

# Hospital Volume, Length of Stay, and Readmission Rates in High-Risk Surgery

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**Objective:** Aimed at reducing surgical deaths, several recent initiatives have attempted to establish volume-based referral strategies in high-risk surgery. Although payers are leading the most visible of these efforts, it is unknown whether volume standards will also reduce resource use.

**Methods:** We studied postoperative length of stay and 30-day readmission rate after 14 cardiovascular and cancer procedures using the 1994-1999 national Medicare database (total n = 2.5 million). We used regression techniques to examine the relationship between length of stay, 30-day readmission, and hospital volume, adjusting for age, gender, race, comorbidity score, admission acuity, and mean social security income.

**Results:** Mean postoperative length of stay ranged from 3.4 days (carotid endarterectomy) to 19.6 days (esophagectomy). There was no consistent relationship between volume and mean length of stay; it significantly increased across volume strata for 7 of the 14 procedures and significantly decreased across volume strata for the other 7. Mean length of stay at very-low-volume and very-high-volume hospitals differed by more than 1 day for 6 procedures. Of these, the mean length of stay was shorter in high-volume hospitals for 3 procedures (pancreatic resection, esophagectomy, cystectomy), but longer for other procedures (aortic and mitral valve replacement, gastrectomy). The 30-day readmission rate also varied widely by procedure, ranging from 9.9% (nephrectomy) to 22.2% (mitral valve

replacement). However, volume was not related to 30-day readmission rate with any procedure.

**Conclusion:** Although hospital volume may be an important predictor of operative mortality, it is not associated with resource use as reflected by length of stay or readmission rates.

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As evidence mounts that high-volume hospitals have better outcomes in selected surgical procedures,<sup>1-4</sup> interest in volume-based referral initiatives is growing. Among the most visible of these, the Leapfrog group, a coalition of public and private payers representing more than 30 million patients, is encouraging patients to undergo surgery at hospitals meeting minimum volume standards for 5 high-risk procedures.<sup>5</sup> Although the primary impetus for these efforts is reducing mortality, many also assume that high-volume hospitals will provide surgery less expensively than low-volume hospitals as a function of lower complication rates and better economies of scale.<sup>6-10</sup>

However, this assumption has not been well tested. Although prior studies have examined relationships between hospital volume and costs,<sup>7,11-25</sup> most studies have relied on hospital charges (adjusted with cost-charge ratios), a notoriously poor surrogate for resource use.<sup>26</sup> Their findings have varied widely, perhaps because of the heterogeneity in the procedures and populations on which these studies were based. Several studies have examined relationships between volume and length of stay, a popular surrogate for hospital costs. Although most suggested shorter length of stay at high-volume hospitals, many of these studies were based on relatively old data or information from individual states, which may not be broadly generalizable.<sup>13,21-25</sup>

To address this issue systematically, we studied length of stay and 30-day readmission rates with 14 cardiovascular and cancer procedures using the national Medicare database. In earlier work, we used this database to describe relationships between hospital volume and mortality.<sup>1</sup> In this analysis, we used similar methods to determine whether hospital volume is related to 2 important components of hospital cost.

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## METHODS

### Databases

Utilizing data from the Medicare claims database, we used 100% national samples from the Health Care Financing Administration's MEDPAR and denominator files for years 1994-1999. This file contains hospital discharge abstracts for acute care hospitalizations of all U.S. Medicare recipients under the hospital (Part A) insurance program. Only patients in fee-for-service arrangements are included in the MEDPAR file; thus, our sample excludes Medicare patients enrolled in risk-bearing health maintenance organizations (less than 10%) during this time period. We excluded patients under age 65 or over age 99.

### Patients and Procedures

Admissions for each of the 6 cardiovascular and 8 major cancer procedures in our analysis were identified using appropriate procedure codes from the *International Classification of Diseases*, version 9 (ICD-9).<sup>27</sup> Patients undergoing abdominal aortic aneurysm (AAA) repair were excluded if their discharge abstracts contained diagnosis or procedure codes suggesting aneurysm rupture and/or thoracoabdominal aneurysms. We also excluded patients with end-stage renal disease (determined from the denominator file) from our lower extremity bypass cohort, to reduce potential contamination with upper extremity shunts and bypass procedures performed for dialysis access (ICD-9 codes do not distinguish upper from lower extremity bypass). We excluded from our coronary artery bypass grafting cohort patients undergoing simultaneous valve replacement. Finally, for the 8 major cancer resections, our cohort was restricted to patients who also had a diagnosis code for the malignancy associated with the operation (eg, patients undergoing colectomy were also required to have a diagnosis code for colon cancer).

### Outcome Measures

Our primary outcome measures were postoperative length of stay and 30-day readmission rate. Length of stay was defined as the period from the index procedure to hospital discharge for the index admission. Readmission to any hospital within 30 days of discharge after the index procedure was designated as a 30-day readmission.

### Hospital Volume

Methods for establishing volume categories have been described in detail elsewhere.<sup>1</sup> In brief, volume was measured at the hospital level, expressed as the average numbers of procedures per year. Although volume was evaluated as a continuous variable, for presentation purposes we also created categorical variables. For each procedure, the hospitals

were ranked in order of increasing total hospital volume, and then 5 volume groups were defined by the selections of whole number cutoff points for annual volume that most closely sorted the patients into 5 groups of equal size (quintiles). To reflect most accurately the overall institutional experience with each type of operation, we combined the replacement of aortic and mitral valves into the single category of heart-valve replacement and lobectomy and pneumonectomy into the category of lung resection in determining hospital volume. However, length of stay and readmission rates for these procedures were assessed separately.

We used linear regression to examine the relationship between hospital volume and length of stay (a continuous variable) and logistic regression to examine hospital volume and readmission rate (a binary variable). In preliminary analysis, we noted that patients with very long lengths of stay substantially skewed the distribution of this variable, thus violating the normality assumption of our regression model. For this reason, we performed logarithmic transformation of this variable in our analysis.<sup>28</sup> To account for potential confounding by patient characteristics, we used multiple logistic regression techniques to adjust for the following variables: age, gender, race (black or nonblack), comorbidities (as defined by Charlson score,<sup>29,30</sup>) admission acuity (elective, urgent, or emergency), and mean Social Security income. However, because our results were only negligibly affected by adjustment, we present only observed length of stay and readmission rates here. All tests of significance are at the  $P < 0.05$  level, and all  $P$  values are two-tailed. The institutional review board at Dartmouth Medical School approved our study protocol.

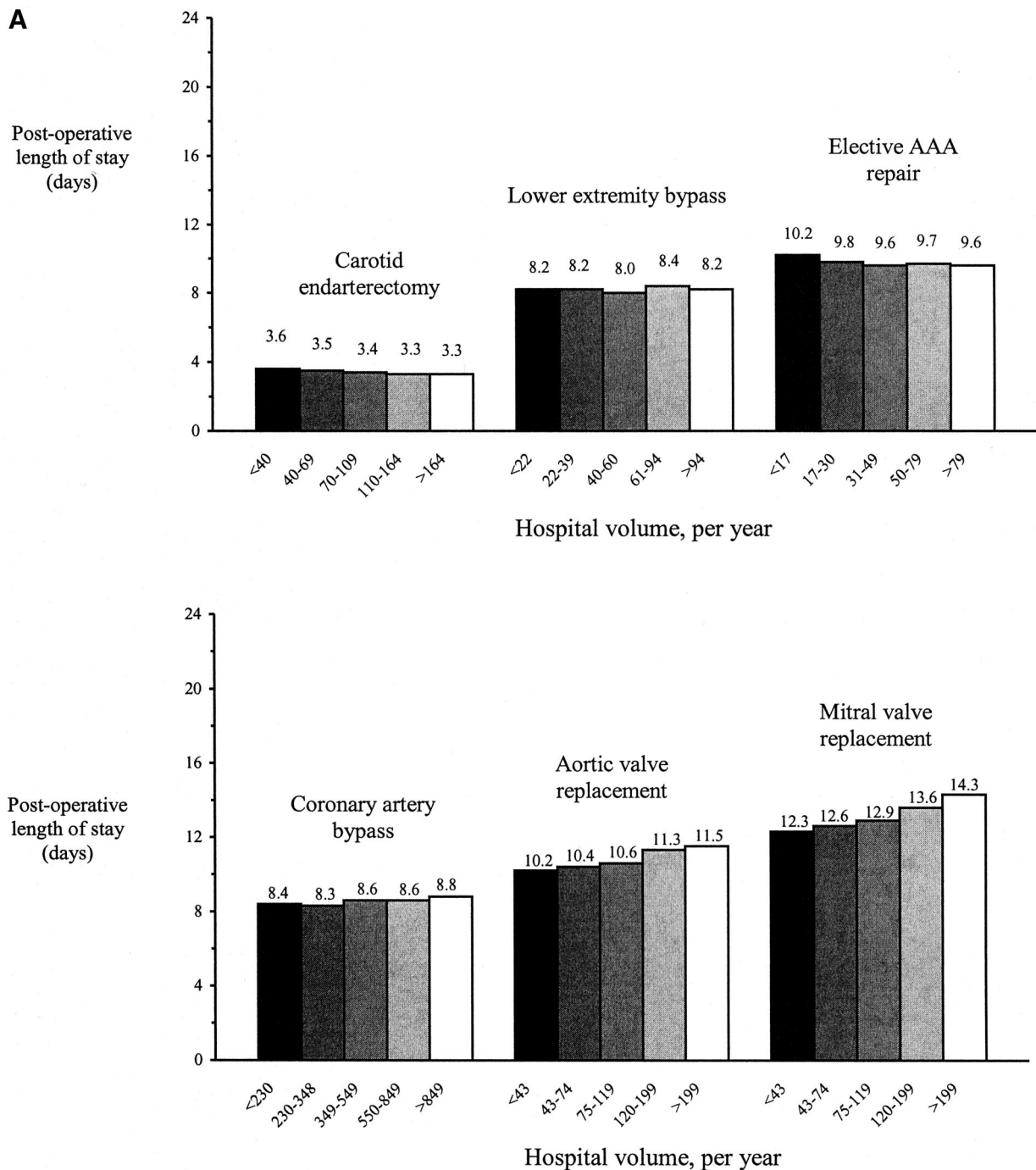
## RESULTS

### Patient Characteristics

During the study period of 1994-1999, approximately 2.5 million Medicare patients underwent 1 of the 14 high-risk surgical procedures. As described in our previous report,<sup>1</sup> patient age and sex did not differ consistently across hospital volume strata. For most procedures, black patients were more likely to undergo surgery at lower-volume hospitals, but Charlson comorbidity scores tended to be slightly higher at high-volume hospitals. Patients at low-volume hospitals, particularly those undergoing cancer resections, were more likely to be admitted nonelectively.

### Length of Stay

Postoperative length of stay varied widely across procedures (Fig. 1a and b). Mean length of stay was shortest in carotid endarterectomy (3.4 days), and longest for esophagectomy (19.6 days). In general, patients undergoing cancer resections had longer mean lengths of stay than those undergoing cardiovascular procedures. Several cancer resections



**FIGURE 1.** (a) Mean postoperative length of stay for 6 cardiovascular procedures, based on data from the national Medicare population (1994–1999).  $P < 0.05$  for all differences across volume strata. (b) Mean postoperative length of stay for 8 cancer resections, based on data from the national Medicare population (1994–1999).  $P < 0.05$  for all differences across volume strata.

were associated with mean lengths of stay in excess of 10 days (cystectomy, gastrectomy, esophagectomy, and pancreatic resection).

Because of very large sample sizes, there were statistically significant associations between volume and length of stay for all 14 procedures. However, there was no consistent



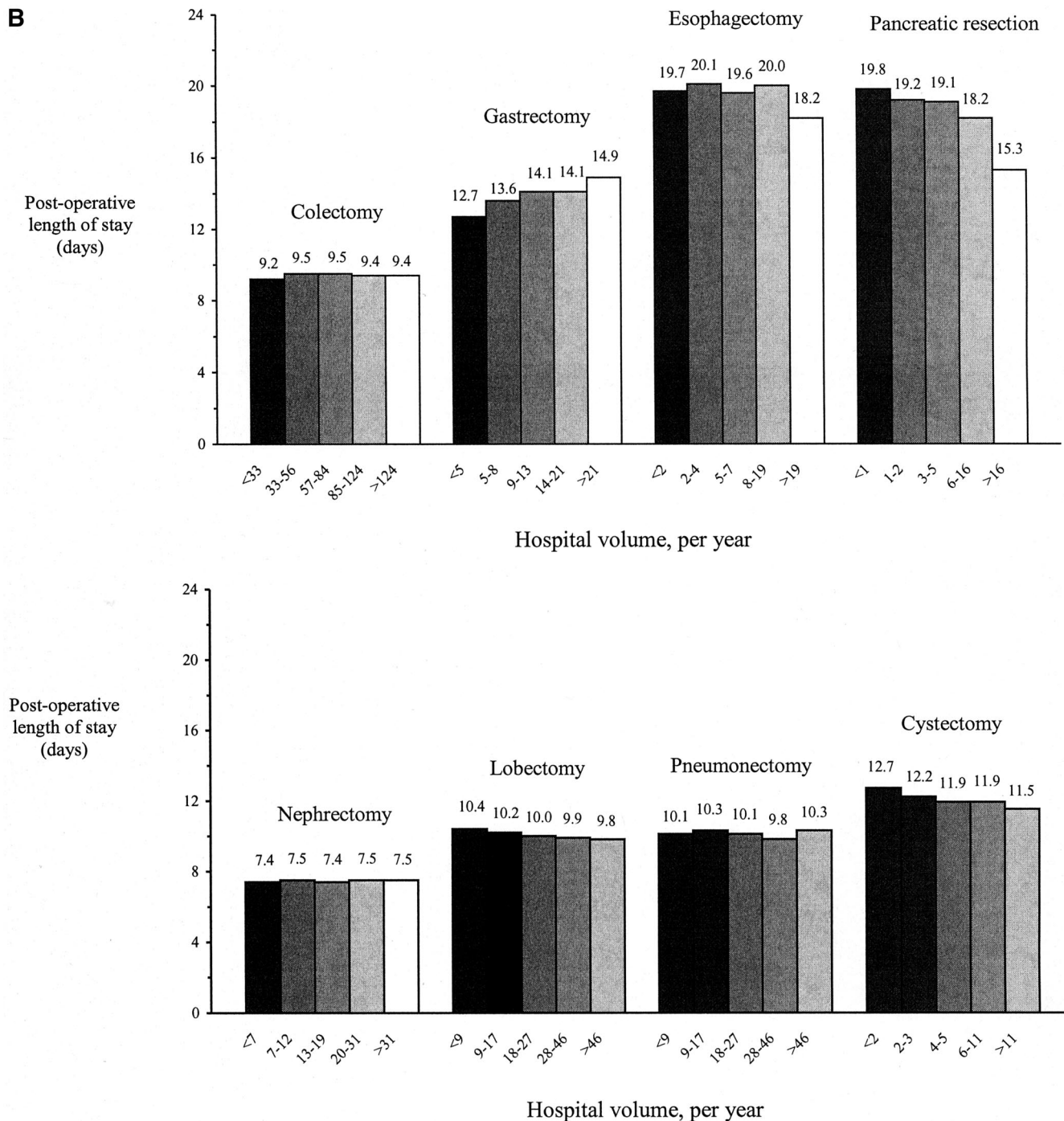


FIGURE 1. Continued

direction for this effect. Mean postoperative length of stay increased across volume strata for 7 of the 14 procedures and decreased across volume strata for the other 7.

Volume was associated with meaningful differences in length of stay for only a limited number of procedures. The largest difference occurred in pancreatic resection; mean

postoperative length of stay was 4.5 days shorter in very-high-volume hospitals (compared with very-low-volume hospitals). Mean postoperative length of stay at very-low-volume and very-high-volume hospitals differed by more than 1 day for 6 procedures. Of these, length of stay was shorter in high-volume hospitals for 3 procedures (pancreatic resection,

**TABLE 1.** 30-Day Readmission Rate (%) for 14 Different Operations, Based on Data From the National Medicare Population (1994–1999)

Procedure	Readmission Rate (%), by Hospital Volume Quintile					
	Overall	Very Low	Low	Medium	High	Very High
Cardiovascular procedures						
Carotid endarterectomy*	11.2	11.5	11.3	11.2	10.9	11.2
Coronary artery bypass	16.7	16.9	16.3	16.6	16.9	16.7
Lower extremity bypass	19.2	19.9	18.7	18.7	19.4	19.1
Elective AAA repair	10.9	11.4	10.1	10.8	10.8	11.4
Aortic valve replacement	19.3	18.9	19.1	19.7	19.8	19.2
Mitral valve replacement	22.2	21.9	22.1	22.6	22.2	21.9
Cancer resections						
Nephrectomy	9.9	10.7	9.7	9.4	9.4	10.3
Colectomy*	11.1	11.5	11.4	11.0	10.8	10.6
Pulmonary lobectomy*	11.1	11.3	10.5	10.7	11.1	11.9
Pneumonectomy	18.1	18.8	17.0	17.0	17.7	20.0
Gastrectomy	16.6	16.6	16.4	16.3	16.8	16.6
Cystectomy	21.4	22.4	20.4	20.6	21.4	22.2
Esophagectomy	18.4	19.1	17.9	18.2	18.4	18.7
Pancreatic resection*	18.7	16.6	17.8	18.5	19.5	20.3

Adjusted Data were essentially unchanged and are omitted for clarity.

\*Test of trend ( $P < 0.05$ ).

esophagectomy, cystectomy), but longer in high-volume hospitals for 3 other procedures (aortic and mitral valve replacement, and gastrectomy). Differences in length of stay of less than 1 day were observed for the remaining 8 procedures.

### 30-Day Readmission Rate

The 30-day readmission rate also varied widely across procedures (Table 1). The lowest readmission rate was 9.9% (nephrectomy), and the highest was 22.2% (mitral valve replacement). Statistically significant changes across volume strata were noted for only 4 of the 14 procedures. Readmission rates increased with volume for 2 procedures (pulmonary lobectomy and pancreatic resection) and decreased with volume for 2 procedures (carotid endarterectomy and colectomy). Although these differences were statistically significant, none were large enough to be considered clinically meaningful.

### DISCUSSION

Using a large, national database, we examined the association between hospital volume and resource utilization by studying length of stay and 30-day readmission rate for 14 high-risk surgical procedures. Hospital volume was not consistently related to length of stay or 30-day readmission rates. Rather, the nature of the procedures themselves was a more important determinant of length of stay and 30-day readmission rate.

Although our study is the first to examine the association between readmission and volume, others have examined relationships between hospital volume and length of stay. In contrast to our findings, prior studies have reported shorter lengths of stay in higher volume hospitals.<sup>13,17,21,22,24,25</sup> There may be several reasons for these differing conclusions. First, most of these studies were often limited to a single state or region. Since practice varies widely, their findings may not be generalizable to other parts of the country. Second, many of the prior studies were performed using data from more than a decade ago. Because length of stay has decreased over time for most procedures, volume may be a less important determinant of length of stay than it was 10 years ago. Lastly, publication bias may explain the lack of studies showing no association between volume and length of stay. It is well known that studies with negative results are less likely to be published.<sup>31-33</sup>

Our study has several limitations. First, because our study was limited to the Medicare population, our results may not be generalizable to patients less than 65 years of age. However, it is important to note that the Medicare population comprises approximately 60% of all patients undergoing these procedures.<sup>1</sup> Second, we may not have fully accounted for differences in case-mix across volume strata, because the limits of administrative data for risk adjustment are well known.<sup>34-39</sup> Thus, it may be possible that our study would

have detected shorter length of stay at high-volume hospitals with better data for risk adjustment. However, this could only occur if patients in high-volume hospitals were systematically older and sicker, a premise not supported in the volume-outcome literature.<sup>4</sup>

Length of stay and 30-day readmission rates are imperfect proxies for hospital-based costs because they do not reflect intensity of hospital care. In other words, hospitals with similar lengths of stay may differ in how resources are used during hospitalization. Intensity of care is known to differ between teaching and nonteaching hospitals.<sup>40-46</sup> In general, patients at teaching hospitals tend to receive more diagnostic tests and spend more time in the intensive care unit. However, it remains unknown whether similar differences in intensity of care are present between high-volume and low-volume hospitals.

A full accounting of the economic effects of volume-based referral initiatives would need to consider other potential costs.<sup>47</sup> These include administrative costs associated with the referral process (eg, transfer of medical information). Another potential cost may be duplication of services, including specialist consultations and preoperative imaging.

A full accounting of resource use must also consider what happens to patients after discharge. In many of the procedures studied here, intermediate care facilities are used as a resource for nonacute care and rehabilitation, allowing a shorter length of stay during the “acute” hospitalization.<sup>48</sup> How often these intermediate care facilities are used, across different procedures and volume categories, is unknown. It is also important to consider the use of home health services, which has also increased dramatically in recent years.<sup>49-51</sup> At this time, however, it is not known whether use of home health services varies by hospital volume.

Lastly, it is important to consider how volume-based referral initiatives might affect the total number of procedures performed, at least for discretionary procedures. Emphasis on procedure volume as a quality indicator creates incentives for hospitals and surgeons to operate more often. Because of the subjective nature of clinical decision making for conditions such as lifestyle-limiting coronary disease, small aortic aneurysms, and asymptomatic carotid stenosis, the use of surgery could be increased without overtly “inappropriate” procedures.<sup>52,53</sup> Also, geographic regions with the highest procedure rates tend to be dominated by high-volume surgeons, a phenomenon labeled the “enthusiasm hypothesis” by Chassin.<sup>54</sup> Thus, efforts to concentrate care in high-volume centers might drive patients toward surgeons with lower thresholds to operate, further increasing the number of procedures performed.

Although not a true resource cost, policy makers must also consider the indirect effects of redistributing surgical revenue.<sup>47</sup> Because surgery is a well-known profit center at most hospitals, loss of caseloads could threaten the viability

of some low-volume hospitals. It could also adversely affect their ability to recruit and retain surgeons. These indirect effects could threaten patient access to basic surgical care. To avoid this problem, the Leapfrog group has exempted hospitals in rural areas from their evidence-based referral initiative. Advocates for other volume-based initiatives should take similar caution.

Clearly, a full accounting of the likely effects of volume-based referral initiatives on resource use is difficult given the data currently available. However, to the extent that length of stay and readmission rates reflect overall costs, volume-based referral initiatives seem more likely to decrease mortality than the cost of delivering high-risk surgery.

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