Treatment quality and outcomes vary with hospital burden of uninsured and Medicaid patients with cancer in early non–small cell lung cancer

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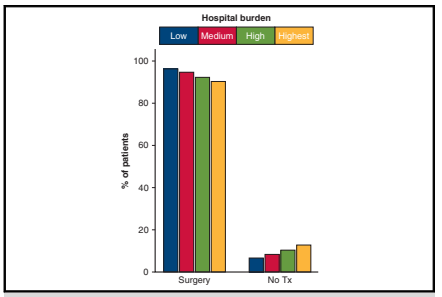
ABSTRACT

Objectives: Safety-net hospitals deliver a significant level of care to uninsured patients, Medicaid-enrolled patients, and other vulnerable patients. Little is known about the impact of safety-net hospital status on outcomes in non–small cell lung cancer. We aimed to compare treatment characteristics and outcomes between hospitals categorized according to their relative burden of uninsured or Medicaid-enrolled patients with non–small cell lung cancer.

Methods: We queried the National Cancer Database for patients with clinical stage I and II non–small cell lung cancer presenting from 2004 to 2018. We categorized hospitals on the basis of their relative burden of uninsured or Medicaid-enrolled patients with non–small cell lung cancer into low-burden (<8.2%), medium-burden (8.2%-12.0%), high-burden (12.1%-16.8%), and highest burden (>16.8%) quartiles. We investigated the impact of care at these hospitals on outcomes while controlling for sociodemographic, clinical, and facility characteristics.

Results: We identified 204,189 patients treated at 1286 facilities. There were 592 low-burden, 297 medium-burden, 219 high-burden, and 178 highest burden hospitals. Patients at highest burden hospitals were more likely to be younger, male, Black, and Hispanic ($P < .01$), and to reside in rural, low-income, and low-educated regions ($P < .01$). Patients at these facilities had a greater likelihood of not receiving surgery, undergoing an open procedure, undergoing a regional lymph node examination involving less than 10 lymph nodes, having a length of stay more than 4 days, and not receiving treatment ($P < .05$).

Conclusions: Our results indicate reduced treatment quality and higher mortality in patients undergoing surgery for early non–small cell lung cancer at hospitals with an increased burden of uninsured or Medicaid-enrolled patients with non–small cell lung cancer. There is a need to raise the standard of care to improve outcomes in vulnerable populations. (JTCVS Open 2022;11:272-85)



Treatment characteristics by hospital burden of uninsured or Medicaid-enrolled patients.

CENTRAL MESSAGE

We observed reduced quality of care and higher mortality in patients with early lung cancer receiving surgery at centers with an increased burden of uninsured patients or Medicaid-enrolled patients with lung cancer.

PERSPECTIVE

Safety-net hospitals are crucial to providing access to care for the underprivileged, and our findings emphasize the need to raise the standard of care in patients undergoing early lung cancer treatment at these facilities to ultimately improve outcomes in medically marginalized populations.

Social determinants of health impact treatment quality and survival in patients with non–small cell lung cancer (NSCLC).[1,2] Safety-net hospitals have previously been grouped with other proposed patient- and facility-specific contributors of these healthcare disparities.[3] The Institute of Medicine defines safety-net hospitals as "those providers that organize and deliver a significant level of health care and other related services to uninsured, Medicaid, and other

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Abbreviations and Acronyms

AJCC = American Joint Committee on Cancer
aOR = adjusted odds ratio
IRB = Institutional Review Board
NCDB = National Cancer Database
NSCLC = non–small cell lung cancer

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vulnerable patients."[4] Safety-net hospitals have been associated with reduced adherence to quality-of-care measures and a lower use of curative-intent surgery in patients with NSCLC.[5,6] These findings may be partially explained by limited resources and services that hinder adequate provision of costly and complex treatments[7,8] because these hospitals at baseline are subject to lower compensation due to the underinsured nature of their patient population[9] and are susceptible to further financial penalties in light of ongoing revisions to healthcare policy.[10] We noted that there is a paucity of literature investigating the impact of safety-net hospital status on treatment and outcomes in NSCLC. With an anticipated increase in demand for care at safety-net hospitals,[11] understanding how outcomes may differ in patients treated at such institutions will become even more pressing.

The National Cancer Database (NCDB) is the largest cancer registry in the world that currently captures 72% of all newly diagnosed malignancies annually in the United States from more than 1500 Commission on Cancer–approved facilities.[12] The objective of our study was to use this contemporary nationwide patient cohort to compare treatment characteristics and perioperative outcomes between hospitals categorized according to their relative burden of uninsured or Medicaid-enrolled patients with NSCLC. We also aimed to elucidate factors associated with care at a hospital with a high burden of uninsured or Medicaid-enrolled patients with NSCLC. We hypothesized that care at such facilities would be associated with reduced treatment quality and inferior outcomes.

MATERIALS AND METHODS

Data Source

The NCDB is a joint project of the Commission on Cancer of the American College of Surgeons and the American Cancer Society. The Institutional Review Board (IRB) or equivalent ethics committee (Biomedical Research Alliance of New York) approved the study protocol and publication of data. Patient written consent for the publication of the study data was waived by the IRB. IRB exemption was granted due to nonhuman subjects determination (Investigator Initiated Protocol 21-511/BRANY File # 21-15-264-337 [06/24/2021]).

Selection of Study Population

In this retrospective cohort study, we queried the NCDB for patients diagnosed with American Joint Committee on Cancer (AJCC) clinical stage I or II NSCLC from 2004 to 2018. Clinical stage was reported using the AJCC clinical staging edition prevalent at the time of diagnosis (AJCC 6: 2004-2009, AJCC 7: 2010-2017, AJCC 8: 2018). We excluded patients who were diagnosed and treated at separate facilities. We also excluded those patients whose insurance status was not known.

Variables

Covariates. We included the following variables in our analysis: age at diagnosis, sex, race, ethnicity, year of diagnosis, insurance status, ZIP code level income, ZIP code level education, county of residence, facility type, facility region, distance to treatment facility, Charlson-Deyo comorbidity score, clinical stage, clinical T stage, clinical N stage, pathologic stage, tumor size, tumor histology, type of treatment provided, and type of surgery performed.

Hospital burden of uninsured or Medicaid-enrolled patients with non–small cell lung cancer. We categorized hospitals on the basis of their percentage of uninsured or Medicaid-enrolled patients with stage I to IV NSCLC treated into low-burden (<8.2%), medium-burden (8.2%-12.0%), high-burden (12.1%-16.8%), and highest burden (>16.8%) quartiles. A similar categorization has been used in prior studies to investigate hospital safety-net burden.[13,14] We were unable to calculate safety-net burden inclusive of all cancer and noncancer diagnoses at a particular facility because our dataset was limited to only NSCLC cases.

Outcome measures. The outcomes of interest included performing surgery, open thoracotomy, conversion to thoracotomy, anatomic resection, examination of 10 or more regional lymph nodes, pathologic nodal upstaging, positive surgical margins, length of stay more than 4 days, 30-day mortality, unplanned readmission, recommending adjuvant chemotherapy for pathologic stage II disease or higher, and providing no treatment. For the outcomes of performing surgery and recommending chemotherapy, hospitals were not included in the "not performed" and "not recommended" groups, respectively, in the event of nontreatment, if patients were documented not to be candidates due to risk factors or patient refusal. Likewise, for the outcome of providing no treatment, hospitals were not included in the "not provided" group in the event of nontreatment if patients refused treatment and the refusal was documented.

Statistical Analysis

We used SPSS Statistical software version 25 (IBM SPSS Statistics for Macintosh, Version 25.0; IBM Corp) for statistical analyses. We determined univariate differences among low-, medium-, high-, and highest burden hospitals using the Pearson chi-square test for categorical variables.

To understand the patient population affected by any potential differences in treatment quality at higher burden facilities, we used multivariable logistic regression to determine factors that were independently associated with treatment at highest burden facilities. We included the following variables in the regression model on the basis of a priori hypotheses: age at diagnosis, sex, ethnicity, year of diagnosis, insurance status, ZIP code level income, ZIP code level education, county of residence, facility type, facility region, distance to treatment facility, Charlson-Deyo comorbidity score, tumor size, clinical N stage, and tumor histology.

We also fitted multivariable logistic regression models with the outcome of interest as the dependent variable to determine the effect of hospital burden of uninsured or Medicaid-enrolled patients with NSCLC on each outcome. Hospital burden was included as a predictor. Other predictors were included in the models on the basis of a priori hypotheses and varied by outcome measure. These are listed in the footnote of Table 1. We performed this analysis in the entire cohort for the following 2 outcome measures: performing surgery and providing no treatment. We performed this

TABLE 1. Results of the multivariable regression models showing adjusted odds ratios for various outcomes of interest associated with hospital burden of uninsured or Medicaid-enrolled patients with lung cancer

Outcome	aOR (95% CI)	*P* value
Surgery performed*		
Low burden	Reference	
Medium burden	0.88 (0.76-1.03)	.10
High burden	0.96 (0.80-1.15)	.70
Highest burden	0.58 (0.46-0.73)	<**.01**
Open thoracotomy†		
Low burden	Reference	
Medium burden	1.00 (0.97-1.03)	1.00
High burden	1.36 (1.31-1.41)	<**.01**
Highest burden	1.47 (1.40-1.56)	<**.01**
Conversion to thoracotomy‡		
Low burden	Reference	
Medium burden	1.06 (0.99-1.13)	.10
High burden	1.14 (1.05-1.24)	<**.01**
Highest burden	1.19 (1.05-1.34)	**.01**
Anatomic resection§		
Low burden	Reference	
Medium burden	0.94 (0.90-0.97)	<**.01**
High burden	0.95 (0.91-0.99)	**.03**
Highest burden	1.04 (0.97-1.11)	.30
≥10 regional lymph nodes examined‖		
Low burden	Reference	
Medium burden	0.85 (0.83-0.88)	<**.01**
High burden	0.77 (0.75-0.80)	<**.01**
Highest burden	0.87 (0.83-0.92)	<**.01**
Pathologic nodal upstaging for clinical N0¶		
Low burden	Reference	
Medium burden	1.04 (0.98-1.09)	.20
High burden	1.03 (0.97-1.10)	.30
Highest burden	1.02 (0.93-1.11)	.70
Pathologic nodal upstaging for clinical N1¶		
Low burden	Reference	
Medium burden	0.87 (0.72-1.06)	.20
High burden	0.74 (0.59-0.93)	**.01**
Highest burden	0.59 (0.41-0.85)	<**.01**
Positive surgical margins#		
Low burden	Reference	
Medium burden	1.14 (1.05-1.25)	<**.01**
High burden	1.25 (1.13-1.38)	<**.01**
Highest burden	1.05 (0.90-1.23)	.50
>4 d length of stay**		
Low burden	Reference	
Medium burden	1.08 (1.05-1.12)	<**.01**
High burden	1.34 (1.29-1.40)	<**.01**
Highest burden	1.47 (1.39-1.55)	<**.01**
30-d mortality**		
Low burden	Reference	
Medium burden	1.09 (0.97-1.23)	.20
High burden	1.23 (1.07-1.42)	<**.01**
Highest burden	1.39 (1.39-1.13)	<**.01**
Unplanned readmission**		
Low burden	Reference	
Medium burden	0.99 (0.91-1.06)	.70
High burden	0.83 (0.76-1.20)	.80
Highest burden	1.04 (0.91-1.19)	.60
Adjuvant chemotherapy for pathologic stage ≥ II#		
Low burden	Reference	
Medium burden	1.00 (0.93-1.07)	.90
High burden	1.00 (0.92-1.09)	1.00
Highest burden	0.98 (0.87-1.10)	.70
No treatment provided*		
Low burden	Reference	
Medium burden	1.43 (1.04-1.97)	**.04**
High burden	1.08 (0.74-1.60)	.70
Highest burden	2.11 (1.31-3.40)	<**.01**

Bold indicates statistical significance. *aOR*, Adjusted odds ratio; *CI*, confidence interval. *Adjusted for age, sex, race, ethnicity, year of diagnosis, insurance status, ZIP code level income, education level, residence county, facility type, facility region, distance to facility, Charlson score, pathologic stage, tumor size, clinical N stage, and tumor histology. †Adjusted for age, year of diagnosis, insurance status, ZIP code level income, education level, residence county, facility type, facility region, Charlson score, pathologic stage, tumor size, clinical N stage, tumor histology, type of treatment received, and type of surgery performed. ‡Adjusted for age, year of diagnosis, facility type, Charlson score, pathologic stage, tumor size, clinical N stage, tumor histology, type of treatment received, and type of surgery performed. §Adjusted for age, year of diagnosis, facility type, Charlson score, pathologic stage, tumor size, clinical N stage, tumor histology, and type of treatment received. ‖Year of diagnosis, facility type, Charlson score, pathologic stage, tumor size, clinical N stage, tumor histology, type of treatment received, and type of surgery performed. ¶Adjusted for age, year of diagnosis, facility type, facility region, Charlson score, tumor size, tumor histology, and type of surgery performed. #Adjusted for age, sex, race, ethnicity, year of diagnosis, insurance status, ZIP code level income, education level, residence county, facility type, facility region, distance to facility, Charlson score, tumor size, tumor histology, and type of surgery performed. **Adjusted for age, sex, race, ethnicity, year of diagnosis, insurance status, ZIP code level income, education level, residence county, facility type, facility region, distance to facility, Charlson score, pathologic stage, tumor size, clinical N stage, tumor histology, and type of surgery performed.

analysis only in patients undergoing surgery for the following outcome measures: performing an open procedure, performing an anatomic resection, examination of 10 or more regional lymph nodes, pathologic nodal upstaging, positive surgical margins, length of stay more than 4 days, 30-day mortality, and unplanned readmission. This analysis was performed in patients undergoing minimally invasive surgery for the conversion-to-thoracotomy outcome measure and in patients with pathologic stage II disease or higher for the outcome measure of appropriate adjuvant chemotherapy recommendation.

We assessed collinearity in the multivariable regression models by examining variance inflation factors. These were examined for each variable in the model with a value of more than 5 indicating collinearity. We also ran collinearity diagnostics in which we considered dimensions with 2 or more variables having variance proportions more than 0.5 to be indicative of collinearity. Independent variables were included in the multivariable models unless they were highly correlated with 1 or more other independent variables. The facility identification variable was used as a cluster-level variable in order to account for clustering within a facility. Clustering was accounted for in all the multivariable models.

RESULTS

There were a total of 204,189 patients treated at 1286 facilities. There were 592 (46.0%) low-burden hospitals,

TABLE 2. Baseline demographic and clinical characteristics of patients with stage I and II non–small cell lung cancer according to the relative burden of uninsured or Medicaid-enrolled patients with lung cancer at a facility

Variable	Low burden N (cases) = 101,793 (49.9%) N (facilities) = 592 (46.0%)	Medium burden N (cases) = 53,022 (26.0%) N (facilities) = 297 (23.1%)	High burden N (cases) = 34,808 (17.0%) N (facilities) = 219 (17.0%)	Highest burden N (cases) = 14,566 (7.1%) N (facilities) = 178 (13.9%)	*P* value
Age/y					
Median	71	70	70	67	
Age/y					**<.01**
<55	6167 (6.1%)	3752 (7.1%)	2630 (7.6%)	1659 (11.4%)	
55-64	19,080 (18.7%)	11,060 (20.9%)	7824 (22.5%)	4256 (29.2%)	
65-74	39,118 (38.4%)	20,229 (38.2%)	13,476 (38.7%)	4974 (34.1%)	
≥75	37,428 (36.8%)	17,981 (33.9%)	10,878 (31.3%)	3677 (25.2%)	
Sex					**<.01**
Male	45,320 (44.5%)	24,420 (46.1%)	16,568 (47.6%)	6920 (47.5%)	
Female	56,473 (55.5%)	28,602 (53.9%)	18,240 (52.4%)	7646 (52.5%)	
Race					**<.01**
White	91,669 (90.1%)	46,337 (87.4%)	29,241 (84.0%)	10,116 (69.4%)	
Black	6811 (6.7%)	5119 (9.7%)	4401 (12.6%)	3477 (23.9%)	
Other	3313 (3.3%)	1566 (3.0%)	1166 (3.3%)	973 (6.7%)	
Ethnicity					**<.01**
Non-Hispanic	100,239 (98.5%)	52,216 (98.5%)	34,422 (98.9%)	14,082 (96.7%)	
Hispanic	1554 (1.5%)	806 (1.5%)	386 (1.1%)	484 (3.3%)	
Insurance status					**<.01**
Not insured	792 (0.8%)	594 (1.1%)	694 (2.0%)	822 (5.6%)	
Private insurance	24,940 (24.5%)	11,367 (21.4%)	6837 (19.6%)	3159 (21.7%)	
Medicaid	2953 (2.9%)	2996 (5.7%)	2512 (7.2%)	2207 (15.2%)	
Medicare	72,227 (71.0%)	37,382 (70.5%)	24,257 (69.7%)	8226 (56.5%)	
Other government	831 (0.8%)	683 (1.3%)	508 (1.5%)	152 (1.0%)	
ZIP code level income					**<.01**
<$40,227/y	10,836 (12.0%)	10,244 (22.3%)	9463 (30.6%)	4353 (33.9%)	
$40,227-$50,353/y	17,179 (19.0%)	11,474 (25.0%)	8275 (26.7%)	2986 (23.3%)	
$50,354-$63,332/y	22,722 (25.2%)	11,297 (24.6%)	6478 (20.9%)	2512 (19.6%)	
≥$63,333/y	39,526 (43.8%)	12,876 (28.1%)	6744 (21.8%)	2987 (23.3%)	
% without high school degree					**<.01**
≥17.6%	12,940 (14.3%)	8640 (18.8%)	9036 (29.1%)	4787 (37.2%)	
10.9%-17.5%	21,009 (23.2%)	14,281 (31.1%)	10,248 (33.0%)	3819 (29.7%)	
6.3%-10.8%	28,229 (31.2%)	13,506 (29.4%)	7497 (24.2%)	2676 (20.8%)	
<6.3%	28,213 (31.2%)	9563 (20.8%)	4237 (13.7%)	1580 (12.3%)	
Residence county					**<.01**
Metropolitan	86,226 (87.2%)	42,566 (81.8%)	26,881 (79.0%)	12,038 (84.4%)	
Urban	11,069 (11.2%)	8485 (16.3%)	6425 (18.9%)	1943 (13.6%)	
Rural	1560 (1.6%)	1013 (1.9%)	742 (2.2%)	287 (2.0%)	
Facility type					**<.01**
CCP	3846 (3.8%)	2275 (4.3%)	2437 (7.0%)	774 (5.4%)	
CCCP	48,720 (48.1%)	19,706 (37.4%)	14,074 (40.6%)	1839 (12.7%)	
ARP	27,085 (26.7%)	19,520 (37.0%)	14,112 (40.8%)	10,151 (70.3%)	
INCP	21,650 (21.4%)	11,244 (21.3%)	4005 (11.6%)	1671 (11.6%)	
Facility region					**<.01**
New England	7221 (7.1%)	4863 (9.2%)	2837 (8.2%)	446 (3.1%)	
Atlantic	37,204 (36.7%)	18,476 (35.0%)	16,081 (46.4%)	5115 (35.4%)	
Central	41,977 (41.4%)	23,798 (45.1%)	13,409 (38.7%)	6734 (46.7%)	
Mountain	3989 (3.9%)	1771 (3.4%)	437 (1.3%)	250 (1.7%)	
Pacific	10,910 (10.8%)	3837 (7.3%)	1864 (5.4%)	1890 (13.1%)	

(Continued)

TABLE 2. Continued

Variable	Low burden N (cases) = 101,793 (49.9%) N (facilities) = 592 (46.0%)	Medium burden N (cases) = 53,022 (26.0%) N (facilities) = 297 (23.1%)	High burden N (cases) = 34,808 (17.0%) N (facilities) = 219 (17.0%)	Highest burden N (cases) = 14,566 (7.1%) N (facilities) = 178 (13.9%)	*P* value
Distance from facility					**<.01**
<5 miles	26,883 (29.5%)	14,272 (30.8%)	9230 (29.5%)	4909 (37.8%)	
5-15 miles	33,639 (36.9%)	15,235 (32.9%)	10,372 (33.1%)	3993 (30.8%)	
>15 miles	30,550 (33.5%)	16,855 (36.4%)	11,687 (37.4%)	4079 (31.4%)	
Charlson-Deyo score					**<.01**
0	52,586 (51.7%)	26,852 (50.6%)	17,699 (50.8%)	7766 (53.3%)	
1	30,136 (29.6%)	15,585 (29.4%)	10,288 (29.6%)	4193 (28.8%)	
2	12,072 (11.9%)	6675 (12.6%)	4313 (12.4%)	1701 (11.7%)	
≥3	6999 (6.9%)	3910 (7.4%)	2508 (7.2%)	906 (6.2%)	
Clinical stage					**<.01**
I	85,563 (84.1%)	43,893 (82.8%)	28,045 (80.6%)	11,703 (80.3%)	
II	16,230 (15.9%)	9129 (17.2%)	6763 (19.4%)	2863 (19.7%)	
Tumor size					**<.01**
<3 cm	69,124 (69.1%)	35,463 (68.5%)	22,506 (66.2%)	9297 (65.9%)	
3-5 cm	22,666 (22.7%)	11,883 (22.9%)	8210 (24.1%)	3452 (24.5%)	
5.1-7 cm	5651 (5.7%)	3062 (5.9%)	2353 (6.9%)	916 (6.5%)	
>7 cm	2576 (2.6%)	1376 (2.7%)	929 (2.7%)	447 (3.2%)	
Clinical T stage					**<.01**
T1	70,269 (69.6%)	35,952 (68.3%)	22,399 (65.3%)	9429 (65.3%)	
T2	24,175 (23.9%)	12,934 (24.6%)	9214 (26.9%)	3785 (26.2%)	
T3	6571 (6.5%)	3743 (7.1%)	2692 (7.8%)	1224 (8.5%)	
Clinical N stage					**<.01**
N0	95,410 (95.0%)	49,490 (94.4%)	31,937 (93.6%)	13,479 (93.8%)	
N1	5035 (5.0%)	2913 (5.6%)	2171 (6.4%)	893 (6.2%)	
Tumor histology					**<.01**
Squamous cell carcinoma	28,172 (29.2%)	16,355 (32.5%)	11,202 (33.6%)	4220 (30.4%)	
Adenocarcinoma	50,358 (52.2%)	25,317 (50.2%)	15,723 (47.2%)	7108 (51.3%)	
Neuroendocrine	2752 (2.9%)	1365 (2.7%)	1022 (3.1%)	388 (2.8%)	
Other	15,112 (15.7%)	7351 (14.6%)	5389 (16.2%)	2151 (15.5%)	

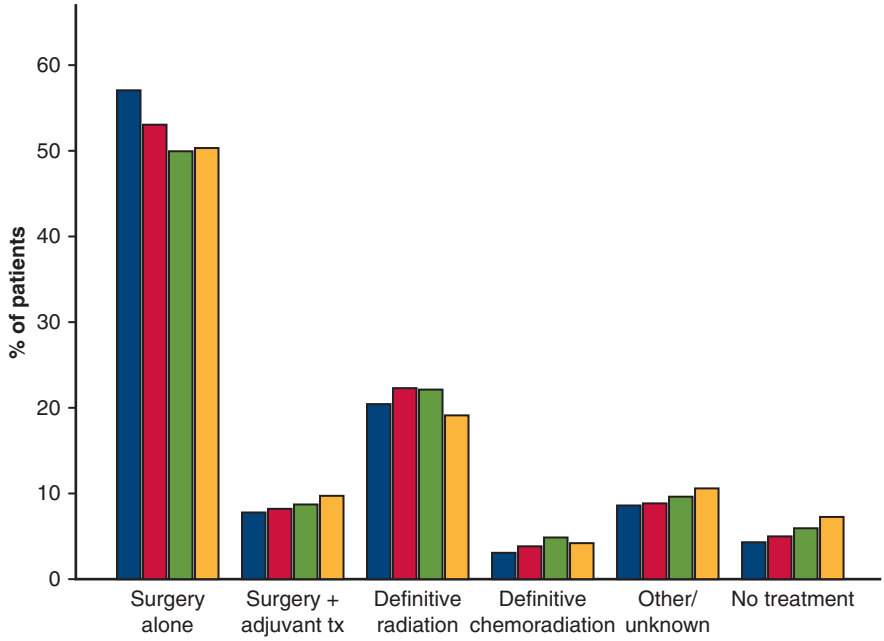
Bold indicates statistical significance. *CCP*, Community Cancer Program; *CCCP*, Comprehensive Community Cancer Program; *ARP*, Academic/Research Program; *INCP*, Integrated Network Cancer Program.

297 (23.1%) medium-burden hospitals, 219 (17.0%) high-burden hospitals, and 178 (13.9%) highest burden hospitals. Table 2 shows significant differences in baseline demographic and clinical characteristics among the 4 groups. Higher burden hospitals had a greater proportion of patients with more advanced clinical stage. Figures 1 and 2 illustrate differences in overall and surgical treatment characteristics, respectively, by hospital burden. Higher burden hospitals had higher rates of adjuvant therapy, nonsurgical treatment, and nontreatment.

Table 3 shows the results of the multivariable regression model outlining the factors associated with care at highest burden hospitals. Associated characteristics included younger age, male sex, black race, and Hispanic ethnicity ($P < .01$). Residence in nearby (<5 miles to hospital), lower-income, lower-education, and rural areas was also associated with care at highest burden hospitals ($P < .01$). These hospitals were more likely to be academic/research programs (adjusted odds ratio [aOR], 3.09, $P < .01$).

Table 4 shows group differences in the outcomes of interest among the 4 comparison groups. There were significant differences across all outcomes except conversion to thoracotomy ($P = .06$) and unplanned readmission ($P = .08$).

Table 1 shows the results of the multivariable regression models outlining the association between hospital burden of uninsured or Medicaid-enrolled patients with lung cancer and various outcomes of interest. Compared with patients treated at low-burden hospitals, those treated at medium-, high-, and highest burden hospitals were associated with a reduced likelihood of undergoing a regional lymph node examination involving 10 or more nodes during surgery ($P < .01$). Patients at these facilities had increased odds of having a length of stay more than 4 days ($P < .01$). Compared with patients treated at low-burden hospitals, those treated at high- and highest burden hospitals were more likely to undergo an open procedure and had increased odds of death within 30 days of their operation ($P < .01$). Such patients also had increased odds of undergoing a



	Hospital burden			
	Low	Medium	High	Highest
	(n)	(n)	(n)	(n)
Surgery alone	57,633	27,937	17,260	7283
Surgery + adjuvant treatment	7877	4296	2962	1380
Definitive radiation	20,560	11,701	7643	2748
Definitive chemoradiation	2997	1966	1653	587
Other/unknown	8559	4584	3287	1522
No treatment	4167	2538	2003	1046

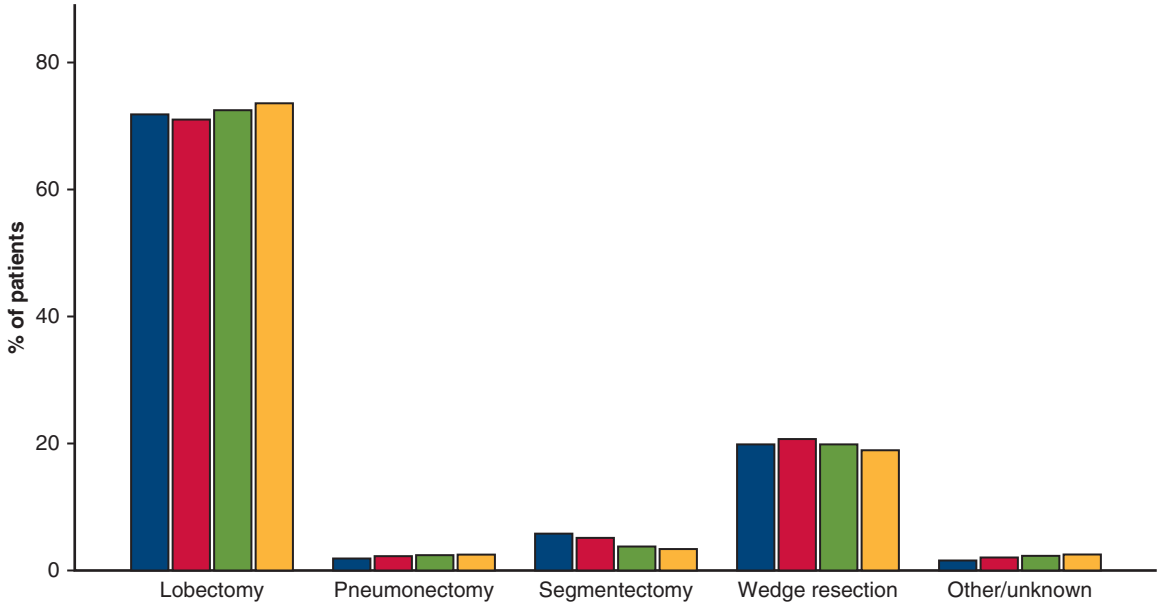
FIGURE 1. Hospitals with a higher burden of uninsured or Medicaid-enrolled patients with NSCLC had higher rates of adjuvant therapy, nonsurgical treatment, and nontreatment in patients with clinical stage I or II NSCLC, $P < .01$.

conversion to thoracotomy and reduced odds of pathologic nodal upstaging for clinical N1 disease ($P < .05$). Compared with patients undergoing operation at low-burden hospitals, those receiving surgical treatment at medium- and high-burden hospitals had a greater likelihood of positive surgical margins ($P < .01$). Finally, those at highest burden hospitals had a reduced likelihood of undergoing surgery and a greater likelihood of not receiving any treatment ($P < .01$).

DISCUSSION

There is a paucity of data assessing the impact of hospital burden of uninsured or Medicaid-enrolled patients on perioperative outcomes in NSCLC. Hospital safety-net burden has previously been investigated in patients with other types of cancers with varying results. Hoehn and colleagues[15] concluded that vulnerable patients with hepatocellular carcinoma are less likely to receive curative surgery at safety-net hospitals and have worse short-term outcomes. Others have also reported inferior outcomes in patients with cancers of the colon, larynx, and esophagus.[13,16,17] In contrast, studies investigating this relationship in patients with cancers of the rectum, pancreas, and head and neck have reported equivalent outcomes irrespective of hospital payer mix.[18-20] It is possible that the factors that affect treatment quality and outcomes differ by type of cancer and procedure and should be the focus of subsequent studies.

We observed lower surgery rates in medium- (63%) and high-burden (60%) hospitals compared with low-burden hospitals (67%), which may not be indicative of guideline noncompliance in the presence of appropriate referrals for stereotactic body radiation therapy. Our results suggest that this was the case for these hospitals, which had higher rates of definitive radiation treatment (22%) than



	Hospital burden			
	Low	Medium	High	Highest
Lobectomy	(n) 48,730	(n) 23,715	(n) 15,240	(n) 6670
Pneumonectomy	1152	700	481	214
Segmentectomy	3876	1683	791	301
Wedge resection	13,481	6896	4194	1707
Other/unknown	1091	619	453	224

FIGURE 2. Comparison of the types of operations performed according to the relative burden of uninsured or Medicaid-enrolled patients with NSCLC. Lobectomy and wedge resection were performed most frequently in patients with clinical stage I or II NSCLC, $P < .01$.

low-burden hospitals (20%). However, highest burden quartile hospitals were approximately half as likely to perform surgery for stage I and II NSCLC compared with low-burden hospitals even after accounting for those who were documented not to be candidates for resection (aOR, 0.58, $P < .01$). In addition, these hospitals also had a lower definitive radiation treatment rate (19%) compared with low-burden hospitals and were twice as likely to not provide patients with any treatment (aOR, 2.11, $P < .01$). Other differences in outcomes included a longer length of stay in higher burden hospitals, which is likely linked to a greater propensity for open thoracotomy seen at these hospitals, as has been well documented.[21] Likewise, a higher likelihood of pathologic nodal upstaging in clinical N1 disease at low-burden hospitals correlates well with a higher likelihood of examining 10 or more regional lymph nodes at these institutions. Others have reported a linear relationship between the number of lymph nodes examined and the odds of upstaging.[22] Hospital differences in rates of open thoracotomy, lymph node harvest, and length of stay may also be reflective of differences in surgeon training and subspecialty between these institutions. For instance, Virgo and colleagues[6] noted that high safety-net burden hospitals were less likely to have a dedicated general thoracic surgeon on staff, who in turn have been observed to perform a greater number of minimally invasive lobectomies than cardiac surgeons and general surgeons.[23] Finally, although medium- (n = 1112) and high-burden (n = 794) hospitals had a greater likelihood of positive surgical margins, this trend did not continue in highest burden hospitals. We hypothesize that this is because this quartile may have been relatively underpowered (n = 276) to demonstrate a medium to small absolute difference.

Our findings suggest an association among Black race, higher burden hospital care, and reduced treatment quality, which is in line with robust literature evidencing racial healthcare disparities in lung cancer treatment. For instance, Namburi and colleagues[2] observed Black patients to be significantly more likely than White patients to be subject to lower treatment quality in the form of lower surgery

TABLE 3. Results of the multivariable regression model showing the factors associated with care at a facility with the highest burden of uninsured or Medicaid-enrolled patients with lung cancer

Variable	aOR (95% CI)	*P* value
Age/y		
<55	Reference	
55-64	0.96 (0.88-1.04)	.30
65-74	0.82 (0.75-0.89)	**<.01**
≥75	0.74 (0.68-0.81)	**<.01**
Sex		
Male	Reference	
Female	0.89 (0.85-0.93)	**<.01**
Race		
White	Reference	
Black	1.93 (1.83-2.03)	**<.01**
Other	1.57 (1.45-1.71)	**<.01**
Ethnicity		
Non-Hispanic	Reference	
Hispanic	1.52 (1.36-1.71)	**<.01**
Year of diagnosis		
2004	Reference	
2005	2.00 (0.24-16.4)	.50
2006	2.26 (0.26-19.7)	.50
2007	2.26 (0.27-18.7)	.50
2008	3.12 (0.39-24.8)	.20
2009	4.70 (0.62-35.4)	.30
2010	3.18 (0.43-23.5)	.30
2011	3.28 (0.44-24.2)	.30
2012	3.22 (0.44-23.8)	.20
2013	3.42 (0.46-25.3)	.20
2014	3.42 (0.46-25.3)	.20
2015	3.61 (0.49-26.7)	.20
2016	3.71 (0.50-27.4)	.20
2017	3.93 (0.53-29.1)	.20
2018	4.04 (0.55-29.8)	.20
Insurance status		
Not insured	Reference	
Private insurance	0.23 (0.20-0.25)	**<.01**
Medicaid	0.56 (0.50-0.63)	**<.01**
Medicare	0.23 (0.21-0.26)	**<.01**
Other government	0.26 (0.21-0.32)	**<.01**
ZIP code level income		
<$40,227/y	Reference	
$40,227-$50,353/y	0.93 (0.87-0.98)	**.01**
$50,354-$63,332/y	0.84 (0.79-0.90)	**<.01**
≥$63,333/y	0.84 (0.78-0.91)	**<.01**
% without high school degree		
≥17.6%	Reference	
10.9%-17.5%	0.71 (0.68-0.75)	**<.01**
6.3%-10.8%	0.55 (0.51-0.58)	**<.01**
<6.3%	0.35 (0.32-0.38)	**<.01**
Residence county		
Metropolitan	Reference	
Urban	1.28 (1.20-1.36)	**<.01**
Rural	1.42 (1.23-1.65)	**<.01**
Facility type		
CCP	Reference	
CCCP	0.35 (0.35-0.36)	**<.01**
ARP	3.09 (3.00-3.19)	**<.01**
INCP	0.81 (0.79-0.83)	**<.01**
Facility region		
New England	Reference	
Atlantic	2.14 (2.08-2.21)	**<.01**
Central	2.92 (2.82-3.01)	**<.01**
Mountain	3.22 (3.05-3.41)	**<.01**
Pacific	6.08 (5.88-6.28)	**<.01**
Distance from facility		
<5 miles	Reference	
5-15 miles	0.79 (0.75-0.83)	**<.01**
>15 miles	0.61 (0.58-0.65)	**<.01**
Charlson-Deyo score		
0	Reference	
1	1.06 (1.01-1.10)	**.03**
2	1.06 (0.99-1.13)	.09
≥3	0.92 (0.84-1.00)	.05
Tumor size		
<3 cm	Reference	
3-5 cm	1.10 (1.05-1.16)	**<.01**
5.1-7 cm	1.10 (1.01-1.20)	**.03**
>7 cm	1.22 (1.08-1.38)	**<.01**
Clinical N stage		
N0	Reference	
N1	1.04 (0.96-1.13)	.40
Tumor histology		
Squamous cell carcinoma	Reference	
Adenocarcinoma	0.94 (0.90-0.99)	**.01**
Neuroendocrine	0.91 (0.80-1.04)	.20
Other	0.95 (0.89-1.01)	.09

Bold indicates statistical significance. *aOR*, Adjusted odds ratio; *CI*, confidence interval; *CCP*, Community Cancer Program; *CCCP*, Comprehensive Community Cancer Program; *ARP*, Academic/Research Program; *INCP*, Integrated Network Cancer Program.

use for stage I NSCLC. The data clearly suggest that racial differences in care leave much to be desired. Other factors associated with higher burden care included academic facility teaching status. Others have also reported this previously.[17,19] This finding is unexpected and interesting given that academic centers are widely reported to have superior survival outcomes in NSCLC by virtue of being more guideline concordant than other center types.[1,24] This suggests that achieving better outcomes in this group of patients is an exceedingly complex and multifactorial process and one that clearly needs further study.

Another noteworthy finding of our study was the association of higher burden hospitals with a more advanced disease stage at presentation. Underinsured populations have been reported to present with a higher disease stage resulting from reduced participation in screening programs and

TABLE 4. Outcomes of interest according to the relative burden of uninsured or Medicaid-enrolled patients with lung cancer at a facility

Variable	Low burden	Medium burden	High burden	Highest burden	*P* value
Surgery					**<.01**
Not performed	24,185 (23.8%)	14,617 (27.6%)	10,438 (30.0%)	4143 (28.4%)	
Performed	68,299 (67.1%)	33,583 (63.3%)	21,139 (60.7%)	9098 (62.5%)	
Patient refused/not indicated	9130 (9.0%)	4702 (8.9%)	3137 (9.0%)	1258 (8.6%)	
Unknown	179 (0.2%)	120 (0.2%)	94 (0.3%)	67 (0.5%)	
Surgical approach					**<.01**
Minimally invasive	34,928 (51.8%)	16,962 (51.0%)	9250 (44.5%)	4211 (47.0%)	
Open thoracotomy	32,505 (48.2%)	16,270 (49.0%)	11,525 (55.5%)	4747 (53.0%)	
Conversion to thoracotomy					.06
No	31,730 (90.8%)	15,394 (90.8%)	8319 (89.9%)	3812 (90.5%)	
Yes	3198 (9.2%)	1568 (9.2%)	931 (10.1%)	399 (9.5%)	
Type of resection					**<.01**
Nonanatomic	14,541 (21.3%)	7485 (22.3%)	4627 (21.9%)	1913 (21.0%)	
Anatomic	53,758 (78.7%)	26,098 (77.7%)	16,512 (78.1%)	7185 (79.0%)	
Regional lymph nodes examined					**<.01**
<10	38,600 (59.7%)	19,654 (62.0%)	12,934 (63.5%)	5125 (57.7%)	
≥10	26,103 (40.3%)	12,063 (38.0%)	7427 (36.5%)	3764 (42.3%)	
Pathologic N stage (clinical N0)					**.02**
N0	54,722 (91.6%)	26,745 (91.3%)	16,288 (91.1%)	7251 (90.9%)	
N1	3391 (5.7%)	1678 (5.7%)	1032 (5.8%)	472 (5.9%)	
N2	1613 (2.7%)	883 (3.0%)	554 (3.1%)	255 (3.2%)	
Pathologic N stage (clinical N1)					**.02**
N0	755 (27.7%)	424 (28.6%)	306 (28.8%)	137 (30.2%)	
N1	1585 (58.1%)	877 (59.1%)	639 (60.2%)	276 (60.8%)	
N2	390 (14.3%)	184 (12.4%)	116 (10.9%)	41 (9.0%)	
Surgical margins					**<.01**
Negative	65,393 (97.1%)	31,930 (96.6%)	19,973 (96.2%)	8660 (96.9%)	
Positive	1940 (2.9%)	1112 (3.4%)	794 (3.8%)	276 (3.1%)	
Length of stay					**<.01**
≤4 d	34,805 (52.1%)	15,953 (49.4%)	8889 (44.6%)	4096 (46.8%)	
>4 d	32,023 (47.9%)	16,361 (50.6%)	11,030 (55.4%)	4652 (53.2%)	
30-d mortality					**<.01**
No	58,375 (98.3%)	28,713 (98.0%)	17,968 (97.7%)	7639 (98.1%)	
Yes	1023 (1.7%)	582 (2.0%)	420 (2.3%)	151 (1.9%)	
Unplanned readmission					.08
No	65,344 (96.0%)	32,165 (95.9%)	20,251 (96.0%)	8545 (95.8%)	
Yes	2738 (4.0%)	1367 (4.1%)	844 (4.0%)	377 (4.2%)	
Adjuvant chemotherapy (pathologic stage ≥ II)					**.04**
Not recommended	5198 (38.4%)	2601 (37.3%)	1655 (36.5%)	723 (36.0%)	
Recommended or reason for no recommendation documented	8345 (61.6%)	4369 (62.7%)	2883 (63.5%)	1288 (64.0%)	
Treatment					**<.01**
Provided	95,336 (94.3%)	49,347 (93.6%)	31,951 (92.6%)	13,171 (91.1%)	
Not provided	3893 (3.9%)	2397 (4.5%)	1875 (5.4%)	990 (6.8%)	
Active surveillance	739 (0.7%)	384 (0.7%)	225 (0.7%)	102 (0.7%)	
Patient refused	762 (0.8%)	376 (0.7%)	303 (0.9%)	102 (0.7%)	
Unknown	350 (0.3%)	217 (0.4%)	151 (0.4%)	88 (0.6%)	

Bold indicates statistical significance.

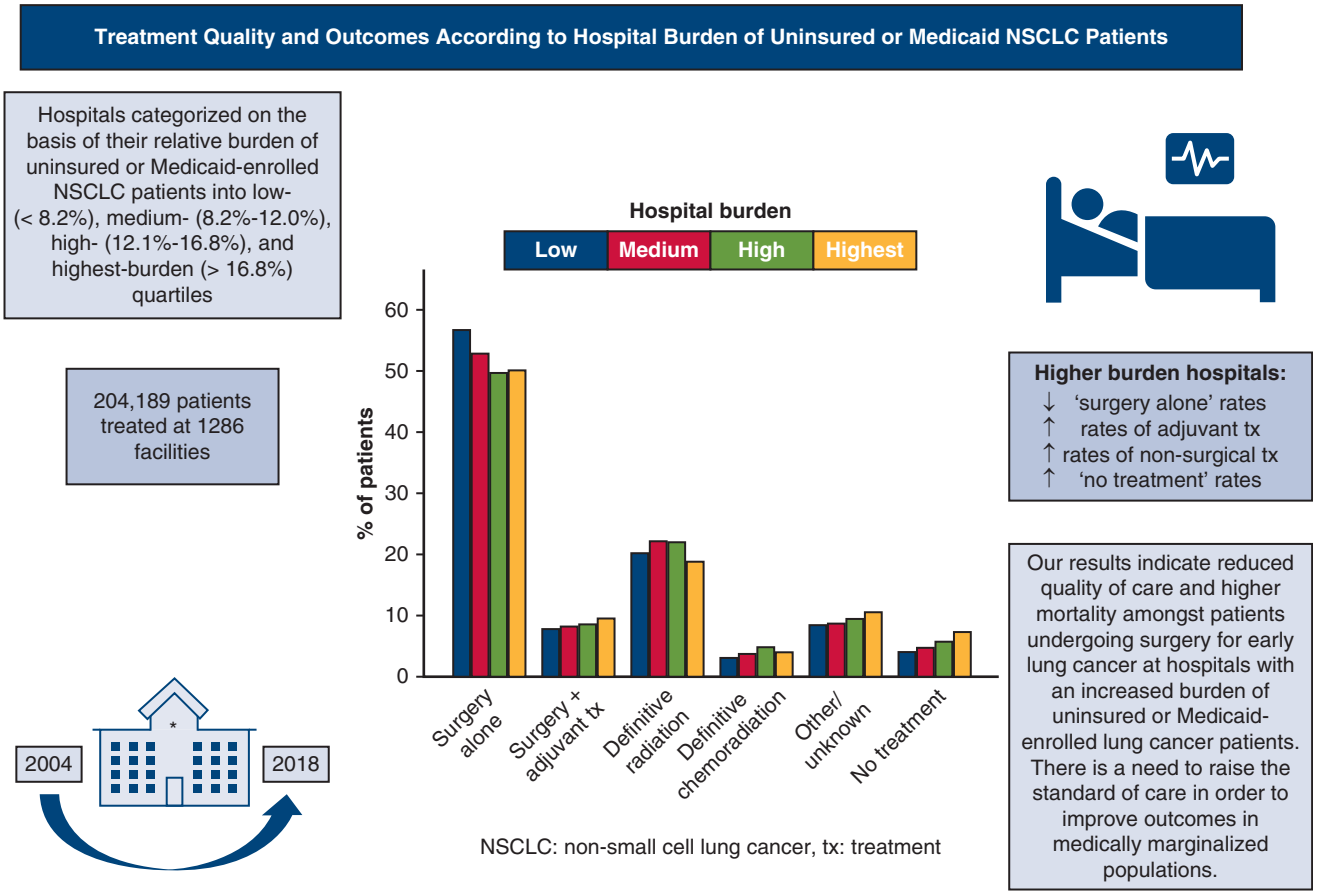


FIGURE 3. Graphical depiction of varying treatment characteristics according to the relative burden of uninsured or Medicaid-enrolled patients with NSCLC in the NCDB from 2004 to 2018 treated at hospitals categorized into low-, medium-, high-, and highest burden quartiles. Higher burden hospitals had higher rates of adjuvant therapy, nonsurgical treatment, and nontreatment in patients with clinical stage I or II NSCLC. These findings emphasize the need to raise the standard of care at these facilities to ultimately improve outcomes in medically marginalized populations. *NSCLC*, Non–small cell lung cancer; *tx*, treatment.

delays in presenting to a care provider after the onset of symptoms.[25] This in turn has been due to various financial, social, and healthcare access–related hurdles.[26] These findings underscore the important role that safety-net hospitals must play in increasing screening rates and reducing the percentage of patients presenting with advanced disease. We noted increased adjuvant therapy rates in higher burden hospitals, which may also be a function of a more advanced disease stage at presentation, particularly because our results suggest that hospital burden was not associated with an appropriate recommendation of adjuvant chemotherapy for pathologic stage II disease or higher after controlling for other clinical characteristics.

Study Limitations

Our analysis is limited by its retrospective nature, and there were several unmeasured clinical and social confounders that we were unable to account for. For instance, we did not have information pertaining to cardiopulmonary status, specific comorbidities, smoking status, the number of surgeons present at a hospital, individual surgeon training, and access to follow-up care. It must also be noted that the NCDB, similar to other large databases, has missing data (Table E1), which may introduce a degree of bias into the results. The NCDB does not include information on cause of death, which precludes any assessment of lung cancer-specific survival. Additionally, because of our large sample size, our results frequently reached statistical significance despite small absolute differences, which may not be clinically relevant. An example of this was the anatomic resection outcome measure, which was interpreted as not being clinically significant. We were also unable to determine the true safety-net burden for facilities, the calculation of which requires information on all cancer and noncancer diagnoses at a particular facility, because our dataset was limited to only NSCLC cases. Finally, it is important to consider the effect of a lack of high-volume centers in a particular hospital burden quartile on outcomes. We have made a note of case load information according to hospital burden in Table E2, which shows that medium-burden hospitals had the highest median number

of cases/hospital (747), whereas highest burden hospitals had the lowest (566).

CONCLUSIONS

Our results indicate reduced quality of care and higher mortality particularly among patients undergoing surgery for early lung cancer at hospitals with an increased burden of uninsured or Medicaid-enrolled patients with lung cancer (Figure 3). Safety-net hospitals are crucial to providing access to care for the underprivileged, and our findings emphasize the need to raise the standard of care in patients undergoing early lung cancer treatment at these facilities to ultimately improve outcomes in medically marginalized populations.

Webcast

You can watch a Webcast of this AATS meeting presentation by going to: https://www.aats.org/resources/1547.

Conflict of Interest Statement

C.C.: Commission on Cancer: Consultant. All other authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

References

1. Muslim Z, Stroever S, Baig MZ, Weber JF, Connery CP, Bhora FY. Social determinants and facility type impact adherence to best practices in operable IIIAN2 lung cancer. *Interact Cardiovasc Thorac Surg*. 2022;34:49-56.
2. Namburi N, Timsina L, Ninad N, Ceppa D, Birdas T. The impact of social determinants of health on management of stage I non–small cell lung cancer. *Am J Surg*. 2022;223:1063-6.
3. Brandel MG, Rennert RC, Lopez Ramos C, Santiago-Dieppa DR, Steinberg JA, Sarkar RR, et al. Management of glioblastoma at safety-net hospitals. *J Neurooncol*. 2018;139:389-97.
4. Institute of Medicine Committee on the changing market, managed care, and the future viability of safety net providers. In: Ein Lewin M, Altman S, eds. *America's Health Care Safety Net: Intact but Endangered*. National Academies Press (US); 2000.
5. Sarkar RR, Courtney PT, Bachand K, Sheridan PE, Riviere PJ, Guss ZD, et al. Quality of care at safety-net hospitals and the impact on pay-for-performance reimbursement. *Cancer*. 2020;126:4584-92.
6. Virgo KS, Little AG, Fedewa SA, Chen AY, Flanders WD, Ward EM. Safety-net burden hospitals and likelihood of curative-intent surgery for non–small cell lung cancer. *J Am Coll Surg*. 2011;213:633-43.
7. Go DE, Abbott DE, Wima K, Hanseman DJ, Ertel AE, Chang AL, et al. Addressing the high costs of pancreaticoduodenectomy at safety-net hospitals. *JAMA Surg*. 2016;151:908-14.
8. Hoehn RS, Wima K, Vestal MA, Weilage DJ, Hanseman DJ, Abbott DE, et al. Effect of hospital safety-net burden on cost and outcomes after surgery. *JAMA Surg*. 2016;151:120-8.
9. McAlearney AS, Murray K, Sieck C, Lin JJ, Bellacera B, Bickell NA. The challenge of improving breast cancer care coordination in safety-net hospitals: barriers, facilitators, and opportunities. *Med Care*. 2016;54:147-54.
10. Gilman M, Hockenberry JM, Adams EK, Milstein AS, Wilson IB, Becker ER. The financial effect of value-based purchasing and the hospital readmissions reduction program on safety-net hospitals in 2014: a cohort study. *Ann Intern Med*. 2015;163:427-36.
11. Fung V, Liang CY, Shi J, Seo V, Overhage L, Dow WH, et al. Potential effects of eliminating the individual mandate penalty in California. *Health Aff (Millwood)*. 2019;38:147-54.
12. Lerro CC, Robbins AS, Phillips JL, Stewart AK. Comparison of cases captured in the national cancer data base with those in population-based central cancer registries. *Ann Surg Oncol*. 2013;20:1759-65.
13. Sridhar P, Bhatt M, Qureshi MM, Asokan S, Truong MT, Suzuki K, et al. Esophageal cancer presentation, treatment, and outcomes vary with hospital safety-net burden. *Ann Thorac Surg*. 2019;107:1472-9.
14. Gamble CR, Huang Y, Tergas AI, Khoury-Collado F, Hou JY, St Clair CM, et al. Quality of care and outcomes of patients with gynecologic malignancies treated at safety-net hospitals. *JNCI Cancer Spectr*. 2019;3:pkz039.
15. Hoehn RS, Hanseman DJ, Dhar VK, Go DE, Edwards MJ, Shah SA. Opportunities to improve care of hepatocellular carcinoma in vulnerable patient populations. *J Am Coll Surg*. 2017;224:697-704.
16. Hrebinko KA, Rieser C, Nassour I, Tohme S, Sabik LM, Khan S, et al. Patient factors limit colon cancer survival at safety-net hospitals: a national analysis. *J Surg Res*. 2021;264:279-86.
17. Qureshi MM, Oladeru OT, Lam CM, Dyer MA, Mak KS, Hirsch AE, et al. Disparities in laryngeal cancer treatment and outcomes: an analysis by hospital safety-net burden. *Laryngoscope*. 2021;131:E1987-97.
18. Hoehn RS, Go DE, Hanseman DJ, Shah SA, Paquette IM. Hospital safety-net burden does not predict differences in rectal cancer treatment and outcomes. *J Surg Res*. 2018;221:204-10.
19. Genther DJ, Gourin CG. The effect of hospital safety-net burden status on short-term outcomes and cost of care after head and neck cancer surgery. *Arch Otolaryngol Head Neck Surg*. 2012;138:1015-22.
20. Dhar VK, Hoehn RS, Kim Y, Xia BT, Jung AD, Hanseman DJ, et al. Equivalent treatment and survival after resection of pancreatic cancer at safety-net hospitals. *J Gastrointest Surg*. 2018;22:98-106.
21. Giambrone GP, Smith MC, Wu X, Gaber-Baylis LK, Bhat AU, Zabih R, et al. Variability in length of stay after uncomplicated pulmonary lobectomy: is length of stay a quality metric or a patient metric? *Eur J Cardiothorac Surg*. 2016;49:e65-71.
22. Bott MJ, Patel AP, Crabtree TD, Colditz GA, Kreisel D, Krupnick AS, et al. Pathologic upstaging in patients undergoing resection for stage I non-small cell lung cancer: are there modifiable predictors? *Ann Thorac Surg*. 2015;100:2048-53.
23. Cooke DT, Wisner DH. Who performs complex noncardiac thoracic surgery in United States academic medical centers? *Ann Thorac Surg*. 2012;94:1060-4.
24. Samson P, Patel A, Crabtree TD, Morgensztern D, Robinson CG, Colditz GA, et al. Multidisciplinary treatment for stage IIIA non-small cell lung cancer: does institution type matter? *Ann Thorac Surg*. 2015;100:1773-9.
25. Bradley CJ, Neumark D, Shickle LM, Farrell N. Differences in breast cancer diagnosis and treatment: experiences of insured and uninsured women in a safety-net setting. *Inquiry*. 2008;45:323-39.
26. Ward EM, Fedewa SA, Cokkinides V, Virgo K. The association of insurance and stage at diagnosis among patients aged 55 to 74 years in the National Cancer Database. *Cancer J*. 2010;16:614-21.

Key Words: disparities, lung cancer, Medicaid, quality measures, safety-net, uninsured

Discussion

Presenter: Dr Zaid Muslim

Dr Cherie Erkmen *(Philadelphia, Pa)*. I'm interested in this work because we know that we have disparities. We know, even though we have technology and innovation, that we are not delivering the standard of care to many people based on disparities. So, we know in lung cancer, we're looking at later diagnoses, we're looking at worse outcomes and overall poor mortality. But most of our studies are looking at the individual level or at the provider level. I commend you and your co-authors for really looking at the institutional level because this is a knowledge gap among us. That being said, I'd like to compliment you on the idea of getting 88,000 patients and 1300 institutions. These are powerful data. I have 3 questions for you. One of them is in regard to the comorbidities. So, you did do a comorbidity index and an analysis of that. How can you separate out the individual factors in comorbidities in people at low-resourced institutions having more comorbidities? How do you separate out the providers who you showed have a propensity to do open procedures in positive margins and inadequate lymph node dissection? How can you make a generalization about the institutional level when you have those other factors that are so powerful?

Dr Zaid Muslim *(Danbury, Conn)*. Essentially, the problem that we face is that there are a combination of patient factors, facility factors. You mentioned the patients at these higher-burden centers are more likely to have more comorbidities, and that may not be down to the institution. That may just be the nature of the patient population that they face. I think this indicates to bigger problems in the healthcare system that these patients, for whatever reason, for maybe lack of follow-up, lack of healthcare access, do have unresolved or comorbidities that are not addressed. And that effectively impacts our outcomes when we look at these kind of data. So, I think we can try and control for that in our multivariable models, but with the NCDB, to a great extent, we're limited to what we can control for. We did look at facility volume, facility region, facility teaching status on the facility level and comorbidities, race, insurance status, income on the patient level. But I think further studies are needed to pinpoint which factors are responsible for these outcomes.

Dr Erkmen. I have a question about how you stratified the institutions into low, middle, and high. How did you get a significant difference between just the very slight number of Medicare, Medicaid, and uninsured patients? The differentiation is between 8% and 12%, but you still found a significant difference. What would you say is accounting for that? How will you account for institutions like mine that have 75% to 80% of people who are underinsured and poorly insured?

Dr Muslim. Sure. I think that's a good question and something that we've given a lot of thought to. I think the logic behind categorizing them this way was again splitting the distribution into an equally spaced threshold just to generate 4 comparison groups that represent the spectrum of hospital burden. As to why there's a significant difference with such a small difference in the percentage of uninsured patients, it's a good question. I think we certainly see that patients on the extreme ends of the spectrum have a greater magnitude of differences in outcomes versus the patients who are closer together on the distribution. So essentially, there is a pattern of or a relationship that appears to be between hospital burden and outcomes. But again, the study does a better job of outlining that there is a potential problem. Essentially, we need more granular data and more prospective studies to hone in on why that is.

As for your second part, the hospitals with the larger percentage of uninsured or underinsured patients, we need to recognize that not all hospitals are the same. I think it's easy to extrapolate from this data that we're generalizing and calling all high-burden hospitals bad, but even high-burden hospitals can have good outcomes. And we saw in our study that academic hospitals are more likely to be high burden, but we also saw in our study that they're more likely to have better outcomes. So, that clearly shows that in academic hospitals, there are characteristics and qualities that allow them to have better outcomes despite seeing a large number of underinsured or uninsured patients, and we need to study why that is. I think it's an interesting point to consider.

TABLE E1. Percentages of nonmissing and missing data for each variable

Variable	Nonmissing data n (%)	Missing data n (%)
Exposure variable		
Burden of uninsured or Medicaid-enrolled	204,189 (100%)	0 (0%)
Covariates		
Age/y	204,189 (100%)	0 (0%)
Sex	204,189 (100%)	0 (0%)
Race	204,189 (100%)	0 (0%)
Ethnicity	204,189 (100%)	0 (0%)
Year of diagnosis	204,189 (100%)	0 (0%)
Insurance status	204,189 (100%)	0 (0%)
ZIP code level income	179,952 (88.1%)	24,237 (11.9%)
% without high school degree	180,261 (88.3%)	23,928 (11.7%)
Residence county	199,235 (97.6%)	4954 (2.4%)
Facility type	203,109 (99.5%)	1080 (0.5%)
Facility region	203,109 (99.5%)	1080 (0.5%)
Distance from facility	181,704 (89.0%)	22,485 (11.0%)
Charlson-Deyo score	204,189 (100%)	0 (0%)
Tumor size	199,911 (97.9%)	4278 (2.1%)
Clinical stage	204,189 (100%)	0 (0%)
Clinical T	202,387 (99.1%)	1802 (0.9%)
Clinical N	201,328 (98.6%)	2861 (1.4%)
Pathologic stage	120,675 (91.3%)	11,444 (8.7%)
Tumor histology	193,985 (95.0%)	10,204 (5.0%)
Treatment type	202,759 (99.3%)	1430 (0.7%)
Surgery type	132,119 (100%)	0 (0%)
Outcome variables		
Surgery	204,189 (100%)	0 (0%)
Surgical approach	130,398 (99.3%)	1721 (0.7%)
Conversion to thoracotomy	65,351 (100%)	0 (0%)
Type of resection	132,119 (100%)	0 (0%)
Regional lymph nodes examined	125,670 (95.1%)	6449 (4.9%)
Pathologic N stage	119,479 (90.4%)	12,640 (9.6%)
Surgical margins	130,078 (98.5%)	2041 (1.5%)
Length of stay	127,809 (96.7%)	4310 (3.3%)
30-d mortality	114,871 (86.9%)	17,248 (13.1%)
Unplanned readmission	131,631 (99.6%)	488 (0.4%)
Adjuvant chemotherapy (pathologic stage $\geq$ II)	27,062 (99.5%)	146 (0.5%)
Treatment	202,759 (99.3%)	1430 (0.7%)
Vital status	178,594 (87.5%)	25,595 (12.5%)
Months between diagnosis and last contact/death	178,548 (87.4%)	25,641 (12.6%)

The default listwise deletion was used for missing data.

TABLE E2. Stage I to IV non–small cell lung cancer case load information according to hospital burden of uninsured or Medicaid-enrolled patients with non–small cell lung cancer

Variable	Low burden	Medium burden	High burden	Highest burden
No. of cases per hospital				
Mean	402	431	430	232
Median	657	747	726	566
No. of hospitals				
<10 anatomic resections/y	443	227	172	158
10-20 anatomic resections/y	98	46	31	11
>20 anatomic resections/y	52	27	17	9