



# Assessing the number of annual lung cancer resections performed in the United States

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**Background:** The number of lung cancer resections performed annually in the United States (U.S.) has not been previously assessed. The objective of this study is to estimate the total number of lung cancer resections performed every year in the U.S.

**Methods:** The number of lung cancer resections performed in the U.S. in 2016 and 2017 was estimated by using indirect multiplier methods based on the number of lung cancer resections in the National Cancer Database (NCDB) and the proportion of lung cancer cases captured by the NCDB using the United States Cancer Statistics (USCS) Data Set as reference.

**Results:** In 2016, 37,141 lung cancer resections were documented in the NCDB and the NCDB captured 65.2% of incident lung cancer cases in the U.S. In 2017, 36,844 lung cancer resections were documented in the NCDB and the NCDB captured 65.1% of incident lung cancer cases in the U.S. Based on these metrics, an estimated 57,000 lung cancer resections were performed in 2016 and over an estimated 56,600 lung cancer resections were performed in 2017 in the U.S. Of these lung cancer resections, an estimated 10,300 (18.2%) wedge resections, 2,800 (4.9%) segmentectomies, 40,000 (70.6%) lobectomies, 80 (0.1%) bronchial sleeve resections, 1,400 (2.5%) extended lobectomies, 1,600 (2.8%) pneumonectomies, and 40 (0.07%) extended pneumonectomies were performed in 2017.

**Conclusions:** Based on this national analysis, an approximately 56,000 to 57,000 lung cancer resections are performed in the U.S. annually. Lobectomies are the most common lung cancer operations performed in the U.S.

**Keywords:** Lung cancer; thoracic surgery; lobectomy

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## Introduction

Every year, over 238,000 individuals in the United States (U.S.) are diagnosed with lung cancer (1). Surgery offers the best chance at cure for most patients with early-stage disease. However, the number of annual lung cancer resections performed in the U.S. has not previously been

assessed. The objectives of this study are: (I) to assess the percentage of lung cancer cases in the U.S. captured by the National Cancer Database (NCDB) in 2016 and 2017; (II) to estimate the total number of lung cancer resections performed in the U.S. in 2016 and 2017; and (III) to estimate the number of each type of resection performed

in 2016 and 2017 in the U.S. We present this article in accordance with the TREND reporting checklist (available at <https://shc.amegroups.com/article/view/10.21037/shc-22-7/rc>).

## Methods

### Data source

The NCDB is a clinical oncology database and a joint project of the Commission on Cancer of the American College of Surgeons and the American Cancer Society. The NCDB currently captures 70% of all newly diagnosed malignancies in the U.S. annually, from more than 1,500 affiliated facilities (2). For the years of study inclusion (2016-2017), clinical and pathological staging information is directly recorded in the NCDB using American Joint Committee on Cancer (AJCC) 6<sup>th</sup> and 7<sup>th</sup> edition Tumor, Nodes, and Metastases (TNM) Staging (3). However, in the present study, the staging was reclassified using best available data according to AJCC 8<sup>th</sup> edition criteria.

### Study design

This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was deemed exempt from review by the Massachusetts General Hospital Institutional Review Board (No. 2020P004110;

02/02/21). Informed consent was not required because all data analyzed was deidentified. Patients diagnosed with non-small-cell lung cancer (NSCLC) and small-cell lung cancer (SCLC) in the 2017 NCDB Participant User Data File who were diagnosed at or underwent treatment at a Commission on Cancer (CoC)-accredited cancer program from 2016 to 2017 were identified for inclusion, using the International Classification of Diseases for Oncology, 3<sup>rd</sup> edition histology and topography codes.

Within this population, we identified patients who underwent surgical resection for lung cancer. We estimated the annual number of lung cancer resections and the number of each type of resection performed in 2016 and 2017 using the indirect multiplier method described below. The year 2017 was chosen for analysis because it is the most recent, available year of data in the NCDB. We also included the year 2016 in our analysis because mortality data were not available in the NCDB for the year 2017 at the time of this writing.

### Statistical analysis

#### Indirect multiplier method

We employed a previously described indirect multiplier method (4) to estimate the annual number of lung cancer resections performed in the U.S. Briefly, the indirect multiplier method uses two data sources to estimate population size: benchmark data and multiplier data. Benchmark data provides a count of the population that meet a certain criterion. Multiplier data provides a proportion of the population that meet the same criterion from a separate sample (4). In this study, benchmark data include the number of lung cancer resections documented in the NCDB during the study period. Multiplier data indicate the proportion of all lung cancer cases captured within the NCDB. The reciprocal of the proportion is the multiplier, which can be used to adjust benchmark data to provide a national estimate of the number of lung cancer resections (5).

Benchmark data was obtained from the NCDB. With regard to the multiplier data, we estimated the proportion of incident lung cancer cases in the U.S. that were captured by the NCDB for each year of the study. We compared the number of lung cancer cases in the NCDB to the number of lung cancer cases in the United States Cancer Statistics (USCS) Data Set (6). Data in the USCS were provided by central cancer registries participating in Centers for Disease Control and Prevention (CDC)'s National Program

### Highlight box

#### Key findings

- Approximately 56,000 to 57,000 lung cancer resections are performed in the U.S. annually.
- Lobectomy is the most common operation, and the second most common operation is wedge resection in the U.S.

#### What is known and what is new?

- The number of lung cancer resections performed annually in the United States has not been previously assessed.
- In 2016, 37,141 lung cancer resections were documented in the NCDB and the NCDB captured 65.2% of incident lung cancer cases in the U.S. In 2017, 36,844 lung cancer resections were documented in the NCDB and the NCDB captured 65.1% of incident lung cancer cases in the U.S.

#### What is the implication, and what should change now?

- It is possible that the percentage of lung cancer cases captured in the NCDB was overestimated, leading to an underestimation of the total number of lung cancer resections performed each year.

**Table 1** Estimated number of lung cancer resections in 2016

Variables	Number of resections in the National Cancer Database, n (%)	Estimated number of resections, n
Wedge resection	7,017 (18.9)	10,767
Segmentectomy	1,704 (4.6)	2,615
Lobectomy or bilobectomy	25,893 (69.7)	39,732
Bronchial sleeve resection	45 (0.1)	69
Extended lobectomy (with chest wall, pericardium, or diaphragm)	1,044 (2.8)	1,602
Pneumonectomy	1,155 (3.1)	1,772
Extended pneumonectomy	16 (0.04)	25
Other	267 (0.7)	410
Total	37,141 (100.0)	56,992

of Cancer Registries (NPCR) and/or National Cancer Institute (NCI)'s Surveillance, Epidemiology, and End Results (SEER) Program and submitted to CDC and NCI in 2019. Of note, the USCS does not capture *in situ* (non-invasive) lung cancer cases. Accordingly, we excluded *in situ* (non-invasive) lung cancer cases in the NCDB. The multiplier was calculated by dividing the number of incident lung cancer cases in the NCDB by the number of incident lung cancer cases in the USCS each year and taking its reciprocal.

We used the indirect multiplier method to assess the number of annual lung cancer resections and the number of each type of lung cancer resection performed in the U.S. each year. We estimated the number of wedge resections, segmentectomies, lobectomies and bilobectomies, bronchial sleeve resection, extended lobectomies (with chest wall, pericardium, or diaphragm), pneumonectomies, and extended pneumonectomies performed each year in the U.S. Changes in the number of operations performed each year were assessed using univariate Poisson regression. Statistical analysis was performed using Stata/MP software, version 13.1 for PC (StataCorp, College Station, TX, USA).

## Results

In 2016, there were 145,257 lung cancer cases documented in the NCDB and 222,894 incident lung cancers in the USCS. In 2017, there were 143,841 lung cancer cases in the NCDB and 221,121 incident lung cancers in the USCS. In the NCDB, 37,128 patients and 36,822 patients underwent lung cancer resections in 2016 and 2017, respectively.

Baseline characteristics and perioperative outcomes of patients in the NCDB, stratified by operation type, are detailed in [Tables S1-S4](#).

The NCDB captured 65.2% and 65.1% of incident lung cancer cases in 2016 and 2017 that were recorded in the USCS database. Using the indirect multiplier method, we estimate there were approximately 57,000 lung cancer resections performed in the U.S. in 2016 and over 56,600 lung cancer resections performed in the U.S. in 2017. In 2016, we estimate there were 25,893 (69.7%) lobectomies and bilobectomies, 7,017 (18.9%) wedge resections, 1,704 (4.6%) segmentectomies, 1,155 (3.1%) pneumonectomies, 1,044 (2.8%) extended lobectomies, 45 (0.1%) bronchial sleeve resections, and 16 (0.04%) extended pneumonectomies performed in the U.S. ([Table 1](#)). In 2017, we estimate there were 26,008 (70.6%) lobectomies and bilobectomies, 6,692 (18.2%) wedge resections, 1,814 (4.9%) segmentectomies, 1,017 (2.8%) pneumonectomies, 927 (2.5%) extended lobectomies, 52 (0.1%) bronchial sleeve resections, and 24 (0.1%) extended pneumonectomies performed in the U.S. ([Table 2](#)).

From 2016–2017, the number of lung cancer resections performed in the U.S. did not significantly change (56,992 to 56,639,  $P=0.24$ ). In an analysis stratified by surgery type, there was a 6.7% (2,615 to 2,789,  $P=0.007$ ) increase in case volume for segmentectomy from 2016–2017. Conversely, there was a 4.5% (10,767 to 10,287,  $P=0.001$ ) decrease in the case volume for wedge resection, 11.8% (1,772 to 1,563,  $P=0.001$ ) decrease in the case volume for pneumonectomy, and 11.0% (1,602 to 1,425,  $P<0.001$ ) decrease in case volume for extended lobectomy from 2016. The case

**Table 2** Estimated number of lung cancer resections in 2017

Variables	Number of resections in the National Cancer Database, n (%)	Estimated number of resections, n
Wedge resection	6,692 (18.2)	10,287
Segmentectomy	1,814 (4.9)	2,789
Lobectomy or bilobectomy	26,008 (70.6)	39,981
Bronchial sleeve resection	52 (0.1)	80
Extended lobectomy (with chest wall, pericardium, or diaphragm)	927 (2.5)	1,425
Pneumonectomy	1,017 (2.8)	1,563
Extended pneumonectomy	24 (0.07)	37
Other	310 (0.8)	477
Total	36,844 (100.0)	56,639

volumes for lobectomy and bilobectomy (39,732 to 39,981,  $P=0.29$ ), bronchial sleeve resection (69 to 80,  $P=0.42$ ), and extended pneumonectomy (25 to 37,  $P=0.23$ ) did not significantly change from 2016–2017.

## Discussion

In this national analysis, using indirect multiplier methods, we estimated the number of lung cancer resections performed in the U.S. in 2016 and 2017. Each year, we estimate there are approximately 56,000–57,000 lung cancer resections performed in the U.S. Lobectomy is the most common operation and the second most common operation is wedge resection.

The main strength of this study is that we used the NCDB to estimate the total number of annual lung cancer resections in the U.S. The NCDB is the largest clinical database in the U.S. In addition to its much larger size, the NCDB has several advantages over other administrative databases such as the Nationwide Inpatient Sample. Administrative databases are based on hospital discharge records, have only limited clinical data, and can be subject to reimbursement bias. Moreover, a previous study has shown that there are significant inaccuracies in the documentation of surgical treatments and a systematic underreporting of procedures in administrative databases (7). Unlike administrative databases, data in the NCDB are obtained from all available components of the medical record and are manually abstracted by trained registrars (8). Furthermore, the NCDB contains information on a large

number of clinical data, including patient and tumor characteristics, cancer staging, type of first course treatment administered, use of neoadjuvant and adjuvant treatments, and short- and long-term overall survival.

There are several limitations to this study. Importantly, the accuracy of indirect multiplier methods is dependent on the quality of the existing datasets. Thus, one potential limitation would be discrepancies between the datasets used to generate the multiplier. Of note, Veteran Administration (VA) Hospitals reporting data are excluded from the 2017 NCDB participant user file and an unknown number of VA hospitals report data to the USCS (9). Since the United States Cancer Statistics Database includes some, but not all, data from VA hospitals, it is possible that the number of lung cancer cases captured in the United States Cancer Statistics Database slightly underestimates the total number of lung cancer cases diagnosed in the U.S. each year. As such, it is possible that the percentage of lung cancer cases captured in the NCDB was overestimated, leading to an underestimation of the total number of lung cancer resections performed each year. Due to the small number of lung cancer cases from the VA that are not reported to the United States Cancer Statistics Database, the extent of this underestimation should be very small. Another potential limitation would be biases in the benchmark dataset (the number of resections in NCDB). CoC-accredited hospitals that report data to the NCDB are generally larger and offer a greater range of treatment services, potentially resulting in a higher resection rate among patients in the NCDB and an overestimate of the number of resections (10). Lastly, the

NCDB does not reliably capture pulmonary resections for metastatic disease (e.g., metastasectomy for colon cancer that has metastasized to the lung) and does not capture resections for benign disease (2,8). In this regard, our analysis may have underestimated the number of resections in the U.S.

## Conclusions

In conclusion, this is the first study to use a national clinical oncology database to estimate the total number of lung cancer resections in the U.S. Every year, we estimate there are 56,000–57,000 lung cancer resections performed in the U.S., with lobectomy being the most common operation.

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The data used in the study are derived from a de-identified NCDB file. The American College of Surgeons and the CoC 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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## Footnote

*Reporting Checklist:* The authors have completed the TREND reporting checklist. Available at <https://shc.amegroups.com/article/view/10.21037/shc-22-7/rc>

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*Conflicts of Interest:* All authors have completed the ICMJE uniform disclosure form (available at <https://shc.amegroups.com/article/view/10.21037/shc-22-7/coif>). The authors have no conflicts of interest to declare.

*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was deemed exempt from review by the Massachusetts General Hospital Institutional Review Board (IRB#: 2020P004110; 02/02/21). Informed consent was not required because all data analyzed was deidentified.

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Table S1 Baseline characteristics of patients undergoing lung cancer resection in the National Cancer Database in 2016 stratified by operation type

Factor	Wedge resection	Segmentectomy	Lobectomy	Sleeve lobectomy	Extended lobectomy	Pneumonectomy	Extended pneumonectomy	Other	P value
N	7017	1704	25893	45	1044	1155	16	267	
Age (years), median (IQR)	70.0 (63.0, 75.0)	69.0 (63.0, 75.0)	68.0 (61.0, 74.0)	58.0 (50.0, 66.0)	66.0 (59.0, 73.0)	63.0 (56.0, 70.0)	69.0 (61.0, 74.5)	67.0 (60.0, 73.0)	<0.001
Sex									<0.001
Male	2953 (42.1%)	692 (40.6%)	11854 (45.8%)	26 (57.8%)	526 (50.4%)	730 (63.2%)	7 (43.8%)	151 (56.6%)	
Female	4064 (57.9%)	1012 (59.4%)	14039 (54.2%)	19 (42.2%)	518 (49.6%)	425 (36.8%)	9 (56.3%)	116 (43.4%)	
Race									0.026
White	6082 (86.7%)	1513 (88.8%)	22523 (87.0%)	39 (86.7%)	909 (87.1%)	1006 (87.1%)	16 (100.0%)	227 (85.0%)	
Black	596 (8.5%)	108 (6.3%)	2174 (8.4%)	4 (8.9%)	99 (9.5%)	91 (7.9%)	0 (0.0%)	30 (11.2%)	
Native American	25 (0.4%)	4 (0.2%)	73 (0.3%)	1 (2.2%)	4 (0.4%)	4 (0.3%)	0 (0.0%)	1 (0.4%)	
Asian	192 (2.7%)	55 (3.2%)	796 (3.1%)	1 (2.2%)	22 (2.1%)	31 (2.7%)	0 (0.0%)	7 (2.6%)	
Unknown	122 (1.7%)	24 (1.4%)	327 (1.3%)	0 (0.0%)	10 (1.0%)	23 (2.0%)	0 (0.0%)	2 (0.7%)	
CDCC Score <sup>1</sup>									<0.001
0	3710 (52.9%)	880 (51.6%)	14640 (56.5%)	25 (55.6%)	608 (58.2%)	702 (60.8%)	7 (43.8%)	164 (61.4%)	
1	1892 (27.0%)	484 (28.4%)	6707 (25.9%)	15 (33.3%)	266 (25.5%)	280 (24.2%)	6 (37.5%)	74 (27.7%)	
2	844 (12.0%)	212 (12.4%)	2752 (10.6%)	3 (6.7%)	108 (10.3%)	105 (9.1%)	1 (6.3%)	21 (7.9%)	
≥3	571 (8.1%)	128 (7.5%)	1794 (6.9%)	2 (4.4%)	62 (5.9%)	68 (5.9%)	2 (12.5%)	8 (3.0%)	
Clinical T Status									<0.001
T1a	1307 (18.6%)	226 (13.3%)	1438 (5.6%)	4 (8.9%)	26 (2.5%)	13 (1.1%)	0 (0.0%)	11 (4.1%)	
T1b	3083 (43.9%)	767 (45.0%)	7553 (29.2%)	14 (31.1%)	129 (12.4%)	69 (6.0%)	0 (0.0%)	23 (8.6%)	
T1c	1047 (14.9%)	339 (19.9%)	5547 (21.4%)	4 (8.9%)	117 (11.2%)	79 (6.8%)	1 (6.3%)	24 (9.0%)	
T2a	587 (8.4%)	208 (12.2%)	4932 (19.0%)	9 (20.0%)	169 (16.2%)	200 (17.3%)	0 (0.0%)	27 (10.1%)	
T2b	139 (2.0%)	44 (2.6%)	1918 (7.4%)	4 (8.9%)	107 (10.2%)	140 (12.1%)	2 (12.5%)	12 (4.5%)	
T3	315 (4.5%)	71 (4.2%)	2625 (10.1%)	3 (6.7%)	250 (23.9%)	302 (26.1%)	5 (31.3%)	36 (13.5%)	
T4	373 (5.3%)	28 (1.6%)	1505 (5.8%)	7 (15.6%)	222 (21.3%)	322 (27.9%)	6 (37.5%)	73 (27.3%)	
Unknown	166 (2.4%)	21 (1.2%)	375 (1.4%)	0 (0.0%)	24 (2.3%)	30 (2.6%)	2 (12.5%)	61 (22.8%)	
Clinical N Status									<0.001
N0	5759 (82.1%)	1513 (88.8%)	21012 (81.1%)	34 (75.6%)	744 (71.3%)	646 (55.9%)	8 (50.0%)	96 (36.0%)	
N1	171 (2.4%)	30 (1.8%)	1583 (6.1%)	2 (4.4%)	119 (11.4%)	231 (20.0%)	3 (18.8%)	24 (9.0%)	
N2	291 (4.1%)	28 (1.6%)	1377 (5.3%)	3 (6.7%)	98 (9.4%)	161 (13.9%)	1 (6.3%)	71 (26.6%)	
N3	66 (0.9%)	2 (0.1%)	97 (0.4%)	0 (0.0%)	7 (0.7%)	7 (0.6%)	1 (6.3%)	26 (9.7%)	
Unknown	730 (10.4%)	131 (7.7%)	1824 (7.0%)	6 (13.3%)	76 (7.3%)	110 (9.5%)	3 (18.8%)	50 (18.7%)	
Tumor Size (mm), median (IQR)	15.0 (11.0, 22.0)	18.0 (13.0, 25.0)	25.0 (17.0, 37.0)	24.0 (14.0, 40.0)	41.0 (25.0, 60.0)	50.0 (35.0, 70.0)	69.0 (50.0, 131.0)	37.0 (22.0, 65.0)	<0.001
Tumor Location									<0.001
Main Bronchus	6 (0.1%)	4 (0.2%)	72 (0.3%)	10 (22.2%)	10 (1.0%)	120 (10.4%)	1 (6.3%)	24 (9.0%)	
Right Upper Lobe	2173 (31.0%)	325 (19.1%)	8628 (33.3%)	17 (37.8%)	395 (37.8%)	200 (17.3%)	0 (0.0%)	57 (21.3%)	
Right Middle Lobe	367 (5.2%)	23 (1.3%)	1703 (6.6%)	3 (6.7%)	70 (6.7%)	35 (3.0%)	1 (6.3%)	9 (3.4%)	
Right Lower Lobe	1270 (18.1%)	370 (21.7%)	4849 (18.7%)	2 (4.4%)	195 (18.7%)	95 (8.2%)	1 (6.3%)	32 (12.0%)	
Left Upper Lobe	1879 (26.8%)	569 (33.4%)	6224 (24.0%)	3 (6.7%)	156 (14.9%)	330 (28.6%)	7 (43.8%)	48 (18.0%)	
Left Lower Lobe	1022 (14.6%)	359 (21.1%)	3843 (14.8%)	5 (11.1%)	81 (7.8%)	193 (16.7%)	1 (6.3%)	36 (13.5%)	
Bilateral	4 (0.1%)	0 (0.0%)	4 (<1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Overlapping Lesion of the Lung	48 (0.7%)	9 (0.5%)	231 (0.9%)	3 (6.7%)	96 (9.2%)	114 (9.9%)	3 (18.8%)	2 (0.7%)	
Unknown	248 (3.5%)	45 (2.6%)	339 (1.3%)	2 (4.4%)	41 (3.9%)	68 (5.9%)	2 (12.5%)	59 (22.1%)	
Histology									<0.001
Adenocarcinoma	3815 (54.4%)	932 (54.7%)	13838 (53.4%)	1 (2.2%)	445 (42.6%)	329 (28.5%)	7 (43.8%)	115 (43.1%)	
Squamous Cell Carcinoma	1295 (18.5%)	329 (19.3%)	5910 (22.8%)	12 (26.7%)	341 (32.7%)	579 (50.1%)	4 (25.0%)	64 (24.0%)	
Large Cell Carcinoma	91 (1.3%)	29 (1.7%)	440 (1.7%)	2 (4.4%)	31 (3.0%)	21 (1.8%)	1 (6.3%)	4 (1.5%)	
Adenosquamous Cell Carcinoma	127 (1.8%)	24 (1.4%)	557 (2.2%)	1 (2.2%)	33 (3.2%)	18 (1.6%)	0 (0.0%)	5 (1.9%)	
Carcinoid	633 (9.0%)	132 (7.7%)	1677 (6.5%)	20 (44.4%)	64 (6.1%)	67 (5.8%)	1 (6.3%)	20 (7.5%)	
Tumors Formerly Classified as Bronchioalveolar Carcinoma	637 (9.1%)	179 (10.5%)	2078 (8.0%)	1 (2.2%)	54 (5.2%)	54 (4.7%)	0 (0.0%)	2 (0.7%)	
Non-Small Cell Lung Cancer, Not Otherwise Specified	69 (1.0%)	11 (0.6%)	349 (1.3%)	2 (4.4%)	20 (1.9%)	17 (1.5%)	0 (0.0%)	13 (4.9%)	
Small Cell Lung Cancer	173 (2.5%)	29 (1.7%)	412 (1.6%)	0 (0.0%)	9 (0.9%)	13 (1.1%)	0 (0.0%)	23 (8.6%)	
Carcinoma	17 (0.2%)	6 (0.4%)	97 (0.4%)	1 (2.2%)	12 (1.1%)	5 (0.4%)	0 (0.0%)	1 (0.4%)	
Other	160 (2.3%)	33 (1.9%)	535 (2.1%)	5 (11.1%)	35 (3.4%)	52 (4.5%)	3 (18.8%)	20 (7.5%)	
Grade									<0.001
Well-differentiated	1411 (20.1%)	341 (20.0%)	4256 (16.4%)	15 (33.3%)	109 (10.4%)	88 (7.6%)	1 (6.3%)	13 (4.9%)	
Moderately-differentiated	2689 (38.3%)	731 (42.9%)	10492 (40.5%)	7 (15.6%)	340 (32.6%)	412 (35.7%)	3 (18.8%)	49 (18.4%)	
Poorly Differentiated	1649 (23.5%)	381 (22.4%)	7515 (29.0%)	14 (31.1%)	405 (38.8%)	468 (40.5%)	10 (62.5%)	81 (30.3%)	
Undifferentiated	124 (1.8%)	24 (1.4%)	419 (1.6%)	0 (0.0%)	25 (2.4%)	19 (1.6%)	0 (0.0%)	4 (1.5%)	
Unknown	1144 (16.3%)	227 (13.3%)	3211 (12.4%)	9 (20.0%)	165 (15.8%)	168 (14.5%)	2 (12.5%)	120 (44.9%)	
Insurance Status									<0.001
Uninsured	67 (1.0%)	11 (0.6%)	302 (1.2%)	2 (4.4%)	16 (1.5%)	26 (2.3%)	1 (6.3%)	7 (2.6%)	
Private Insurance/managed care	1745 (24.9%)	439 (25.8%)	7802 (30.1%)	22 (48.9%)	339 (32.5%)	466 (40.3%)	6 (37.5%)	79 (29.6%)	
Medicaid	348 (5.0%)	79 (4.6%)	1516 (5.9%)	6 (13.3%)	69 (6.6%)	99 (8.6%)	0 (0.0%)	23 (8.6%)	
Medicare	4707 (67.1%)	1140 (66.9%)	15631 (60.4%)	13 (28.9%)	595 (57.0%)	517 (44.8%)	9 (56.3%)	148 (55.4%)	
Other Government	78 (1.1%)	14 (0.8%)	380 (1.5%)	0 (0.0%)	13 (1.2%)	33 (2.9%)	0 (0.0%)	8 (3.0%)	
Unknown	72 (1.1%)	21 (1.2%)	262 (1.0%)	2 (4.4%)	12 (1.1%)	14 (1.2%)	0 (0.0%)	2 (0.7%)	
Facility Type									<0.001
Community Cancer Program	406 (5.8%)	117 (6.9%)	1451 (5.6%)	1 (2.2%)	66 (6.3%)	78 (6.8%)	0 (0.0%)	34 (12.7%)	
Comprehensive Community Cancer Program	2610 (37.2%)	562 (33.0%)	10371 (40.1%)	5 (11.1%)	417 (39.9%)	401 (34.7%)	5 (31.3%)	112 (41.9%)	
Academic/research Program	3138 (44.7%)	755 (44.3%)	10182 (39.3%)	30 (66.7%)	428 (41.0%)	484 (41.9%)	10 (62.5%)	91 (34.1%)	
Integrated Cancer Network	829 (11.8%)	260 (15.3%)	3656 (14.1%)	2 (4.4%)	111 (10.6%)	158 (13.7%)	0 (0.0%)	26 (9.7%)	
Unknown	34 (0.5%)	10 (0.6%)	233 (0.9%)	7 (15.6%)	22 (2.1%)	34 (2.9%)	1 (6.3%)	4 (1.5%)	
Distance from the Hospital (miles), median (IQR)	11.6 (5.0, 27.5)	11.4 (5.2, 26.5)	12.1 (5.4, 28.3)	18.2 (11.8, 60.3)	13.1 (5.5, 33.3)	16.4 (6.4, 39.8)	28.0 (6.5, 81.8)	11.7 (4.7, 31.5)	<0.001
Income (\$)²									<0.001
<40,227	967 (13.8%)	189 (11.1%)	3931 (15.2%)	6 (13.3%)	174 (16.7%)	213 (18.4%)	3 (18.8%)	51 (19.1%)	
40227-50353	1215 (17.3%)	290 (17.0%)	4846 (18.7%)	8 (17.8%)	201 (19.3%)	240 (20.8%)	4 (25.0%)	57 (21.3%)	
50354-63332	1429 (20.4%)	307 (18.0%)	5419 (20.9%)	9 (20.0%)	214 (20.5%)	246 (21.3%)	4 (25.0%)	47 (17.6%)	
>63332	2494 (35.5%)	628 (36.9%)	7916 (30.6%)	12 (26.7%)	302 (28.9%)	309 (26.8%)	5 (31.3%)	79 (29.6%)	
Unknown	912 (13.0%)	290 (17.0%)	3781 (14.6%)	10 (22.2%)	153 (14.7%)	147 (12.7%)	0 (0.0%)	33 (12.4%)	
Education³									<0.001
≥17.6%	1146 (16.3%)	225 (13.2%)	4251 (16.4%)	7 (15.6%)	179 (17.1%)	211 (18.3%)	2 (12.5%)	68 (25.5%)	
10.9-17.5%	1577 (22.5%)	374 (21.9%)	6082 (23.5%)	13 (28.9%)	258 (24.7%)	298 (25.8%)	4 (25.0%)	57 (21.3%)	
6.3-10.8%	1805 (25.7%)	430 (25.2%)	6571 (25.4%)	7 (15.6%)	252 (24.1%)	283 (24.5%)	5 (31.3%)	53 (19.9%)	
<6.3%	1588 (22.6%)	386 (22.7%)	5251 (20.3%)	8 (17.8%)	207 (19.8%)	218 (18.9%)	5 (31.3%)	56 (21.0%)	
Unknown	901 (12.8%)	289 (17.0%)	3738 (14.4%)	10 (22.2%)	148 (14.2%)	145 (12.6%)	0 (0.0%)	33 (12.4%)	
Surgical Approach									<0.001
Open	2430 (34.6%)	609 (35.7%)	11040 (42.6%)	23 (51.1%)	581 (55.7%)	797 (69.0%)	13 (81.3%)	88 (33.0%)	
Video-assisted Thoracoscopic Surgery	3539 (50.4%)	774 (45.4%)	9056 (35.0%)	15 (33.3%)	279 (26.7%)	192 (16.6%)	0 (0.0%)	114 (42.7%)	
Robotic	750 (10.7%)	273 (16.0%)	4303 (16.6%)	4 (8.9%)	77 (7.4%)	39 (3.4%)	0 (0.0%)	8 (3.0%)	
Unknown	298 (4.2%)	48 (2.8%)	1494 (5.8%)	3 (6.7%)	107 (10.2%)	127 (11.0%)	3 (18.8%)	57 (21.3%)	

<sup>1</sup>, CDCC = Charlson comorbidity score; <sup>2</sup>, National Cancer Database (NCDB) codes income level as average household income of the zip code where the patient lives; <sup>3</sup>, NCDB codes education level as the number of adults age 25 or older in the patient's zip code who did not graduate from high school.

**Table S2** Baseline characteristics of patients undergoing lung cancer resection in the National Cancer Database in 2017 stratified by operation type

Factor	Wedge resection	Segmentectomy	Lobectomy	Sleeve lobectomy	Extended lobectomy	Pneumonectomy	Extended pneumonectomy	Other	P value
N	6692	1814	26008	52	927	1017	24	310	
Age (years), median (IQR)	70.0 (63.0, 75.0)	69.0 (63.0, 75.0)	68.0 (61.0, 74.0)	58.0 (37.0, 69.0)	67.0 (59.0, 73.0)	63.0 (56.0, 70.0)	65.5 (59.5, 70.5)	66.0 (59.0, 72.0)	<0.001
Sex									<0.001
Male	2756 (41.2%)	716 (39.5%)	11386 (43.8%)	27 (51.9%)	487 (52.5%)	620 (61.0%)	15 (62.5%)	166 (53.5%)	
Female	3936 (58.8%)	1098 (60.5%)	14622 (56.2%)	25 (48.1%)	440 (47.5%)	397 (39.0%)	9 (37.5%)	144 (46.5%)	
Race									0.008
White	5815 (86.9%)	1604 (88.4%)	22503 (86.5%)	42 (80.8%)	790 (85.2%)	894 (87.9%)	19 (79.2%)	265 (85.5%)	
Black	566 (8.5%)	124 (6.8%)	2210 (8.5%)	7 (13.5%)	94 (10.1%)	71 (7.0%)	4 (16.7%)	32 (10.3%)	
Native American	21 (0.3%)	6 (0.3%)	81 (0.3%)	0 (0.0%)	7 (0.8%)	5 (0.5%)	1 (4.2%)	1 (0.3%)	
Asian	187 (2.8%)	50 (2.8%)	858 (3.3%)	1 (1.9%)	23 (2.5%)	29 (2.9%)	0 (0.0%)	10 (3.2%)	
Unknown	103 (1.5%)	30 (1.7%)	356 (1.4%)	2 (3.8%)	13 (1.4%)	18 (1.8%)	0 (0.0%)	2 (0.6%)	
CDCC Score <sup>1</sup>									<0.001
0	3553 (53.1%)	918 (50.6%)	14820 (57.0%)	27 (51.9%)	548 (59.1%)	618 (60.8%)	13 (54.2%)	185 (59.7%)	
1	1718 (25.7%)	524 (28.9%)	6641 (25.5%)	17 (32.7%)	236 (25.5%)	262 (25.8%)	4 (16.7%)	68 (21.9%)	
2	783 (11.7%)	204 (11.2%)	2675 (10.3%)	4 (7.7%)	91 (9.8%)	89 (8.8%)	4 (16.7%)	32 (10.3%)	
≥3	638 (9.5%)	168 (9.3%)	1872 (7.2%)	4 (7.7%)	52 (5.6%)	48 (4.7%)	3 (12.5%)	25 (8.1%)	
Clinical T Status									<0.001
T1a	1239 (18.5%)	223 (12.3%)	1579 (6.1%)	5 (9.6%)	19 (2.0%)	31 (3.0%)	0 (0.0%)	22 (7.1%)	
T1b	3014 (45.0%)	902 (49.7%)	7916 (30.4%)	12 (23.1%)	129 (13.9%)	50 (4.9%)	1 (4.2%)	35 (11.3%)	
T1c	1000 (14.9%)	366 (20.2%)	5642 (21.7%)	8 (15.4%)	115 (12.4%)	75 (7.4%)	2 (8.3%)	25 (8.1%)	
T2a	565 (8.4%)	181 (10.0%)	4723 (18.2%)	13 (25.0%)	136 (14.7%)	167 (16.4%)	2 (8.3%)	30 (9.7%)	
T2b	115 (1.7%)	30 (1.7%)	1942 (7.5%)	7 (13.5%)	89 (9.6%)	122 (12.0%)	0 (0.0%)	18 (5.8%)	
T3	280 (4.2%)	65 (3.6%)	2660 (10.2%)	4 (7.7%)	214 (23.1%)	276 (27.1%)	5 (20.8%)	37 (11.9%)	
T4	319 (4.8%)	38 (2.1%)	1312 (5.0%)	1 (1.9%)	212 (22.9%)	266 (26.2%)	13 (54.2%)	80 (25.8%)	
Unknown	160 (2.4%)	9 (0.5%)	234 (0.9%)	2 (3.8%)	13 (1.4%)	30 (2.9%)	1 (4.2%)	63 (20.3%)	
Clinical N Status									<0.001
N0	5410 (80.8%)	1595 (87.9%)	21321 (82.0%)	34 (65.4%)	672 (72.5%)	556 (54.7%)	11 (45.8%)	139 (44.8%)	
N1	146 (2.2%)	32 (1.8%)	1435 (5.5%)	5 (9.6%)	102 (11.0%)	211 (20.7%)	4 (16.7%)	22 (7.1%)	
N2	285 (4.3%)	38 (2.1%)	1315 (5.1%)	6 (11.5%)	77 (8.3%)	140 (13.8%)	6 (25.0%)	65 (21.0%)	
N3	69 (1.0%)	6 (0.3%)	74 (0.3%)	0 (0.0%)	7 (0.8%)	15 (1.5%)	0 (0.0%)	28 (9.0%)	
Unknown	782 (11.7%)	143 (7.9%)	1863 (7.2%)	7 (13.5%)	69 (7.4%)	95 (9.3%)	3 (12.5%)	56 (18.1%)	
Tumor Size (mm), median (IQR)	15.0 (11.0, 22.0)	18.0 (13.0, 24.0)	25.0 (16.0, 36.0)	23.0 (15.0, 38.0)	40.0 (25.0, 64.0)	47.0 (32.0, 70.0)	77.0 (34.0, 110.0)	35.0 (19.0, 58.0)	<0.001
Tumor Location									<0.001
Main Bronchus	9 (0.1%)	6 (0.3%)	69 (0.3%)	12 (23.1%)	12 (1.3%)	89 (8.8%)	0 (0.0%)	38 (12.3%)	
Right Upper Lobe	2047 (30.6%)	392 (21.6%)	8625 (33.2%)	22 (42.3%)	314 (33.9%)	156 (15.3%)	4 (16.7%)	48 (15.5%)	
Right Middle Lobe	324 (4.8%)	22 (1.2%)	1768 (6.8%)	6 (11.5%)	81 (8.7%)	28 (2.8%)	0 (0.0%)	17 (5.5%)	
Right Lower Lobe	1216 (18.2%)	358 (19.7%)	4795 (18.4%)	3 (5.8%)	166 (17.9%)	86 (8.5%)	4 (16.7%)	39 (12.6%)	
Left Upper Lobe	1771 (26.5%)	632 (34.8%)	6255 (24.1%)	2 (3.8%)	148 (16.0%)	324 (31.9%)	7 (29.2%)	64 (20.6%)	
Left Lower Lobe	1002 (15.0%)	351 (19.3%)	3924 (15.1%)	5 (9.6%)	76 (8.2%)	166 (16.3%)	2 (8.3%)	30 (9.7%)	
Bilateral	6 (0.1%)	1 (0.1%)	2 (<1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.3%)	
Overlapping Lesion of the Lung	61 (0.9%)	15 (0.8%)	189 (0.7%)	0 (0.0%)	87 (9.4%)	109 (10.7%)	4 (16.7%)	10 (3.2%)	
Unknown	256 (3.8%)	37 (2.0%)	381 (1.5%)	2 (3.8%)	43 (4.6%)	59 (5.8%)	3 (12.5%)	63 (20.3%)	
Histology									<0.001
Adenocarcinoma	3693 (55.2%)	957 (52.8%)	14111 (54.3%)	4 (7.7%)	367 (39.6%)	321 (31.6%)	8 (33.3%)	129 (41.6%)	
Squamous Cell Carcinoma	1256 (18.8%)	380 (20.9%)	5814 (22.4%)	14 (26.9%)	322 (34.7%)	498 (49.0%)	7 (29.2%)	83 (26.8%)	
Large Cell Carcinoma	107 (1.6%)	26 (1.4%)	414 (1.6%)	1 (1.9%)	20 (2.2%)	11 (1.1%)	1 (4.2%)	0 (0.0%)	
Adenosquamous Cell Carcinoma	121 (1.8%)	28 (1.5%)	462 (1.8%)	0 (0.0%)	22 (2.4%)	23 (2.3%)	1 (4.2%)	4 (1.3%)	
Carcinoid	559 (8.4%)	131 (7.2%)	1727 (6.6%)	24 (46.2%)	79 (8.5%)	61 (6.0%)	2 (8.3%)	27 (8.7%)	
Tumors Formerly Classified as Bronchioloalveolar Carcinoma	559 (8.4%)	205 (11.3%)	2192 (8.4%)	1 (1.9%)	55 (5.9%)	29 (2.9%)	1 (4.2%)	8 (2.6%)	
Non-Small Cell Lung Cancer, Not Otherwise Specified	62 (0.9%)	14 (0.8%)	258 (1.0%)	0 (0.0%)	20 (2.2%)	19 (1.9%)	1 (4.2%)	10 (3.2%)	
Small Cell Lung Cancer	186 (2.8%)	33 (1.8%)	395 (1.5%)	0 (0.0%)	11 (1.2%)	10 (1.0%)	0 (0.0%)	25 (8.1%)	
Carcinoma	16 (0.2%)	9 (0.5%)	101 (0.4%)	0 (0.0%)	5 (0.5%)	9 (0.9%)	1 (4.2%)	1 (0.3%)	
Other	133 (2.0%)	31 (1.7%)	534 (2.1%)	8 (15.4%)	26 (2.8%)	36 (3.5%)	2 (8.3%)	23 (7.4%)	
Grade									<0.001
Well-differentiated	1349 (20.2%)	355 (19.6%)	4137 (15.9%)	15 (28.8%)	96 (10.4%)	66 (6.5%)	0 (0.0%)	20 (6.5%)	
Moderately-differentiated	2559 (38.2%)	752 (41.5%)	10691 (41.1%)	11 (21.2%)	302 (32.6%)	339 (33.3%)	7 (29.2%)	65 (21.0%)	
Poorly Differentiated	1498 (22.4%)	415 (22.9%)	7198 (27.7%)	9 (17.3%)	365 (39.4%)	436 (42.9%)	10 (41.7%)	84 (27.1%)	
Undifferentiated	109 (1.6%)	24 (1.3%)	366 (1.4%)	0 (0.0%)	17 (1.8%)	19 (1.9%)	1 (4.2%)	9 (2.9%)	
Unknown	1177 (17.6%)	268 (14.8%)	3616 (13.9%)	17 (32.7%)	147 (15.9%)	157 (15.4%)	6 (25.0%)	132 (42.6%)	
Insurance Status									<0.001
Uninsured	53 (0.8%)	9 (0.5%)	284 (1.1%)	1 (1.9%)	8 (0.9%)	24 (2.4%)	0 (0.0%)	11 (3.5%)	
Private Insurance/managed care	1621 (24.2%)	469 (25.9%)	7527 (28.9%)	22 (42.3%)	264 (28.5%)	401 (39.4%)	10 (41.7%)	90 (29.0%)	
Medicaid	346 (5.2%)	86 (4.7%)	1554 (6.0%)	5 (9.6%)	70 (7.6%)	96 (9.4%)	2 (8.3%)	21 (6.8%)	
Medicare	4528 (67.7%)	1222 (67.4%)	16012 (61.6%)	22 (42.3%)	552 (59.5%)	461 (45.3%)	11 (45.8%)	180 (58.1%)	
Other Government	81 (1.2%)	15 (0.8%)	402 (1.5%)	2 (3.8%)	20 (2.2%)	19 (1.9%)	1 (4.2%)	7 (2.3%)	
Unknown	63 (0.9%)	13 (0.7%)	229 (0.8%)	0 (0.0%)	13 (1.4%)	16 (1.6%)	0 (0.0%)	1 (0.3%)	
Facility Type									<0.001
Community Cancer Program	365 (5.5%)	94 (5.2%)	1314 (5.1%)	0 (0.0%)	65 (7.0%)	70 (6.9%)	1 (4.2%)	20 (6.5%)	
Comprehensive Community Cancer Program	2320 (34.7%)	551 (30.4%)	10384 (39.9%)	11 (21.2%)	349 (37.6%)	356 (35.0%)	4 (16.7%)	118 (38.1%)	
Academic/research Program	3185 (47.6%)	938 (51.7%)	10479 (40.3%)	21 (40.4%)	389 (42.0%)	428 (42.1%)	15 (62.5%)	130 (41.9%)	
Integrated Cancer Network	792 (11.8%)	222 (12.2%)	3590 (13.8%)	6 (11.5%)	104 (11.2%)	137 (13.5%)	3 (12.5%)	34 (11.0%)	
Unknown	30 (0.4%)	9 (0.5%)	241 (0.9%)	14 (26.9%)	20 (2.2%)	26 (2.6%)	1 (4.2%)	8 (2.6%)	
Distance from the Hospital (miles), median (IQR)	12.5 (5.6, 28.9)	13.1 (5.7, 31.9)	12.5 (5.5, 29.4)	17.5 (7.6, 54.3)	14.4 (6.0, 30.7)	15.2 (6.9, 36.2)	14.6 (5.7, 70.7)	14.8 (5.0, 37.6)	<0.001
Income (\$) <sup>2</sup>									<0.001
<40,227	945 (14.1%)	209 (11.5%)	3902 (15.0%)	9 (17.3%)	134 (14.5%)	150 (14.7%)	4 (16.7%)	56 (18.1%)	
40227-50353	1153 (17.2%)	307 (16.9%)	4774 (18.4%)	9 (17.3%)	218 (23.5%)	202 (19.9%)	3 (12.5%)	58 (18.7%)	
50354-63332	1323 (19.8%)	320 (17.6%)	5256 (20.2%)	12 (23.1%)	190 (20.5%)	230 (22.6%)	4 (16.7%)	71 (22.9%)	
>63332	2284 (34.1%)	666 (36.7%)	7985 (30.7%)	15 (28.8%)	247 (26.6%)	275 (27.0%)	9 (37.5%)	71 (22.9%)	
Unknown	987 (14.7%)	312 (17.2%)	4091 (15.7%)	7 (13.5%)	138 (14.9%)	160 (15.7%)	4 (16.7%)	54 (17.4%)	
Education <sup>3</sup>									<0.001
≥17.6	1053 (15.7%)	247 (13.6%)	4197 (16.1%)	11 (21.2%)	147 (15.9%)	171 (16.8%)	1 (4.2%)	64 (20.6%)	
10.9-17.5	1457 (21.8%)	362 (20.0%)	5881 (22.6%)	18 (34.6%)	224 (24.2%)	250 (24.6%)	6 (25.0%)	68 (21.9%)	
6.3-10.8	1686 (25.2%)	445 (24.5%)	6558 (25.2%)	6 (11.5%)	246 (26.5%)	254 (25.0%)	6 (25.0%)	78 (25.2%)	
<6.3	1523 (22.8%)	448 (24.7%)	5323 (20.5%)	10 (19.2%)	173 (18.7%)	184 (18.1%)	7 (29.2%)	48 (15.5%)	
Unknown	973 (14.5%)	312 (17.2%)	4049 (15.6%)	7 (13.5%)	137 (14.8%)	158 (15.5%)	4 (16.7%)	52 (16.8%)	
Surgical Approach									<0.001
Open	2074 (31.0%)	536 (29.5%)	9878 (38.0%)	33 (63.5%)	508 (54.8%)	656 (64.5%)	17 (70.8%)	112 (36.1%)	
Video-assisted Thoracoscopic Surgery	3363 (50.3%)	794 (43.8%)	9117 (35.1%)	10 (19.2%)	230 (24.8%)	168 (16.5%)	4 (16.7%)	124 (40.0%)	
Robotic	941 (14.1%)	417 (23.0%)	5441 (20.9%)	4 (7.7%)	90 (9.7%)	76 (7.5%)	1 (4.2%)	21 (6.8%)	
Unknown	314 (4.7%)	67 (3.7%)	1572 (6.0%)	5 (9.6%)	99 (10.7%)	117 (11.5%)	2 (8.3%)	53 (17.1%)	

<sup>1</sup>, CDCC = Charlson comorbidity score; <sup>2</sup>, National Cancer Database (NCDB) codes income level as average household income of the zip code where the patient lives; <sup>3</sup>, NCDB codes education level as the number of adults age 25 or older in the patient's zip code who did not graduate from high school.



**Table S3** Pathologic characteristics and perioperative outcomes of patients undergoing lung cancer resection in the National Cancer Database in 2016 stratified by operation type

Factor	Wedge resection	Segmentectomy	Lobectomy	Sleeve lobectomy	Extended lobectomy	Pneumonectomy	Extended pneumonectomy	Other	P value
N	7017	1704	25893	45	1044	1155	16	267	
Pathologic T Status									<0.001
T1a	1155 (16.5%)	204 (12.0%)	1313 (5.1%)	4 (8.9%)	26 (2.5%)	15 (1.3%)	0 (0.0%)	11 (4.1%)	
T1b	2510 (35.8%)	623 (36.6%)	6204 (24.0%)	15 (33.3%)	100 (9.6%)	51 (4.4%)	0 (0.0%)	29 (10.9%)	
T1c	773 (11.0%)	271 (15.9%)	4646 (17.9%)	4 (8.9%)	95 (9.1%)	55 (4.8%)	0 (0.0%)	26 (9.7%)	
T2a	1327 (18.9%)	350 (20.5%)	6439 (24.9%)	10 (22.2%)	177 (17.0%)	207 (17.9%)	1 (6.3%)	33 (12.4%)	
T2b	129 (1.8%)	43 (2.5%)	1800 (7.0%)	4 (8.9%)	86 (8.2%)	123 (10.6%)	2 (12.5%)	14 (5.2%)	
T3	587 (8.4%)	140 (8.2%)	3564 (13.8%)	4 (8.9%)	296 (28.4%)	332 (28.7%)	5 (31.3%)	36 (13.5%)	
T4	342 (4.9%)	50 (2.9%)	1537 (5.9%)	4 (8.9%)	241 (23.1%)	345 (29.9%)	6 (37.5%)	46 (17.2%)	
Unknown	194 (2.8%)	23 (1.3%)	390 (1.5%)	0 (0.0%)	23 (2.2%)	27 (2.3%)	2 (12.5%)	72 (27.0%)	
Pathologic N Status									<0.001
N0	4818 (68.7%)	1461 (85.7%)	19998 (77.2%)	30 (66.7%)	717 (68.7%)	446 (38.6%)	5 (31.3%)	60 (22.5%)	
N1	176 (2.5%)	75 (4.4%)	3290 (12.7%)	12 (26.7%)	169 (16.2%)	476 (41.2%)	7 (43.8%)	14 (5.2%)	
N2	296 (4.2%)	67 (3.9%)	2160 (8.3%)	1 (2.2%)	115 (11.0%)	211 (18.3%)	4 (25.0%)	15 (5.6%)	
N3	9 (0.1%)	1 (0.1%)	17 (0.1%)	0 (0.0%)	3 (0.3%)	7 (0.6%)	0 (0.0%)	6 (2.2%)	
Unknown	1718 (24.5%)	100 (5.9%)	428 (1.7%)	2 (4.4%)	40 (3.8%)	15 (1.3%)	0 (0.0%)	172 (64.4%)	
Pathologic M Status									<0.001
M0	5326 (75.9%)	1457 (85.5%)	22640 (87.4%)	37 (82.2%)	836 (80.1%)	936 (81.0%)	9 (56.3%)	82 (30.7%)	
M1	470 (6.7%)	41 (2.4%)	469 (1.8%)	3 (6.7%)	41 (3.9%)	33 (2.9%)	2 (12.5%)	69 (25.8%)	
Unknown	1221 (17.4%)	206 (12.1%)	2784 (10.8%)	5 (11.1%)	167 (16.0%)	186 (16.1%)	5 (31.3%)	116 (43.4%)	
Number of Lymph Nodes Examined	4093 (60.9%)	1462 (89.6%)	24524 (98.7%)	41 (97.6%)	939 (96.4%)	1095 (99.1%)	14 (100.0%)	97 (39.6%)	<0.001
Number of Lymph Nodes Examined, median (IQR)	2.0 (0.0, 6.0)	6.0 (3.0, 10.0)	11.0 (7.0, 17.0)	9.0 (5.0, 22.0)	12.0 (7.0, 20.0)	16.0 (11.0, 24.0)	16.0 (7.5, 25.5)	0.0 (0.0, 5.0)	<0.001
Surgical Margins									<0.001
Negative Margins	6204 (88.4%)	1615 (94.8%)	24787 (95.7%)	37 (82.2%)	920 (88.1%)	1025 (88.7%)	13 (81.3%)	100 (37.5%)	
Positive Margins	574 (8.2%)	69 (4.0%)	958 (3.7%)	4 (8.9%)	108 (10.3%)	119 (10.3%)	3 (18.8%)	60 (22.5%)	
Unknown	239 (3.4%)	20 (1.2%)	148 (0.6%)	4 (8.9%)	16 (1.5%)	11 (1.0%)	0 (0.0%)	107 (40.1%)	
Length of Stay (Days), median (IQR)	3.0 (2.0, 5.0)	4.0 (2.0, 5.0)	5.0 (3.0, 7.0)	5.0 (4.0, 7.0)	6.0 (4.0, 8.0)	5.0 (4.0, 7.0)	6.0 (4.0, 10.0)	3.0 (0.0, 6.0)	<0.001
30-day Readmission									<0.001
No	6749 (96.2%)	1641 (96.3%)	24727 (95.5%)	42 (93.3%)	992 (95.0%)	1071 (92.7%)	15 (93.8%)	260 (97.4%)	
Yes	237 (3.4%)	49 (2.9%)	981 (3.8%)	2 (4.4%)	38 (3.6%)	70 (6.1%)	1 (6.3%)	5 (1.9%)	
Unknown	31 (0.4%)	14 (0.8%)	185 (0.7%)	1 (2.2%)	14 (1.3%)	14 (1.2%)	0 (0.0%)	2 (0.7%)	
30-day Mortality									<0.001
No	6815 (97.1%)	1669 (97.9%)	25223 (97.4%)	43 (95.6%)	1008 (96.6%)	1077 (93.2%)	16 (100.0%)	223 (83.5%)	
Yes	114 (1.6%)	14 (0.8%)	398 (1.5%)	1 (2.2%)	22 (2.1%)	73 (6.3%)	0 (0.0%)	32 (12.0%)	
Unknown	88 (1.3%)	21 (1.2%)	272 (1.1%)	1 (2.2%)	14 (1.3%)	5 (0.4%)	0 (0.0%)	12 (4.5%)	
90-day Mortality									<0.001
No	6637 (94.6%)	1645 (96.5%)	24615 (95.1%)	41 (91.1%)	969 (92.8%)	1027 (88.9%)	14 (87.5%)	195 (73.0%)	
Yes	234 (3.3%)	30 (1.8%)	763 (2.9%)	3 (6.7%)	50 (4.8%)	113 (9.8%)	2 (12.5%)	57 (21.3%)	
Unknown	146 (2.1%)	29 (1.7%)	515 (2.0%)	1 (2.2%)	25 (2.4%)	15 (1.3%)	0 (0.0%)	15 (5.6%)	

**Table S4** Pathologic characteristics and perioperative outcomes of patients undergoing lung cancer resection in the National Cancer Database in 2017 stratified by operation type

Factor	Wedge resection	Segmentectomy	Lobectomy	Sleeve lobectomy	Extended lobectomy	Pneumonectomy	Extended pneumonectomy	Other	P value
N	6692	1814	26008	52	927	1017	24	310	
Pathologic T Status									<0.001
T1a	1101 (16.5%)	205 (11.3%)	1462 (5.6%)	4 (7.7%)	18 (1.9%)	30 (2.9%)	0 (0.0%)	19 (6.1%)	
T1b	2385 (35.6%)	737 (40.6%)	6540 (25.1%)	13 (25.0%)	102 (11.0%)	48 (4.7%)	0 (0.0%)	36 (11.6%)	
T1c	716 (10.7%)	288 (15.9%)	4633 (17.8%)	10 (19.2%)	88 (9.5%)	50 (4.9%)	2 (8.3%)	28 (9.0%)	
T2a	1326 (19.8%)	363 (20.0%)	6334 (24.4%)	9 (17.3%)	148 (16.0%)	150 (14.7%)	0 (0.0%)	41 (13.2%)	
T2b	107 (1.6%)	30 (1.7%)	1837 (7.1%)	5 (9.6%)	71 (7.7%)	111 (10.9%)	0 (0.0%)	21 (6.8%)	
T3	565 (8.4%)	137 (7.6%)	3599 (13.8%)	7 (13.5%)	270 (29.1%)	287 (28.2%)	6 (25.0%)	42 (13.5%)	
T4	317 (4.7%)	44 (2.4%)	1363 (5.2%)	2 (3.8%)	217 (23.4%)	308 (30.3%)	16 (66.7%)	51 (16.5%)	
Unknown	175 (2.6%)	10 (0.6%)	240 (0.9%)	2 (3.8%)	13 (1.4%)	33 (3.2%)	0 (0.0%)	72 (23.2%)	
Pathologic N Status									<0.001
N0	4613 (68.9%)	1539 (84.8%)	20196 (77.7%)	34 (65.4%)	617 (66.6%)	413 (40.6%)	10 (41.7%)	77 (24.8%)	
N1	174 (2.6%)	71 (3.9%)	3175 (12.2%)	8 (15.4%)	179 (19.3%)	412 (40.5%)	7 (29.2%)	25 (8.1%)	
N2	285 (4.3%)	81 (4.5%)	2264 (8.7%)	8 (15.4%)	100 (10.8%)	169 (16.6%)	6 (25.0%)	21 (6.8%)	
N3	10 (0.1%)	3 (0.2%)	20 (0.1%)	0 (0.0%)	1 (0.1%)	3 (0.3%)	0 (0.0%)	4 (1.3%)	
Unknown	1610 (24.1%)	120 (6.6%)	353 (1.4%)	2 (3.8%)	30 (3.2%)	20 (2.0%)	1 (4.2%)	183 (59.0%)	
Pathologic M Status									<0.001
M0	5967 (89.2%)	1743 (96.1%)	25354 (97.5%)	50 (96.2%)	883 (95.3%)	967 (95.1%)	21 (87.5%)	119 (38.4%)	
M1	410 (6.1%)	39 (2.1%)	450 (1.7%)	1 (1.9%)	23 (2.5%)	26 (2.6%)	2 (8.3%)	69 (22.3%)	
Unknown	315 (4.7%)	32 (1.8%)	204 (0.8%)	1 (1.9%)	21 (2.3%)	24 (2.4%)	1 (4.2%)	122 (39.4%)	
Number of Lymph Nodes Examined	4035 (63.0%)	1544 (89.5%)	24790 (98.7%)	49 (100.0%)	852 (96.7%)	969 (98.6%)	23 (95.8%)	101 (40.7%)	<0.001
Number of Lymph Nodes Examined, median (IQR)	2.0 (0.0, 6.0)	7.0 (3.0, 12.0)	11.0 (7.0, 17.0)	13.5 (6.0, 25.5)	12.0 (7.0, 20.0)	16.0 (10.0, 24.0)	17.0 (11.5, 22.5)	1.0 (0.0, 19.0)	<0.001
Surgical Margins									<0.001
Negative Margins	5977 (89.3%)	1727 (95.2%)	24873 (95.6%)	36 (69.2%)	826 (89.1%)	897 (88.2%)	15 (62.5%)	98 (31.6%)	
Positive Margins	478 (7.1%)	66 (3.6%)	972 (3.7%)	13 (25.0%)	92 (9.9%)	108 (10.6%)	9 (37.5%)	66 (21.3%)	
Unknown	237 (3.5%)	21 (1.2%)	163 (0.6%)	3 (5.8%)	9 (1.0%)	12 (1.2%)	0 (0.0%)	146 (47.1%)	
Length of Stay (Days), median (IQR)	3.0 (2.0, 5.0)	3.0 (2.0, 5.0)	4.0 (3.0, 7.0)	5.0 (4.0, 6.5)	6.0 (4.0, 9.0)	5.0 (4.0, 7.0)	8.5 (6.0, 12.5)	2.0 (0.0, 5.0)	<0.001
30-day Readmission									0.14
No	6387 (95.4%)	1744 (96.1%)	24799 (95.4%)	48 (92.3%)	867 (93.5%)	958 (94.2%)	24 (100.0%)	294 (94.8%)	
Yes	262 (3.9%)	55 (3.0%)	1034 (4.0%)	3 (5.8%)	48 (5.2%)	49 (4.8%)	0 (0.0%)	13 (4.2%)	
Unknown	43 (0.6%)	15 (0.8%)	175 (0.7%)	1 (1.9%)	12 (1.3%)	10 (1.0%)	0 (0.0%)	3 (1.0%)	