Mortality index is more accurate than volume in predicting outcome and failure to rescue in Medicare beneficiaries undergoing robotic right upper lobectomy

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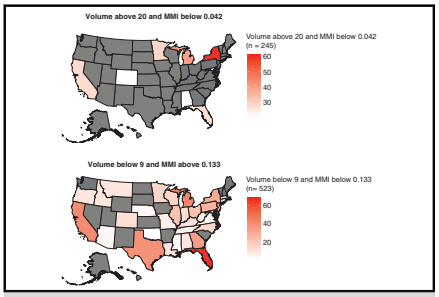
ABSTRACT

Background: Surgical volume is known to influence failure to rescue (FTR), defined as death following a complication. Robotic lung surgery continues to expand and there is variability in outcomes among hospitals. We sought to estimate the contribution of hospital-based factors on outcomes and FTR following robotic right upper lobectomy (RRUL).

Methods: Using the Centers for Medicare and Medicaid Services inpatient claims database, we evaluated all patients age ≥65 years with a diagnosis of lung cancer who underwent RRUL between January 2018 and December 2020. We excluded patients who had undergone segmentectomy, sublobar, wedge, or bronchoplastic resection; had metastatic or nonmalignant disease; or had a history of neoadjuvant chemotherapy. Primary outcomes included FTR rate, length of stay (LOS), readmissions, conversion to open surgery, complications, and costs. We analyzed hospitals by tertiles of volume and Medicare Mortality Index (MMI). Defined as the institutional number of deaths per number of survivors, MMI is a marker of overall hospital performance and quality. Propensity score models were adjusted for confounding using goodness of fit.

Results: Data for 4317 patients who underwent robotic right upper lobectomy were analyzed. Hospitals were categorized by volume of cases (low, <9; medium, 9-20; high, >20) and MMI (low, <0.04; medium, 0.04-0.13; high, >0.13). After propensity score balancing, patients from tertiles of lowest volume and highest MMI had higher costs ($34,222 vs $30,316; $P = .006$), as well as higher mortality (odds ratio, 7.46; 95% confidence interval, 2.67-28.2; $P < .001$). Compared to high-volume centers, low-volume centers had higher rates of conversion to open surgery, respiratory failure, hemorrhagic anemia, and death; longer LOS; and greater cost ($P < .001$ for all). The C-statistic for volume as a predictor of overall mortality was 0.6, and the FTR was 0.8. Hospitals in the highest tertile of MMI had the highest rates of conversion to open surgery ($P = .01$), pneumothorax ($P = .02$), and respiratory failure ($P < .001$). They also had the highest mortality and rate of readmission, longest LOS, and greatest costs ($P < .001$ for all) and the shortest survival ($P < .001$). The C-statistic for MMI as a predictor of overall mortality was 0.8, and FTR was 0.9.

Conclusions: The MMI incorporates hospital-based factors in the adjudication of outcomes and is a more sensitive predictor of FTR rates than volume alone. Combining MMI and volume may provide a metric that can guide quality improvement and cost-effectiveness measures in hospitals seeking to implement robotic lung surgery programs. (JTCVS Open 2024;18:276-305)



Distribution of patients in each category of volume and mortality index (centers with the lowest volume and the highest mortality index vs centers with the highest volume and lowest mortality index) across the United States. States without any patients are in gray.

CENTRAL MESSAGE

Volume alone is not the most accurate predictor of outcomes.

PERSPECTIVE

Adding institutional mortality data to volume allows for more accurate prediction.

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Abbreviations and Acronyms

CI = confidence interval
EM = estimated mean
FTR = failure to rescue
HR = hazard ratio
IPTW = inverse probability of treatment weighting
LOS = length of stay
MMI = Medicare Mortality Index
OR = odds ratio
RRUL = robotic right upper lobectomy
SMD = standardized mean difference

Surgical volume is an accepted marker of quality, and the volume–outcome relationship is a commonly cited adjudication of surgical performance.[1] This relationship favors high volume and has evolved into a surrogate for lower mortality and superior outcomes. Consequently, efforts have been made to catalog volume thresholds for various surgical procedures and use these values to delineate quality metrics for surgeons and hospitals alike. This is true for lung resections.[1-3] An example of this is the Leapfrog Group, a coalition of employers and insurers engaged in health policy advocacy, who recommend an annual hospital volume of 40 lung resections, below which would be considered a potential erosion in quality standards.[4]

Volume–outcome relationships are complex and may be easily influenced by imprecise risk adjustment and misaligned statistical methodologies. The relationship can be misleading and result in conclusions that produce inaccurate volume thresholds, marginalize surgeons, and serve to the detriment of smaller, critical access, and rural hospitals.[5-9] Moreover, the potential miscalculations can threaten the financial viability of lower-volume institutions and may inadvertently impose an excess burden of travel and restrict access for rural patients and marginalized communities forced to travel greater distances in search of care at higher-volume centers.[5-9]

Despite statistical adjustment, volume alone is not the predominant predictor of improved outcomes.[9,10] Indeed, the opportunity to perform high-volume surgery is often facilitated by a larger comprehensive, interconnected matrix that permits many cases to be performed safely in the first place. This multidisciplinary coalition typically includes intensive care staffing, favorable insurance networks, blood bank services, optimized nursing ratios, a plethora of medical specialties, and several other stakeholders, each contributing to elevate the level of quality and without which high volume alone would not be sufficient. Within the spectrum of hospitals, however, complications occur equally across quintiles of volume.[3] Not all hospitals can successfully rescue the patient, mitigate the consequences, and prevent mortality.[3]

In this analysis, we hypothesize that the Medicare Mortality Index (MMI), a registry-derived surrogate for the contribution of hospital factors responsible for the probability that a surgical patient will survive a hospitalization, is a more accurate predictor of outcomes than volume.

METHODS

Study Design

We conducted a retrospective observational analysis using the 2018-2020 Inpatient Standard Analytical Files maintained by the Centers for Medicare & Medicaid Services, the US federal agency within the US Department of Health and Human Services (HHS), responsible for Medicaid and the Children's Health Insurance Program administration and Medicare administration in partnership with state governments. We sought to evaluate the variation in outcomes when comparing centers across a spectrum of case volume and MMI in patients with lung cancer who underwent robotic right upper lobectomy (RRUL). The study was conducted according to the STROBE (STrengthening the Reporting of OBservational Studies in Epidemiology) guidelines and the CHAMP (CHecklist for Statistics Assessment of Medical Papers) statement.[11,12] Our rationale for using the MMI, defined as the institutional number of deaths per number of survivors, was drawn from previous experience described by the Optum Group in which a claims dataset with full death records was used to develop a model that classifies the end of observations into death or nondeath. This model was externally validated by applying it to 3 US claims datasets, where it demonstrated the ability to predict whether the end of observation was due to death in the claims data, with a discriminative performance of 0.986 on the area under the receiver operating characteristic curve.[13]

Ethics

This study was approved by the West Virginia University Institutional Review Board (WVU IRB 2210660362) on October 14, 2022.

Inclusion Criteria

We included patients with upper lobe lung cancer who had undergone RRUL and used the International Classification of Diseases, Tenth Revision (ICD-10) diagnosis code classification system to define the terms. Right upper lobectomy was selected as a standard, commonly performed anatomic lung resection (Table E1).

Exclusion Criteria

We excluded patients who underwent segmentectomies and other sublobar resections for uniformity due to the varied complexity of different anatomical resections and variations in anatomy (Table E2).

Outcome Variables

Our main outcomes were overall mortality (death at any time, including death during the index visit and after discharge), death at 30 days and 1 year

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after discharge, as well as the cost of hospitalization and failure to rescue (FTR) rate, defined as death following a complication.

Predictor Variables

Our predicting variables included (1) center volume, calculated as the average number of robot-assisted right upper lobectomy (RRUL) procedures performed annually at a center; (2) MMI, calculated as the number of deaths/number of survivors; and (3) a combination of center volume and MMI. We categorized both variables into levels based on the tertiles of the patient population. Although not commonly used in the literature, MMI is a reference metric used by the federal payor to estimate comparative mortality within institutions, is a surrogate for all-cause mortality, and serves as an important "rule of thumb" means of adjudication that providers should be aware of. We combined the categorized variables of volume and MMI to compare centers with the lowest volume (lowest tertile) and highest MMI (highest tertile) to centers with the highest volume (highest tertile) and lowest MMI (lowest tertile).

Potential Confounder Variables

We integrated clinical judgment and literature evidence to elucidate crucial confounders, as this combination outperforms isolated clinical or evidence-based criteria.[14] As such, we selected age,[15] sex,[16] race,[15] comorbidity index (ie, Elixhauser score and Charlson score), diabetes mellitus,[17] peripheral artery disease,[18] other cardiac diseases,[18] chronic lung disease, gastrointestinal (GI) bleeding, liver disease,[19] dysrhythmia,[18] and anemia (Table E3).

Statistical Methods

Exploratory analysis. We evaluated the variables to ascertain frequency, percentage, and near-zero variance for categorical variables and distribution for numerical variables (ie, age, Elixhauser score, and Charlson score) and their respective missing value patterns.[20] We implemented variable categorizations to avoid near-zero variance and compared the data using the standardized mean difference (SMD), the difference between proportions or means divided by the combined standard deviation. We observed that SMD = 0.2 corresponded to a small effect, SMD = 0.5 corresponded to a medium effect, and SMD = 0.8 corresponded to a large effect.[21] Additionally, we provided P values for the t test for numerical variables and the χ^2 test for categorical variables. $P < .05$ was considered to indicate statistical significance (Figure 1).

Propensity Score Analysis

We used a propensity score method based on inverse probability of treatment weighting (IPTW) to evaluate the relationship between the combination of variables (ie, lowest volume and highest MMI vs highest volume and lowest MMI) and the outcomes (costs, FTR, and mortality). Each patient was assigned a weight by IPTW that was inversely proportional to the likelihood of experiencing the intervention.[11] The following covariates were selected as independent variables: age, sex, race, comorbidity index (ie, Elixhauser score and Charlson score), diabetes mellitus, peripheral artery disease, other cardiac diseases, chronic lung disease, GI bleeding, liver disease, dysrhythmia, and anemia. We examined the covariate balance between the treatment groups.[22-24] The SMD method was used for continuous variables, and differences in proportion was used for binary variables. A variable was considered an unbalanced covariate if >0.1. The IPTW, generated using logistic regression, was used to balance the variables. The treatment impact for each outcome was then estimated using a double-robust technique.

We accounted for the balance achieved by propensity scores. We used the estimated marginal mean (EM; ie, predicted means) for numerical outcomes and odds ratio OR for dichotomous outcomes, expressing each with 95% confidence interval (CI) and P value. Our analyses indicated that Elixhauser score was not balanced in the original data. We adjusted all subsequent analyses for this unbalanced covariate using IPTW (Figure 2, *A*). For time-to-event analysis, we used Cox proportional hazards models to evaluate time to death.[25] The outcomes were represented by a dichotomous variable and results expressed as hazard ratio (HR) with 95% CI. Each was considered significant when the 95% CI did not exceed 1.0. We used the C-statistic to assess the ability of the logistic regression model to predict an outcome. Tables E10 to E12 display the model goodness of fit after propensity score adjustment. We performed all analyses using R.[24]

RESULTS

Volume Considerations

The study cohort comprised 4317 Medicare beneficiaries with right upper lobe cancer who underwent RRUL (Table 1). The sample was predominately female (54.1%) and white (87.8%), with an average age of 71.5 ± 6.48 years. There were 3 tertiles of volume: <9, 9 to 20, and >20. Those with a volume <9 had higher Charlson scores (mean, 2.29 ± 1.12 for volume <9 vs 2.19 ± 1.11 for volume 9-20 vs 2.14 ± 1.1 for volume >20; $P = .001$) and Elixhauser score (4.07 ± 1.85 vs 3.82 ± 1.79 vs 3.79 ± 1.78; $P < .001$). They also had a higher rate of conversion to open surgery (2.35% vs 1.98% vs 1.14%; $P = .047$), a longer mean length of stay (LOS; 5.42 ± 4.76 days vs 4.92 ± 4.21 days vs 4.31 ± 3.61 days; $P < .001$), and greater mean total charges ($135,657 ± $109,656 vs $125,946 $107,595 vs $114,872 ± $82,804; $P < .001$). Figure 2, *A* and *C*, Figure 3, *A* displays the hospital volume distribution for upper lobe cancer robotic resection. Figure 2, *C* shows the outcome distribution among the tertiles of volume, and Figure 3, *A* displays the distribution of volume across the United States.

MMI Considerations in Patients Who Underwent RRUL

The hospitals were categorized into tertiles by MMI: <0.042, 0.042-0.133, and >0.133 (Table 2). Figure 3, *A* displays the outcome distribution among these tertiles. Compared to hospitals with an MMI of 0.042 to 0.133 or an MMI <0.042, hospitals with an MMI >0.133 had a higher mean Charlson score (2.18 ± 1.06 for MMI <0.042 vs 2.1 ± 1.08 for MMI 0.042-0.133 vs 2.34 ± 1.17 for MMI >0.133; $P = .001$) and mean Elixhauser score (3.87 ± 1.77 vs 3.74 ± 1.77 vs 4.09 ± 1.88, respectively; $P < .001$), a higher rate of FTR (death in combination with any complication; 0.068% vs 0.488% vs 1.71%, respectively; $P < .001$), and a higher rate of 30-day readmission (6.96% vs 9.97% vs 10.9%; $P < .001$) (Figure 3, *B*; Table E4).

Propensity Score Analysis Across MMI Tertiles

Compared to patients treated in hospitals with an MMI <0.042, those in hospitals with an MMI of 0.042-0.133 had statistically significantly higher rates of overall mortality (OR, 20.4; 95% CI, 13.4-32.9; $P < .001$), in-hospital death (OR, 8.8; 95% CI, 3.15-35.6; $P < .001$), postdischarge death within 30 days (OR, 8.49; 95% CI, 2.9-

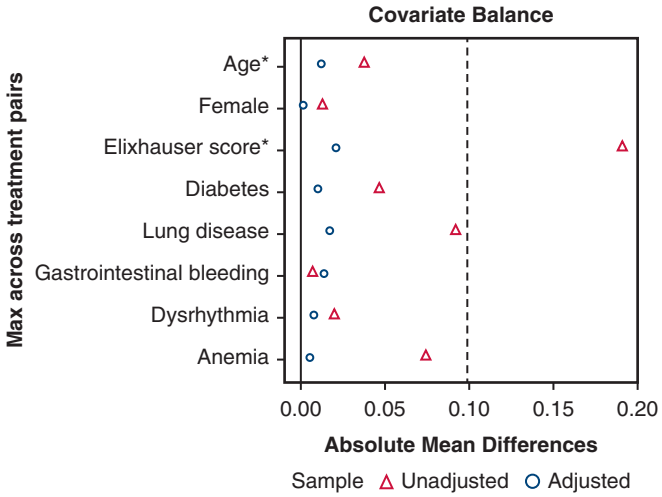

FIGURE 1. Covariate balance before and after adjustment among tertiles of MMI.

37.5; $P < .001$), postdischarge death within 60 days (OR, 13.4; 95% CI, 4.72-58.1; $P < .001$), postdischarge death within 1 year (OR, 11.2; 95% CI, 6.78-20.1; $P < .001$) (Table 3). Compared to patients treated in hospitals with an MMI <0.042, those in hospitals with an MMI >0.133 had higher rates of overall mortality (OR, 63.9; 95% CI,

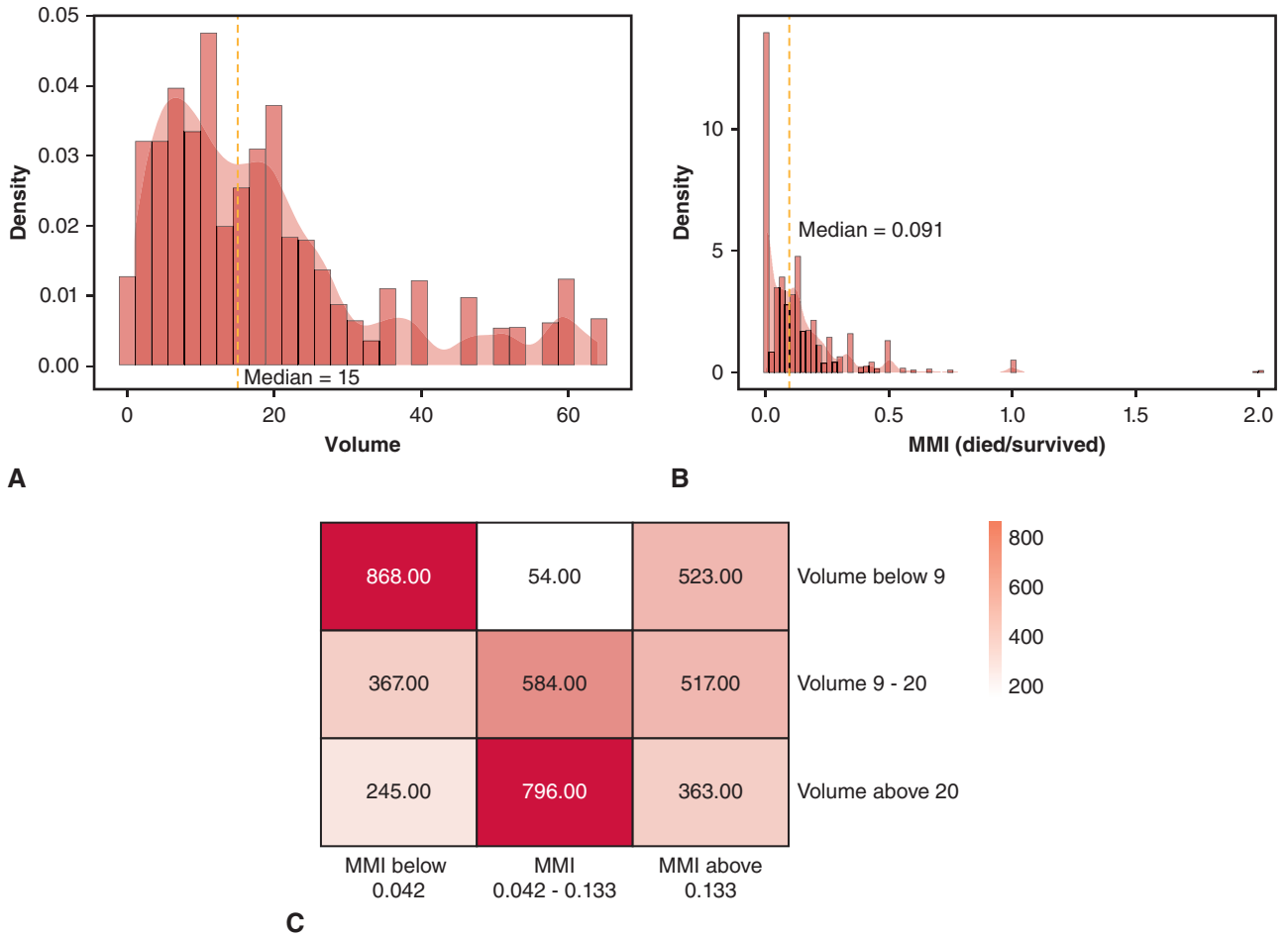

FIGURE 2. A, Volume distribution for patients who underwent robotic resection. B, Medicare Mortality Index (*MMI*) distribution for patients who underwent robotic right upper lobectomy. C, Distribution of patients who underwent robotic resection.

TABLE 1. Study sample characteristics and unadjusted comparisons across tertiles of claim volume in patients with upper lobe cancer who underwent robotic resection

Variable	Total (N = 4317)	Volume <9 (N = 1445)	Volume 9-20 (N = 1468)	Volume >20 (N = 1404)	*P* value
Age, y, mean ± SD	71.5 ± 6.48	71.3 ± 6.45	71.4 ± 6.59 [SMD, −0.02]	71.7 ± 6.39 [SMD, −0.059]	.273
Female sex, n (%)	2337 (54.1)	755 (52.2)	794 (54.1) [SMD, −0.037]	788 (56.1) [SMD, −0.078]	.116
Race, n (%)			[SMD, 0.018]	[SMD, 0.099]	.113
Black	260 (6.02)	100 (6.92)	95 (6.47)	65 (4.63)	
Other	267 (6.18)	90 (6.23)	91 (6.2)	86 (6.13)	
White	3790 (87.8)	1255 (86.9)	1282 (87.3)	1253 (89.2)	
Charlson score, mean ± SD	2.21 ± 1.11	2.29 ± 1.12	2.19 ± 1.11 [SMD, 0.088]	2.14 ± 1.1 [SMD, 0.137]	.001
Elixhauser score, mean ± SD	3.9 ± 1.81	4.07 ± 1.85	3.82 ± 1.79 [SMD, 0.138]	3.79 ± 1.78 [SMD, 0.154]	.001
Diabetes, n (%)	982 (22.7)	347 (24)	335 (22.8) [SMD, 0.028]	300 (21.4) [SMD, 0.063]	.241
Peripheral artery disease, n (%)	320 (7.41)	109 (7.54)	109 (7.43) [SMD, 0.004]	102 (7.26) [SMD, 0.011]	.96
Cardiac disease, n (%)	140 (3.24)	39 (2.7)	59 (4.02) [SMD, −0.073]	42 (2.99) [SMD, −0.018]	.107
Lung disease, n (%)	2057 (47.6)	745 (51.6)	672 (45.8) [SMD, 0.116]	640 (45.6) [SMD, 0.12]	.001
Gastrointestinal bleeding, n (%)	1387 (32.1)	467 (32.3)	478 (32.6) [SMD, −0.005]	442 (31.5) [SMD, 0.018]	.811
Liver disease, n (%)	106 (2.46)	41 (2.84)	35 (2.38) [SMD, 0.028]	30 (2.14) [SMD, 0.045]	.471
Dysrhythmia, n (%)	1216 (28.2)	433 (30)	404 (27.5) [SMD, 0.054]	379 (27) [SMD, 0.066]	.168
Anemia, n (%)	700 (16.2)	273 (18.9)	248 (16.9) [SMD, 0.052]	179 (12.7) [SMD, 0.169]	<.001
Thoracoscopy converted to open surgery, n (%)	79 (1.83)	34 (2.35)	29 (1.98) [SMD, 0.026]	16 (1.14) [SMD, 0.093]	.047

SD, Standard deviation; *SMD*, standardized mean difference.

42.2-103; $P < .001$) and in-hospital death (OR, 29.1; 95% CI, 11.1-115; $P < .001$). Patients in hospitals with a MMI of 0.042 to 0.133 also had a longer time to any complication at the index visit (censored at 1 year) (OR, 1.33; 95% CI, 1.02-1.72; $P = .033$) and higher rates of FTR (OR, 7.91; 95% CI, 2.8-32.2; $P < .001$), readmission within 30 days after discharge (OR, 1.52; 95% CI, 1.31-1.77; $P < .001$), and readmission within 60 days after discharge (OR, 1.26; 95% CI, 1.1-1.43; $P < .001$) (Figure 2, *B*).

Further comparison of patient-specific outcomes between hospitals with an MMI <0.04 and hospitals with an MMI >0.133 is further elaborated in Table E5. Unadjusted comparisons across between hospitals with lowest volume and the lowest MMI and hospitals with the highest volume and highest MMI within the subgroup of patients with upper lobe cancer who underwent RRUL is presented in Table E6. The results of subgroup analysis across tertiles of MMI in patients who underwent RRUL are provided in Table E7.

Effects of Low Volume and High MMI on Mortality and Costs

Hospitals with the lowest volume and highest MMI had the highest mean total cost ($26,533 ± $14,748 for volume >20 and MMI <0.042 vs $31,932 ± $24,827 for volume <9 and MMI >0.133; $P < .001$) and higher mean total charges ($97,992 ± $72,997 vs $144,506 ± $141,455; $P < .001$) (Table 4). These hospitals also had a higher overall mortality rate (2.86% vs 29.6%; $P < .001$) and death within 1 year after discharge (2.04% vs 16.8%; $P < .001$). Figure 3, *C* displays the distribution of patients in each category of volume and MMI (centers with the lowest volume and the highest MMI vs centers with the highest volume and lowest MMI) (Figure E1).

Propensity Score Analysis of Volume and MMI

We used propensity score models to compare centers with lowest volume and highest MMI (122 hospitals, 523 patients) to centers with the highest volume and lowest MMI (9 hospitals, 245 patients) in the subgroup of patients with upper lobe cancer who underwent RRUL (Table E8). Results for patients with upper lobe cancer indicated that hospitals with the lowest volume and highest MMI had the highest odds of overall mortality across all categories (OR, 14.2; 95% CI, 9.19-23.2; $P < .001$), 30-day mortality (OR, 10.1; 95% CI, 3.03-53.9; $P < .001$), and 1-year mortality (OR, 9.5; 95% CI, 5.68-17.1; $P < .001$) (Table E9). The Cox proportional hazard adjusted models also indicated that these lowest-volume/highest-mortality hospitals had a greater risk of death after discharge (HR, 11.9; 95% CI, 4.95-28.8; $P < .001$). Moreover, these hospitals were associated with higher total cost (estimated mean

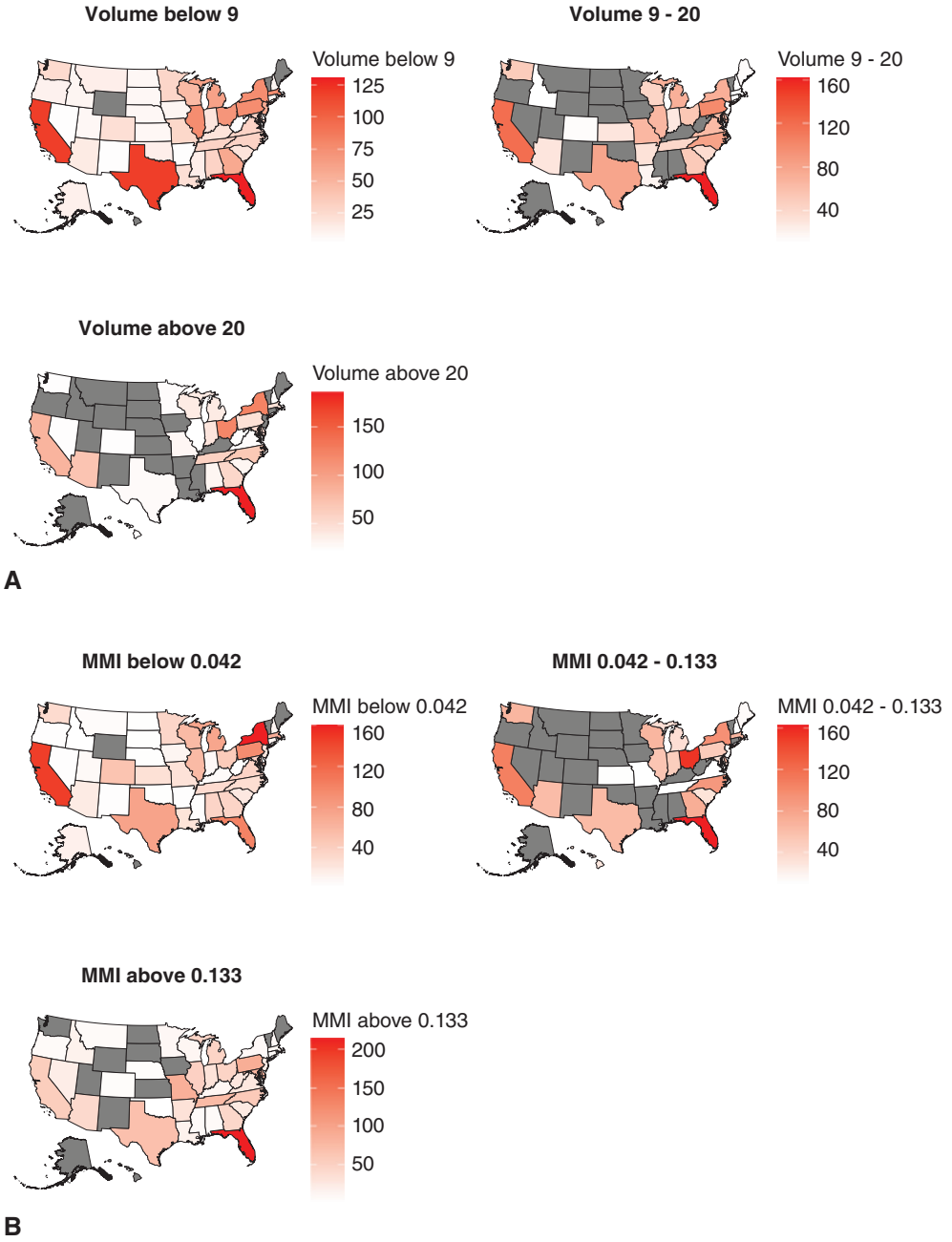

FIGURE 3. A, Distribution of patients in each volume tertile across the United States. States without any patients are in *gray*. B, Distribution of patients in each Medicare Mortality Index (*MMI*) tertile across the United States. States without any patients are in *gray*. C, Distribution of patients in each category of volume and MMI (centers with the lowest volume and the highest MMI vs centers with the highest volume and lowest MMI) across the United States. States without any patients are in *gray*.

[EM], $30,316 [95% CI, $27,513-$33,119] vs $34,222 [95% CI, $31,480-$36,965]; $P = .006$) and total charges (EM, $117,170 [95% CI, $101,718-$132,622] vs $155,252 [95% CI, $140,134-$170,370]; $P < .001$). We used the C-statistic to assess the ability of the logistic regression model to predict an outcome. Tables E10 to E12 present the goodness of fit, including the C-statistics after propensity score adjustment. Values >0.8 indicate a robust model.[26] The C-statistic for volume as a predictor of FTR was 0.8, that for MMI was 0.9, and that for the combination of volume and MMI was 0.8. As an overall mortality predictor, the C-statistic for volume was 0.6, that for MMI was 0.8, and that for the combination of volume and MMI was 0.78 (Tables E10 to E12).

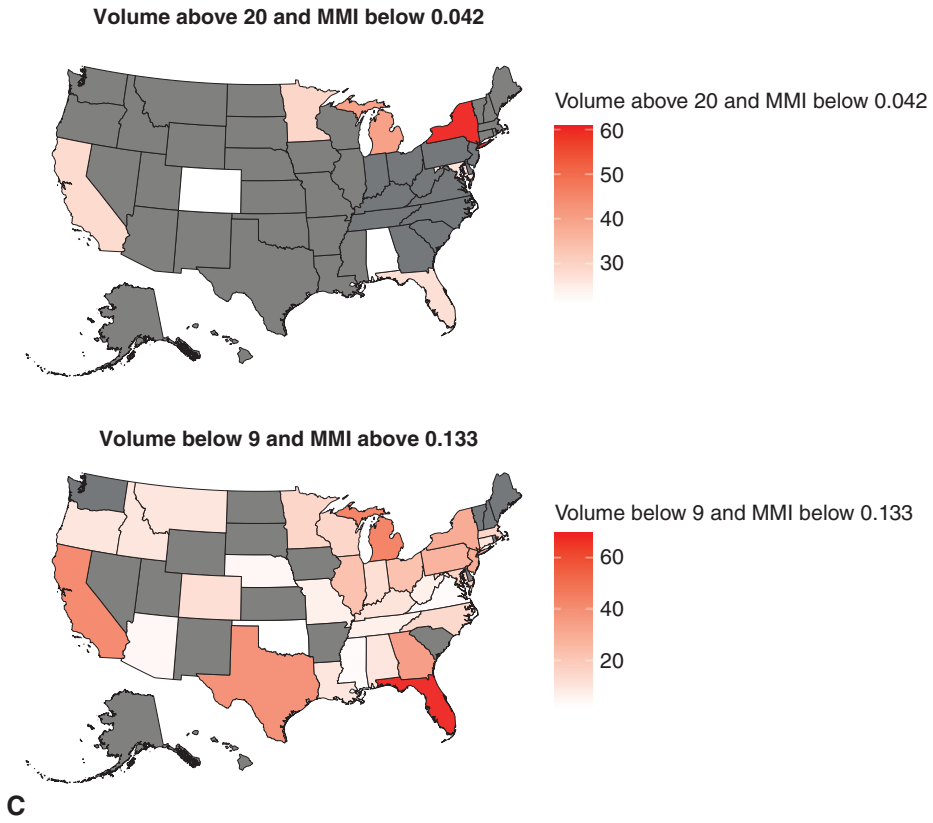

FIGURE 3. Continued.

DISCUSSION

Our results confirm the volume–outcome relationship that supports improved outcomes with higher volume. In this vein, we observed that higher volume is associated with lower rates of respiratory failure, hemorrhagic anemia, conversion to open procedure, and even death. High volume also was associated with corresponding decreases in LOS and overall costs (Figure E3). However, the inclusion of hospital factors as captured by the MMI, defined as number of deaths/number of survivors, highlights the often-overlooked contribution of hospital factors in determining outcomes and quality. High MMI is associated with higher costs, number of complications, and FTR and mortality rates. The MMI has greater predictive power than volume alone. An awareness of the influence of these hospital factors is relevant when establishing novel, high-tech service lines, such as robotic surgery, as these services will be highly influenced by the existing structural characteristics and will influence implementation and quality. As such, the 122 hospitals with the highest MMI and lowest volume had the correspondingly highest mortality, readmission rate, LOS, and cost of hospitalization and the shortest survival across the spectrum of volume and mortality. Furthermore, the independent magnitude of effect attributed to these hospital factors is greater than that of volume and, as such, low volume and high MMI proffer the worst outcomes.

Contrary to our findings, Harrison and colleagues,[27] in their analysis of adult patients who underwent lobectomy/pneumonectomy or esophagectomy for cancer in California, Florida, and New York between 2009 and 2011 using the State Inpatient Databases and Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality, found that majority of patients undergo lung resections at hospitals below proposed cutoff levels, and that these proposed standards for lung resection are not associated with statistically significant differences in outcomes. However, newer studies that also used national databases have demonstrated that higher-volume centers are positively correlated with improved 90-day survival, shorter LOS, and decreased rates of conversion to open thoracotomy, attributed to increased costs.[28,29] A cost-effectiveness specific analysis by Subramaniam and colleagues[5] that used the National Cancer Database stratifying outcomes based on Leapfrog volume standards found that undergoing surgery for clinical stage I non–small cell lung cancer at hospitals that meet Leapfrog volume standards is cost-effective. Although those studies did not specifically use MMI as a tool for categorization, the improved 90-day survival in high-volume centers further

TABLE 2. Study sample characteristics and unadjusted comparison across the tertiles of MMI within the subgroup of patients with upper lobe cancer who underwent robotic resection

Variable	Total (N = 4317)	MMI <0.042 (N = 1480)	MMI 0.042-0.133 (N = 1434)	MMI >0.133 (N = 1403)	*P* value
Age, y, mean ± SD	71.5 ± 6.48	71.3 ± 6.38	71.6 ± 6.53 [SMD, −0.038]	71.5 ± 6.52 [SMD, −0.032]	.542
Female sex, n (%)	2337 (54.1)	802 (54.2)	785 (54.7) [SMD, −0.011]	750 (53.5) [SMD, 0.015]	.789
Race, n (%)			[SMD, 0.103]	[SMD, 0.081]	.014
Black	260 (6.02)	103 (6.96)	66 (4.6)	91 (6.49)	
Other	267 (6.18)	102 (6.89)	94 (6.56)	71 (5.06)	
White	3790 (87.8)	1275 (86.1)	1274 (88.8)	1241 (88.5)	
Charlson score, mean ± SD	2.21 ± 1.11	2.18 ± 1.06	2.1 ± 1.08 [SMD, 0.079]	2.34 ± 1.17 [SMD, −0.142]	.001
Elixhauser score, mean ± SD	3.9 ± 1.81	3.87 ± 1.77	3.74 ± 1.77 [SMD, 0.076]	4.09 ± 1.88 [SMD, −0.117]	.001
Diabetes, n (%)	982 (22.7)	331 (22.4)	296 (20.6) [SMD, 0.042]	355 (25.3) [SMD, −0.069]	.011
Peripheral artery disease, n (%)	320 (7.41)	123 (8.31)	88 (6.14) [SMD, 0.084]	109 (7.77) [SMD, 0.02]	.067
Cardiac disease, n (%)	140 (3.24)	47 (3.18)	45 (3.14) [SMD, 0.002]	48 (3.42) [SMD, −0.014]	.899
Lung disease, n (%)	2057 (47.6)	704 (47.6)	618 (43.1) [SMD, 0.09]	735 (52.4) [SMD, −0.097]	<.001
Gastrointestinal bleeding, n (%)	1387 (32.1)	482 (32.6)	457 (31.9) [SMD, 0.015]	448 (31.9) [SMD, 0.014]	.905
Liver disease, n (%)	106 (2.46)	42 (2.84)	31 (2.16) [SMD, 0.043]	33 (2.35) [SMD, 0.031]	.477
Dysrhythmia, n (%)	1216 (28.2)	406 (27.4)	397 (27.7) [SMD, −0.006]	413 (29.4) [SMD, −0.044]	.432
Anemia, n (%)	700 (16.2)	213 (14.4)	193 (13.5) [SMD, 0.027]	294 (21) [SMD, −0.173]	<.001
Upper lobe cancer, n (%)	4317 (100)	1480 (100)	1434 (100) [SMD, 0]	1403 (100) [SMD, 0]	.352
Thoracoscopy converted to open surgery, n (%)	79 (1.83)	36 (2.43)	11 (0.767) [SMD, 0.133]	32 (2.28) [SMD, 0.01]	.001

MMI, Medicare Mortality Index; *SD*, standard deviation; *SMD*, standardized mean difference.

corroborates the significant impact of volume and MMI on patient outcomes. An apodictic lesson can be learned from the study by Pollock and colleagues,[28] whose analysis of a single-payer system affirmed the substantial benefits to patient outcomes and cost-effectiveness gained from regionalizing lung cancer care.

Medicare data include publicly reported 30-day risk-standardized mortality measures that are condition-specific and procedure-specific. The MMI is a useful indicator of hospital performance, as it compares mortality across the spectrum of hospitals that treat Medicare beneficiaries. This is the first application of this index to adjudicate outcomes in lung resections. The higher the MMI, the higher the mortality observed. The procedure under evaluation in our analysis, right upper lobectomy, is considered a standard thoracic surgical anatomic resection with limited anatomic variation and a comparatively low perioperative mortality.[30] Condition-specific mortality measures include myocardial infarction, chronic obstructive pulmonary disease, heart, failure, stroke, and pneumonia. The MMI is a surrogate for quality, and a low index is associated with better outcomes, survival, functional ability, and quality of life.

The literature is replete with comparisons of robotic versus open surgical approaches to lobectomies.[10,31-33] Indeed, there is a tacit acceptance of the advantages of the minimally, invasive robotic approach and it has become a legitimate alternative to video assisted thoracic surgery.[10,33] Advantages include decreased operative blood loss, faster postoperative recovery, fewer complications, and a less steep learning curve.[34-36] The burgeoning growth of viable robotic programs, nevertheless, is predicated on an existence of a platform of services that can permit, reliable, high-quality outcomes. The inclusion, therefore, of hospital factors in the adjudication of quality is therefore an important consideration. When hospitals embark on starting such programs, these factors can exert an even greater influence on outcomes than volume and if overlooked, can potentially jeopardize the program. In this vein, appropriately staffed intensive care units, optimized nursing ratios, functional cardiology, catheterization units, multi-specialty clinical teams, pharmacy, and rapid response teams are all integral in the maintenance of high-quality care and pivotal in reducing overall mortality in any given institution.

In the analysis, we focus on robotic right upper lobectomy, the most commonly performed anatomic lung resection. We infer that volume is a powerful predictor of outcomes. It remains, nonetheless, an imperfect surrogate

TABLE 3. Association among the tertiles of MMI for patients with upper lobe cancer who underwent robotic resection and each outcome adjusted through propensity score

Outcome	MMI <0.042	MMI 0.042-0.133	MMI >0.133
Death at any time	OR 1 [Referent]	20.4 (13.4-32.9) [$P < .001$]	63.9 (42.2-103) [$P < .001$]
Death in hospital	OR 1 [Referent]	8.8 (3.15-35.6) [$P < .001$]	29.1 (11.1-115) [$P < .001$]
Death within 30 d after discharge	OR 1 [Referent]	8.49 (2.9-37.5) [$P < .001$]	21.6 (7.82-93) [$P < .001$]
Death within 60 d after discharge	OR 1 [Referent]	13.4 (4.72-58.1) [$P < .001$]	41.2 (15.2-176) [$P < .001$]
Death within 90 d after discharge	OR 1 [Referent]	21.9 (7.93-94.1) [$P < .001$]	60.9 (22.6-259) [$P < .001$]
Death within 1 y after discharge	OR 1 [Referent]	11.2 (6.78-20.1) [$P < .001$]	40.7 (25.1-72) [$P < .001$]
Time to death after discharge, d	EM 161 (−48.3 to 371)	402 (345-458) [$P = .064$]	344 (302-386) [$P = .195$]
Time to death after discharge	HR 1 [Referent]	20 (8.77-45.8) [$P < .001$]	50.8 (22.5-115) [$P < .001$]
Time to death after discharge, 1 y follow-up	HR 1 [Referent]	10.8 (4.26-27.1) [$P < .001$]	35.3 (14.4-86.2) [$P < .001$]
Long-term survival	OR 1 [Referent]	0.049 (0.03-0.075) [$P < .001$]	0.016 (0.01-0.024) [$P < .001$]
Thoracoscopy procedure converted to open procedure	OR 1 [Referent]	0.311 (0.208-0.454) [$P < .001$]	0.846 (0.635-1.12) [$P = .247$]
Death in combination with any complication at the index visit (FTR)	OR 1 [Referent]	7.91 (2.8-32.2) [$P < .001$]	18.5 (6.91-73.1) [$P < .001$]
Death in combination with 1 complication at the index visit	OR 1 [Referent]	4.43 (1.47-18.6) [$P = .017$]	7.87 (2.79-31.9) [$P < .001$]
Readmission within 30 d after discharge	OR 1 [Referent]	1.52 (1.31-1.77); $P < .001$	1.59 (1.37-1.86) [$P < .001$]
Pneumothorax (index visit)	OR 1 [Referent]	0.737 (0.626-0.867); $P < .001$	0.852 (0.728-0.997) [$P = .046$]
Pyothorax without fistula (index visit)	OR 1 [Referent]	2.06 (0.527-10.1) [$P = .318$]	2.34 (0.64-11.2) [$P = .226$]
Pyothorax without fistula (within 1 y after discharge)	OR 1 [Referent]	1.02 (0.18-5.99) [$P = .977$]	0.858 (0.136-5.2) [$P = .861$]
Pyothorax with fistula (index visit)	OR 1 [Referent]	0.516 (0.248-1.02) [$P = .064$]	1.39 (0.82-2.4) [$P = .224$]
Atelectasis (index visit)	OR 1 [Referent]	0.844 (0.723-0.985) [$P = .032$]	1.16 (1.01-1.35) [$P = .039$]
Pleural effusion (index visit)	OR 1 [Referent]	0.698 (0.502-0.965) [$P = .031$]	1.34 (1.01-1.77) [$P = .041$]
Pleural effusion (within 30 d after discharge)	OR 1 [Referent]	2.12 (0.526-10.9) [$P = .312$]	5.63 (1.76-26.5) [$P = .009$]
Other postprocedural complications and disorders of respiratory system (index visit)	OR 1 [Referent]	1.1 (0.694-1.76) [$P = .681$]	0.799 (0.48-1.32) [$P = .381$]
Postprocedural air leak (index visit)	OR 1 [Referent]	1.19 (1.04-1.36) [$P = .009$]	1.02 (0.889-1.17) [$P = .792$]
Air leak (index visit)	OR 1 [Referent]	1.29 (1.14-1.47) [$P < .001$]	1.18 (1.04-1.34) [$P = .01$]
Acute pulmonary insufficiency following thoracic surgery (index visit)	OR 1 [Referent]	1.46 (1.02-2.08) [$P = .037$]	2.03 (1.46-2.85) [$P < .001$]
Acute postprocedural respiratory failure (index visit)	OR 1 [Referent]	1.36 (0.785-2.4) [$P = .275$]	2.99 (1.87-4.97) [$P < .001$]
Acute and chronic postprocedural respiratory failure (index visit)	OR 1 [Referent]	0.368 (0.089-1.2) [$P = .12$]	0.241 (0.043-0.889) [$P = .053$]
Postprocedural hemorrhage of a respiratory system organ or structure following a respiratory system procedure (index visit)	OR 1 [Referent]	0.433 (0.157-1.06) [$P = .08$]	0.843 (0.397-1.77) [$P = .65$]

(Continued)

TABLE 3. Continued

Outcome	MMI <0.042	MMI 0.042-0.133	MMI >0.133
Intraoperative hemorrhage and hematoma of a respiratory system organ or structure complicating a respiratory system procedure (index visit)	OR 1 [Referent]	2.07 (0.537-10.1) [$P = .31$]	2.99 (0.867-14) [$P = .108$]
Postprocedural cardiac functional disturbances following surgery (index visit)	OR 1 [Referent]	1.38 (0.974-1.97) [$P = .072$]	0.59 (0.378-0.906) [$P = .017$]
Hemorrhagic disorder due to extrinsic circulating anticoagulants (index visit)	OR 1 [Referent]	0.972 (0.191-4.78) [$P = .971$]	3.08 (0.987-12.5) [$P = .072$]
Postprocedural hypotension (index visit)	OR 1 [Referent]	1.86 (1.28-2.74) [$P = .001$]	1.75 (1.19-2.58) [$P = .005$]
Acute posthemorrhagic anemia (index visit)	OR 1 [Referent]	0.803 (0.649-0.995) [$P = .045$]	1.02 (0.827-1.27) [$P = .828$]
Acute posthemorrhagic anemia (within 1 y after discharge)	OR 1 [Referent]	0.591 (0.194-1.63) [$P = .321$]	1.86 (0.864-4.25) [$P = .123$]
Time to acute posthemorrhagic anemia	HR 1 [Referent]	0.97 (0.655-1.44) [$P = .88$]	1.65 (1.17-2.33) [$P = .004$]
Time to acute posthemorrhagic anemia (censored at 1 y)	HR 1 [Referent]	1.09 (0.67-1.76) [$P = .737$]	1.57 (1.01-2.44) [$P = .043$]
Any complication at the index visit	OR 1 [Referent]	1.02 (0.931-1.11) [$P = .692$]	1.1 (1.01-1.21) [$P = .028$]
Any complication within 30 d of discharge	OR 1 [Referent]	1.51 (0.529-4.66) [$P = .447$]	5.27 (2.31-14.5) [$P < .001$]
Length of stay, d	EM 5.7 (5.52-5.89)	5.23 (5.06-5.4) [$P < .001$]	5.86 (5.67-6.06) [$P = .264$]
Total charges, $	EM 113,011 (108,659-117,538)	115,602 (111,143-120,241) [$P = .542$]	109,420 (105,181-113,830) [$P = .291$]

MMI, Medicare Mortality Index; *OR*, odds ratio; *HR*, hazard ratio; *EM*, estimated mean.

for quality. Several reports corroborate our findings that the magnitude of effect proffered by volume is not the predominant arbiter of postoperative outcomes.[37,38] As such, it would be insufficient to try to predict outcomes using solely volume. Indeed, high-volume centers can have poor outcomes, and low-volume centers can have excellent outcomes (Figure E2). As such, a more granular inclusion of the systems, structures, and environmental infrastructure that constitute the matrix of hospital factors is a worthwhile consideration in predicting outcomes, particularly in the context of novel, high–resource-intensive service lines, such as robotic surgery.

Our analysis has several limitations. First, these outcomes are derived from a claims database designed for administrative and reimbursement purposes, not explicitly for clinical purposes. The accuracy of the data is dependent

TABLE 4. Study sample characteristics and unadjusted comparison across claim volume and MMI (centers with the lowest volume and the highest MMI vs centers with the highest volume and lowest MMI) in the subgroup of patients with upper lobe cancer who underwent robotic resection

Variable	Total (N = 768)	Volume >20 and MMI <0.042 (N = 245)	Volume <9 and MMI >0.133 (N = 523)	*P* value
Total costs, $, mean ± SD	30,209 ± 22,249	26,533 ± 14,748	31,932 ± 24,827 [SMD, −0.265]	<.001
Total charges, $, mean ± SD	129,668 ± 125,633	97,992 ± 72,997	144,506 ± 141,455 [SMD, −0.414]	<.001
Death at any time, n (%)	162 (21.1)	7 (2.86)	155 (29.6) [SMD, −0.779]	<.001
Death in hospital, n (%)	20 (2.6)	1 (0.408)	19 (3.63) [SMD, −0.231]	.018
Death within 30 d after discharge, n (%)	15 (1.95)	1 (0.408)	14 (2.68) [SMD, −0.185]	.066
Death within 1 y after discharge, n (%)	93 (12.1)	5 (2.04)	88 (16.8) [SMD, −0.523]	<.001
Time to death after discharge, d, mean ± SD	341 ± 276	200 ± 140	347 ± 279 [SMD, −0.676]	.05

MMI, Medicare Mortality Index; *SD*, standard deviation; *SMD*, standardized mean difference.

on the accuracy of coding, which increases the potential for coding-related errors and bias.[39] Second, by focusing only on RRUL, we risked systematic bias by omitting other lung resections and decreased the ability to extrapolate to other anatomic resections or surgical approaches. Third, we were not afforded stage-specific data and assumed that the absence of a diagnosis of advanced metastatic disease or of concurrent use of systematic therapies is an indicator of surgically resectable disease. Fourth, this database is missing crucial variables, such as oncologic data and medical tests. Nonetheless, by using Centers for Medicare & Medicaid Services data, we have analyzed data on 98% of adults age $\geq$65 years enrolled in Medicare, capturing a real-world experience of Medicare beneficiaries undergoing RRUL.[39] This provides a window into the intersection of volume and hospital factors in the prediction of surgical outcomes after robotic surgery.

In conclusion, the MMI incorporates hospital-based factors in adjudicating outcomes and is a more sensitive predictor of FTR rates than volume alone. Furthermore, using both MMI and volume can serve as a standard for hospitals considering incorporating robotic lung surgery programs. This approach can aid in improving quality and cost efficiency rather than solely relying on hospital volume.

Conflict of Interest Statement

The 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.

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Key Words: mortality index, robotic lung surgery, Medicare beneficiaries, right upper lobectomy, failure to rescue

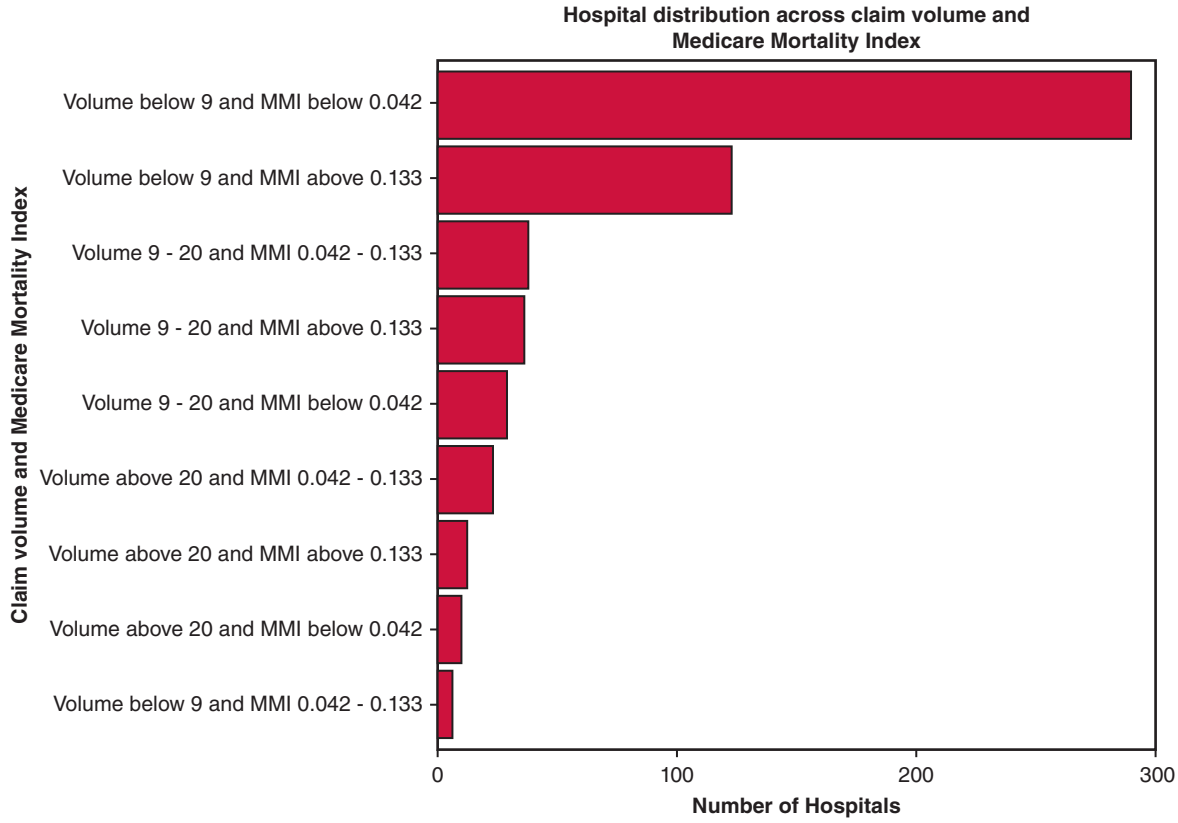

FIGURE E1. Number of hospitals across claim volume and Medicare Mortality Index tertiles. *MMI*, Medicare Mortality Index.

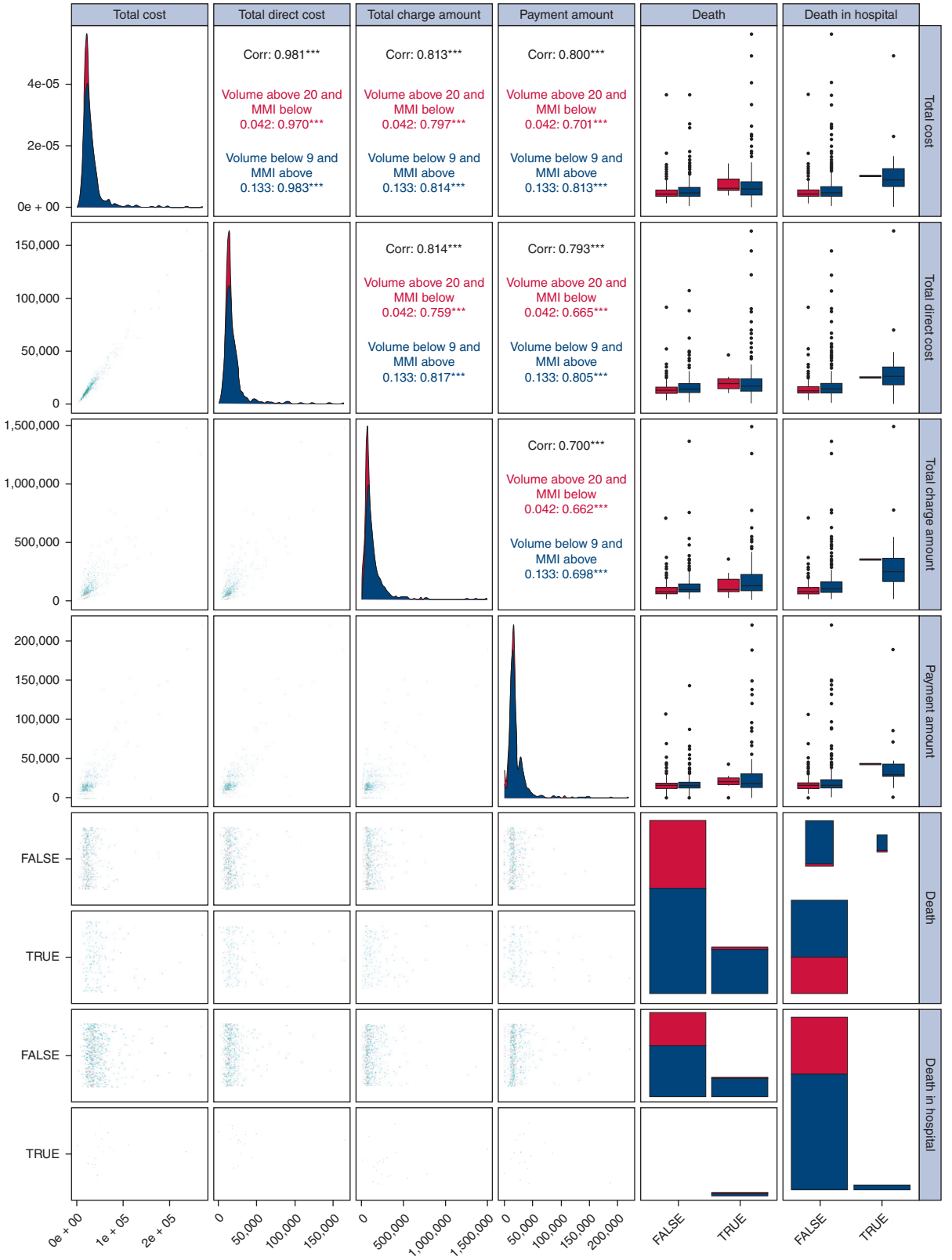

FIGURE E2. Correlation (*Corr*) of outcomes in each category of volume and Medicare Mortality Index (*MMI*) (centers with the lowest volume and the highest MMI vs centers with the highest volume and lowest MMI) for patients who underwent robotic resection.

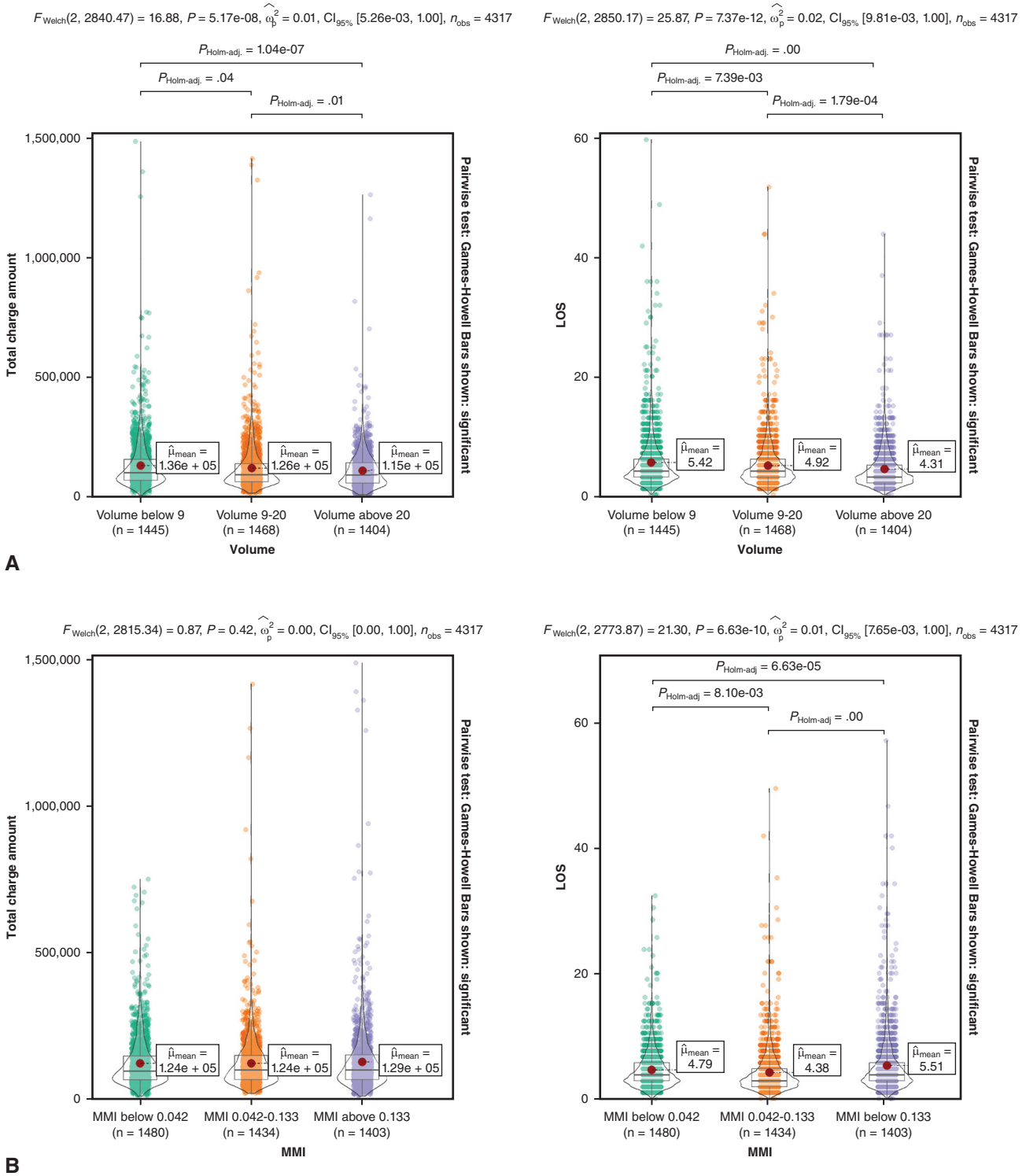

FIGURE E3. A, Distribution of length of stay and charges by volume. B, Distribution of length of stay and charges by Medicare Mortality Index mortality index. *LOS*, Length of stay; *MMI*, Medicare Mortality Index.

TABLE E1. ICD-10 diagnosis code classification system for inclusion criteria

Diagnosis	ICD-10 codes
Upper lobe lung cancer	C34.1 (Malignant neoplasm of upper lobe, bronchus or lung), C34.10 (Malignant neoplasm of upper lobe, unspecified bronchus or lung), C34.11 (Malignant neoplasm of upper lobe, right bronchus or lung), and C34.12 (Malignant neoplasm of upper lobe, left bronchus or lung)
Open lung resection	0BTC0ZZ (Resection of right upper lung lobe, open approach), 0BTD0ZZ (Resection of right middle lung lobe, open approach), 0BTF0ZZ (Resection of right lower lung lobe, open approach), 0BTG0ZZ (Resection of left upper lung lobe, open approach), 0BTH0ZZ (Resection of lung lingula, open approach), and 0BTJ0ZZ (Resection of left lower lung lobe, open approach)
Robotic lung resection	8E0W0CZ (Robotic-assisted procedure of trunk region, open approach), 8E0W3CZ (Robotic-assisted procedure of trunk region, percutaneous approach), 8E0W4CZ (Robotic-assisted procedure of trunk region, percutaneous endoscopic approach), 8E0W7CZ (Robotic-assisted procedure of trunk region, via natural or artificial opening), 8E0W8CZ (Robotic-assisted procedure of trunk region, via natural or artificial opening endoscopic), and 8E0WXCZ (Robotic-assisted procedure of trunk region)

ICD-10, International Classification of Diseases, Tenth Revision.

TABLE E2. ICD-10 diagnosis code classification system for exclusion criteria

Diagnosis	ICD-10 codes
Segmentectomies procedures and other resection besides lobe	0BT30ZZ (Resection, main bronchus, right, open approach), 0BT40ZZ (Resection, upper lobe bronchus, right, open approach), 0BT50ZZ (Resection, middle lobe bronchus, right, open approach), 0BT60ZZ (Resection, lower lobe bronchus, right, open approach), 0BT70ZZ (Resection, main bronchus, left, open approach), 0BT80ZZ (Resection, upper lobe bronchus, left, open approach), 0BT90ZZ (Resection, lingula bronchus, open approach), 0BTB0ZZ (Resection, lower lobe bronchus, left, open approach), 0BTK0ZZ (Resection of right lung, open approach), 0BTL0ZZ (Resection of left lung, open approach), 0BTM0ZZ (Resection of lungs, bilateral, open approach), 0BTT0ZZ (Resection, diaphragm, open approach), 8E0W0CZ (Robotic-assisted procedure of trunk region, open approach), 8E0W3CZ (Robotic-Assisted procedure of trunk region, percutaneous approach), 8E0W4CZ (Robotic-assisted procedure of trunk region, percutaneous endoscopic approach), 8E0W7CZ (Robotic-assisted procedure of trunk region, via natural or artificial opening), 8E0W8CZ (Robotic-assisted procedure of trunk region, via natural or artificial opening endoscopic), 8E0WXCZ (Robotic-assisted procedure of trunk region), 0BT14ZZ (Resection, trachea, percutaneous endoscopic), 0BT24ZZ (Resection, carina, percutaneous endoscopic), 0BT34ZZ (Resection, main bronchus, right, percutaneous endoscopic), 0BT44ZZ (Resection, upper lobe bronchus, right, percutaneous endoscopic), 0BT54ZZ (Resection, middle lobe bronchus, right, percutaneous endoscopic), 0BT64ZZ (Resection, lower lobe bronchus, right, percutaneous endoscopic), 0BT74ZZ (Resection, main bronchus, left, percutaneous endoscopic), 0BT84ZZ (Resection, upper lobe bronchus, left, percutaneous endoscopic), 0BT94ZZ (Resection, lingula bronchus, percutaneous endoscopic), 0BTB4ZZ (Resection, lower lobe bronchus, left, percutaneous endoscopic), 0BTK4ZZ (Resection, lung, right, percutaneous endoscopic), 0BTL4ZZ (Resection, lung, left, percutaneous endoscopic), 0BTM4ZZ (Resection, lungs, bilateral, percutaneous endoscopic), 0BTT4ZZ (Resection, diaphragm, percutaneous endoscopic), 0BBC0ZX (Excision, upper lung lobe, right, open approach), 0BBC0ZZ (Excision, upper lung lobe, right, open approach), 0BBD0ZX (Excision, middle lung lobe, right, open approach), 0BBD0ZZ (Excision, middle lung lobe, right, open approach), 0BBF0ZX (Excision, lower lung lobe, right, open approach), 0BBF0ZZ (Excision, lower lung lobe, right, open approach), 0BBG0ZX (Excision, upper lung lobe, left, open approach), 0BBG0ZZ (Excision, upper lung lobe, left open approach), 0BBH0ZX (Excision, lung lingula, open approach), 0BBH0ZZ (Excision, lung lingula, open approach), 0BBJ0ZX (Excision, lower lung lobe, left open approach), 0BBJ0ZZ (Excision, lower lung lobe, left open approach), 0BBK0ZX (Excision, lung, right, open approach), 0BBK0ZZ (Excision, lung, right, open approach), 0BBL0ZX (Excision, lung, left, open approach), 0BBL0ZZ (Excision, lung, left, open approach), 0BBM0ZX (Excision, lungs, bilateral, open approach), 0BBM0ZZ (Excision, lungs, bilateral, open approach), 0BBC4ZX (Excision, Upper lung lobe, right, percutaneous endoscopic), 0BBC4ZZ (Excision, Upper lung lobe, right, percutaneous endoscopic), 0BBD4ZX (Excision, Middle lung lobe, right, percutaneous endoscopic), 0BBD4ZZ (Excision, Middle lung lobe, right, percutaneous endoscopic), 0BBF4ZX (Excision, Lower lung lobe, right, percutaneous endoscopic), 0BBF4ZZ (Excision, Lower lung lobe, right, percutaneous endoscopic), 0BBG4ZX (Excision, Upper lung lobe, left percutaneous endoscopic), 0BBG4ZZ (Excision, Upper lung lobe, left, percutaneous endoscopic), 0BBH4ZX (Excision, lung lingula, percutaneous endoscopic), 0BBH4ZZ (Excision, lung lingula, percutaneous endoscopic), 0BBJ4ZX (Excision, lower lung lobe, left, percutaneous endoscopic), 0BBJ4ZZ (Excision, lower lung lobe, left, percutaneous endoscopic), 0BBK4ZX (Excision, lung, right, percutaneous endoscopic), 0BBK4ZZ (Excision, lung, right, percutaneous endoscopic), 0BBL4ZX (Excision, lung, left, percutaneous endoscopic), 0BBL4ZZ (Excision, lung, left, percutaneous endoscopic), 0BBM4ZX (Excision, lungs, bilateral, percutaneous endoscopic), and 0BBM4ZZ (Excision, lungs, bilateral, percutaneous endoscopic).

ICD-10, International Classification of Diseases, Tenth Revision.

TABLE E3. ICD-10 diagnosis code classification system for participants' inclusion criteria

Diagnosis	ICD-10 codes
Diabetes mellitus	E08x (Diabetes mellitus due to underlying condition), E09x (Drug or chemical induced diabetes mellitus), E10x (Type 1 diabetes mellitus), E11 (Type 2 diabetes mellitus), E12x (Malnutrition-related diabetes mellitus), E13x (Other specified diabetes mellitus), and E14x (Unspecified diabetes mellitus).
Peripheral artery disease	I70 (Atherosclerosis), I72 (Other aneurysm), I73 (Other peripheral vascular diseases), I77.1 (Stricture of artery), I79.0 (Aneurysm of aorta in diseases classified elsewhere), and I79.1 (Aortitis in diseases classified elsewhere).
Other cardiac disease	I23.0 (Hemopericardium as current complication following acute myocardial infarction), I30 (Acute pericarditis), I31.8 (Other specified diseases of pericardium), I31.9 (Disease of pericardium, unspecified), I34.0 (Nonrheumatic mitral (valve) insufficiency), I34.8 (Other nonrheumatic mitral valve disorders), I35 (Nonrheumatic aortic valve disorders), I36.0 (Nonrheumatic tricuspid-valve-stenosis), I36.8 (Other nonrheumatic tricuspid valve disorders), I37.0 (Nonrheumatic pulmonary valve stenosis), I37.8 (Other pulmonary valve disorders), I51.4 (Myocarditis, unspecified), I51.5 (Myocardial degeneration), I51.7 (Cardiomegaly), I51.81 (Takotsubo syndrome), I51.89 (Other ill-defined heart diseases), and I51.9 (Heart disease, unspecified).
Chronic lung disease	J40 (Bronchitis, not specified as acute or chronic), J41 (Simple and mucopurulent chronic bronchitis), J42 (Unspecified chronic bronchitis), J43 (Emphysema), J44 (Other chronic obstructive pulmonary disease), J45 (Asthma), J47 (Bronchiectasis), J60 (Coalworker's pneumoconiosis), J61 (Pneumoconiosis due to asbestos and other mineral fibers), J62 (Pneumoconiosis due to dust containing silica), J63 (Pneumoconiosis due to other inorganic dusts), J64 (Unspecified pneumoconiosis), J65 (Pneumoconiosis associated with tuberculosis), J66 (Airway disease due to specific organic dust), J67 (Hypersensitivity pneumonitis due to organic dust), J684 (Chronic respiratory conditions due to chemicals, gases, fumes and vapors), J701 (Chronic and other pulmonary manifestations due to radiation), J703 (Chronic drug-induced interstitial lung disorders).
Gastrointestinal bleeding	K228 (Other specified diseases of esophagus), K250 (Acute gastric ulcer with hemorrhage), K252 (Acute gastric ulcer with both hemorrhage and perforation), K254 (Chronic or unspecified gastric ulcer with hemorrhage), K256 (Chronic or unspecified gastric ulcer with both hemorrhage and perforation), K260 (Acute duodenal ulcer with hemorrhage), K262 (Acute duodenal ulcer with both hemorrhage and perforation), K264 (Chronic or unspecified duodenal ulcer with hemorrhage), K266 (Chronic or unspecified duodenal ulcer with both hemorrhage and perforation), K284 (Chronic or unspecified gastrojejunal ulcer with hemorrhage), K290 (Acute gastritis), K922 (Gastrointestinal hemorrhage, unspecified), K25 (Gastric ulcer), K26 (Duodenal ulcer), K27 (Peptic ulcer, site unspecified), K28 (Gastrojejunal ulcer), K21 (Gastro-esophageal reflux disease), K221 (Ulcer of esophagus).
Liver disease	B18 (Chronic viral hepatitis), I85 (Esophageal varices), I864 (Gastric varices), I982 (Oesophageal varices in diseases classified elsewhere), K70 (Alcoholic liver disease), K711 (Toxic liver disease with hepatic necrosis), K713 (Toxic liver disease with chronic persistent hepatitis), K714 (Toxic liver disease with chronic lobular hepatitis), K715 (Toxic liver disease with chronic active hepatitis), K717 (Toxic liver disease with fibrosis and cirrhosis of liver), K72 (Hepatic failure, not elsewhere classified), K73 (Chronic hepatitis, not elsewhere classified), K74 (Fibrosis and cirrhosis of liver), K760 (Fatty (change of) liver, not elsewhere classified), K762 (Central hemorrhagic necrosis of liver), K763 (Infarction of liver), K764 (Peliosis hepatis), K765 (Hepatic veno-occlusive disease), K766 (Portal hypertension), K767 (Hepatorenal syndrome), K768 (Other specified diseases of liver), K769 (Liver disease, unspecified), Z944 (Liver transplant status).
Dysrhythmia	I441 (Atrioventricular block, second degree), I442 (Atrioventricular block, complete), I443 (Other and unspecified atrioventricular block), I456 (Pre-excitation syndrome), I459 (Conduction disorder, unspecified), I46 (Cardiac arrest), I47 (Paroxysmal tachycardia), I49 (Other cardiac arrhythmias), R000 (Tachycardia, unspecified), R001 (Bradycardia, unspecified), R008 (Bradycardia, unspecified), T821 (Mechanical complication of cardiac electronic device), Z450 (Encounter for adjustment and management of cardiac device), Z950 (Presence of cardiac pacemaker).
Anemia	D50 (Iron deficiency anemia), D51 (Vitamin B12 deficiency anemia), D52 (Folate deficiency anemia), D53 (Other nutritional anemias), D55 (Anemia due to enzyme disorders), D56 (Thalassemia), D57 (Sickle-cell disorders), D58 (Other hereditary hemolytic anemias), D59 (Acquired hemolytic anemia), D60 (Acquired pure red cell aplasia-erythroblastopenia), D61 (Other aplastic anemias and other bone marrow failure syndromes), D62 (Acute posthemorrhagic anemia), D63 (Anemia in chronic diseases classified elsewhere), D64 (Other anemias).

ICD-10, International Classification of Diseases, Tenth Revision.

TABLE E4. Study sample characteristics and unadjusted comparisons across the tertiles of claim volume in the subgroup of patients with upper lobe cancer who underwent robotic resection

Variable	Total (N = 4317), n (%)	Volume <9 (N = 1445), n (%)	Volume 9-20 (N = 1468), n (%)	Volume >20 (N = 1404), n (%)	*P* value
Abscess of lung without pneumonia (index visit)	2 (0.046)	1 (0.069)	0 (0) [SMD, 0.037]	1 (0.071) [SMD, −0.001]	.597
Other postprocedural complications and disorders of respiratory system (index visit)	34 (0.788)	14 (0.969)	6 (0.409) [SMD, 0.068]	14 (0.997) [SMD, −0.003]	.129
Air leak (index visit)	570 (13.2)	159 (11)	218 (14.9) [SMD, −0.115]	193 (13.7) [SMD, −0.083]	.007
Acute pulmonary insufficiency following thoracic surgery (index visit)	80 (1.85)	26 (1.8)	21 (1.43) [SMD, 0.029]	33 (2.35) [SMD, −0.039]	.185
Acute postprocedural respiratory failure (index visit)	40 (0.927)	19 (1.31)	13 (0.886) [SMD, 0.041]	8 (0.57) [SMD, 0.077]	.114
Hemorrhagic disorder due to extrinsic circulating anticoagulants (index visit)	6 (0.139)	2 (0.138)	2 (0.136) [SMD, 0.001]	2 (0.142) [SMD, −0.001]	.999
Death at any time	446 (10.3)	161 (11.1)	156 (10.6) [SMD, 0.017]	129 (9.19) [SMD, 0.065]	.208
Death in hospital	44 (1.02)	19 (1.31)	13 (0.886) [SMD, 0.041]	12 (0.855) [SMD, 0.044]	.389
Death within 30 d after discharge	30 (0.695)	15 (1.04)	11 (0.749) [SMD, 0.031]	4 (0.285) [SMD, 0.093]	.051
Death within 60 d after discharge	53 (1.23)	26 (1.8)	17 (1.16) [SMD, 0.053]	10 (0.712) [SMD, 0.098]	.03
Death within 90 d after discharge	76 (1.76)	32 (2.21)	26 (1.77) [SMD, 0.032]	18 (1.28) [SMD, 0.071]	.167
Death within 1 y after discharge	226 (5.24)	92 (6.37)	77 (5.25) [SMD, 0.048]	57 (4.06) [SMD, 0.104]	.022
MMI			[SMD, 1.07]	[SMD, 1.49]	<.001
<0.042	1480 (34.3)	868 (60.1)	367 (25)	245 (17.5)	
0.042-0.133	1434 (33.2)	54 (3.74)	584 (39.8)	796 (56.7)	
>0.133	1403 (32.5)	523 (36.2)	517 (35.2)	363 (25.9)	

SMD, Standardized mean difference; *MMI*, Medicare Mortality Index.

TABLE E5. Study sample characteristics and unadjusted comparison across all combinations of claim volume and MMI within the subgroup of patients with upper lobe cancer who underwent robotic right upper lobe resection

Characteristic	Vol 9-20/MMI <0.042-0.133 (N = 584)	Vol 9-20/MMI > 0.133 (N = 517)	Vol 9-20/MMI < 0.042 (N = 367)	Vol >20/MMI 0.042-0.133 (N = 796)	Vol >20/MMI > 0.133 (N = 363)	Vol >20/MMI <0.042 (N = 2 45)	Vol <9/MMI 0.042-0.133 (N = 54)	Vol <9/MMI > 0.133 (N = 523)	Vol <9/MMI < 0.042 (N = 868)	*P* value
Age, y, mean ± SD	71.2 ± 6.88	71.7 ± 6.44 [SMD, −0.084]	71.5 ± 6.31 [SMD, −0.051]	71.9 ± 6.31 [SMD, −0.118]	71.1 ± 6.28 [SMD, 0.003]	71.7 ± 6.73 [SMD, −0.081]	70.8 ± 5.65 [SMD, 0.061]	71.6 ± 6.75 [SMD, −0.069]	71.2 ± 6.3 [SMD, 0.001]	.211
Female sex, n (%)	318 (54.5)	268 (51.8) [SMD, 0.052]	208 (56.7) [SMD, −0.045]	442 (55.5) [SMD, −0.022]	210 (57.9) [SMD, −0.069]	136 (55.5) [SMD, −0.021]	25 (46.3) [SMD, 0.164]	272 (52) [SMD, 0.049]	458 (52.8) [SMD, 0.034]	.448
Elixhauser score, mean ± SD	3.78 ± 1.76	3.93 ± 1.85 [SMD, −0.083]	3.74 ± 1.76 [SMD, 0.019]	3.67 ± 1.76 [SMD, 0.06]	4.07 ± 1.8 [SMD, −0.167]	3.77 ± 1.75 [SMD, 0.003]	4.26 ± 1.99 [SMD, −0.258]	4.25 ± 1.96 [SMD, −0.254]	3.96 ± 1.77 [SMD, −0.101]	<.001
Diabetes, n (%)	125 (21.4)	130 (25.1) [SMD, −0.089]	80 (21.8) [SMD, −0.01]	159 (20) [SMD, 0.035]	93 (25.6) [SMD, −0.1]	48 (19.6) [SMD, 0.045]	12 (22.2) [SMD, −0.02]	132 (25.2) [SMD, −0.091]	203 (23.4) [SMD, −0.048]	.195
Lung disease, n (%)	245 (42)	264 (51.1) [SMD, −0.183]	163 (44.4) [SMD, −0.05]	342 (43) [SMD, −0.02]	194 (53.4) [SMD, −0.232]	104 (42.4) [SMD, −0.01]	31 (57.4) [SMD, −0.313]	277 (53) [SMD, −0.222]	437 (50.3) [SMD, −0.169]	<.001
Gastrointestinal bleeding, n (%)	193 (33)	160 (30.9) [SMD, 0.045]	125 (34.1) [SMD, −0.021]	246 (30.9) [SMD, 0.046]	111 (30.6) [SMD, 0.053]	85 (34.7) [SMD, −0.035]	18 (33.3) [SMD, −0.006]	177 (33.8) [SMD, −0.017]	272 (31.3) [SMD, 0.037]	.869
Dysrhythmia, n (%)	167 (28.6)	142 (27.5) [SMD, 0.025]	95 (25.9) [SMD, 0.061]	211 (26.5) [SMD, 0.047]	105 (28.9) [SMD, −0.007]	63 (25.7) [SMD, 0.065]	19 (35.2) [SMD, −0.142]	166 (31.7) [SMD, −0.069]	248 (28.6) [SMD, 0.001]	.461
Anemia, n (%)	96 (16.4)	103 (19.9) [SMD, −0.09]	49 (13.4) [SMD, 0.087]	88 (11.1) [SMD, 0.157]	65 (17.9) [SMD, −0.039]	26 (10.6) [SMD, 0.171]	9 (16.7) [SMD, −0.006]	126 (24.1) [SMD, −0.191]	138 (15.9) [SMD, 0.015]	<.001
Death at any time, n (%)	46 (7.88)	110 (21.3) [SMD, −0.387]	0 (0) [SMD, 0.414]	65 (8.17) [SMD, −0.011]	57 (15.7) [SMD, −0.244]	7 (2.86) [SMD, 0.224]	6 (11.1) [SMD, −0.111]	155 (29.6) [SMD, −0.58]	0 (0) [SMD, 0.414]	<.001
Death in hospital, n (%)	3 (0.514)	10 (1.93) [SMD, −0.129]	0 (0) [SMD, 0.102]	5 (0.628) [SMD, −0.015]	6 (1.65) [SMD, −0.11]	1 (0.408) [SMD, 0.016]	0 (0) [SMD, 0.102]	19 (3.63) [SMD, −0.22]	0 (0) [SMD, 0.102]	<.001
Death within 30 d after discharge, n (%)	5 (0.856)	6 (1.16) [SMD, −0.03]	0 (0) [SMD, 0.131]	1 (0.126) [SMD, 0.105]	2 (0.551) [SMD, 0.037]	1 (0.408) [SMD, 0.057]	1 (1.85) [SMD, −0.086]	14 (2.68) [SMD, −0.139]	0 (0) [SMD, 0.131]	<.001
Long-term survival, n (%)	538 (92.1)	407 (78.7) [SMD, 0.387]	367 (100) [SMD, −0.414]	731 (91.8) [SMD, 0.011]	306 (84.3) [SMD, 0.244]	238 (97.1) [SMD, −0.224]	48 (88.9) [SMD, 0.111]	368 (70.4) [SMD, 0.58]	868 (100) [SMD, −0.414]	<.001
Thoracoscopy converted to open surgery, n (%)	7 (1.2)	15 (2.9) [SMD, −0.12]	7 (1.91) [SMD, −0.057]	4 (0.503) [SMD, 0.076]	8 (2.2) [SMD, −0.078]	4 (1.63) [SMD, −0.037]	0 (0) [SMD, 0.156]	9 (1.72) [SMD, −0.044]	25 (2.88) [SMD, −0.119]	.014
Readmission within 30 d, n (%)	57 (9.76)	52 (10.1) [SMD, −0.01]	28 (7.63) [SMD, 0.076]	80 (10.1) [SMD, −0.01]	36 (9.92) [SMD, −0.005]	14 (5.71) [SMD, 0.152]	6 (11.1) [SMD, −0.044]	65 (12.4) [SMD, −0.085]	61 (7.03) [SMD, 0.099]	.023
Pneumothorax, n (%)	55 (9.42)	36 (6.96) [SMD, 0.09]	35 (9.54) [SMD, −0.004]	35 (4.4) [SMD, 0.199]	35 (9.64) [SMD, −0.008]	24 (9.8) [SMD, −0.013]	1 (1.85) [SMD, 0.333]	34 (6.5) [SMD, 0.108]	66 (7.6) [SMD, 0.065]	.002
Pyothorax without fistula, n (%)	1 (0.171)	1 (0.193) [SMD, −0.005]	0 (0) [SMD, 0.059]	1 (0.126) [SMD, 0.012]	1 (0.275) [SMD, −0.022]	1 (0.408) [SMD, −0.044]	0 (0) [SMD, 0.059]	1 (0.191) [SMD, −0.005]	0 (0) [SMD, 0.059]	.872
Pyothorax with fistula, n (%)	4 (0.685)	3 (0.58) [SMD, 0.013]	0 (0) [SMD, 0.117]	0 (0) [SMD, 0.117]	2 (0.551) [SMD, 0.017]	1 (0.408) [SMD, 0.038]	0 (0) [SMD, 0.117]	6 (1.15) [SMD, −0.049]	7 (0.806) [SMD, −0.014]	.159
Lung abscess without pneumonia, n (%)	0 (0)	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	1 (0.275) [SMD, −0.074]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	1 (0.115) [SMD, −0.048]	.599
Lung abscess with pneumonia, n (%)	0 (0)	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	<.001
Atelectasis, n (%)	46 (7.88)	48 (9.28) [SMD, −0.05]	26 (7.08) [SMD, 0.03]	53 (6.66) [SMD, 0.047]	50 (13.8) [SMD, −0.191]	22 (8.98) [SMD, −0.04]	3 (5.56) [SMD, 0.093]	56 (10.7) [SMD, −0.098]	84 (9.68) [SMD, −0.064]	.007
Pleural effusion, n (%)	9 (1.54)	17 (3.29) [SMD, −0.114]	6 (1.63) [SMD, −0.008]	11 (1.38) [SMD, 0.013]	11 (3.03) [SMD, −0.1]	4 (1.63) [SMD, −0.007]	0 (0) [SMD, 0.177]	14 (2.68) [SMD, −0.079]	20 (2.3) [SMD, −0.056]	.224
Air leak, n (%)	103 (17.6)	64 (12.4) [SMD, 0.148]	51 (13.9) [SMD, 0.103]	95 (11.9) [SMD, 0.161]	69 (19) [SMD, −0.035]	29 (11.8) [SMD, 0.164]	8 (14.8) [SMD, 0.077]	59 (11.3) [SMD, 0.181]	92 (10.6) [SMD, 0.203]	<.001
Respiratory failure, n (%)	4 (0.685)	8 (1.55) [SMD, −0.082]	1 (0.272) [SMD, 0.06]	5 (0.628) [SMD, 0.007]	3 (0.826) [SMD, −0.016]	0 (0) [SMD, 0.117]	0 (0) [SMD, 0.117]	13 (2.49) [SMD, −0.145]	6 (0.691) [SMD, −0.001]	.005
Postprocedural hemorrhage, n (%)	0 (0)	3 (0.58) [SMD, −0.108]	0 (0) [SMD, 0]	1 (0.126) [SMD, −0.05]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	1 (1.85) [SMD, −0.194]	2 (0.382) [SMD, −0.088]	5 (0.576) [SMD, −0.108]	.069
Intraoperative hemorrhage, n (%)	2 (0.342)	1 (0.193) [SMD, 0.029]	1 (0.272) [SMD, 0.013]	0 (0) [SMD, 0.083]	0 (0) [SMD, 0.083]	0 (0) [SMD, 0.083]	0 (0) [SMD, 0.083]	2 (0.382) [SMD, −0.007]	0 (0) [SMD, 0.083]	.454

(Continued)

TABLE E5. Continued

Characteristic	Vol 9-20/MMI <0.042-0.133 (N = 584)	Vol 9-20/MMI > 0.133 (N = 517)	Vol 9-20/MMI < 0.042 (N = 367)	Vol >20/MMI 0.042-0.133 (N = 796)	Vol >20/MMI > 0.133 (N = 363)	Vol >20/MMI <0.042 (N = 2 45)	Vol <9/MMI 0.042-0.133 (N = 54)	Vol <9/MMI > 0.133 (N = 523)	Vol <9/MMI < 0.042 (N = 868)	*P* value
Sepsis, n (%)	0 (0)	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	3 (0.574) [SMD, −0.107]	0 (0) [SMD, 0]	.005
Superficial surgical site infection, n (%)	0 (0)	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	1 (0.275) [SMD, −0.074]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	1 (0.191) [SMD, −0.062]	0 (0) [SMD, 0]	.426
Wound dehiscence, n (%)	0 (0)	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	0 (0) [SMD, 0]	1 (0.191) [SMD, −0.062]	0 (0) [SMD, 0]	.509
Any complication, n (%)	268 (45.9)	223 (43.1) [SMD, 0.055]	164 (44.7) [SMD, 0.024]	304 (38.2) [SMD, 0.156]	193 (53.2) [SMD, −0.146]	98 (40) [SMD, 0.119]	26 (48.1) [SMD, −0.045]	243 (46.5) [SMD, −0.011]	360 (41.5) [SMD, 0.089]	<.001
Any complication within 30 d of discharge, n (%)	1 (0.171)	3 (0.58) [SMD, −0.067]	1 (0.272) [SMD, −0.022]	2 (0.251) [SMD, −0.017]	1 (0.275) [SMD, −0.022]	0 (0) [SMD, 0.059]	0 (0) [SMD, 0.059]	6 (1.15) [SMD, −0.121]	1 (0.115) [SMD, 0.015]	.089
LOS, d, mean ± SD	1.61 ± 0.509	1.67 ± 0.538 [SMD, −0.116]	1.59 ± 0.457 [SMD, 0.045]	1.47 ± 0.507 [SMD, 0.284]	1.62 ± 0.523 [SMD, −0.005]	1.55 ± 0.505 [SMD, 0.129]	1.49 ± 0.584 [SMD, 0.226]	1.76 ± 0.594 [SMD, −0.271]	1.67 ± 0.484 [SMD, −0.113]	<.001
Total costs, $, mean ± SD	10.1 ± 0.445	10.1 ± 0.456 [SMD, 0.155]	10.1 ± 0.478 [SMD, 0.145]	10.1 ± 0.423 [SMD, 0.044]	10.1 ± 0.4 [SMD, 0.099]	10.1 ± 0.397 [SMD, 0.07]	10.1 ± 0.479 [SMD, 0.019]	10.2 ± 0.52 [SMD, −0.183]	10.1 ± 0.445 [SMD, 0.049]	<.001
Total charges, $, mean ± SD	11.6 ± 0.586	11.5 ± 0.595 [SMD, 0.064]	11.5 ± 0.583 [SMD, 0.04]	11.5 ± 0.547 [SMD, 0.035]	11.4 ± 0.671 [SMD, 0.231]	11.3 ± 0.638 [SMD, 0.449]	11.5 ± 0.508 [SMD, 0.092]	11.6 ± 0.655 [SMD, −0.11]	11.6 ± 0.58 [SMD, −0.085]	<.001

MMI, Medicare Mortality Index; *SD*, standard deviation; *SMD*, standardized mean difference; *LOS*, length of stay.

TABLE E6. Study sample characteristics and unadjusted comparison across centers with the lowest volume and lowest MMI versus centers with the highest volume and highest MMI within the subgroup of patients with upper lobe cancer who underwent robotic right upper lobe resection

Variable	Total (N = 612)	Vol <9 and MMI <0.042 (N = 431)	Vol >20 and MMI >0.133 (N = 181)	*P* value
Age, y, mean ± SD	71 ± 6.25	71 ± 6.24	71 ± 6.29 [SMD, −0.001]	.988
Female sex, n (%)	335 (54.7)	234 (54.3)	101 (55.8) [SMD, −0.03]	.8
Diabetes, n (%)	153 (25)	104 (24.1)	49 (27.1) [SMD, −0.067]	.506
Lung disease, n (%)	313 (51.1)	220 (51)	93 (51.4) [SMD, −0.007]	1
Gastrointestinal bleeding, n (%)	191 (31.2)	133 (30.9)	58 (32) [SMD, −0.026]	.847
Dysrhythmia, n (%)	181 (29.6)	128 (29.7)	53 (29.3) [SMD, 0.009]	.995
Anemia, n (%)	107 (17.5)	75 (17.4)	32 (17.7) [SMD, −0.007]	1
Death at any time, n (%)	26 (4.25)	0 (0)	26 (14.4) [SMD, −0.579]	<.001
Death in hospital, n (%)	1 (0.163)	0 (0)	1 (0.552) [SMD, −0.105]	.654
Death within 30 d after discharge, n (%)	2 (0.327)	0 (0)	2 (1.1) [SMD, −0.149]	.159
Death within 60 d after discharge, n (%)	4 (0.654)	0 (0)	4 (2.21) [SMD, −0.213]	.011
Death within 90 d after discharge, n (%)	5 (0.817)	0 (0)	5 (2.76) [SMD, −0.238]	.003
Death within 1 y after discharge, n (%)	11 (1.8)	0 (0)	11 (6.08) [SMD, −0.36]	<.001
Time to death after discharge, d, mean ± SD	381 ± 262	(+-)	381 ± 262	
Time to death after discharge, d, mean ± SD	233 ± 319	228 ± 313	247 ± 331	
Time to death after discharge (1-y follow-up), d, mean ± SD	141 ± 164	140 ± 162	143 ± 167	
Long-term survival, n (%)	586 (95.8)	431 (100)	155 (85.6) [SMD, 0.579]	<.001
Thoracoscopy procedure converted to open procedure, n (%)	16 (2.61)	14 (3.25)	2 (1.1) [SMD, 0.147]	.215
Death in combination with any complication at the index visit, n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Death in combination with any complication within 90 d, n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Death in combination with any complication within 1 y, n (%)	2 (0.327)	0 (0)	2 (1.1) [SMD, −0.149]	.159
Death in combination with 1 complication at the index visit, n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Death in combination with 2 complications at the index visit, n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Death in combination with 3 complications at the index visit, n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Readmission within 30 d after discharge, n (%)	50 (8.17)	28 (6.5)	22 (12.2) [SMD, −0.196]	.03
Readmission within 60 d after discharge, n (%)	74 (12.1)	44 (10.2)	30 (16.6) [SMD, −0.188]	.039
Readmission within 90 d after discharge, n (%)	90 (14.7)	54 (12.5)	36 (19.9) [SMD, −0.201]	.026
Readmission within 1 y after discharge, n (%)	158 (25.8)	97 (22.5)	61 (33.7) [SMD, −0.251]	.005
Time until readmission after discharge, d, mean ± SD	199 ± 218	196 ± 221	203 ± 215 [SMD, −0.031]	.829
Time until readmission after discharge, d, mean ± SD	175 ± 275	172 ± 267	183 ± 293	
Time until readmission after discharge (1-y follow-up), d, mean ± SD	115 ± 151	116 ± 150	112 ± 152	
Pneumothorax (index visit), n (%)	42 (6.86)	25 (5.8)	17 (9.39) [SMD, −0.136]	.153
Pyothorax without fistula (index visit), n (%)	1 (0.163)	0 (0)	1 (0.552) [SMD, −0.105]	.654

(Continued)

TABLE E6. Continued

Variable	Total (N = 612)	Vol <9 and MMI <0.042 (N = 431)	Vol >20 and MMI >0.133 (N = 181)	*P* value
Pyothorax without fistula (within 1 y after discharge), n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Time to pyothorax without fistula, d, mean ± SD	238 ± 325	225 ± 312	269 ± 351	
Time to pyothorax without fistula (censored at 1 y, d, mean ± SD)	142 ± 164	139 ± 162	148 ± 170	
Pyothorax with fistula (index visit), n (%)	3 (0.49)	2 (0.464)	1 (0.552) [SMD, −0.012]	1
Abscess of lung without pneumonia (index visit), n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Abscess of lung with pneumonia (index visit), n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Atelectasis (index visit), n (%)	64 (10.5)	39 (9.05)	25 (13.8) [SMD, −0.15]	.107
Atelectasis (within 1 y after discharge), n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Time to atelectasis, d, mean ± SD	233 ± 321	223 ± 311	256 ± 345	
Time to atelectasis (censored at 1 y), d, mean ± SD	139 ± 163	138 ± 161	143 ± 168	
Pleural effusion (index visit), n (%)	22 (3.59)	14 (3.25)	8 (4.42) [SMD, −0.061]	.636
Pleural effusion (within 30 d after discharge), n (%)	1 (0.163)	0 (0)	1 (0.552) [SMD, −0.105]	.654
Pleural effusion (within 1 y after discharge), n (%)	4 (0.654)	1 (0.232)	3 (1.66) [SMD, −0.148]	.148
Time to pleural effusion, d, mean ± SD	233 ± 321	222 ± 310	257 ± 346	
Time to pleural effusion (censored at 1 y), d, mean ± SD	139 ± 163	138 ± 161	142 ± 168	
Other postprocedural complications and disorders of respiratory system (index visit), n (%)	7 (1.14)	5 (1.16)	2 (1.1) [SMD, 0.005]	1
Postprocedural air leak (index visit), n (%)	63 (10.3)	50 (11.6)	13 (7.18) [SMD, 0.152]	.135
Air leak (index visit), n (%)	86 (14.1)	48 (11.1)	38 (21) [SMD, −0.271]	.002
Acute pulmonary insufficiency following thoracic surgery (index visit), n (%)	20 (3.27)	8 (1.86)	12 (6.63) [SMD, −0.239]	.005
Acute postprocedural respiratory failure (index visit), n (%)	5 (0.817)	3 (0.696)	2 (1.1) [SMD, −0.043]	.983
Acute and chronic postprocedural respiratory failure (index visit), n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Postprocedural hemorrhage of a respiratory system organ or structure following a respiratory system procedure (index visit), n (%)	3 (0.49)	3 (0.696)	0 (0) [SMD, 0.118]	.623
Intraoperative hemorrhage and hematoma of a respiratory system organ or structure complicating a respiratory system procedure (index visit), n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Sepsis following a procedure (index visit), n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Superficial surgical site infection (index visit), n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Wound dehiscence (index visit), n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Postprocedural cardiac functional disturbances following surgery (index visit), n (%)	14 (2.29)	12 (2.78)	2 (1.1) [SMD, 0.122]	.331
Hemorrhagic disorder due to extrinsic circulating anticoagulants (index visit), n (%)	1 (0.163)	1 (0.232)	0 (0) [SMD, 0.068]	1
Adverse effect of anticoagulants (index visit), n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Postprocedural septic shock (index visit), n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Postprocedural cardiogenic shock (index visit), n (%)	(%)	(%)	(%) [SMD, 0]	<.001

(Continued)

TABLE E6. Continued

Variable	Total (N = 612)	Vol <9 and MMI <0.042 (N = 431)	Vol >20 and MMI >0.133 (N = 181)	*P* value
Postprocedural shock unspecified (index visit), n (%)	(%)	(%)	(%) [SMD, 0]	<.001
Postprocedural hypotension (index visit), n (%)	4 (0.654)	2 (0.464)	2 (1.1) [SMD, −0.073]	.728
Acute posthemorrhagic anemia (index visit), n (%)	58 (9.48)	38 (8.82)	20 (11) [SMD, −0.075]	.478
Acute posthemorrhagic anemia (within 1 y after discharge), n (%)	1 (0.163)	1 (0.232)	0 (0) [SMD, 0.068]	1
Time to acute posthemorrhagic anemia, d, mean ± SD	234 ± 320	222 ± 309	260 ± 344	
Time to acute posthemorrhagic anemia (censored at 1 y), d, mean ± SD	140 ± 163	138 ± 161	146 ± 169	
Other intraoperative complications of respiratory system (index visit)	(%)	(%)	(%) [SMD, 0]	<.001
Any complication at the index visit	281 (45.9)	177 (41.1)	104 (57.5) [SMD, −0.332]	<.001
Any complication within 30 d of discharge	2 (0.327)	1 (0.232)	1 (0.552) [SMD, −0.051]	1
Any complication within 1 y of discharge	11 (1.8)	5 (1.16)	6 (3.31) [SMD, −0.146]	.134
Time to any complication at the index visit, d, mean ± SD	216 ± 311	209 ± 300	235 ± 336	
Time to any complication at the index visit (censored at 1 y), d, mean ± SD	132 ± 160	132 ± 159	131 ± 164	
LOS, d, mean ± SD	1.65 ± 0.503	1.67 ± 0.489	1.61 ± 0.535 [SMD, 0.101]	.266
Total costs, $, mean ± SD	10.1 ± 0.451	10.1 ± 0.463	10.1 ± 0.42 [SMD, 0.046]	.6
Total direct cost, $, mean ± SD	9.6 ± 0.463	9.59 ± 0.475	9.64 ± 0.43 [SMD, −0.112]	.2
Total charges, $, mean ± SD	11.6 ± 0.632	11.6 ± 0.604	11.4 ± 0.678 [SMD, 0.308]	<.001
Payment amount, $, mean ± SD	9.28 ± 2.08	9.39 ± 1.84	9.04 ± 2.56 [SMD, 0.159]	.094

MMI, Medicare Mortality Index; *SD*, standard deviation; *SMD*, standardized mean difference; *LOS*, length of stay.

TABLE E7. Study sample characteristics and unadjusted comparison across the tertiles of MMI within the subgroup of patients with upper lobe cancer who underwent robotic right upper lobe resection

Variable	Total (N = 4317), n (%)	MMI <0.042 (N = 1480), n (%)	MMI 0.042-0.133 (N = 1434), n (%)	MMI >0.133 (N = 1403), n (%)	*P* value
Other postprocedural complications and disorders of respiratory system (index visit)	34 (0.788)	12 (0.811)	12 (0.837) [SMD, −0.003]	10 (0.713) [SMD, 0.011]	.925
Air leak (index visit)	570 (13.2)	172 (11.6)	206 (14.4) [SMD, −0.082]	192 (13.7) [SMD, −0.062]	.074
Acute pulmonary insufficiency following thoracic surgery (index visit)	80 (1.85)	18 (1.22)	23 (1.6) [SMD, −0.033]	39 (2.78) [SMD, −0.112]	.005
Acute postprocedural respiratory failure (index visit)	40 (0.927)	7 (0.473)	9 (0.628) [SMD, −0.021]	24 (1.71) [SMD, −0.119]	<.001
Hemorrhagic disorder due to extrinsic circulating anticoagulants (index visit)	6 (0.139)	1 (0.068)	1 (0.07) [SMD, −0.001]	4 (0.285) [SMD, −0.052]	.202
Death at any time	446 (10.3)	7 (0.473)	117 (8.16) [SMD, −0.385]	322 (23) [SMD, −0.746]	<.001
Death in hospital	44 (1.02)	1 (0.068)	8 (0.558) [SMD, −0.088]	35 (2.49) [SMD, −0.217]	<.001
Death within 30 d after discharge	30 (0.695)	1 (0.068)	7 (0.488) [SMD, −0.08]	22 (1.57) [SMD, −0.167]	<.001
Death within 60 d after discharge	53 (1.23)	1 (0.068)	11 (0.767) [SMD, −0.109]	41 (2.92) [SMD, −0.237]	<.001
Death within 90 d after discharge	76 (1.76)	1 (0.068)	18 (1.26) [SMD, −0.147]	57 (4.06) [SMD, −0.284]	<.001
Death within 1 y after discharge	226 (5.24)	5 (0.338)	48 (3.35) [SMD, −0.225]	173 (12.3) [SMD, −0.508]	<.001
Claim volume			[SMD, 1.52]	[SMD, 0.438]	<.001
<9	1445 (33.5)	868 (58.6)	54 (3.77)	523 (37.3)	
9-20	1468 (34)	367 (24.8)	584 (40.7)	517 (36.8)	
>20	1404 (32.5)	245 (16.6)	796 (55.5)	363 (25.9)	

MMI, Medicare Mortality Index; *SMD*, standardized mean difference.

TABLE E8. Number of hospitals in each tertile of volume and MMI

	MMI		
Volume	**<0.042**	**0.042-0.133**	**>0.133**
<9	290	6	122
9-20	29	38	36
>20	9	23	12

MMI, Medicare Mortality Index.

TABLE E9. Association between volume and MMI (centers with the lowest volume and the highest MMI vs centers with the highest volume and lowest MMI) adjusted via propensity score

Variable	Volume >20 and MMI <0.042	Volume <9 and MMI >0.133
Total costs	EM 30,316 (27,513-33,119)	34,222 (31,480-36,965) [$P = .006$]
Total direct costs	EM 17,971 (16,308-19,634)	20,591 (18,964-22,218) [$P = .002$]
Total charges	EM 117,170 (101,718-132,622)	155,252 (140,134-170,370) [$P < .001$]
Payment amount	EM 19,472 (17,206-21,737)	23,089 (20,873-25,305) [$P = .002$]
Death at any time	OR 1 [Referent]	14.2 (9.19-23.2) [$P < .001$]
Death in hospital	OR 1 [Referent]	7.46 (2.67-28.2) [$P < .001$]
Death within 30 d after discharge	OR 1 [Referent]	10.1 (3.03-53.9) [$P = .001$]
Death within 1 y after discharge	OR 1 [Referent]	9.5 (5.68-17.1) [$P < .001$]
Time to death after discharge, d	EM 116 (−55.3 to 287)	312 (244-380) [$P = .019$]
Time to death after discharge	HR 1 [Referent]	11.9 (4.95-28.8) [$P < .001$]
Time to death after discharge (1-y follow-up)	HR 1 [Referent]	8.81 (3.36-23.1) [$P < .001$]

MMI, Medicare Mortality Index; *EM*, estimated mean; *OR*, odds ratio; *HR*, hazard ratio.

TABLE E10. Model goodness of fit for the association with tertiles of volume

Outcome	BIC	AIC	C-statistic
Death at any time	2707.16316	2777.23663	0.6712157
Death in hospital	405.82205	475.89552	0.863272
Death within 30 d after discharge	331.04547	401.11895	0.8382707
Death within 60 d after discharge	506.83324	576.90671	0.8234805
Death within 90 d after discharge	692.3938	762.46728	0.7869063
Death within 1 y after discharge	1678.21847	1748.29195	0.6938364
Time to death after discharge, d	5605.75006	5653.70749	0.5992721
Time to death after discharge	6142.41229	6182.37681	NA
Time to death after discharge (1-y follow-up)	3590.9399	3625.14525	NA
Long-term survival	2707.16316	2777.23663	0.6712157
Thoracoscopy procedure converted to open procedure	782.3105	852.38398	0.6848988
Death in combination with any complication at the index visit (FTR)	314.03067	384.10414	0.8854288
Death in combination with any complication within 90 d	79.77587	149.84935	0.9185297
Death in combination with any complication within 1 y	255.50388	325.57735	0.7712067
Death in combination with 1 complication at the index visit	185.64148	255.71496	0.8426098
Death in combination with 2 complications at the index visit	92.20464	162.27811	0.9639045
Death in combination with 3 complications at the index visit	92.8052	162.87868	0.9325395
Readmission within 30 d after discharge	2641.51223	2711.58571	0.5942789
Readmission within 60 d after discharge	3260.33367	3330.40714	0.5921249
Readmission within 90 d after discharge	3631.80076	3701.87424	0.5981056
Readmission within 1 y after discharge	4969.10905	5039.18253	0.597879
Time until readmission after discharge, d	19,883.02661	19,946.51012	0.5420963
Time until readmission after discharge	23,019.30656	23,072.20949	NA
Time until readmission after discharge (1-y follow-up)	18,939.63442	18,990.32466	NA
Pneumothorax (index visit)	2288.03425	2358.10772	0.5764136
Pyothorax without fistula (index visit)	100.89183	170.9653	0.8807701
Pyothorax without fistula (within 1 y after discharge)	64.63425	134.70772	0.8732422
Time to pyothorax without fistula	647.88774	664.52335	NA
Time to pyothorax without fistula (censored at 1 y)	589.08184	604.63532	NA
Pyothorax with fistula (index visit)	290.62855	360.70203	0.7367307
Abscess of lung without pneumonia (index visit)	44.4429	114.51637	0.9865006
Abscess of lung with pneumonia (index visit)	22	92.07348	NA
Atelectasis (index visit)	2518.28591	2588.35939	0.6545624
Atelectasis (within 1 y after discharge)	57.92013	127.99361	0.9531757
Time to atelectasis	1982.43337	2010.55521	NA
Time to atelectasis (censored at 1 y)	1514.45399	1539.67188	NA
Pleural effusion (index visit)	882.17013	952.2436	0.630903
Pleural effusion (within 30 d after discharge)	120.38009	190.45356	0.8096861
Pleural effusion (within 1 y after discharge)	315.84842	385.9219	0.7821376
Time to pleural effusion	3700.61773	3734.95495	NA
Time to pleural effusion (censored at 1 y)	3097.49507	3129.85949	NA
Other postprocedural complications and disorders of respiratory system (index visit)	400.06555	470.13903	0.7112112
Postprocedural air leak (index visit)	3083.47267	3153.54615	0.5686714
Air leak (index visit)	3360.05071	3430.12419	0.5707801

(Continued)

TABLE E10. Continued

Outcome	BIC	AIC	C-statistic
Acute pulmonary insufficiency following thoracic surgery (index visit)	764.63941	834.71288	0.7225912
Acute postprocedural respiratory failure (index visit)	436.90621	506.97968	0.7481821
Acute and chronic postprocedural respiratory failure (index visit)	83.01001	153.08348	0.9358998
Postprocedural hemorrhage of a respiratory system organ or structure following a respiratory system procedure (index visit)	160.04815	230.12163	0.8750097
Intraoperative hemorrhage and hematoma of a respiratory system organ or structure complicating a respiratory system procedure (index visit)	100.42536	170.49883	0.86403
Sepsis following a procedure (index visit)	53.44567	123.51914	0.9826534
Infection following a procedure, superficial incisional surgical site (index visit)	40.1214	110.19487	0.9960603
Disruption of external operation (surgical) wound (index visit)	22.00002	92.07349	1
Postprocedural cardiac functional disturbances following surgery (index visit)	527.51729	597.59077	0.8110426
Hemorrhagic disorder due to extrinsic circulating anticoagulants (index visit)	99.3091	169.38258	0.8887536
Adverse effect of anticoagulants (index visit)	42.96439	113.03786	0.9884705
Postprocedural septic shock (index visit)	28.64615	98.71963	0.9989574
Postprocedural cardiogenic shock (index visit)	22	92.07348	1
Postprocedural shock unspecified (index visit)	55.31504	125.38852	0.976047
Postprocedural hypotension (index visit)	624.41886	694.49234	0.7236958
Acute posthemorrhagic anemia (index visit)	971.84337	1041.91685	0.9662563
Acute posthemorrhagic anemia (within 1 y after discharge)	172.07872	242.1522	0.7942702
Time to acute posthemorrhagic anemia	3026.30265	3058.98123	NA
Time to acute posthemorrhagic anemia (censored at 1 y)	1972.8928	2001.01464	NA
Other intraoperative complications of respiratory system (index visit)	27.54521	97.61868	0.9997683
Any complication at the index visit	5534.95274	5605.02622	0.6594846
Any complication within 30 d of discharge	199.79255	269.86602	0.7715791
Any complication within 1 y of discharge	772.99236	843.06584	0.6851841
Time to any complication at the index visit	8470.17505	8512.92267	NA
Time to any complication at the index visit (censored at 1 y)	6729.61251	6769.82274	NA
Length of stay	5919.82923	5996.27303	0.6451003
Total cost	4899.89414	4976.33793	0.5971119
Total direct cost	5080.89728	5157.34107	0.5938493
Total charge amount	7502.58108	7579.02487	0.5869688
Payment amount	17,721.69423	17,798.13802	0.5681087

BIC, Bayes information criterion; *AIC*, Akaike information criterion; *NA*, not applicable; *FTR*, failure to rescue.

TABLE E11. Model goodness of fit for the association with tertiles of MMI

Outcome	BIC	AIC	C-statistic
Death at any time	2274.42481	2344.49829	0.8222351
Death in hospital	371.34988	441.42336	0.9015728
Death within 30 d after discharge	315.25933	385.33281	0.8780771
Death within 60 d after discharge	466.02454	536.09801	0.8841132
Death within 90 d after discharge	627.37547	697.44894	0.8705447
Death within 1 y after discharge	1465.23878	1535.31226	0.826597
Time to death after discharge, d	5599.92086	5647.87829	0.605067
Time to death after discharge	5787.53497	5827.49949	NA
Time to death after discharge (1-y follow-up)	3387.84963	3422.05498	NA
Long-term survival	2274.42481	2344.49829	0.8222351
Thoracoscopy procedure converted to open procedure	772.243	842.31647	0.7036189
Death in combination with any complication at the index visit (FTR)	294.72109	364.79457	0.9092693
Death in combination with any complication within 90 d	76.05739	146.13086	0.9496521
Death in combination with any complication within 1 y	231.84374	301.91721	0.8794799
Death in combination with 1 complication at the index visit	181.80931	251.88279	0.8708293
Death in combination with 2 complications at the index visit	82.70348	152.77695	0.9829964
Death in combination with 3 complications at the index visit	88.96578	159.03926	0.9586766
Readmission within 30 d after discharge	2628.01652	2698.09	0.6065812
Readmission within 60 d after discharge	3246.59514	3316.66862	0.6010191
Readmission within 90 d after discharge	3610.61097	3680.68445	0.6089425
Readmission within 1 y after discharge	4924.13633	4994.20981	0.6159065
Time until readmission after discharge, d	19,882.69725	19,946.18077	0.5428375
Time until readmission after discharge	22,971.41981	23,024.32274	NA
Time until readmission after discharge (1-y follow-up)	18,899.32894	18,950.01918	NA
Pneumothorax (index visit)	2288.2161	2358.28958	0.5689724
Pyothorax without fistula (index visit)	101.76025	171.83373	0.8356723
Pyothorax without fistula (within 1 y after discharge)	67.28875	137.36223	0.7768506
Time to pyothorax without fistula	648.11378	664.7494	NA
Time to pyothorax without fistula (censored at 1 y)	589.20052	604.754	NA
Pyothorax with fistula (index visit)	293.73393	363.80741	0.713083
Abscess of lung without pneumonia (index visit)	44.33245	114.40593	0.9910776
Abscess of lung with pneumonia (index visit)	22	92.07348	NaN
Atelectasis (index visit)	2513.44892	2583.52239	0.6586829
Atelectasis (within 1 y after discharge)	58.16497	128.23844	0.9570005
Time to atelectasis	1973.08077	2001.20262	NA
Time to atelectasis (censored at 1 y)	1506.72915	1531.94703	NA
Pleural effusion (index visit)	876.49579	946.56926	0.6483252
Pleural effusion (within 30 d after discharge)	117.5921	187.66557	0.8161841
Pleural effusion (within 1 y after discharge)	311.39216	381.46563	0.7851075
Time to pleural effusion	3686.85327	3721.19049	NA
Time to pleural effusion (censored at 1 y)	3082.64907	3115.01349	NA
Other postprocedural complications and disorders of respiratory system (index visit)	403.9724	474.04587	0.6818784
Postprocedural air leak (index visit)	3081.83788	3151.91136	0.56898
Air leak (index visit)	3366.63646	3436.70993	0.5676548

(Continued)

TABLE E11. Continued

Outcome	BIC	AIC	C-statistic
Acute pulmonary insufficiency following thoracic surgery (index visit)	763.03099	833.10446	0.7220055
Acute postprocedural respiratory failure (index visit)	430.54859	500.62207	0.770166
Acute and chronic postprocedural respiratory failure (index visit)	85.18778	155.26126	0.9071429
Postprocedural hemorrhage of a respiratory system organ or structure following a respiratory system procedure (index visit)	164.18285	234.25632	0.8498161
Intraoperative hemorrhage and hematoma of a respiratory system organ or structure complicating a respiratory system procedure (index visit)	104.57301	174.64649	0.8163612
Sepsis following a procedure (index visit)	53.59607	123.66954	0.9807217
Infection following a procedure, superficial incisional surgical site (index visit)	37.75663	107.83011	0.9964079
Disruption of external operation (surgical) wound (index visit)	27.31764	97.39111	0.9995366
Postprocedural cardiac functional disturbances following surgery (index visit)	521.43157	591.50505	0.8293012
Hemorrhagic disorder due to extrinsic circulating anticoagulants (index visit)	97.66871	167.74218	0.8937022
Adverse effect of anticoagulants (index visit)	40.67081	110.74429	0.9955968
Postprocedural septic shock (index visit)	24.77261	94.84609	0.9998842
Postprocedural cardiogenic shock (index visit)	22	92.07348	1
Postprocedural shock unspecified (index visit)	54.73263	124.8061	0.9792922
Postprocedural hypotension (index visit)	625.66	695.73348	0.7220722
Acute posthemorrhagic anemia (index visit)	972.80145	1042.87492	0.965798
Acute posthemorrhagic anemia (within 1 y after discharge)	171.27089	241.34437	0.799216
Time to acute posthemorrhagic anemia	3015.19983	3047.87841	NA
Time to acute posthemorrhagic anemia (censored at 1 y)	1970.45769	1998.57954	NA
Other intraoperative complications of respiratory system (index visit)	30.94922	101.0227	0.9994786
Any complication at the index visit	5535.47628	5605.54976	0.6592302
Any complication within 30 d of discharge	193.62569	263.69916	0.8028514
Any complication within 1 y of discharge	762.37878	832.45225	0.710735
Time to any complication at the index visit	8449.34419	8492.09181	NA
Time to any complication at the index visit (censored at 1 y)	6712.07201	6752.28225	NA
Length of stay	5933.63394	6010.07773	0.6432688
Total cost	4901.78914	4978.23293	0.5952555
Total direct cost	5079.7166	5156.16039	0.5927512
Total charge amount	7525.39785	7601.84164	0.5854657
Payment amount	17,723.5099	17,799.9537	0.567806

BIC, Bayes information criterion; *AIC*, Akaike information criterion; *NA*, not applicable; *FTR*, failure to rescue.

TABLE E12. Model goodness of fit for the association between volume and MMI (centers with the lowest volume and the highest MMI versus centers with the highest volume and lowest MMI)

Outcome	BIC	AIC	C statistic
Death in combination with any complication at the index visit (FTR)	141.426171330622	183.220278928951	0.844090305444887
Total cost	17,503.5193	17,554.601	0.588656
Total direct cost	16,725.4339	16,776.5156	0.585233
Total charge amount	20,151.9947	20,203.0764	0.6146699
Payment amount	17,217.4144	17,268.4961	0.5960797
Death at any time	659.1427	705.5806	0.7864055
Death in hospital	161.7826	208.2205	0.8540107
Death within 30 d after discharge	143.6061	190.044	0.8235502
Death within 60 d after discharge	202.9485	249.3864	0.8427846
Death within 90 d after discharge	238.4431	284.881	0.8282948
Death within 1 y after discharge	516.7367	563.1746	0.7450816
Time to death after discharge, d	1996.6904	2029.2045	0.6385193
Time to death after discharge	1625.686	1652.2885	NA
Time to death after discharge (1-y follow-up)	1140.897	1163.6904	NA

BIC, Bayes information criterion; *AIC*, Akiake information criterion; *FTR*, failure to rescue; *NA*, not applicable.