
Who Receives Their Complex Cancer Surgery at Low-Volume Hospitals?

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BACKGROUND: Previous literature has consistently shown worse operative outcomes at low-volume hospitals (LVH) after complex cancer surgery. Whether patient-related factors impact this association remains unknown. We hypothesize that patient-related factors contribute to receipt of complex cancer surgery at LVH.

STUDY DESIGN: Using the 2003–2008 National Inpatient Sample, we identified 59,841 patients who underwent cancer operations for lung, esophagus, and pancreas tumors. Logistic regression models were used to examine the impact of sociodemographic factors on receipt of complex cancer surgery at LVH.

RESULTS: Overall, 38.4% received their cancer surgery at LVH. A higher proportion of esophagectomies were performed at LVH (70.3%), followed by pancreatectomy (38.2%) and lung resection (33.8%). Patients who were non-white, with non-private insurance, and had more comorbidities were all more likely to receive their cancer surgery at LVH (for all, $p < 0.05$). Multivariate analyses continued to demonstrate that non-white race, insurance status, increased comorbidities, region, and nonelective admission predicted receipt of cancer surgery at LVH across all 3 procedures.

CONCLUSIONS: In this large national study, non-white race and increased comorbidities contributed to receipt of cancer surgery at LVH. Patient selection and access to high-volume hospitals are likely reasons worthy of additional investigation. This study provides additional insight into the volume-outcomes relationship. Given the demonstrated outcomes disparity between high-volume hospitals and LVH, future policy and research should encourage mechanisms for referral of patients with cancer to high-volume hospitals for their surgical care. (*J Am Coll Surg* 2012;214:81–87. © 2012 by the American College of Surgeons)

Previous literature has consistently shown worse operative outcomes at low-volume hospitals (LVH) after complex cancer surgery.^{1–3} Compared with their higher-volume counterparts, LVH have demonstrated disparities that extend well beyond the initial hospital stay, including lower long-term

survival after complex cancer operations.^{4,5} As a result, several stakeholders, including the quality-improvement group Leapfrog, recommend referral of patients to high-volume hospitals (HVH) for major surgical and oncologic procedures. In response to these evidence-based recommendations, the United States has seen a trend toward centralized delivery of complex operations at HVH.⁶

Recently, regional studies from California and New York have identified disparities in the use of HVH.^{7,8} Specifically, they identify racial and ethnic minorities and the underinsured as more likely to receive their cancer surgery at an LVH. In these settings, a lack of specialized surgeons, understaffing of intensive care units, and inconsistent post-operative care processes have been associated with worse operative outcomes. These regional studies put forth important yet unaddressed health policy implications about access and referral patterns for complex cancer surgery in the United States. Importantly, identifying which patient factors contribute to receiving cancer surgery at LVH requires additional investigation, as these patients are cur-

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Abbreviations and Acronyms

HVH	= high-volume hospitals
LOS	= length of stay
LVH	= low-volume hospitals
NIS	= Nationwide Inpatient Sample
OR	= odds ratio

rently excluded from the benefits of HVH, including participation in clinical trials and improved survival. However, the potential differences between patients treated at LVH vs HVH have not been fully explored. We hypothesized that patient factors such as age, race and ethnicity, income level, and insurance status contribute to receipt of complex cancer surgery at LVH. We used the National Inpatient Sample (NIS), a nationally representative dataset, to examine the impact of patient factors on receipt of complex cancer surgery at an LVH.

METHODS**Data source**

We used the 2003–2008 NIS. The NIS is part of the Healthcare Cost and Utilization Project, sponsored by the Agency for Healthcare Research and Quality. It contains 5 to 8 million hospital stays from approximately 1,000 hospitals sampled to approximate a 20% stratified sample of US community hospitals each year. The hospital stay data contain patient demographics, clinical diagnoses, outcomes, and resource use information from all discharges in participating hospitals. As the largest all-payer inpatient care database publicly available in the United States, the NIS has been used in several previous studies to evaluate trends in health care use. With well-described sampling methodology and quality control, the NIS provides population-level estimates of health care use in the United States.⁹ As the NIS is available to the public without personal identifiers, this study was exempt from review from the University of Minnesota Institutional Review Board.

Case selection

We identified patients by matching their ICD-9-Clinical Modification codes with a principal diagnosis of primary lung, esophageal, and pancreatic cancer with procedure codes for designated cancer operations. We chose these 3 procedures because of their multispecialty nature and established strong volume–outcomes relationship.^{1–3,10–12} We did not include those who underwent diagnostic or palliative procedures such as mediastinoscopy or laparoscopy.

For patient factors we included age, sex, race and ethnicity, income, insurance status, region, and comorbidities. The NIS uses comorbidity software that maps ICD-9-

Clinical Modification diagnosis codes into comorbidity index, as reported by Elixhauser and colleagues.¹³ Hospital factors assessed included hospital size, location, admission, and teaching status.

Outcomes

For hospital outcomes, we assessed receipt of cancer surgery at LVH, in-hospital mortality, length of stay, and total charges. For hospital volume status, we used the Leapfrog group's definition of LVH and classified those hospitals performing <13 esophagectomies and 11 pancreatectomies per year as LVH.¹⁴ Using the available body of literature, we defined LVH for lung cancer operations as those performing <25 annual lung procedures.^{1,3,5} For our length of stay (LOS) analyses, we defined extended or prolonged LOS as a stay beyond the 75th percentile for all patients who were discharged alive in our study cohort.

Statistical analysis

For our bivariate analyses, we compared patient- and hospital-level factors across all 3 cancer operations by hospital volume (LVH vs HVH). We used chi-square tests to evaluate each categorical variable and *t*-tests for continuous variables.

For each cancer surgery, we constructed logistic regression models to examine the impact of patient characteristics on receipt of cancer surgery at LVH, adjusting for covariates. In all models, we used factors that are statistically significant or clinically relevant from our univariate analyses. To confirm the negative association between LVH and worse operative outcomes, we also assessed the impact of LVH (as a factor) on inpatient mortality and prolonged LOS multivariable models.

We also performed additional sensitivity and interaction analyses. First, we tested for interactions between age, income, insurance, and comorbidity score. Second, because of the close relationship between race/ethnicity and income/insurance status, we repeated our multivariable analyses after separately removing each factor. A *p* value ≤0.5 was considered statistically significant. For all statistical analyses, we used SAS software, version 9.1 (SAS Institute Inc.).

RESULTS

During the study period from 2003 to 2008, we identified a total of 59,841 patients who underwent lung resection, esophagectomy, or pancreatectomy for cancer. Of those, 78.3% had lung resection, 5.6% had esophagectomy, and 16.1% had pancreatectomy. Esophagectomies were most likely to be performed at LVH (70.3%); followed by pancreatectomies (38.2%) and lung resections (33.8%).

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