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RESEARCH ARTICLE

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Rural-urban survival disparities for patients with surgically treated lung cancer

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Abstract

Background: Nonsmall-cell lung cancer (NSCLC) is a common diagnosis among patients living in rural areas and small towns who face unique challenges accessing care. We examined differences in survival for surgically treated rural and small-town patients compared to those from urban and metropolitan areas.

Methods: The National Cancer Database was used to identify surgically treated NSCLC patients from 2004 to 2016. Patients from rural/small-town counties were compared to urban/metro counties. Differences in patient clinical, sociodemographic, hospital, and travel characteristics were described. Survival differences were examined with Kaplan–Meier curves and Cox proportional hazards models.

Results: The study included 366 373 surgically treated NSCLC patients with 12.4% (n = 45 304) categorized as rural/small-town. Rural/small-town patients traveled farther for treatment and were from areas characterized by lower income and education(all $p < 0.001$). Survival probabilities for rural/small-town patients were worse at 1 year (85% vs. 87%), 5 years (48% vs. 54%), and 10 years (26% vs. 31%) ($p < 0.001$). Travel distance >100 miles (hazard ratio [HR] = 1.11, 95% confidence interval [CI]: 1.07–1.16, vs. <25 miles) and living in a rural/small-town county (HR = 1.04, 95% CI: 1.01–1.07) were associated with increased risk for death.

Conclusions: Rural and small-town patients with surgically treated NSCLC had worse survival outcomes compared to urban and metropolitan patients.

KEYWORDS
health disparity, nonsmall-cell lung cancer, rural health

1 | INTRODUCTION

There are an estimated 46–60 million people in the United States (15%–19% of the population) who are considered rural.[1] Rural populations have a lower life expectancy (76.8 years) when compared to US metro or urban populations (78.8 years).[2] Rural populations face numerous challenges with access to cancer screening, diagnostic, and treatment modalities. A growing body of literature has demonstrated disproportionately worse cancer outcomes in rural populations, especially for lung cancer.[3,4] Rural lung cancer patients

have worse survival outcomes based on increasing rurality with a dose-dependent relationship.[5] The largest disparity in survival between rural populations and metro populations is in early-stage non-small-cell lung cancer (NSCLC).[6] Rural patients are less likely to undergo guideline concordant care, especially surgery, which affords the greatest survival benefit.[5,6] These challenges have been exacerbated in recent times by an acceleration in rural hospital closures and persistent provider shortages.[7–12] However, it is unknown whether rural-urban disparities in lung cancer survival persist for those who undergo surgical resection with curative intent. Our hypothesis is that there are persistent rural-urban survival disparities for surgically treated lung cancer.

The purpose of this study was to investigate the relationship between rurality and survival for patients who underwent surgical treatment for NSCLC while controlling for patient, hospital, treatment modality, cancer stage, and travel distance characteristics.

2 | METHODS

2.1 | Data source and study cohort

The National Cancer Database (NCDB) is a hospital-based registry that is estimated to capture 82% of cancers of the lung and bronchus in the United States.[13] The NCDB was used to identify surgically treated NSCLC patients diagnosed from 2004 to 2016 for which all-cause mortality outcome data were available through 2017. Patient information in the NCDB is deidentified and this study is exempt from review by our institution's institutional review board.

2.2 | Geographic areas and rurality

The United States Department of Agriculture Economic Research Service publishes a nine level Rural-Urban continuum code (RUCC). RUCC levels 1–3 are metro counties, 4–7 are urban counties, and 8–9 are completely rural counties. RUCC levels 4–9 are divided by population and adjacency to metro counties. Adjacency of an urban or rural county to a metro county is defined as (1) physical proximity to one or more metro counties, and (2) having 2% or more of the labor force commuting to a metro county. For this study, and unlike other analyses, RUCC levels 1–4 were defined a priori as urban/metro which included the most highly populated metro-adjacent urban counties.[6] RUCC levels 5–9 were defined as rural/small-town. Sensitivity analyses were conducted with different definitions of rurality with unchanged inference. Patients with missing rurality data were omitted.

2.3 | Patient characteristics

NCDB data included patient age, race and ethnicity, sex, socio-demographic characteristics, clinical characteristics at diagnosis, and receipt of chemotherapy or radiation in addition to surgery. Patient age was grouped into <40, 40–49, 50–59, 60–69, 70–79, and 80 or older. Comorbidities in the NCDB are mapped with the Charlson-Deyo score and were grouped by 0, 1, 2, and 3 or more. Patients' income level was based on zip code tabulation area (ZCTA) estimates from each of three periods during the study categorized as quartiles. Educational attainment was similarly calculated from census estimates as quartiles of the percentage of ZCTA residents over age 25 without a high school degree. Patients with missing data for income or education were categorized as missing and included in analyses. Uninsured or Medicaid versus Medicare or private insurance status was used as a proxy for care access. Patient's American Joint Committee on Cancer pathological stage was categorized with sub-stages consolidated into Stage I through Stage IV. Stage 0 patients were omitted, but those with stage data missing were included in the analysis as a separate category. The extent of surgical resection was categorized as unknown, wedge, segmentectomy, lobectomy, and pneumonectomy.

2.4 | Hospital characteristics

Distance from treatment facility was calculated by the distance between the centroid of the patient's zip code to the address of the reporting facility. The patients were grouped into travel distances of >100 miles, >50–100 miles, 25–50 miles, and <25 miles. Facility type was determined by the Commission on Cancer accreditation program and includes Academic, Comprehensive Community, Integrated Network, and Community programs. Designations reflect facility-level capabilities, and volume of new cancers treated. Annual facility surgical volume was empirically categorized as <20, 20–38, 39–71, and 72 or more.

2.5 | Statistical analysis

Chi-square tests were used to determine the significance of population differences between rural/small-town and urban/metro regions. Kaplan–Meier survival probabilities with log-rank tests were used to determine the significance of bivariate urban/metro and rural/small-town differences in survival, and Cox proportional hazards analysis were used to examine differences in mortality controlled for all patient and hospital characteristics. Cox model standard errors were adjusted for clustering of observations within hospitals. All analyses were done with Stata Version 16, College Station, TX.

3 | RESULTS

After excluding patients with missing rurality data ($n = 12\,168$), the study patient cohort included 366 373 surgically treated NSCLC patients treated at 1333 hospitals with 12.4% ($n = 45\,304$) categorized as rural/small-town (Figure 1). Of the 1740 patients with pathological Stage 0 disease who were excluded, 322 received neoadjuvant therapies. Neoadjuvant chemotherapy was administered to 65 patients, neoadjuvant radiation was administered to 32

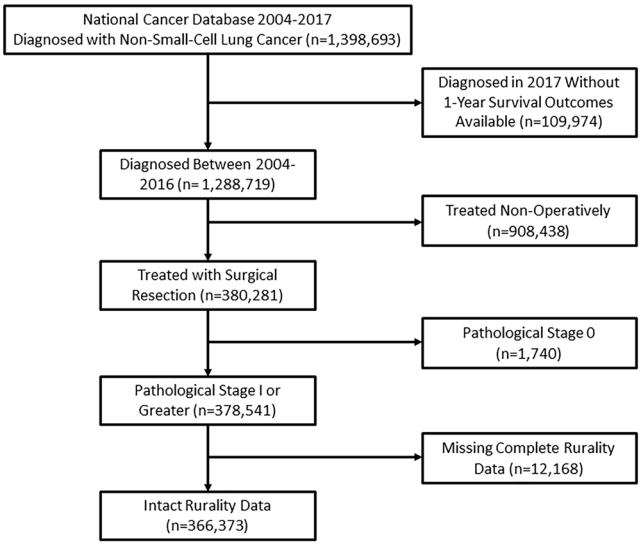

FIGURE 1 Inclusion criteria map

patients, and 225 received both neoadjuvant chemotherapy and radiation (Table S1).

3.1 | Regional differences in patient characteristics

Rural/small-town patients were from areas characterized by lower income and educational attainment (Table 1, all $p < 0.001$). Rural/small-town patients were more likely to be male (54.3% vs. 49.1%) and non-Hispanic White (93.1% vs. 84.8%). They traveled longer distances for care with 17.5% of rural/small-town patients versus 76.5% of urban/metro patients residing within 25 miles of their treatment facility. Rural/small-town patients were less likely to be treated at an academic facility (27.3% vs. 38.7%) and were less likely to be treated at a facility with the highest quartile of surgical volume (27.1% vs. 33.2%). Rural/small-town patients were also less likely to have a Charlson-Deyo Score of zero denoting absence of serious comorbidities (47.1% vs. 51.8%) and were less likely to be pathological Stage I at time of surgery (54.3% vs. 56.0%). Approximately 3.1% of rural/small-town patients and 3.4% of urban/metro patients were found to be pathological Stage IV following surgery.

3.2 | Survival probabilities

All stage overall survival (OS) probabilities for rural/small-town patients were worse at 1 year (85% vs. 87%), 5 years (48% vs. 54%), 10 years (26% vs. 31%), and 15 years (11% vs. 15%) (Table 2, all $p < 0.001$). Rural/small-town patients had worse OS at each individual stage and time point examined (Figures 2–5). Notably large rural/small-town to urban/metro disparities were detected at Stage I 5-year OS outcomes (57% vs. 63%) and Stage IV 1-year OS outcomes (55% vs. 62%).

3.3 | Cox regression results

Living in a rural/small-town location remained an independent risk factor for death for surgically treated patients (hazard ratio [HR]: 1.04, 95% confidence interval [CI]: 1.01–1.07) after controlling for cancer pathological stage, patient sociodemographic and hospital characteristics, treatment modality, and travel distance (Table 1). Risk of death also increased as distance from the treatment facility increased (reference <25 miles), with distance of 25–50 miles (HR: 1.04, 95% CI: 1.01–1.06), >50–100 miles (HR: 1.06, 95% CI: 1.02–1.10) and distance >100 miles (HR: 1.11, 95% CI: 1.07–1.16). Uninsured or Medicaid status was associated with worse OS compared to Medicare or private insurance (HR: 1.19, 95% CI: 1.17–1.22). Treatment with a combination of surgery and radiation therapy was associated with worse OS (HR: 1.39, 95% CI: 1.37–1.41), while treatment with surgery and chemotherapy was associated with improved OS (HR: 0.82, 95% CI: 0.81–0.83) when compared to patients treated with surgery alone. Treatment at an academic versus community facility was associated with improved OS (HR: 0.90, 95% CI: 0.85–0.94), as was treatment at a facility with the highest (vs. lowest) quartile of surgical case volume (HR: 0.89, 95% CI: 0.84–0.93). Asian (HR: 0.71, 95% CI: 0.67–0.77) and Hispanic (HR: 0.83, 95% CI: 0.79–0.88) patients had better OS outcomes than non-Hispanic White patients. Non-Hispanic Black patients had comparable OS outcomes to non-Hispanic White patients (HR: 0.98, 95% CI: 0.96–1.00). Sensitivity analyses were performed including extent of surgical resection variables and including patients who were pathological Stage 0 with inference unchanged (Table S1).

4 | DISCUSSION

Cancers of the lung and bronchus are the leading cause of cancer related death in the United States and the world. Though lung cancer mortality rates are declining in the United States, these reductions ranged from −21% in rural areas to −28% in metro areas between 2007 and 2017.[2] Previous literature has identified rural residence as a risk factor for poor survival outcomes in patients with NSCLC, possibly due to lack for receipt of surgery.[3,5,6,14,15] We found rurality remained an independent risk factor for death for surgically treated NSCLC patients. Multiple factors contribute to this disparity. Rural areas suffer from higher lung cancer incidence, which is due to higher rates of exposure to smoking and secondhand smoke.[16] Primary care provider shortages and lower relative uptake of cancer screening result in higher lung cancer stage at diagnosis in rural populations. Access to physician specialists is limited, and rural patients are less likely to undergo appropriate treatment- especially at early stages when intervention has the greatest impact on survival.[3,17–19]

Effective treatment of NSCLC is stage specific and multidisciplinary. Workforce distribution analyses demonstrated disproportionately

TABLE 1 Cox model results for regional differences in surgically treated NSCLC controlling for patient sociodemographic, clinical, travel distance, and hospital characteristics

Parameter	% Total *n* = 366 373[a]	% Rural/small-town *n* = 45 304	% Urban/metro *n* = 321 069	Hazard ratio (95% CI)
Rurality				
Rural/small-town	12.4			1.04 (1.01–1.07)
Urban/metro	87.6			Reference
Period				
2004–2009	43.3	45.4	43.0	Reference
2010–2014	39.5	38.8	39.6	0.84 (0.83–0.86)
2015–2016	17.2	15.8	17.4	0.69 (0.67–0.72)
Sex				
Male	49.8	54.3	49.1	1.35 (1.33–1.36)
Female				Reference
Age groups				
<40	0.4	0.3	0.4	0.62 (0.56–0.68)
40–49	4.0	4.2	3.9	0.70 (0.68–0.73)
50–59	16.6	17.3	16.5	0.81 (0.79–0.82)
60–69	34.1	35.8	33.8	Reference
70–79	35.1	34.4	35.2	1.34 (1.33–1.36)
>80	9.9	7.9	10.2	1.87 (1.83–1.90)
Race and ethnicity				
Asian	2.2	0.4	2.4	0.71 (0.67–0.77)
Non-Hispanic Black	8.4	4.4	9.0	0.98 (0.96–1.00)
Hispanic	2.4	0.7	2.7	0.83 (0.79–0.88)
Non-Hispanic White	85.8	93.1	84.8	Reference
Other/Unknown	1.2	1.4	1.2	0.88 (0.81–0.95)
Median income quartiles				
1 (lowest)	15.7	36.7	12.7	Reference
2	20.6	35.7	18.5	0.98 (0.96–1.00)
3	24.6	17.2	25.6	0.95 (0.93–0.97)
4 (highest)	32.3	2.7	36.5	0.89 (0.86–0.92)
Missing	6.8	7.8	6.7	Excluded
No high school degree quartiles				
1 (lowest)	15.0	31.5	12.7	Reference
2	22.4	30.8	21.3	1.00 (0.98–1.02)
3	22.9	21.8	23.1	0.98 (0.96–1.01)
4 (highest)	31.4	7.4	34.7	0.95 (0.92–0.98)
Missing	8.2	8.4	8.2	Excluded
Insurance status				
Medicaid or uninsured	6.5	7.8	6.3	1.19 (1.17–1.22)
Medicare or private	93.5	92.2	93.7	Reference

TABLE 1 (Continued)

Parameter	% Total *n* = 366 373[a]	% Rural/small-town *n* = 45 304	% Urban/metro *n* = 321 069	Hazard ratio (95% CI)
Distance from treatment facility				
>100 miles	3.8	12.8	2.5	1.11 (1.07–1.16)
>50–100 miles	7.7	31.2	4.4	1.06 (1.02–1.10)
25–50 miles	13.4	32.0	10.8	1.04 (1.01–1.06)
<25 miles	69.2	17.4	76.5	Reference
Not available	5.9	6.7	5.8	0.43 (0.38–0.48)
Charlson-Deyo Score				
0	51.3	47.1	51.8	Reference
1	33.3	35.7	33.0	1.14 (1.12–1.15)
2	11.4	12.9	11.2	1.31 (1.29–1.34)
≥3	4.0	4.2	4.0	1.56 (1.52–1.60)
Facility type				
Unknown	0.4	0.3	0.4	Excluded
Academic	37.2	27.3	38.7	0.90 (0.86–0.94)
Comprehensive community	41.5	55.3	39.6	0.93 (0.90–0.97)
Integrated network	14.0	7.2	14.9	0.93 (0.88–0.97)
Community	6.9	9.8	6.4	Reference
Annual facility surgical case volume				
<20	16.7	18.6	16.4	Reference
20–38	23.7	24.4	23.6	0.98 (0.95–1.01)
39–71	27.2	29.9	26.8	0.93 (0.90–0.97)
≥72	32.5	27.1	33.2	0.89 (0.85–0.93)
Pathological stage				
Stage missing	11.2	11.5	11.2	1.62 (1.58–1.65)
Stage I	55.8	54.3	56.0	Reference
Stage II	17.3	18.5	17.1	1.63 (1.61–1.66)
Stage III	12.3	12.6	12.3	2.21 (2.17–2.25)
Stage IV	3.3	3.1	3.4	3.69 (3.57–3.82)
Treatment modality				
Surgery only	57.2	57.8	56.8	Reference
Surgery and chemotherapy	29.4	28.9	29.5	0.82 (0.81–0.83)
Surgery and radiation	13.4	13.3	13.7	1.39 (1.37–1.41)

Abbreviations: CI, confidence interval; NSCLC, non-small-cell lung cancer.
[a]All $p < 0.001$.

low concentrations of physicians in the fields of medical oncology, radiation oncology, and thoracic or general surgery in rural areas.[20–23] Previous research found rural lung cancer patients had worse outcomes at earlier stages and were less likely to undergo guideline-concordant care, likely due to barriers in access to high-quality care.[5,6,24] When cancer patients of varying degrees of rurality are enrolled in the same clinical trial and receive the same protocol-driven care, thus eliminating barriers to care access, they have been shown to have similar outcomes.[25] Increasing access to multidisciplinary teams of specialists through telemedicine and optimized referral patterns as well as inclusion of rural patients in clinical trials are important goals for reaching equitable outcomes.

TABLE 2 Survival probabilities by region for patients with surgically treated NSCLC

Survival (months)	12	60	120	180
All stage				
Rural/small-town	84.7%	48.2%	25.6%	11.3%
Urban/metro	87.0%	53.9%	30.8%	15.2%
Stage I				
Rural/small-town	90.4%	57.2%	31.2%	13.8%
Urban/metro	92.1%	63.3%	36.8%	18.1%
Stage II				
Rural/small-town	82.8%	43.8%	22.3%	13.2%
Urban/metro	85.2%	48.1%	27.7%	14.3%
Stage III				
Rural/small-town	75.7%	31.3%	15.2%	4.1%
Urban/metro	79.4%	36.5%	19.4%	9.7%
Stage IV				
Rural/small-town	55.0%	17.3%	7.1%	None
Urban/metro	62.2%	22.4%	10.8%	None
Stage missing				
Rural/small-town	79.0%	40.5%	21.0%	9.9%
Urban/metro	80.1%	44.7%	24.7%	12.0%

Abbreviation: NSCLC, non-small-cell lung cancer.

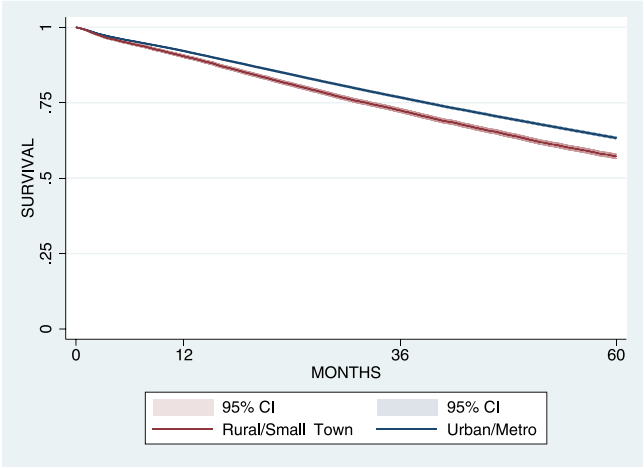

FIGURE 2 Stage I survival estimates. Kaplan–Meier model results for differences in survival by rurality in Stage I surgically treated NSCLC patients. NSCLC, non-small-cell lung cancer

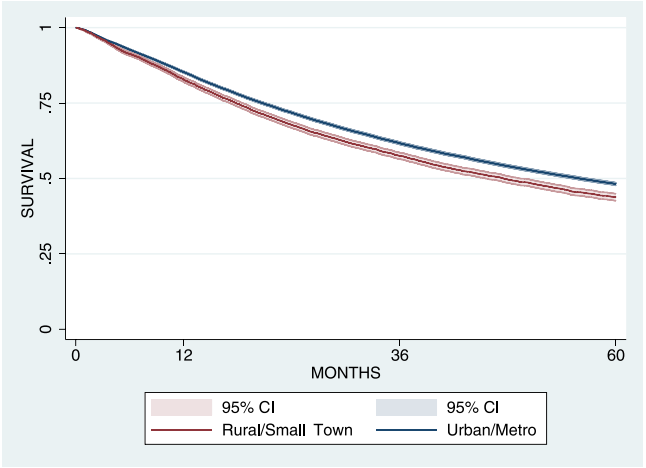

FIGURE 3 Stage II survival estimates. Kaplan–Meier model results for differences in survival by rurality in Stage II surgically treated NSCLC patients. NSCLC, non-small-cell lung cancer

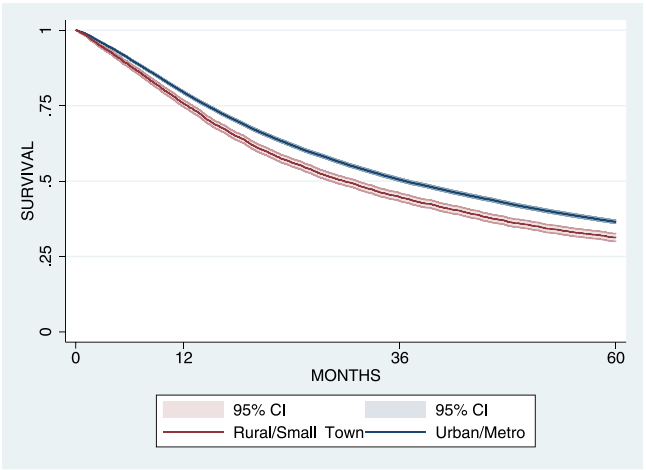

FIGURE 4 Stage III survival estimates. Kaplan–Meier model results for differences in survival by rurality in Stage III surgically treated NSCLC patients. NSCLC, non-small-cell lung cancer

Some of the differences in survival outcomes for rural patients may be attributed to facility level characteristics.[26] Survival outcomes for complex surgical procedures, including lung resections, are superior at academic and high-volume centers.[27–31] These findings resulted in a trend towards regionalization of care towards metro centers, thus increasing travel burden for rural patients.[8,32,33] Our findings confirmed that surgical patient outcomes are better at academic centers and hospitals with higher surgical volume. However, we also found that increasing travel distance had an inverse relationship with survival for surgically treated NSCLC patients. The relationship between travel distance and survival is inconsistent in the literature.[8,34–36] Previous studies demonstrated an association between increasing travel distance with decreased likelihood of undergoing guideline concordant chemotherapy or radiation.[37,38] Though regionalization of complex surgical procedures has proven benefits, the ideal implementation and catchment area of regionalized cancer care is undefined. Determining the optimal balance between patient access to surgical care and surgical case volume has implications for future research and policy decisions.

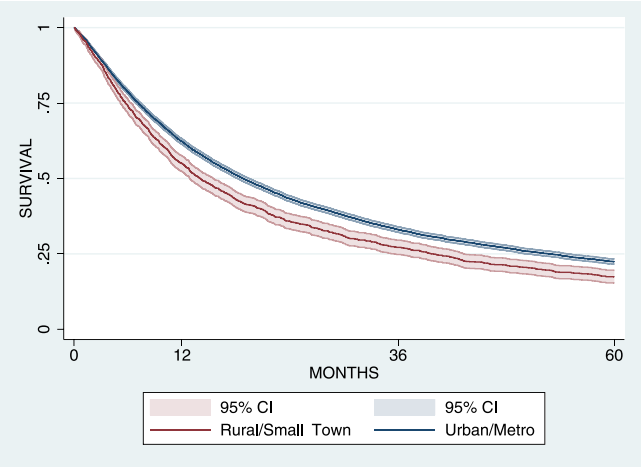

FIGURE 5 Stage IV survival estimates. Kaplan–Meier model results for differences in survival by rurality in Stage IV surgically treated NSCLC patients. NSCLC, non-small-cell lung cancer

5 | LIMITATIONS

The NCDB captures cases from Commission on Cancer (CoC) approved hospitals. Even though there are greater than 1500 reporting hospitals, there are gaps. The entire state of Wyoming, for example, does not have a CoC-approved hospital.[39] Comparisons of CoC-approved hospitals versus non-CoC-approved hospitals demonstrated that non-CoC-approved hospitals are more likely to be smaller, rural, and less likely to have access to oncological treatment services such as cancer screening, tobacco cessation, chemotherapy, and radiation therapy.[39] Of the approximately 18% of cases of lung cancer in the United States that are treated at non-CoC-approved hospitals, most are likely from rural/small-town areas. Considering what is known about the characteristics of non-CoC-approved hospitals, it is probable that the direction of bias would be towards the appearance of better rural survival outcomes in our data.

It is not possible to ascertain the training background of the surgeon performing the operation in the NCDB. Considering there are known rural-urban disparities in access to specialists, it is possible that the training or practice pattern of a patient's surgeon may also contribute to rural-urban disparities in lung cancer survival. Also, disparities in access to minimally invasive surgical techniques may also contribute to disparities in outcomes. Surgical approach is only available in the NCDB from 2010 and later and was not considered in this analysis which included patients from 2004 to 2016.

Additionally, the NCDB does not capture several factors known to be important for short and long-term lung cancer risk, including forced expiratory volume 1, smoking status, and occupation. Increased incidence of rural lung cancer is likely driven by escalating smoking prevalence across the rural-urban continuum, with 28.5% smokers in rural populations versus 18.3% smokers in metro populations.[4,5,40] Differences in smoking status and smoking cessation in lung cancer patients may account for some of the disparities in survival.

The definition of rural for public health research has been subject to debate in the United States for decades. Multiple different definitions are used by government agencies, and those definitions can produce a wide range in estimates of the size and location of the rural population. For example, the rural population is estimated to be approximately 60 million people by the US Census definition which is more expansive than other definitions. The difference in the population size is due to the use of smaller, more precise census tracts which allow for detection of low population density rural areas contained within otherwise high population metro counties. The NCDB uses RUCC which incorporates county-level population measurements and leads to undercounting of rural patients compared to the US Census. However, the RUCC definition not only considers population but also interconnectedness with metro counties through both proximity and commuter data, which may provide useful information as proxies for care access.

6 | CONCLUSIONS

Rurality is a risk factor for worse survival outcomes in lung cancer patients. The cause of the disparity in rural lung cancer survival is multifactorial. Socioeconomic deprivation, cultural beliefs, and geographic isolation leads to decreased cancer screening access, increased smoking prevalence, and insufficient access to high quality care. The crisis of rural hospital closures and worsening rural care provider shortages combined with a trend towards regionalization of specialized care resulted in increased travel burden which disproportionately effects rural patients. We found that rural residence remained an independent risk factor for poor survival outcomes for surgically treated NSCLC patients after controlling for sociodemographic, clinical, and hospital characteristics. Survival also decreased as travel distance to treatment facility increased with a dose-dependent relationship. Efforts to increase access to primary care providers, high-quality cancer care, and LDCT screening as well as continued emphasis on smoking cessation represent practical targets to address health disparities in rural lung cancer populations. Future research investigating rural-urban disparities in access to thoracic surgery specialists, adjuvant therapies, and LDCT may be key in understanding gaps in the quality of care for patients with lung cancer.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from National Cancer Database. Restrictions apply to the availability of these data, and per agreement the authors are not allowed to make the data publicly available (https://www.facs.org/quality-programs/cancer/ncdb/puf). The data used in the study are derived from a deidentified NCDB file. The American College of Surgeons and the Commission on Cancer have not verified and are not responsible for the analytic or statistical methodology employed, or the conclusions drawn from these data by the investigator.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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