mortality rates could not be calculated were excluded, as were counties with missing estimates of any of the survey-based covariates.

Analysis

A generalized linear model with a Poisson distribution and log link was used to examine the association of provider density and other covariates on lung cancer morality. Two models were developed for lung cancer mortality, one for blacks and another for whites. Lung cancer mortality was stratified into tertiles for low (<50), moderate (50–74), and high (>75) deaths per 100,000 people. Adjusted estimates of the effect of provider density were calculated fixing all covariates (e.g., proportion of adult smokers) to the overall population mean. Survey methods were used to weigh each county by its proportion of residents. All analyses were conducted using Stata 11.0.

RESULTS

Specialty providers of lung cancer care services were unevenly distributed among U.S. counties (Table 1).

TABLE 1. Provider Density by County and U.S. Population

	US Counties (n = 3068)	Adult U.S. Population Represented (n = 296,314,208)
Total men		146,066,480 (49%)
Black Men		17,759,152 (12%)
No. of thoracic surgeons		19.7 (9.8, 29.7)
Low (<4/100,000)	2796 (91%)	41%
Moderate (4–15/100,000)	192 (6%)	23%
High (>15/100,000)	80 (3%)	35%
Hospitals with oncology services		6.0 (3.3, 8.7)
Low (<2/100,000)	2663 (87%)	35%
Moderate (2–6/100,000)	345 (11%)	34%
High (>6/100,000)	60 (2%)	32%
Number of primary care physicians		786 (386, 1189)
Low (<250/100,000)	2900 (95%)	48%
Moderate (250–750/100,000)	118 (4%)	23%
High (>750/100,000)	50 (2%)	29%
Proportion of adult smokers		20 (19.5, 20.6)
Low (<20% of population)	739 (24%)	46%
Moderate (21%–24% of population)	966 (32%)	38%
High (>24% of population)	697 (23%)	13%

Ninety-one percent of counties or 41.4% of the U.S. population were served by less than four thoracic surgeons per 100,000 people (Fig. 1). Similarly, 94.5% of counties or 48.2% of the U.S. population were served by less than 250 primary care providers per 100,000 people (Fig. 2). Hospitals with oncology services were slightly better distributed with 34.6%, 33.6%, and 31.7% of the U.S. population served by low (<2), moderate (2–5), and high (>5) number of hospitals per county (Fig. 3).

Consistent with earlier reports, age-adjusted lung cancer mortality rates were significantly higher for blacks compared with whites (58.9 versus 52.4/100,000; $p < 0.05$). The mortality also differed by distribution (Table 2). Only 4.3% of whites reside in zip codes with the highest lung cancer mortality rates (>75/100,000), whereas 11.2% of blacks reside in these high mortality zip codes. Similarly, 24.2% of blacks reside in low lung cancer mortality (<50/100,000) areas in contrast to 45.4% of whites living in areas with low lung cancer mortality.

The model analysis detected no association between density of thoracic surgeons or hospitals providing oncologic services and lung cancer mortality (Table 3). Density of primary care providers, however, was associated with a difference in lung cancer mortality. Counties with high primary care provider density were observed to have reduced lung cancer mortality rates for whites compared with counties with low primary care provider density (49.6/100,000 versus 53.7/100,000; $p = 0.022$). Similarly, counties with high primary care provider density were associated with reduced lung cancer mortality compared with counties with low primary care density for blacks, although this failed to reach statistical significance (56.1/100,000 versus 63.2/100,000; $p = 0.94$).

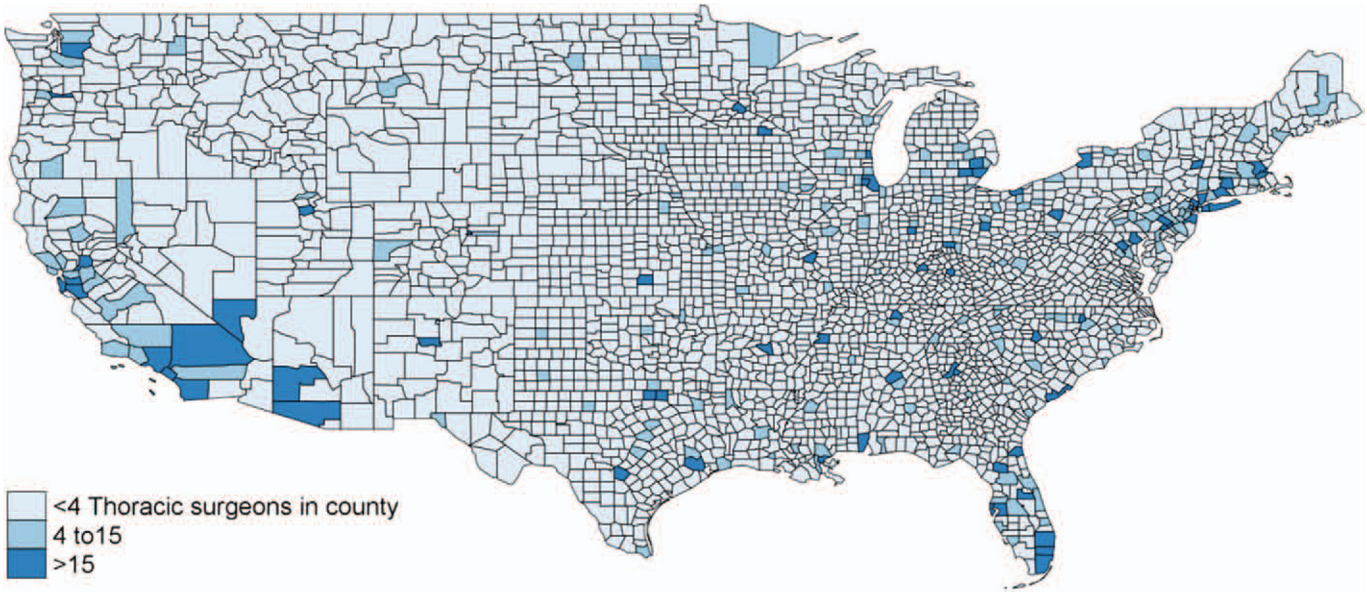

FIGURE 1. Distribution of thoracic surgeons by U.S. counties.

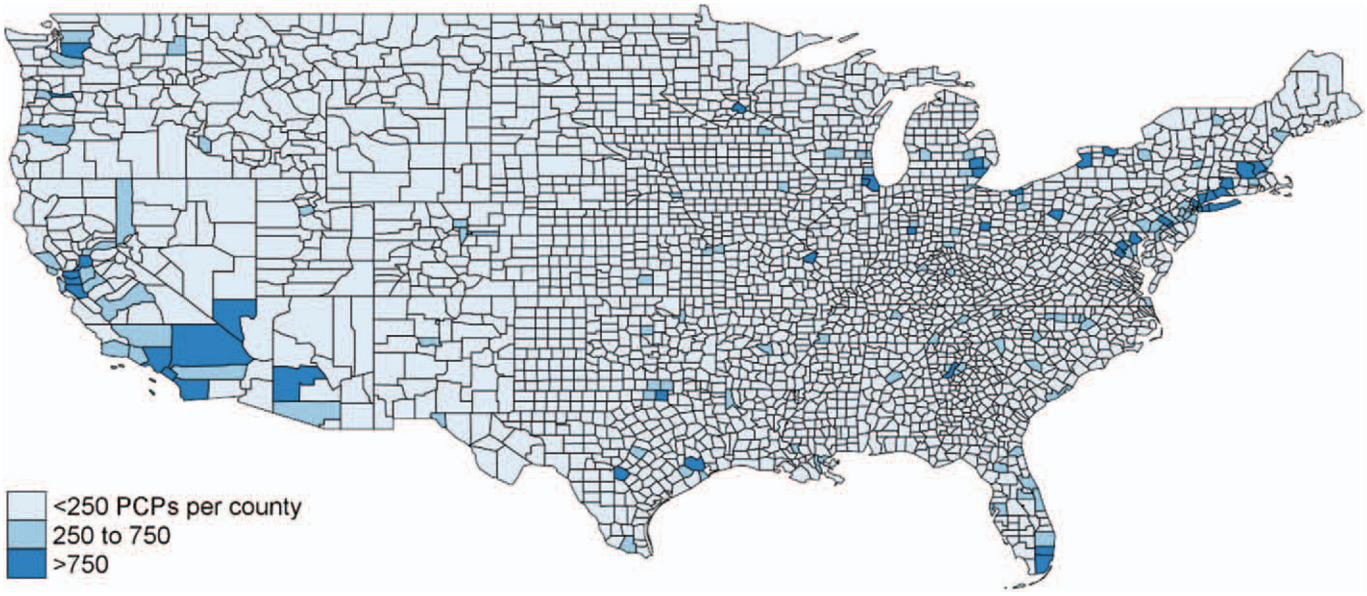

FIGURE 2. Distribution of primary care providers by U.S. counties.

It is important to note that counties with higher proportions of adult smokers were associated with increased lung cancer mortality rates for both whites and blacks ($p < 0.001$), demonstrating that the approach is sensitive to detecting important relationships between lung cancer–related factors, when they are present, and providing validation for the model.

DISCUSSION

Disparities in clinical indicators of health are well documented with regards to defined socioeconomic and geographic characteristics. Our study examined the effect of provider density as a measure of access to cancer resources on lung cancer mortality. Several studies examining access to care have linked poor outcomes to increased travel distances to comprehensive cancer care facilities as a surrogate for resource availability.[3,9–11] Geographic disparities in mortality for prostate cancer have estimated 10% to 30% of this variation related to access to care.[12] Specifically, distance to cancer centers has been identified as a barrier to treatment for colorectal patients, and the correlation has also been established between decreased physician supply and reduced cancer survival in patients with breast cancer.[13,14] Furthermore, rural residents have a twofold to threefold increase in distance to travel, leading to reduced number of visits to specialists and increased reliance on generalists, which again underscores

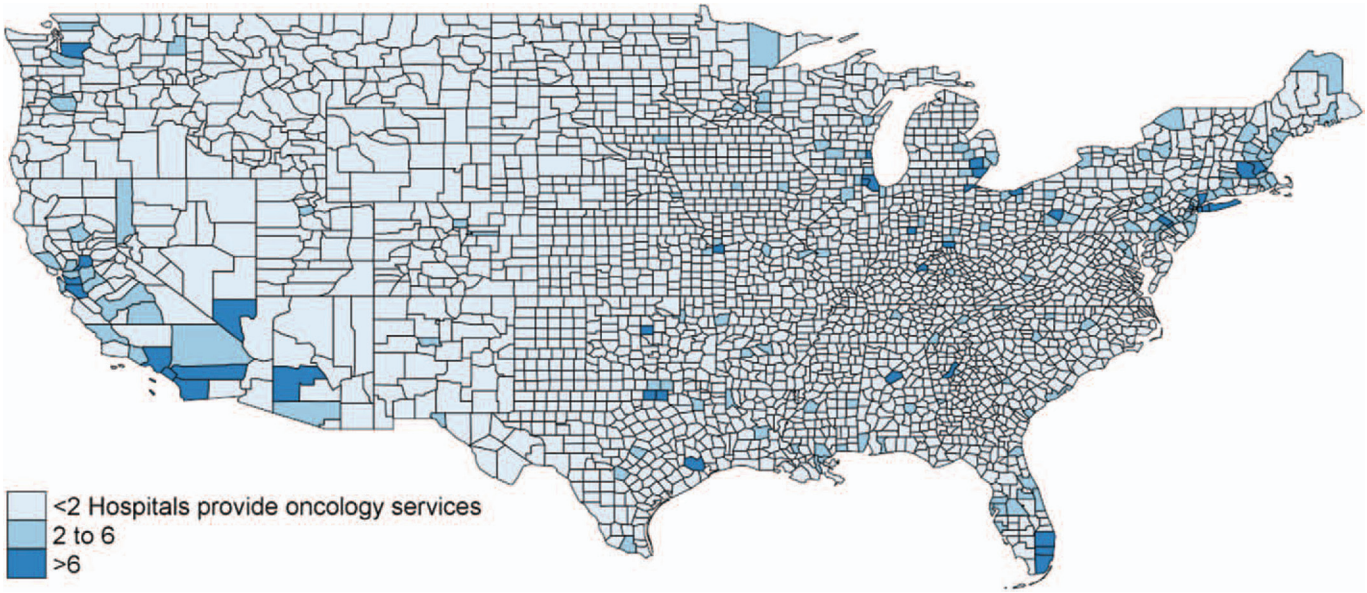

FIGURE 3. Distribution of oncology services by U.S. counties.

TABLE 2. Lung Cancer Mortality by County and U.S. Population

Lung Cancer Mortality Rates	US Counties (n = 3068)	Adult US Population Represented (n = 296,314,208), %
Whites		
Low (<50/100,000)	917 (29.9%)	45.4
Moderate (50–75/100,000)	1660 (54.1%)	50.3
High (>75/100,000)	437 (14.2%)	4.3
No data	54 (1.8%)	0.04
Blacks		
Low (<50/100,000)	266 (8.7%)	24.2
Moderate (50–75/100,000)	585 (19.1%)	45.6
High (>75/100,000)	367 (12.0%)	11.2
No data	1850 (60.3%)	19.1

TABLE 3. Model Output for Lung Cancer Mortality by Provider Density

	Whites (51.3/100,000)	p	Blacks (58.2/100,000)	p
No. of thoracic surgeons				
Low (<4/100,000)	51.1	0.814	54.8	0.144
Moderate (4–15/100,000)	51.2		55.8	
High (>15/100,000)	51.4		59.3	
Hospitals with oncology services				
Low (<2/100,000)	50.6	0.471	56.0	0.386
Moderate (2–6/100,000)	50.9		56.8	
High (>6/100,000)	51.8		59.1	
No. of primary care physicians				
Low (<250/100,000)	53.7	0.022	63.2	0.094
Moderate (250–750/100,000)	52.5		61.1	
High (>750/100,000)	49.6		56.1	
Proportion of adult smokers				
Low (<20% of population)	45.6	<0.001	54.8	<0.001
Moderate (21%–24% of population)	55.1		60.9	
High (>24% of population)	68.3		67.8	

the relative importance of access to care.[12] These geographic differences are not limited to the United States as they have been described in European countries as well with similar implications for resource allocation. The standard of care for treatment of early-stage lung cancer is surgery and consideration of multimodality therapy. Thoracic surgery and oncologic services are paramount to achieving this treatment goal, and thus access to these services makes for an important consideration.

We determined that providers of thoracic oncologic services are unevenly distributed across the United States and this may likely represent centralization of limited resources. This heterogeneity in density, however, was surprisingly not associated with disparities in lung cancer mortality. In contrast, primary care provider density was significantly correlated with lung cancer mortality. The findings reached statistical significance in the white population but failed to do so in blacks. One explanation for this discrepancy could be the fact that smaller sample size and bias of incomplete lung cancer mortality data for the black population may have prohibited the analysis from reaching statistical significance, whereas the findings might otherwise have been the same. Alternatively, these results might be a reflection of the interplay between access to care and use of available resources. Blacks may be less likely to use some healthcare services, even if access and availability are not the primary obstacles. Social beliefs may be powerful contributors to use of services as there is often

a reporting of doubt regarding the necessity and efficacy of surgery as a recommended treatment for lung cancer by some blacks.[15] Thus, primary care provider density may be more directly linked to effective preventive care measures, such as smoking cessation counseling and medications among whites, but even when blacks reside in areas with high density of primary care providers, these services may remain underused, reducing the association between primary care provider density and lung cancer mortality among blacks.

Independent of race, these findings suggest that interventions aimed at primary care providers may deserve more investigation toward improving access to cancer care. Primary care is an essential access point of entry into a highly sophisticated healthcare system and has received renewed interest for interventions aimed at eliminating health disparities. The Institute of Medicine and the Affordable Care Act looked to address this issue by supporting the concept of the Patient Centered Medical Home.[16] It has been promoted as an important component of healthcare transformation in the United States that will concentrate on improvements in screening and chronic care management and lead to a more accessible, effective, safe, and economically sustainable system.[17–19]

The strength of this study lies in the use of large national datasets with pooling of available data for the entire U.S. population. It includes detailed information on demography and socioeconomics at the level of U.S. counties allowing for a robust analysis. The county-level data, however, lacks the granularity to draw causal inferences at the level of the individual that would risk ecological fallacy. We were unable to adjust and account for provider volume (e.g., panel size), facility volume, or cancer stage distribution, which may also impact clinical outcomes. Similarly, other geography-related covariates could not be assessed at the county level, such as potential asbestos exposure. We addressed smoking by examining the number of adult smokers in a given county; however, variations in environmental exposures, resources for smoking cessation, and smoking regulations are also likely to play a role in any ecologic study in lung cancer. We were, however, able to isolate and adjust for the effect of socioeconomic status. Socioeconomic status demonstrates large geographic variability and has been shown to have direct consequences on many cancer outcomes. Specifically, low socioeconomic status is associated with less intense care for non–small-cell lung cancer and is an independent poor prognostic factor for survival in stage I patients.[13] Nonetheless, by controlling for many of the socioeconomic variables clearly linked to health outcomes, we were able to focus on the effects of provider density and access to thoracic oncologic services. Socioeconomic status remains an independent contributor; however, the etiologies of these problems transcend those of the economic underclass. Application of these findings beyond the U.S. population may be appropriate in the setting of other healthcare systems.

The care of lung cancer patients reflects a complicated continuum of care with inherent impediments. Blacks may have fewer referrals for surgical resection, are less likely to accept a recommendation for surgery, and may, as a result, ultimately experience poorer outcomes than their majority counterparts.[20,21] Although it may seem intuitive, efforts to improve access to care may not necessarily lead to improved lung cancer outcomes independent of regional socioeconomic factors and primary care and preventative medicine.

Significant efforts should focus on breaking down barriers to care, increasing use of services and educational programs, including smoking cessation. The protective effect of access to primary care providers should be further explored and maximized to its fullest benefit.

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