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Esophagectomy outcomes at low-volume hospitals: the association between systems characteristics and mortality

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Abstract

Objective—To evaluate the association between systems characteristics and esophagectomy mortality at low-volume hospitals

Summary Background Data—High-volume hospitals have lower esophagectomy mortality rates, but receiving care at such centers is not always feasible. We examined low-volume hospitals and sought to identify characteristics of those with better outcomes.

Methods—Using national data from Medicare and the American Hospital Association, we studied 4,498 elderly patients who underwent an esophagectomy from 2004–2007. We divided hospitals into terciles based on esophagectomy volume and examined characteristics of patients and hospitals (size, nurse ratios, and presence of advanced medical, surgical, and radiological services). Our primary outcome was mortality. We identified five potentially beneficial systems characteristics in our dataset and used multivariable logistic regression to determine whether these characteristics were associated with lower mortality rates at low-volume hospitals.

Results—Of the 874 hospitals that performed esophagectomies, 83% (723) were low-volume hospitals while only 3% (25) were high-volume. Low-volume hospitals performed a median of one esophagectomy during the four-year study period and cared for patients that were older, more likely to be minority, and more likely to have multiple comorbidities compared to high-volume centers. Low-volume hospitals that had at least three of five characteristics (high nurse ratios, lung transplantation services, complex medical oncology services, bariatric surgery services, and PET

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scanners) had markedly lower mortality rates compared to low-volume hospitals with none of these characteristics (12.5% vs. 5.0%; p-value=0.042).

Conclusions—Low-volume hospitals with certain systems characteristics appear to achieve better esophagectomy outcomes. A more comprehensive study of the beneficial characteristics of low-volume hospitals is warranted since high-volume hospitals are difficult to access for many patients.

Mini abstract

Many Americans undergo esophagectomies at low-volume institutions, despite their higher overall mortality rates. We used national Medicare data to examine whether a subset of low-volume hospitals achieved better outcomes. We found that low-volume hospitals with a set of key systems characteristics, such as high nurse ratios and lung transplantation services, had esophagectomy mortality rates that were comparable to medium- and high-volume centers.

Introduction

The relationship between volume and outcome is well established for numerous surgical procedures.[1–14] For some operations, such as esophagectomy, this relationship is especially strong, with high-volume centers achieving substantially lower mortality rates. The strength of the evidence, and therefore the opportunity to improve care, has prompted organizations such as The Leapfrog Group to advocate for concentrating certain high risk procedures at high-volume centers, a process often referred to as regionalization.[15] Early evidence suggests that while a few states have seen an increase in regionalization, it has occurred slowly on a national level.[16, 17] The primary barrier is a lack of high-volume centers in most communities, leading to longer travel times for patients who seek care at these centers[18, 19]. Additionally, many referring physicians are hesitant to send patients outside of local provider networks. Given these barriers to regionalization, low-volume hospitals continue to perform a large number of high risk operations. Since this pattern of care is likely to persist for some time, developing new strategies to improve patient outcomes is critically important.

One option is to focus on the hundreds of low-volume hospitals that perform high risk procedures such as esophagectomy. Though these centers have higher overall mortality rates when compared to high-volume centers, there may be a subset of low-volume hospitals that achieves better outcomes. If we could determine which characteristics are associated with lower mortality rates at low-volume hospitals, we could potentially improve outcomes in two ways. First, we might be able to identify systems mechanisms that other low-volume hospitals could adopt to improve their surgical care. Second, we could expand policy options to help ensure that all patients have access to hospitals with low mortality rates when high-volume centers are not available.

We focused our study on esophagectomy because there are well-established, large mortality differences between high- and low-volume centers. Yet, there are very few high-volume centers. Access is thus an especially pressing issue. We sought to address two specific questions: What are the characteristics of patients who undergo esophagectomies at low-volume institutions? And, are there systems characteristics that are associated with better outcomes at low-volume hospitals?

Methods

Data sources

We used four years of Medicare Provider Analysis and Review (MedPAR) data (2004 through 2007), which contained all inpatient claims of Medicare beneficiaries enrolled in the fee-for-service program. Each hospital admission included a maximum of ten diagnostic codes and six procedures codes as defined by the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9). We linked the hospital data in MedPAR to the annual survey of the American Hospital Association (AHA), which provided detailed hospital characteristics.

Study population

We included all patients age 65 and older who underwent an esophagectomy (ICD-9 procedure codes 42.40, 42.41, 42.42) and had a diagnosis of benign (ICD-9 diagnosis codes 211.0, 456.0–456.2, 530.0, 530.10–530.13, 530.19, 530.2, 530.20, 530.21, 530.3–530.7, 530.81–530.84, 750.3, 862.22, 862.32) or pre-malignant/malignant (ICD-9 diagnosis codes 150.0–150.5, 150.8, 150.9, 151.0, 230.1, 530.85) esophageal disease. 4,542 patients met these criteria. 44 patients who underwent a laryngectomy (ICD-9 procedure code 30.3, 30.4) or pharyngectomy (29.33) at the time of esophagectomy were excluded from the analysis. Thus, the study cohort included 4,498 patients.

Study variables

Patient demographics and comorbidities—The MedPAR File provided information on patient age, gender, race, admission type (urgent or non-urgent) and the presence of as many as 10 comorbidities. To characterize comorbidity, we calculated Charlson scores for each patient on the basis of ICD-9 diagnosis codes. The Charlson score represents a weighted composite measure of overall comorbid status and has been previously validated for use with administrative data.[20]

Hospital characteristics—We selected ten hospital characteristics *a priori* based on their potential to directly or indirectly affect patient outcomes following esophagectomy. They were categorized into 7 general areas: hospital size (number of hospital beds), critical care services (as measured by the presence of a cardiac intensive care unit), surgical specialty services (lung transplantation, kidney transplantation, and bariatric surgery), medical specialty services (complex medical oncology services, indicated by the presence of a bone marrow transplant unit, and cardiac catheterization laboratory), advanced radiology services (presence of a PET scanner), nursing care (number of full-time equivalent nurses per 100 hospital beds), and teaching status (member of the council of teaching hospitals). The threshold for a high nursing ratio was 200 full-time equivalent nurses per 100 hospital beds.[21]

Medicare Esophagectomy volume—We summed each hospital's total Medicare esophagectomy volume over the four-year study period and categorized each hospital as a low-, medium-, or high-volume hospital. Each volume tercile contained nearly equal numbers of patients. Based on this approach, low-volume hospitals performed 1–6 esophagectomies over the four-year period. Medium-volume hospitals performed 7–32 esophagectomies, and high-volume hospitals performed at least 33 esophagectomies.

Comparing Medicare esophagectomy volume to total esophagectomy volume—To examine the degree to which hospital volume misclassification might have occurred (hospitals that performed few esophagectomies on Medicare patients could have performed many esophagectomies on non-Medicare patients), we analyzed the Nationwide Inpatient Sample (NIS) datasets from 2004–2007. The NIS is an all-payer database that uses patient-level data from five to eight million hospitalizations each year to build a 20% stratified sample of U.S. community hospitals. We used the NIS data to calculate the total number of esophagectomies performed at each hospital that was represented in both the Medicare and NIS datasets.

Outcome—The primary outcome was mortality, defined as death within 30 days of surgery or during the postoperative hospitalization.

Statistical Analyses—For the patient-level analyses, we used Rao-Scott Chi-Square tests to compare patient demographics and comorbidity status at low-, medium- and high-volume hospitals.[22] We accounted for clustering at the hospital level in the Rao-Scott Chi-Square tests. For the hospital-level analyses (where each hospital contributed one observation), we used Pearson Chi-Square tests to compare systems characteristics at low-, medium- and high-volume hospitals.

To characterize the relationship between hospital esophagectomy volume and mortality, we used *a priori* hypotheses to select five patient characteristics (age, gender, race, admission type, and Charlson score) and ten potentially beneficial hospital characteristics in our dataset. First, we performed univariate analyses to characterize the associations between these 15 characteristics and mortality (See Supplemental Digital Content, Appendix 1). Next, we performed multi-level, multivariable logistic regression modeling. After calculating unadjusted odds ratios for mortality on the basis of hospital volume (Model 1), we added all five patient characteristics to the model (Model 2). We subsequently added the number of hospital beds to the model (Model 3) and finally we included hospital systems characteristics (Model 4). Systems characteristics with a p-value of <0.1 on univariate analyses were identified as candidate covariates for the regression model. Due to concerns regarding colinearity between lung transplantation services, kidney transplantation services, hospital size, and teaching status, we included only lung transplantation services among those four characteristics. In our judgment, the clinical resources required for lung transplantation were the most relevant for esophagectomy outcomes. Thus, along with patient characteristics and number of hospital beds, five systems characteristics were included in Model 4: lung transplantation services, bariatric surgery services, complex medical oncology services, PET scanning and the nurse to hospital bed ratio. Generalized estimating equations (GEE) were used to account for clustering of patients by hospital in both the unadjusted and adjusted multi-level logistic regression analyses.[23]

To obtain adjusted mortality rates at low-volume hospitals with different numbers of systems characteristics, we created an ordinal variable (0–5) which represented the number of systems characteristics at a low-volume hospital. We calculated adjusted mortality rates as predicted probabilities from a GEE regression model with the potential confounders (gender, age, admission type and Charlson score) set to their average values in the study population. We obtained confidence intervals and a p-value for trend by fitting the GEE logistic regression model with the number of hospital characteristics, gender, age, admission type and Charlson score as covariates. Similarly, to obtain adjusted mortality rates, confidence intervals, and a p-value for trend for the number of hospital beds, we created an ordinal variable representing the four categories of hospital beds (1–200, 201–400, 401–600, >600 beds).

We also measured the frequency and mortality rates according to the location of the esophageal lesion, the disease type, and the type of esophagectomy performed at low-, medium- and high-volume hospitals.

All p-values were two-sided and were considered statistically significant if the p-value was less than 0.05. All analyses were performed with SAS version 9.2 (SAS Institute, Cary, NC).

Results

Of the 4,498 patients with a diagnosis of benign or malignant esophageal disease who underwent an esophagectomy during the study period, the overall mortality rate was 7.1%. From 2004 through 2007, mortality declined from 8.9% to 6.3% (p-value for trend=0.029). Nearly all patients (93.9%) had a diagnosis of pre-malignant or malignant esophageal disease.

Patient characteristics

Patients at low-volume hospitals were more likely to be at least 80 years of age (13% vs. 9%; p=0.015) and non-white (8% vs. 4%; p<0.001) when compared to patients at high-volume hospitals. There were no significant differences in gender between low-volume and high-volume hospitals (Table 1). Patients at low-volume hospitals were more likely to be admitted non-electively (19% vs. 4%; p<0.001) and more often had multiple comorbidities (60% vs. 53% with Charlson score ≥ 3; p=0.009).

Hospital characteristics

Of the 874 hospitals that performed esophagectomies, 83% (n=723) were low-volume centers while only 3% (n=25) were high-volume centers (Table 2). Low-volume hospitals performed a median number of one esophagectomy (Interquartile Range [IQR] 1–3) on elderly patients over the four-year study period. Medium- and high-volume hospitals performed a median number of 10 (IQR 7–14) and 50 (IQR 40–75) esophagectomies, respectively. Annually, low-, medium- and high-volume hospitals performed a median number of 0 (IQR 0–1), 3 (IQR 2–4), and 13 (IQR 9–20) esophagectomies, respectively, on elderly patients. 91.4% (n=799) of hospitals averaged three or fewer esophagectomies per year, while 74.8% (n=654) averaged one or less per year.

Low-volume hospitals were less likely to be large (8% vs. 56% with > 600 beds; p<0.001) and were less likely to have cardiac intensive care units (70% vs. 77%; p<0.001), surgical specialty services such as lung transplantation surgery (3% vs. 70%; p<0.001), and medical specialty services such as complex medical oncology services (8% vs. 96%; p<0.001) compared to high-volume centers. Fewer low-volume hospitals had high nurse to hospital bed ratios (13% vs. 72%; p<0.001), and only 15% were teaching hospitals (vs. 88% of high-volume hospitals; p<0.001).

Medicare volume and total esophagectomy volume

We found a high degree of correlation between a hospital's Medicare volume and its overall esophagectomy volume. Among the 285 hospitals that were classified as low-volume hospitals and were represented in both the Medicare and NIS datasets, the average total number of esophagectomies performed each year was 2.1. Less than 1% of the hospitals that we classified as low-volume (2 out of 285) would have been considered high-volume by the Leapfrog criteria (at least 13 esophagectomies annually).

Multilevel logistic regression modeling

In the unadjusted multivariate analysis (Model 1), the odds of death were four times higher at low-volume vs. high-volume centers (OR 4.0, 95% CI 2.7–5.8; Table 3). After adjusting for patient-related factors (Model 2), the odds of death were somewhat attenuated (OR 3.4, 95% CI 2.3–5.0). These odds remained essentially unchanged after accounting for differences in the number of hospital beds (OR 3.4, 95% CI 2.2–5.2; Model 3). When we added systems characteristics to the regression model (Model 4), low-volume centers still had a higher odds of death compared to high-volume centers (OR 2.2, 95% CI 1.3–3.7), although the magnitude was substantially reduced.

Among low-volume centers, the number of systems characteristics was highly predictive of the mortality rate. The adjusted mortality rate among the 273 low-volume hospitals with none of the five systems characteristics was 12.5% (95% CI 9.4–16.4; Table 4a). Among the 52 hospitals with at least three of the five characteristics, the adjusted mortality rate was 5.0% (95% CI 2.3–10.5; p-value for trend=0.042). Medium- and high-volume hospitals had adjusted mortality rates of 6.0% (95% CI 4.7–7.5) and 2.9% (95% CI 2.0–4.2), respectively.

When we examined whether hospital size alone accounted for differences in mortality among low-volume centers, we found no such relationship. Low-volume hospitals with 200 beds or less (n=188) had an adjusted mortality rate of 9.2% (95% CI 6.0–13.7) while those with more than 600 beds (n=55) had an adjusted mortality rate of 9.1% (95% CI 5.2–15.3; p-value for trend=0.868; Table 4b).

Esophageal lesion location/disease type and type of esophagectomy

The location of the esophageal lesion (upper, mid, lower, other, unspecified, cardia), type of lesion (carcinoma-in-situ, Barrett's) and type of esophagectomy were similar between low-volume hospitals with less than three systems characteristics, low-volume hospitals with at least three of the five systems characteristics, medium-volume hospitals, and high-volume hospitals (See SDC, Appendix 2a and 3a). Low-volume hospitals with at least three systems characteristics generally had lower mortality rates than other low-volume hospitals irrespective of the location of the lesion, disease type (See SDC, Appendix 2b) or the type of esophagectomy performed (See SDC, Appendix 3b).

Discussion

Our findings indicate that a large number of elderly Americans continue to undergo esophagectomies at centers that perform this operation infrequently. Of the 874 centers performing esophagectomies, more than 90% operate on three elderly Medicare patients or fewer each year. Approximately three-fourths perform, on average, one or less annually. These low-volume hospitals treat an older, sicker population that is comprised of a higher percentage of minority patients. Even though low-volume hospitals have worse overall outcomes compared to high-volume hospitals, there is a subset of low-volume hospitals that has considerably lower mortality rates.

Despite the overall mortality benefit seen at high-volume hospitals, many patients do not have access to these centers. Given that Medicare patients comprise 45 to 50% of all esophagectomy patients,[24] we estimate that only 37 hospitals in 24 states would have met the Leapfrog criterion for a high-volume center (performing at least 13 esophagectomies per year[18]). This represents only 4.2% of all esophagectomy hospitals. Furthermore, recent reports suggest that racial minorities, economically disadvantaged patients, and Medicare patients have an especially difficult time accessing high-volume esophagectomy centers.[16] Similar disparities have also been reported for patients undergoing pancreatic resection.[17] Though efforts to refer all esophagectomy patients to centers that meet Leapfrog criteria will undoubtedly continue, further progress may be slow.

Our results offer a supplemental approach by focusing on low-volume hospitals with a set of systems characteristics that perform significantly better than others. Mortality rates at the 52 low-volume hospitals with at least three of the characteristics examined are less than half the rates at the 273 low-volume hospitals with none of these characteristics, and they approach the rates of medium- and high-volume centers. This relationship appears to be independent of hospital size. This suggests that a strategy of expanding systems capabilities at low-volume centers could have beneficial effects and could markedly improve patient access to hospitals that achieve better esophagectomy outcomes.

Others have found similar relationships between key hospital characteristics and mortality. Billingsley et al reported that the presence of a solid organ transplantation program and a cardiac surgery program was an important explanatory variable underlying the inverse relationship between hospital volume and mortality for colectomy patients.[25] Similarly, among 434 hospitals performing pancreatic resections, Joseph et al found that several institutional characteristics had a stronger influence on operative mortality than hospital volume. These characteristics included an ICU staffed by full time intensivists, interventional radiology services, a general surgery residency, and a gastroenterology fellowship.[26] High nursing ratios have been associated with lower mortality rates and lower failure to rescue rates for surgical patients.[27, 28] High intensity ICU physician staffing,[29] cancer center designation[30] and hospital teaching status[31–33] have also been linked with reductions in mortality. Though three of our systems characteristics have not been previously associated with improvements in surgical mortality (bariatric surgical services, complex medical oncology services and PET scanners), we suspect that they are markers for the expertise and technology required to optimize preoperative, intraoperative or postoperative care for esophagectomy patients.

At least one other surgical specialty – bariatric surgery – has already incorporated hospital characteristics into the minimal criteria for the delivery of bariatric surgical services. To obtain a "Center of Excellence" designation by either the American Society for Metabolic and Bariatric Surgery or the American College of Surgeons, which is now required by the Centers for Medicaid and Medicare Services (CMS), minimal hospital and surgeon volume thresholds must be met along with numerous structural measures related to credentialing, consultant availability, and bariatric equipment availability.[34, 35] This combination of volume and structural criteria, along with process measures, could potentially be applied to hospitals that perform esophagectomies and other high risk operations.

There are other options for policymakers who are interested in driving improvements in outcomes after major procedures such as esophagectomy. The number of operations performed and the outcomes from these operations could be made publicly available. New York has already done this with cardiac surgery.[36] Our findings suggest that if certain hospital characteristics are confirmed to be related to better outcomes, hospitals that both offer these services and achieve good outcomes could be highlighted in public reporting efforts. A far more draconian approach could be for payers to not pay for operations in low-volume institutions. However, our findings suggest that there are low-volume centers with potentially good outcomes and until we have a better understanding of why certain low-volume centers seem to be have lower mortality rates than others, restricting where patients undergo surgery may not be warranted.

Our study has important limitations. We were limited by the hospital characteristics that were available in the AHA dataset. The five key systems characteristics that were included in our multivariate models were likely indirect markers for other structural and process measures that were more closely related to esophagectomy outcomes. For example, it is unlikely that the presence of a bone marrow transplant unit in a low-volume hospital had a direct effect on esophagectomy mortality rates. However, the presence of sophisticated blood banking services which are required to manage a bone marrow transplant unit may impact the care of a complex surgical patient. Likewise, high numbers of nurses per hospital bed may not directly translate to improved patient care. Yet, nurses who work at hospitals with higher nurse ratios may have more time to spend on activities that are directly related to patient outcomes, such as medication administration or patient ambulation. Further investigation into this next level of services is warranted.

Since Medicare data are claims-based, they lack the clinical detail to perform thorough risk adjustment. However, the accuracy of these data has improved over time and claims-based, risk-adjusted mortality rates are now being used widely, including for public reporting. A related limitation is that claims data typically lack the granularity necessary to adequately assess morbidity after surgery. It is possible that the low-volume hospitals with multiple systems characteristics had higher rates of morbidity than other low-volume hospitals but were simply better at managing these complications. Further work is needed to determine whether there are differences in morbidity across these different groups of hospitals.

Our results may not be generalizable to younger esophagectomy patients because our cohort of patients was limited to Medicare patients older than age 64. Yet, Medicare patients represent nearly half of esophagectomy patients[24] and our age-restricted cohort of uniformly insured patients should bias our analyses toward the null hypothesis by limiting the amount of confounding from these variables. We focused on the elderly and therefore we could not measure the true volume of any individual hospital. Misclassification of hospital volume could have occurred if Medicare patients were under or overrepresented in our dataset. However, Medicare case volumes have previously been shown to correlate well with total hospital volume and have been used in numerous studies as a proxy for total hospital volume.[3, 6, 19, 25, 37, 38] Further, in our own analyses, we found that among the 285 hospitals for which Medicare and non-Medicare data were available, nearly all institutions classified as low-volume using Medicare data would be classified as low volume if we included both Medicare and non-Medicare patients.

We also lacked data on cancer staging, although previous investigators have not found an association between postoperative mortality and esophageal cancer stage.[38] Finally, we did not have information on surgeon volume which is a known mediator in the relationship between hospital volume and mortality. Though low-volume, low-mortality hospitals may have been staffed by high-volume surgeons, previous studies have found that an exceedingly low number of high-volume surgeons perform esophagectomies at low-volume institutions.[8]

In conclusion, low-volume centers continue to perform esophagectomies on a significant number of elderly Americans. While outcomes at these centers are generally poor, there is a subset of low-volume hospitals with mortality rates that approach those of medium- and high-volume centers. A more comprehensive study of the systems capabilities that enhance outcomes at low-volume centers could have a beneficial impact on esophagectomy outcomes for the large numbers of patients who receive care at these institutions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1 –

Patient characteristics according to hospital volume (by patient)

	Low-volume hospital patients N=1,435 (32%)	Medium-volume hospital patients N=1,531 (34%)	High-volume hospital patients N=1,532 (34%)	P value
Female	330 (23%)	325 (21%)	333 (22%)	0.547
Age				
65–69	500 (35%)	558 (36%)	569 (37%)	0.015
70–79	742 (52%)	819 (54%)	825 (54%)	
≥80	193 (13%)	154 (10%)	138 (9%)	
Non-white	119 (8%)	87 (6%)	54 (4%)	<0.001
Non-elective admission	272 (19%)	140 (9%)	60 (4%)	<0.001
Charlson score ≥ 3	854 (60%)	814 (53%)	816 (53%)	0.009

Table 2 –

Hospital characteristics according to hospital volume (by hospital)

	Low-volume hospitals N=723 (83%)	Medium-volume hospitals N=126 (14%)	High-volume hospitals N=25 (3%)	P value
Hospital size				
≤200 hospital beds	188 (26%)	6 (5%)	2 (8%)	<0.001
201–400 hospital beds	348 (49%)	31 (25%)	4 (16%)	
401–600 hospital beds	124 (17%)	46 (36%)	5 (20%)	
>600 hospital beds	55 (8%)	43 (34%)	14 (56%)	
Critical care				
Cardiac ICU	464 (70%)	106 (88%)	17 (77%)	<0.001
Surgical specialty services				
Lung transplant center	17 (3%)	34 (28%)	16 (70%)	<0.001
Kidney transplant center	72 (11%)	76 (63%)	19 (83%)	<0.001
Bariatric surgery center	318 (49%)	89 (73%)	17 (74%)	<0.001
Medical specialty services				
Complex medical oncology services[±]	54 (8%)	69 (57%)	22 (96%)	<0.001
Cardiac catheterization laboratory	564 (85%)	117 (94%)	20 (87%)	0.048
Radiology services				
PET scanner	242 (37%)	85 (70%)	21 (91%)	<0.001
Nursing care				
>200 FTE RNs per 100 beds	96 (13%)	46 (37%)	18 (72%)	<0.001
Teaching status				
Member of council of teaching hospitals	107 (15%)	81 (64%)	22 (88%)	<0.001

[±]indicated by the presence of a bone marrow transplant unit

ICU = intensive care unit; PET = positron emission tomography; FTE = full-time equivalent; RN = registereds nurse

Table 3 –

Odds of mortality according to hospital volume

	Model 1 OR [95% CI]	Model 2 OR [95% CI]	Model 3 OR [95% CI]	Model 4 OR [95% CI]
Low-volume hospital	4.0 [2.7–5.8]	3.4 [2.3–5.0]	3.4 [2.2–5.2]	2.2 [1.3–3.7]
Medium-volume hospital	2.0 [1.3–3.0]	1.9 [1.2–2.8]	1.9 [1.2–2.9]	1.6 [1.0–2.5]
High-volume hospital	*Ref*	*Ref*	*Ref*	*Ref*

OR = odds ratio; CI = confidence interval

Model 1 = hospital volume alone

Model 2 = Model 1 + patient characteristics

Model 3 = Model 2 + number of hospital beds

Model 4 = Model 3 + systems characteristics

Patient characteristics = gender + age + race + admission type + Charlson score ≥3

Systems characteristics = high nurse ratio + complex medical oncology services + lung transplantation services + bariatric surgery services + PET scanner

PET = positron emission tomography

Table 4a -

Adjusted mortality rates according to the number of systems characteristics at low-volume hospitals versus medium- and high-volume hospitals

	Low-volume hospitals						Medium-volume hospitals	High-volume hospitals
	All low volume hospitals	0 characteristics	1 characteristic	2 characteristics	≥ 3 characteristics	P value		
# of hospitals	723	273	233	165	52		126	25
Mortality rate[a] [95% CI]	10.4 [8.8–12.2]	12.5 [9.4–16.4]	10.7 [7.9–14.3]	9.2 [6.6–12.8]	5.0 [2.3–10.5]	0.042	6.0 [4.7–7.5]	2.9 [2.0–4.2]

Table 4b -

Adjusted mortality rates according to the number of hospital beds at low-volume hospitals

	Low-volume hospitals				
	1–200 hospital beds	**201–400 hospital beds**	**401–600 hospital beds**	**>600 hospital beds**	**P value**
# of hospitals	188	348	124	55	
Mortality rate[a] [95% CI]	9.2 [6.0–13.7]	10.3 [8.0–13.1]	10.9 [7.8–15.2]	9.1 [5.2–15.3]	0.868

[a]adjusted for gender, age, admission type and Charlson score; CI = confidence interval