Temporal trends in centralization and racial disparities in utilization of high-volume hospitals for lung cancer surgery

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Abstract

Racial disparities have been suggested in hospital utilization and outcome for lung cancer surgery, but the effect of hospital centralization on closing this gap is unknown. We hypothesized that centralization has increased the utilization of high- or very-high-volume (HV/VHV) hospitals, a proxy for access to high-quality care, over the study period independently from race.

Inpatient records were extracted from the New York Statewide Planning and Research Cooperative System database (1995–2012) according to Clinical Modification of the International Classification of Diseases, 9th Revision diagnosis codes 162.* and 165.* and surgical procedure codes 32.2–32.6 (n = 31,931). Patients treated exclusively with surgery of black or white race with a valid zip code were included. Logistic models were performed to determine factors associated with utilization of HV/VHV or low- or very-low-volume (LV/VLV) hospitals; these models were subsequently stratified by race.

The percentage of both black and white patients utilizing HV/VHV hospitals increased over the study period (+22.7% and 13.9%, respectively). The distance to the nearest HV/VHV hospital and patient–hospital distance were significantly lower in black compared to white patients, however, blacks were consistently less likely to use HV/VHV than whites (odds ratio$_{adj}$: 0.26; 95% confidence interval: 0.23–0.29), and were significantly more likely to utilize urban, teaching, and lower volume hospitals than whites. Likelihood of HV/VHV utilization decreased with an increasing distance from a HV/VHV hospital, overall and separately for black and white patients.

Although centralization has increased the utilization of HV/VHV for both black and white patients, racial differences in access and utilization of HV hospitals persisted.

Abbreviations: HV = high volume, ICD-9 = Clinical Modification of the International Classification of Diseases, 9th Revision, IQR = interquartile range, L = lobectomy, LR = limited resection, LV = low volume, MV = medium volume, NYC = New York City, NYS = New York State, P = pneumonectomy, SPARCS = Statewide Planning and Research Cooperative System, VHV = very high volume, VLV = very low volume, ZCTA = Zip Code Tabulation Area.

Keywords: geographic proximity, health disparities, hospital volume

1. Introduction

Extensive literature has documented the relationship between hospital volume and cancer surgical outcomes; this has resulted in centralization of cancer care advocating patients to seek cancer surgical procedures at high-volume (HV) hospitals.[1–3] Lung cancer is no exception, and surgery is considered the standard of care for early stage lung cancer, despite ongoing debate over the optimal procedure to use.[4–6] Indeed, studies have found decreased perioperative mortality and improved survival following lung cancer surgery with increasing hospital surgery volume.[3,7–10] However, improvements in lung cancer outcome are not shared equally among racial groups.[11,12]

One possible explanation of the observed disparity is that centralization may decrease access to care and can act as a barrier by increasing travel requirements for patients and their families, possibly preventing and delaying treatment.[1,8,13–15] This travel burden may be inequitable in that it marginalizes already underserved populations according to race, insurance status, and socioeconomic status.

However, in the context of centralization, it has been reported that black patients more commonly undergo surgery at low-volume (LV) and lower quality hospitals, despite living in close proximity to higher quality hospitals.[12,16–18] These paradoxical observations highlighted the complex interplays between access to quality care as measured by geographic spatial access and factors as measured by other indicators of health care access. For example, research has documented that black patients have lower rates of lung surgery compared to whites, despite instances where surgery was the accepted approach.[19–21] Blacks were also less likely to receive timely and appropriate care including surgery, chemotherapy, or radiation for stage III and chemotherapy for stage IV lung cancer compared to whites.[21]

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No study to date has examined temporal trends in geographic availability and utilization of HV hospitals for lung cancer surgery according to race. In this study, we aimed to investigate how centralization and the associated racial differences in lung surgery have evolved over an 18 year time span (1995–2012) in New York State (NYS), in order to shed light on how to reduce geographic and other barrier to quality care, especially among minority groups. We hypothesized that centralization has increased utilization of high- or very-high-volume (HV/VHV) hospitals, a proxy for access to high-quality care, while decreased utilization of low- or very-low-volume (LV/VLV) hospitals, a proxy for access to low-quality care, over the study period for both white and black patient groups. However, blacks would be less affected by the centralization policy, with lower utilization of HV/VHV and higher utilization of LV/VLV compared to whites.

2. Methods

2.1. Study population

The study population was extracted from the New York Statewide Planning and Research Cooperative System (SPARCS) database spanning 1995 to 2012. Patient consent was waived because of the de-identified nature of the SPARCS data. This research was considered exempt by the Icahn School of Medicine at Mount Sinai's Institutional Review Board.

Records were selected based on ICD-9-CM (Clinical Modification of the International Classification of Diseases, 9th Revision) diagnosis codes 162.* (Malignant neoplasm of trachea bronchus and lung) and 165.* (Malignant neoplasm of other and ill-defined sites within the respiratory system and intrathoracic organs). Of the 442,889 hospital discharges fulfilling these criteria, 4646 (1.0%) were excluded because the patient ID was missing. Records were then selected according to the following ICD-9-CM surgical procedure codes: 32.2 (local excision or destruction of lesion or tissue of lung), 32.3 (segmental resection of lung), 32.4 (lobectomy of lung), 32.5 (complete pneumonectomy), and 32.6 (radical dissection of thoracic structures), and grouped into lobectomy (32.4; L), limited resection (32.2, 32.3; LR), and pneumonectomy (32.5, 32.6; P). Patients who underwent other surgical procedures of the lung and with multiple admissions for surgery during the same year were excluded because detailed admission order within each calendar year is not available in the SPARCS database. Patients treated exclusively with surgery of self-reported black or white race with a valid NYS zip code were included (n = 31,931 patients), while 410,958 records were excluded.

2.2. Hospital data

Information on the location (urban/rural) and academic status (teaching/nonteaching) of NYS hospitals were obtained from the NYS Department of Health and the American Hospital Association websites. These two variables were used to create a summed score with a minimum of 1 and maximum of 4, with rural and nonteaching = 1, rural and teaching = 2, urban and nonteaching = 3, and urban and teaching = 4. Lung surgery volumes for each hospital were calculated by summing the lung surgeries performed (ICD-9 codes 32.0–32.9) at each hospital during the study period (1995–2012) before patient selection. Hospitals were divided into 5 groups based on quintiles of annual surgery volumes calculated for each hospital over the study period: VLV (≤7.15 surgeries/year), LV (>7.15–≤13.94

surgeries/year), medium-volume (MV; >13.94–≤24.20 surgeries/year), HV (>24.20–≤55.28 surgeries/year), and VHV (>55.28 surgeries/year). To capture temporal changes in hospital surgery volumes, the quintile cut-offs were applied to each hospital for each study year, as previously reported.[1,22–24] Hospital locations and the time periods during which they were actively performing lung surgery were plotted using ArcMap 10.3.1 to illustrate geographic and temporal variability across NYS.

2.3. Statistical analysis

Descriptive statistics were performed to determine the yearly percentage of VLV, LV, MV, HV, and VHV hospitals utilized for lung surgery, the yearly percentage of surgeries performed at HV/VHV hospitals, and the distance to the nearest HV/VHV hospital for black and white patients over the study period. Chi-square tests for categorical variables and Wilcoxon rank sum tests for continuous variables were used to examine differences in covariates between black and white patients. Patient–hospital distance and the distance to the nearest HV/VHV hospital were calculated from patient and HV/VHV hospital zip code centroids. This was derived for each patient according to their year of admission to account for hospital volume reclassification, and patients were categorized according to tertiles of the nearest HV/VHV hospital distance (0–2.3; >2.3–6.1; >6.1 miles). Admission year was used to study the temporal trends in centralization. Comorbidities were calculated using the Elixhauser index [25] based on 29 comorbidity types derived from the Healthcare Cost and Utilization Project's Elixhauser Comorbidity Software (version 3.7).[26]

Logistic models were performed to determine factors associated with utilization of HV/VHV or LV/VLV hospitals, which were set as dependent variables; these models were subsequently stratified according to race. Statistical analyses were performed using SAS (version 9.4; SAS Institute Inc., Cary, NC) and R (version 3.2.2; R Foundation for Statistical Computing, Vienna, Austria).

3. Results

3.1. Centralization of lung surgery

Patients received care for lung surgery at 134 NYS hospitals in 1995 and at 96 hospitals in 2012. The majority (%) of HV and VHV hospitals were consistently located in major urban areas (Fig. 1). Between 1995–2000 and 2001–2006, 13 hospitals were no longer utilized for lung surgery, including 11 VLV/LV and 2 MV hospitals (Fig. 1). Five of these hospitals were located in major urban centres. From 2001–2006 to 2007–2012, 14 additional hospitals were no longer utilized for lung surgery.

From 1995 to 2012, the overall proportion of VLV, LV, MV, and HV hospitals utilized for surgery decreased from 17.2% to 11.5%, 16.4% to 13.5%, 23.9% to 19.8%, and from 26.1% to 21.9%, respectively, whereas the percentage of VHV hospitals utilized increased from 16.4% to 33.3% (Fig. 2). The distance to the nearest HV/VHV hospital was consistently lower in black (1995: median 2.1 miles; 2012: median 2.1 miles) than in white patients (1995: median 3.8 miles; 2012: median 5.5 miles) over the study period (Fig. 3). Both racial groups showed increased HV/VHV utilization over time, but at a greater rate for blacks and consistently higher utilization in whites (HV/VHV utilization in blacks: 1995: 62.2%, 2012: 84.9%; in whites: 1995: 78.1%, 2012: 92.0%; Fig. 3).

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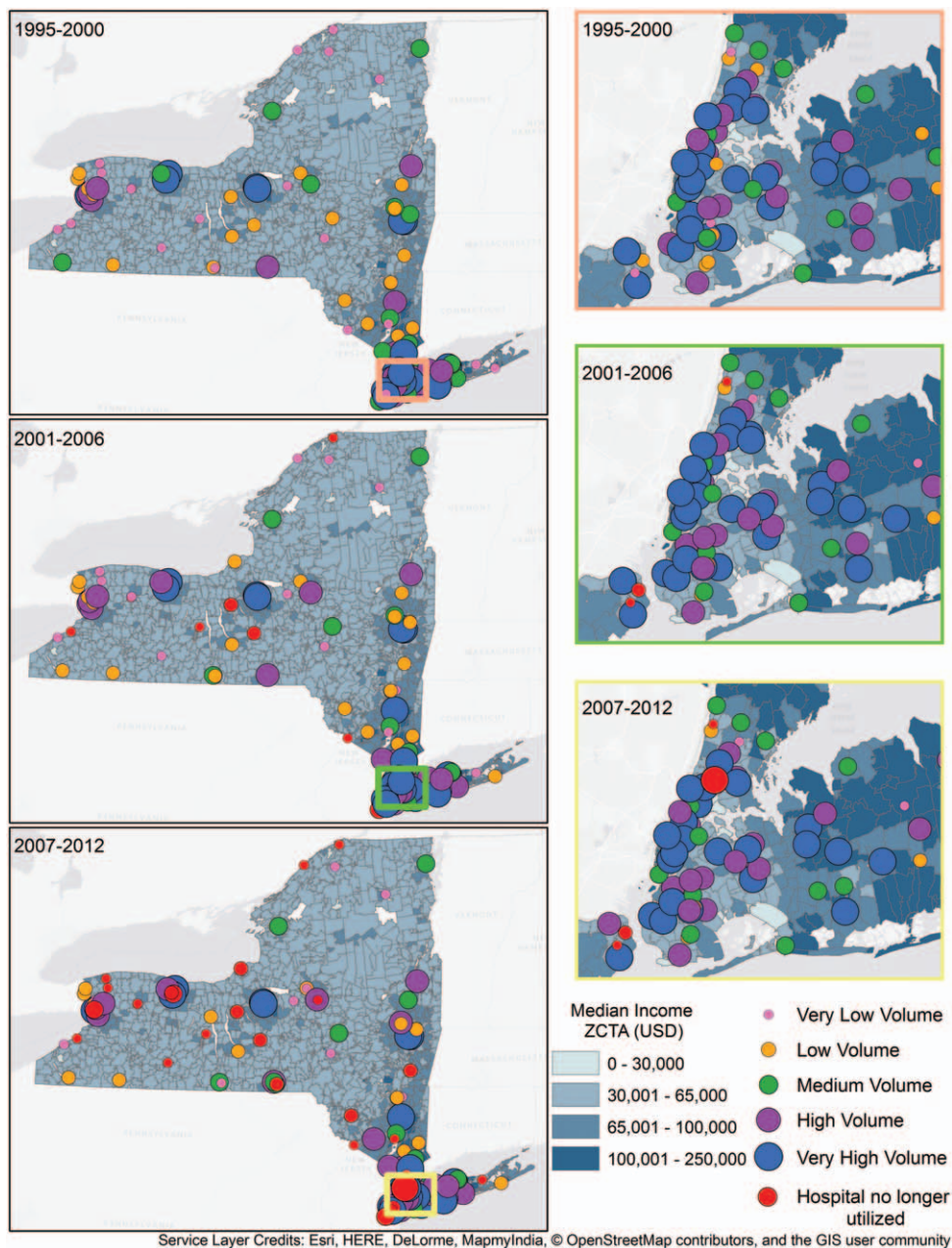
Figure 1. Spatial and temporal variation in hospitals utilized for lung surgery across NYS (left column) and NYC (right column) according to 2012 median household income per ZCTA. Top row: Hospitals utilized for surgery 1995–2000. Middle row: 2001–2006. Bottom row: 2007–2012. NYC = New York City, NYS = New York State, ZCTA = zip code tabulation area.

3.2. Patient characteristics

Black patients were significantly more likely to undergo LR and be younger at admission compared to white patients (Table 1). Black patients were less likely to be covered by Medicare and private insurance than white patients. Furthermore, a greater proportion of black patients attended urban, teaching, and lower volume hospitals than white patients. The distance to the nearest HV/VHV hospital and patient–hospital distance were significantly lower in black patients compared to white patients.

3.3. Utilization of HV/VHV or LV/VLV hospitals

Overall, blacks were less likely to use HV/VHV hospitals (odds ratio [OR]$_{adj}$: 0.27; 95% confidence interval [CI]: 0.23–0.29)

compared to white patients (Table 2). When HV/VHV hospitals were located farther from patients, the odds of HV/VHV utilization decreased, but a dose effect between distance and utilization was only observed in white patients. Utilization of HV/VHV hospitals was significantly positively associated with year of admission (OR$_{adj}$: 1.08; 95% CI: 1.08–1.09) in both races. Patients with Medicaid coverage were less likely to use HV/VHV hospitals compared to Medicare patients, overall (OR$_{adj}$: 0.46; 95% CI: 0.39–0.55) and according to race. Black patients with private insurance were more likely to use HV/VHV hospitals (OR$_{adj}$: 1.39; 95% CI: 1.07–1.81).

Black patients were more likely to use LV/VLV hospitals overall (OR$_{adj}$: 3.40; 95% CI: 2.90–3.98) compared to white patients, and when HV/VHV hospitals were located farther from
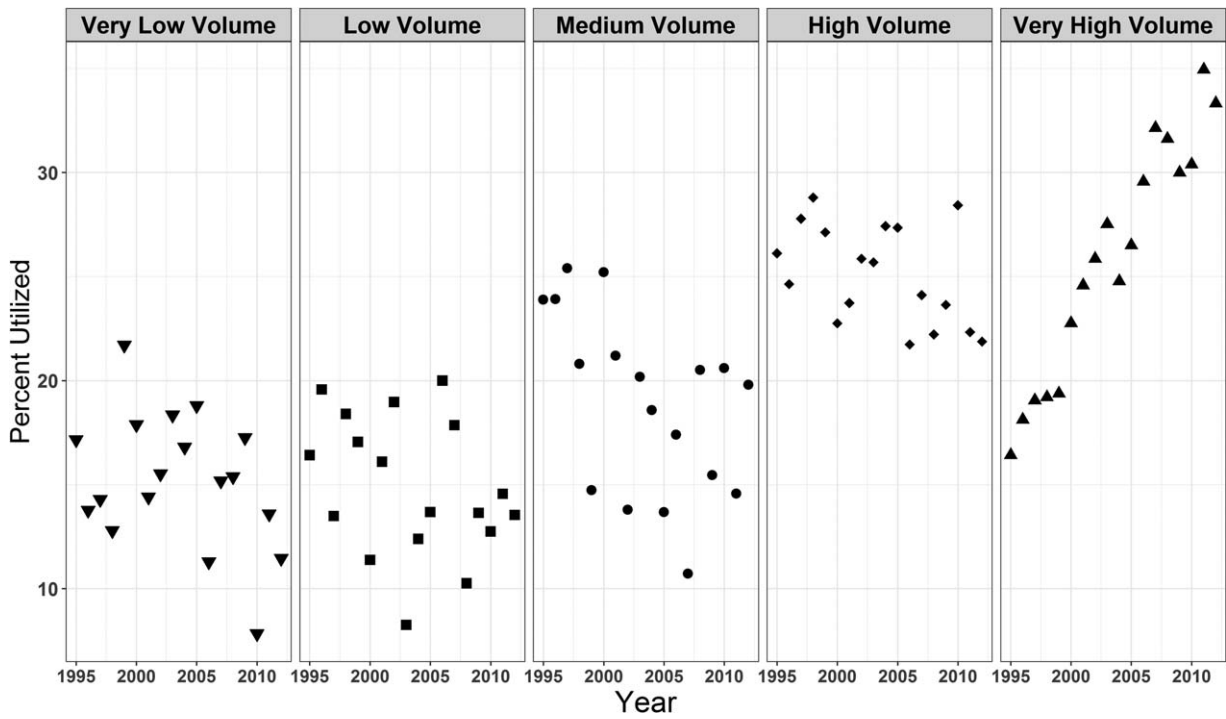
Figure 2. Hospitals utilized for surgery over the study period according to their surgical volume.
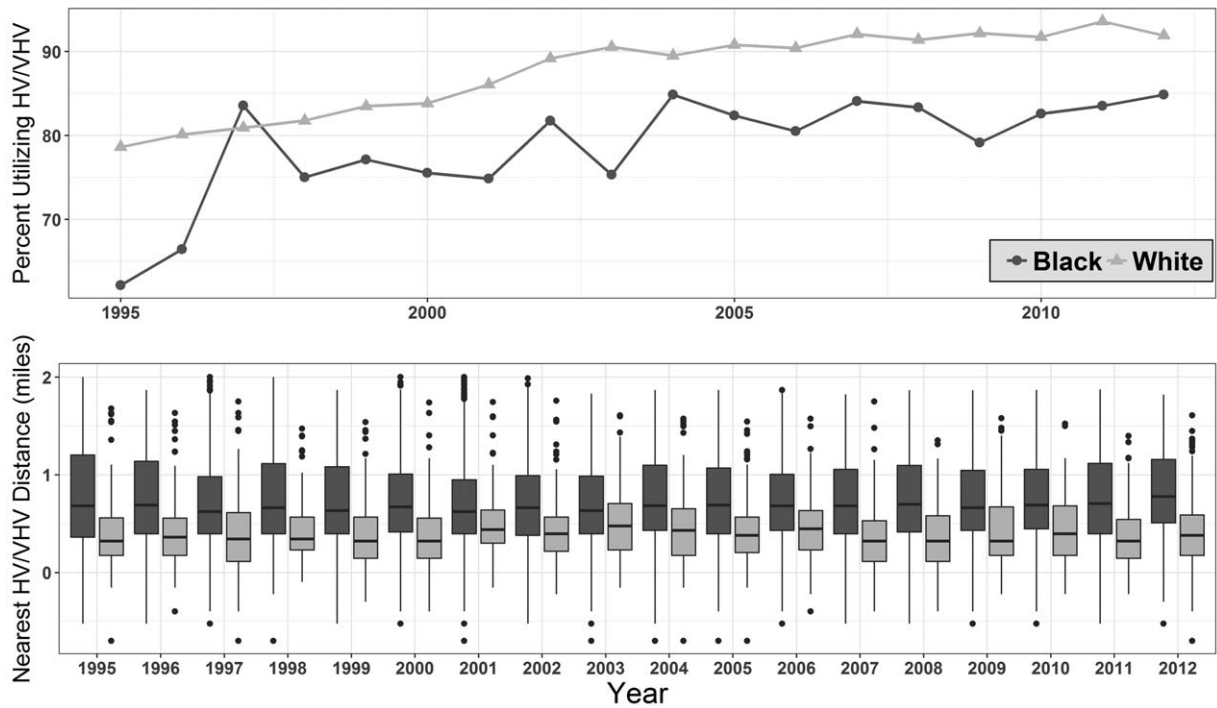

Figure 3. Top: Utilization of HV/VHV hospitals over the study period according to race. Bottom: Distance to the nearest HV/VHV hospital (log-transformed) according to race. HV = high volume, VHV = very high volume.

Table 1

Patient characteristics of the study population according to race.

Variable	Categories	Black (n=2,907)	White (n=29,024)	P-value
Gender	Male	1383 (47.6%)	14,075 (48.5%)	0.3602
	Female	1524 (52.4%)	14,949 (51.5%)	
Age, year	Median (IQR);	64 (56–71)	69 (61–75)	<0.0001
Surgery type	Lobectomy	1529 (52.6%)	16,494 (56.8%)	<0.0001
	Limited Resection	1179 (40.6%)	10,563 (36.4%)	
	Pneumonectomy	199 (6.8%)	1967 (6.8%)	
Year at admission	1995–2000	1025 (32.3%)	10164 (33.5%)	<0.0001
	2001–2006	1048 (33.0%)	10,439 (34.4%)	
	2007–2012	1100 (34.7%)	9732 (32.1%)	
Insurance status	Medicare	1390 (47.8%)	17,365 (59.8%)	<0.0001
	Medicaid	508 (17.4%)	1039 (3.6%)	
	Private insurance	900 (31.0%)	10,075 (34.7%)	
	No insurance/other	109 (3.8%)	545 (1.9%)	
Hospital setting	Rural	236 (8.1%)	6629 (22.8%)	<0.0001
	Urban	2671 (91.9%)	22,395 (77.2%)	
Teaching hospital	No	159 (5.5%)	3244 (11.2%)	<0.0001
	Yes	2748 (94.5%)	25,780 (88.8%)	
Nearest HV/VHV distance	Median (IQR); miles	2.1 (1.2–3.7)	4.1 (2.0–10.0)	<0.0001
Patient–hospital distance	Median (IQR); miles	3.4 (1.7–6.7)	7.6 (3.3–16.2)	<0.0001
Lung surgery volume	Median (IQR)	1168 (441–3117)	1494 (718–4523)	<0.0001
Elixhauser comorbidity index	Median (IQR)	3.0 (0.0–12)	3.0 (0.0–12)	0.2268

HV = high volume, VHV = very high volume, IQR = interquartile range.

patients, the odds of LV/VLV utilization increased in both white and black patients. Patients with Medicaid coverage were more likely to use LV/VLV hospitals compared to Medicare patients, overall (OR_{adj}: 2.09; 95% CI: 1.66–2.62) and according to race. Utilization of LV/VLV hospitals was significantly negatively associated with year of admission (OR_{adj}: 0.96; 95% CI: 0.95–0.97) in both races.

4. Discussion

Despite the large literature on centralization of care, to our knowledge this is the first analysis on racial disparities and temporal trends in geographic access and hospital utilization for lung cancer surgery in NYS.

We show here that centralization has increased the percentage of both black and white patients utilizing HV/VHV hospitals over the study period, narrowing the gap between races from 15.9% in 1995 to 7.1% in 2012. Over the study period however, blacks were consistently less likely to use HV/VHV than whites. When the HV/VHV utilization model was stratified by race, the effect of distance to the nearest HV/VHV on HV/VHV utilization was comparable between races. This suggests that overall utilization of HV hospitals is a function of proximity, in agreement with the literature.[22,27] However, the response between proximity and

Table 2

Factors associated with the utilization of HV/VHV or LV/VLV hospitals.

Variable	Categories	Odds of HV/VHV utilization OR_{adj}* (95% CI)			Odds of LV/VLV utilization OR_{adj}* (95% CI)		
		Overall (n=31,931)	Black (n=2,907)	White (n=29,024)	Overall (n=31,931)	Black (n=2,907)	White (n=29,024)
Nearest HV/VHV distance, miles	0–2.3 miles	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
	>2.3–6.1 miles	0.51 (0.46–0.56)	0.52 (0.42–0.63)	0.47 (0.42–0.54)	1.44 (1.23–1.67)	1.63 (1.23–2.16)	1.46 (1.21–1.75)
	>6.1 miles	0.27 (0.24–0.30)	0.64 (0.46–0.89)	0.24 (0.21–0.27)	2.70 (2.34–3.13)	1.75 (1.14–2.70)	2.91 (2.46–3.43)
Race	Black/White	0.26 (0.23–0.29)	—	—	3.40 (2.90–3.98)	—	—
Gender	Female/Male	1.04 (0.97–1.12)	1.22 (1.01–1.47)	1.03 (0.95–1.11)	0.94 (0.85–1.04)	0.83 (0.64–1.08)	0.95 (0.85–1.06)
Surgery type	Lobectomy	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
	Limited Resection	0.77 (0.72–0.83)	0.78 (0.65–0.95)	0.77 (0.71–0.84)	1.12 (1.00–1.24)	1.18 (0.90–1.55)	1.10 (0.98–1.23)
	Pneumonectomy	1.23 (1.08–1.46)	1.17 (0.80–1.71)	1.27 (1.08–1.49)	0.94 (0.77–1.15)	1.16 (0.71–1.89)	0.95 (0.85–1.06)
Insurance status	Medicare	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
	Medicaid	0.46 (0.39–0.55)	0.52 (0.39–0.69)	0.51 (0.42–0.63)	2.09 (1.66–2.62)	1.92 (1.29–2.87)	1.80 (1.33–2.42)
	Private insurance	1.11 (1.00–1.232)	1.39 (1.07–1.81)	1.05 (0.94–1.17)	0.96 (0.84–1.11)	0.80 (0.55–1.17)	1.02 (0.87–1.19)
	No insurance/Other	0.86 (0.69–1.09)	0.70 (0.43–1.13)	0.94 (0.73–1.23)	1.46 (1.08–1.98)	2.20 (1.22–3.99)	1.20 (0.84–1.72)
Elixhauser comorbidity index	—	0.99 (0.99–0.99)	0.99 (0.98–1.01)	0.99 (0.98–0.99)	1.01 (1.01–1.02)	1.01 (1.00–1.03)	1.01 (1.01–1.02)
Hospital score	—	1.82 (1.76–1.88)	1.16 (1.02–1.33)	1.88 (1.82–1.94)	0.53 (0.51–0.55)	0.93 (0.77–1.12)	0.50 (0.48–0.53)
Age, year	—	0.99 (0.99–1.00)	1.00 (0.99–1.02)	0.99 (0.99–1.00)	1.01 (1.00–1.01)	1.00 (0.98–1.01)	1.01 (1.00–1.02)
Year at admission (continuous)	—	1.08 (1.08–1.09)	1.06 (1.04–1.08)	1.09 (1.08–1.10)	0.96 (0.95–0.97)	0.97 (0.94–0.99)	0.96 (0.94–0.97)

CI = confidence interval, HV = high volume, LV = low volume, OR = odds ratio, VHV = very high volume, VLV = very low volume.
* Models adjusted for distance to the nearest HV/VHV hospital, race, gender, surgery type, type of insurance, Elixhauser comorbidity index, hospital score, age, and year of admission.

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utilization was more evident in white patients, where increasing distance to the nearest HV/VHV hospital could reflect a transition to rural patients. Although studies assert patient travel distances increase in conjunction with centralization for many cancers,[1,22,24,28,29] this work is the first to our knowledge to assert that patient–hospital distance increased over the study period for specifically lung cancer surgery in both whites and blacks, albeit at a greater rate in white patients.

Racial differences in the use of HV hospitals[16–18,27] and in lung cancer care have been previously reported,[19–21] but very few studies have addressed racial disparities for lung surgery in the context of centralization and hospital procedure volume, and none of these studies have done so in a comprehensive way.[12,16,27] One study reported that blacks have lower odds of lung resection at HV hospitals and have higher mortality compared to whites, however neither distance from patient residence to hospital nor hospital proximity were explicitly measured and reported, and the study provided nationwide trends from a brief time period (1998–2003).[12] Other studies incorporated the role of travel distance, travel time, or the influence of geographic proximity to high-quality hospitals on hospital utilization albeit not exclusively for lung cancer surgery.[16,18,27] Publications incorporating geographic proximity were performed on Medicare patients from 2005 to 2008,[18] and therefore could not assess the influence of insurance types on patients choice or were conducted in New York City over 10[16] to 20 years ago.[27] The present work integrates with the conclusion of these three studies that racial disparities exist in HV hospital utilization, but expands to address temporal trends in hospital centralization and how this affects lung cancer surgery disparities in NYS.

This study has some limitations. SPARCS data do not provide cancer stage and are restricted to NYS residents; only black and white patients were included to focus on the comparison between these groups. Black patients were under-represented in the sample, but accurately reflect the proportion of black patients that were exclusively treated with surgery, as patients with other treatments were excluded. Since geographic access has a specific spatial context, these results may not be generalizable to other states, with different population and hospital characteristics. However, as centralization has been reported across the country and for many cancer types, this work can be replicated for other cancers in different regions. Finally, although proximity and insurance are important determinants of quality care, other personal and community variables not captured by SPARCS may be influential in lung surgery treatment and should be areas of future research to address disparities in cancer care.

5. Conclusion

Although centralization increased the utilization of HV/VHV for both black and white patients, racial disparities in access and utilization of HV hospitals are not fully explained by proximity to care or insurance type, indicating that other factors influence seeking care at HV hospitals, and in turn, may contribute to discrepancies in lung cancer outcomes. Specific interventions are needed to address accessing and utilizing quality care in underserved populations.

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