Characterizing the role of a high-volume cancer resection ecosystem on low-volume, high-quality surgical care

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Background. *Our objective was to determine the hospital resources required for low-volume, high-quality care at high-volume cancer resection centers.*

Methods. *Patients who underwent esophageal, pancreatic, and rectal resection for malignancy were identified using Healthcare Cost and Utilization Project State Inpatient Database (Florida and California) between 2007 and 2011. Annual case volume by procedure was used to identify high- and low-volume centers. Hospital data were obtained from the American Hospital Association Annual Survey Database. Procedure risk-adjusted mortality was calculated for each hospital using multilevel, mixed-effects models.*

Results. *A total of 24,784 patients from 302 hospitals met the inclusion criteria. Of these, 13 hospitals were classified as having a high-volume, oncologic resection ecosystem by being a high-volume hospital for ≥2 studied procedures. A total of 11 of 31 studied hospital factors were strongly associated with hospitals that performed a high volume of cancer resections and were used to develop the High Volume Ecosystem for Oncologic Resections (HIVE-OR) score. At low-volume centers, increasing HIVE-OR score resulted in decreased mortality for rectal cancer resection (*$P = .038$*). HIVE-OR was not related to risk-adjusted mortality for esophagectomy (*$P = .421$*) or pancreatectomy (*$P = .413$*) at low-volume centers.*

Conclusion. *Our study found that in some settings, low-volume, high-quality cancer surgical care can be explained by having a high-volume ecosystem. (Surgery 2016;160:839-49.)*

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The relationship between increasing volume and improved outcomes in surgery is a well-studied phenomenon. First described in the late 1970s,[1] the volume and outcome association has since been demonstrated in cardiac surgery, cancer resection, vascular surgery, and colorectal surgery, among others.[2-6] The impact of increasing volume on improved postoperative outcomes is especially well validated for patients undergoing major oncologic resection.[7,8]

Two causal models traditionally have explained the relationship between increasing surgical volume and improved outcomes. The first postulates that high-volume centers leverage the concept of a learning curve, both at the level of the provider and the system. For the provider, proficiency improves with repetition. For the system, team-based familiarity improves outcomes. The second model cites a referral system that has a tendency to send patients to places already providing high-quality care, hence increasing their volume.[9]

More recently, a third explanation suggests that system characteristics within institutions, including technology, staffing, and expertise in other operative procedures, may equip institutions with tools to optimize perioperative care for both malignant and nonmalignant diseases.[10-12] Although many of

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these characteristics would be present in high-volume hospitals, they could also be used by low-volume hospitals to provide high-quality care.

Although there is little debate that increased volume can result in improved outcomes, a better understanding of the hospital ecosystem that supports low-volume, high-quality cancer care may offer new insights into improving operative outcomes and bolstering patient access. Therefore, the overarching goal of this study was to understand the role of a high-volume cancer resection ecosystem on operative quality.

To achieve this, we first characterized the hospital resources that define a high-volume ecosystem for cancer resections. Next, we identified low-volume centers with a high-volume ecosystem. Finally, we investigated whether a high-volume ecosystem could explain low-volume, high-quality care for patients undergoing 3 representative cancer operations.

METHODS

Data sources. Data from the Healthcare Cost and Utilization Project State Inpatient Database (HCUP SID) were linked to the American Hospital Association (AHA) Annual Survey Database. Given its use of deidentified, publicly available data, this study was deemed exempt from needing institutional review board approval. HCUP SID is a state-specific, patient-level data set that was developed by the Agency for Healthcare Research and Quality to inform health care decision-making. HCUP SID is an administrative data set that includes >100 clinical and nonclinical variables obtained from discharge records for all payers.

The AHA Annual Survey database is a hospital-level data source with information from over 6,000 hospitals across the United States. The AHA Annual Survey is given to hospital administrators and includes questions that characterize an institution's structure, service lines, utilization, budget, and staffing. Answers are then compiled into a single database with >1,000 fields.

Patient inclusion criteria. All patients aged ≥18 years who underwent esophageal, pancreatic, or rectal resection for a diagnosis of cancer between 2007 and 2011 in the states of Florida and California were included. International Classification of Diseases, 9th Edition, Clinical Modification (ICD-9-CM) diagnosis and procedure codes were used to define the population of interest. Specific ICD-9-CM case-finding codes are shown in Supplementary Table I.

For each procedure, hospitals were excluded if they performed <1 case per year. Patients without an associated hospital identifier also were excluded. Procedures selected for study were all gastrointestinal cancer resections included in the *Take the Volume Pledge* campaign, each with strong evidence supporting the volume–outcome relationship.[13] The overall study design is shown in Fig 1.

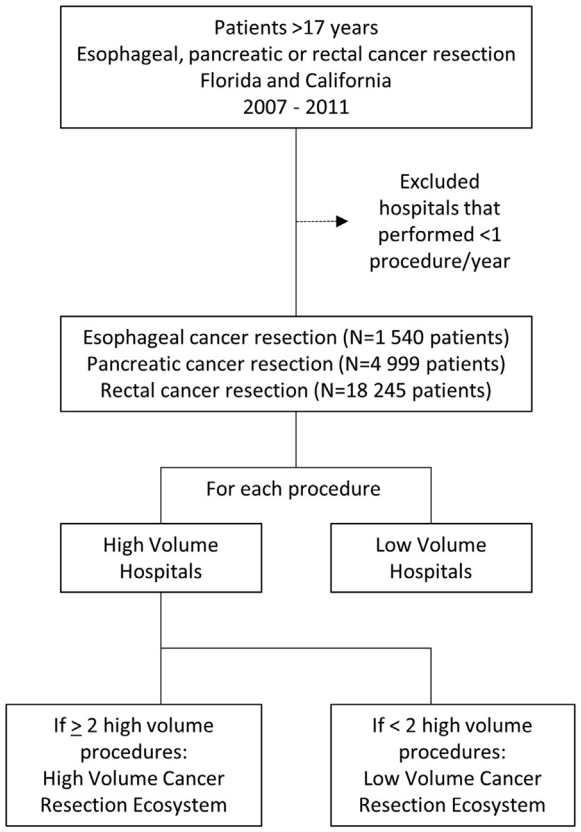

Fig 1. Overview of study design.

Volume thresholds. Hospitals were classified as high or low volume for each procedure. Volume assignments for each procedure were based on published numbers outlined in the *Take the Volume Pledge* campaign.[13] For esophageal and pancreatic cancer resection, high volume was 20. For rectal cancer resection, high volume was 15.

Hospital variables. Hospital-specific variables from the 2011 AHA Annual Survey database were used to characterize the resources available across centers and were grouped into the following categories: infrastructure, size, staffing, perioperative services, and support intensity. Characteristics and groupings were created using a modified nominal group technique with participating members selected by the study authors.[14] Missing values from the AHA Annual Survey were omitted from