Regionalization of High-Risk Surgery and Implications for Patient Travel Times

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For many surgical procedures, operative mortality rates are substantially lower at hospitals that perform them more frequently.1-3 As a result, concentrating selected procedures in higher-volume hospitals is advocated by many.4,5 For example, the Leapfrog Group, a large business coalition, is using a variety of incentives to encourage its employees and enrollees to receive care at hospitals exceeding minimum volume standards for 5 selected procedures.6 Previous analyses suggest that such regionalization policies could avert hundreds, if not thousands, of surgical deaths each year in the United States.6 However, critics note that such policies would disrupt traditional referral patterns and may lead to undesirable consequences for hospitals and patients.7,8

One common criticism is that many patients, particularly those in rural areas, would experience unreasonable travel burdens if required to travel to higher-volume centers for surgery. Although there has been little research exploring whether such concerns are justified, excessive travel burden is an important barrier to access for patients and an inconvenience to their families. As distance increases to health care providers, the use of health care services generally falls.9-11 For surgical patients, the initial procedure may be delayed or the continuity of perioperative care may be impaired. For example, management of late complications or other sequelae of surgery might be left to local clinicians not involved with the surgery.

In this study, we used national Medicare data and US road network information to assess the travel time implications of setting minimum volume standards for pancreatic resection and esophagectomy. These procedures are good candidates because they are usually scheduled electively and are performed infrequently enough that regionalization would not imply redistributions of large populations. Moreover, particularly dramatic volume-outcome relationships have been described for these 2 procedures.1-3,12,13

In a recent analysis of Medicare patients, operative mortality rates with each procedure were 12% higher (in absolute terms) at very low-volume hos-
and esophagectomy has been suggested regionalization of pancreatic resection or older than 99 years were also excluded. Patients younger than 65 years maintenance organizations during this period. Patients younger than 65 years or older than 99 years were also excluded.

Methods
Study Population
By using data from the national Medicare claims files and appropriate International Classification of Diseases, Ninth Revision codes, all Medicare patients undergoing pancreatic resection (codes 52.51, 52.53, 52.7) or esophagectomy (codes 42.40-42.42, 43.99) for cancer between 1994 and 1999 in the 48 continental states were identified. Methods used to define this study cohort are described in detail elsewhere. Only patients in fee-for-service arrangements were included; thus, the sample excludes the approximately 10% of Medicare patients enrolled in risk-bearing health maintenance organizations during this period. Patients younger than 65 years or older than 99 years were also excluded.

Classification of Hospital Procedure Volume
To characterize hospital volume, the average annual number of pancreatic resection or esophagectomy procedures performed by each hospital for any reason on Medicare patients throughout the 6-year period was first determined. Our previous analyses, based on the 1997 Nationwide Inpatient Sample (unpublished data), have indicated high correlations between Medicare-only and total volumes at hospitals performing these procedures (correlation coefficients, 0.91 and 0.98, respectively, for esophagectomy and pancreatic resection). For this reason, hospital volume status was assigned according to estimated total volumes to make the volume estimates more easily interpretable. Total volumes were determined by multiplying each hospital’s observed Medicare volume by the overall total/Medicare ratio for each procedure (2.0 for pancreatic resection; 2.1 for esophagectomy).

To avoid potential bias, volume cut points were selected before the travel-time analysis was performed. As with the authors’ previous work, hospitals were ranked in order of increasing total volume, and whole-number cut points were chosen that most closely sorted patients into 5 evenly sized groups or quintiles (very low, low, medium, high, and very high volume; Table 1).

Assessment of Travel Burden
For each patient in the study population, the travel time (by the quickest route) was estimated between the patient’s ZIP code of residence and the ZIP code of the hospital in which he or she underwent surgery. Travel times were then calculated from each ZIP code of patient residence to the nearest hospital meeting or exceeding the specified minimum volume standard for the given procedure. ZIP code centroids, the center point of a geographic region defined by a ZIP code, were used to designate travel route origins (patient residences) and destinations (hospitals). For 99% of the ZIP codes, postal delivery–based centroids were available (ZIP code inventory data; Geographic Data Technology Inc, Lebanon, NH); these centroids approximate the population center within a ZIP code polygon. Geographic centroids were used for the ZIP codes without delivery-based centroids.

ArcView Network Analyst (Environmental Systems Research Institute, Redlands, Calif) was used to determine the shortest travel route (in minutes) between any pair of origin and destination centroids. Travel costs were estimated as the product of road distance and travel speed by using 2000 US road network data (Dynamap/Highways Routing; Geographic Data Technology Inc). Roads were classified into the following segments: limited access highways (ie, interstates), primary highways, secondary highways, local roads, access ramps/rotaries, and ferry crossings. Each road segment was assigned an average travel speed, adjusted for its

Table 1. Number of Medicare Patients and Risk-Adjusted Operative Mortality According to Hospital Procedure Volume

<table>
<thead>
<tr>
<th>Procedure Volume</th>
<th>Volume Level</th>
<th>Very Low</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Very High</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pancreatic resection</td>
<td>Estimated total (Medicare and non-Medicare) volume per year</td>
<td>&lt;1</td>
<td>1-2</td>
<td>3-5</td>
<td>6-16</td>
<td>&gt;16</td>
<td>168</td>
</tr>
<tr>
<td>Hospitals, No. (%)</td>
<td>1028 (55)</td>
<td>555 (30)</td>
<td>168 (9)</td>
<td>90 (5)</td>
<td>27 (1)</td>
<td>1868</td>
<td></td>
</tr>
<tr>
<td>Medicare patients, No. (%)</td>
<td>1563 (15)</td>
<td>2757 (26)</td>
<td>1885 (18)</td>
<td>2166 (21)</td>
<td>159 (21)</td>
<td>10530</td>
<td></td>
</tr>
<tr>
<td>Patients eligible for travel time analysis, No. (%)</td>
<td>1494 (15)</td>
<td>2650 (27)</td>
<td>1782 (18)</td>
<td>2037 (21)</td>
<td>1862 (19)</td>
<td>9825</td>
<td></td>
</tr>
<tr>
<td>Risk-adjusted operative mortality (Medicare), %</td>
<td>16.3</td>
<td>14.6</td>
<td>11.0</td>
<td>7.2</td>
<td>3.8</td>
<td>11.0</td>
<td></td>
</tr>
<tr>
<td>Esophagectomy</td>
<td>Estimated total (Medicare and non-Medicare) volume per year</td>
<td>&lt;2</td>
<td>2-4</td>
<td>5-7</td>
<td>8-19</td>
<td>&gt;19</td>
<td>1575</td>
</tr>
<tr>
<td>Hospitals, No. (%)</td>
<td>618 (39)</td>
<td>620 (39)</td>
<td>187 (12)</td>
<td>119 (8)</td>
<td>31 (2)</td>
<td>1575</td>
<td></td>
</tr>
<tr>
<td>Medicare patients, No. (%)</td>
<td>861 (14)</td>
<td>1817 (29)</td>
<td>1091 (17)</td>
<td>1393 (23)</td>
<td>1175 (19)</td>
<td>6337</td>
<td></td>
</tr>
<tr>
<td>Patients eligible for travel time analysis, No. (%)</td>
<td>825 (14)</td>
<td>1734 (29)</td>
<td>1053 (18)</td>
<td>1330 (23)</td>
<td>1029 (17)</td>
<td>5971</td>
<td></td>
</tr>
<tr>
<td>Risk-adjusted operative mortality (Medicare), %</td>
<td>20.3</td>
<td>17.8</td>
<td>16.2</td>
<td>11.4</td>
<td>8.4</td>
<td>15.5</td>
<td></td>
</tr>
</tbody>
</table>

*Excludes patients with missing ZIP code information; those in Alaska, Hawaii, and areas lacking road connectivity; and those with listed primary residence more than 400 km (250 miles) from the hospital performing surgery.
†See Birnkrauer et al for details related to assessment of mortality and risk adjustment.
location in rural and nonrural areas (TABLE 2). In the absence of an accepted standard, travel speeds were assigned through a consensus process that included the investigators and the Bureaus of Primary Health Care and Health Professions of the Health Resources and Services Administration. Because origin and destination centroids often did not intersect the road network, a straight line was computed (travel speed 56 km/hour [35 mph]) to the nearest road segment. These travel costs were then added to the travel costs of the other intervening road segments.

To minimize bias from patients who sought care when they were not near their primary residence, patients were excluded whose straight-line distance between their residence and the hospital where they received their care exceeded 400 km (250 miles; 5% of patients). Also excluded were patients in "special case" areas such as Alaska, Hawaii, and some isolated islands that have incomplete or unknown road connectivity (1%).

In sensitivity analysis, travel time assessments were repeated after the study sample was restricted to patients residing in rural areas by using 1990 census data to characterize patient ZIP codes of residence as either rural or nonrural. Approximately 5% of patients overall were excluded from this analysis because their ZIP code could not be matched to the census data. SAS version 8 (SAS Institute, Cary, NC) was used for statistical analysis.

RESULTS
Status Quo
Between 1994 and 1999, 1868 US hospitals performed at least 1 pancreatic resection for cancer in Medicare beneficiaries; 1575 performed at least 1 esophagectomy for cancer (Table 1). The large majority of these hospitals were categorized as very high volume (1% pancreatic resection; 2% esophagectomy), these hospitals performed about 20% of these procedures (21% and 18%, respectively).

TABLE 3 summarizes overall travel times for all Medicare patients undergoing pancreatic resection or esophagectomy in the status quo and with increasingly stringent minimum volume standards. With pancreatic resection, 61% of patients traveled less than 30 minutes; 76%, less than 1 hour. Ten percent of patients traveled at least 120 minutes to undergo their procedures. Similar travel times were observed for esophagectomy. Overall travel times would increase if minimum volume standards were implemented, the degree depending on the volume cut point. Overall travel times would change only modestly with low- or medium-volume standards but much more substantially with very high-volume standards (Table 3).

Additional travel times were then determined for patients required to change to higher-volume hospitals (FIGURE). With low-volume standards, approximately 15% of patients would need to change hospitals, and of these, most would need to travel less than 30 additional minutes (74% pancreatic resection; 56% esophagectomy).

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Only a minority of patients would increase their travel times by an hour or more (11% pancreatectomy; 9% esophagectomy) or 120 or more minutes (3% each procedure). Many patients affected by low-volume standards already lived closer to a high-volume hospital (25% pancreatectomy; 26% esophagectomy), so their travel times would potentially fall. With very high-volume standards, however, approximately 80% of patients would need to change hospitals, and of these, more than 50% would increase their travel time by at least an hour.

Patients in Rural Areas

Patients residing in rural areas accounted for 14% and 15% of all Medicare patients undergoing pancreatic resection or esophagectomy, respectively. As seen in Table 4, these patients traveled significantly longer for surgery than patients living in nonrural areas. With low- or medium-volume standards, travel times for patients in rural areas would not change substantially for either procedure. With very high-volume standards, however, the proportion of patients traveling long distances for surgery would increase sharply. For example, patients undergoing esophagectomy would need to travel long distances for surgery in nearly 40% of hospitals, compared to only 14% of hospitals with low-volume standards.

### Table 4. Sensitivity Analysis Restricted to Patients in Rural Areas*

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Status quo</th>
<th>With minimum volume standard (procedures/y)</th>
<th>Higher volume standard (procedures/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low (≥1)</td>
<td>Medium (≥3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>269 (21)</td>
<td>377 (29)</td>
</tr>
<tr>
<td>Pancreatic resect</td>
<td>Status quo</td>
<td>178 (14)</td>
<td>396 (31)</td>
</tr>
<tr>
<td></td>
<td>Low (≥1)</td>
<td>79 (6)</td>
<td>316 (25)</td>
</tr>
<tr>
<td></td>
<td>Medium (≥3)</td>
<td>26 (2)</td>
<td>198 (15)</td>
</tr>
<tr>
<td></td>
<td>High (≥6)</td>
<td>2 (0)</td>
<td>59 (5)</td>
</tr>
<tr>
<td></td>
<td>Very High (≥17)</td>
<td>7 (1)</td>
<td>44 (5)</td>
</tr>
<tr>
<td>Esophagectomy</td>
<td>Status quo</td>
<td>161 (19)</td>
<td>266 (31)</td>
</tr>
<tr>
<td></td>
<td>Low (&lt;2)</td>
<td>117 (14)</td>
<td>282 (33)</td>
</tr>
<tr>
<td></td>
<td>Medium (≥3)</td>
<td>60 (7)</td>
<td>233 (27)</td>
</tr>
<tr>
<td></td>
<td>High (≥8)</td>
<td>34 (4)</td>
<td>161 (19)</td>
</tr>
<tr>
<td></td>
<td>Very High (≥20)</td>
<td>7 (1)</td>
<td>44 (5)</td>
</tr>
</tbody>
</table>

*Distribution of travel times for Medicare patients (1994-1999) for the status quo and if all patients were required to undergo these procedures in hospitals exceeding a minimum volume standard.
†Total (Medicare plus non-Medicare) volume.
‡Five percent of patients could not be classified as living in rural or nonrural areas.
74% or 73% of rural patients undergoing pancreatic resection or esophagectomy, respectively, would need to travel at least 2 hours for their procedures.

**COMMENT**

Although not the only policy consideration, the trade-off between potential reductions in operative mortality and travel burden is central to debates about regionalization. The present findings suggest that low- or even medium-volume standards could be set for pancreatic resection and esophagectomy without imposing unreasonable travel burdens on most patients. Most patients required to have surgery at a higher-volume center would add fewer than 30 minutes to their travel times. Travel times for many patients would actually decrease. Standards set at such conservative levels would affect a majority of hospitals currently performing these 2 procedures but less than half of patients undergoing them. Volume standards set at higher levels could reduce operative mortality rates for a greater number of patients. However, this analysis suggests that these potential benefits would come at the price of substantially increased travel times and access issues for many patients, particularly in rural areas.

To our knowledge, only 2 studies have assessed the geographic implications of regionalizing surgical services. In a study of pediatric cardiac surgery in California, Chang and Klitzner\(^15\) found that referral to high-volume hospitals would cause only a 20.8-km (13-mile) average increase in patient travel. However, the study did not account for the effect of different road types on travel “costs” and was limited to a single state. In another study, Grumbach et al\(^16\) examined the delivery of coronary artery bypass graft (CABG) surgery in New York, California, and Canada. Although this procedure is performed at substantially fewer hospitals than pancreatic resection and esophagectomy, they found that most patients lived within 25 miles of the hospital performing their CABG and that excluding low-volume hospitals would have a negligible effect on travel distances. Unlike the present study, however, that study measured travel with straight-line (“as the crow flies”) distances between patient residences and hospitals. There is also a fundamental difference in the procedures examined in the present analysis and that by Grumbach et al.\(^16\) Low-volume hospitals perform pancreatic resection and esophagectomy only a few times a year, on average. Moving these procedures elsewhere would have little effect on either hospitals or surgeons. In contrast, because CABG is much more common, a hospital performing 200 procedures per year is considered to have low volume. Policies shutting down such services would not go unnoticed by affected surgeons and hospitals.

The present analysis has several limitations. First, it focused only on Medicare patients, who constitute about half of all patients undergoing these 2 procedures. Although impossible to confirm empirically, volume standards probably would not have significantly different implications for travel burdens in younger populations. Second, only 2 operations of a much broader list of procedures for which many advocate regionalization were assessed. Third, the travel time calculations are estimates. Assigning populations to ZIP code centroids may give falsely low travel times for some populations while overestimating travel times for others. Patients residing in heavily congested urban areas may have longer travel times than patients in other metropolitan areas. Patients who already live a distance from hospitals are at a higher risk for substantially greater travel burden in inclement weather or if private transportation is unavailable.

Exposing patients to unreasonable travel burdens is only 1 of the potential downsides of setting minimum volume standards for selected procedures. With some procedures, regionalization could have negative effects on quality of urgent or related procedures at low-volume hospitals. For example, the hospital no longer performing elective abdominal aneurysm repair could be less proficient at dealing with patients with ruptured aneurysms. Second, volume standards could lead to unnecessary procedures as a result of provider incentives to increase their volumes. And finally, regionalization could result in reduced patient access to basic surgical care if low-volume hospitals became less able to recruit or retain surgeons. These concerns may be important for many procedures for which volume standards are being considered. However, they are not persuasive for pancreatic resection or esophagectomy. These procedures are almost exclusively elective and nondiscretionary enough that unnecessary surgery is unlikely. Because low-volume hospitals perform pancreatic resection or esophagectomy fewer than 1 or 2 times a year on average, volume standards would not threaten the financial well-being of low-volume surgeons or hospitals.

Most ongoing initiatives aimed at concentrating selected surgical procedures in high-volume hospitals are focused primarily on educating patients. Although some purchasers participating in the Leapfrog Group are selectively contracting with higher-volume hospitals, the main thrust of this effort consists of informing patients about the importance of procedure volume with selected operations and giving patients information about volumes at hospitals near them. With such policies, patients can make their own decisions about trade-offs between travel time, convenience, and risk reduction. Because of strong financial incentives for the hospitals to maintain the status quo, however, it is not clear that policies focusing primarily on patient education are likely to result in significant reductions in the numbers of patients undergoing surgery at very low-volume hospitals.

For this reason, payment-based or other regulatory approaches may be desirable for procedures for which the benefits of regionalization would greatly outweigh its harms. As 1 precedent, the Center for Medicare & Medicaid Services has minimum volume requirements for reimbursement of selected transplant procedures in Medicare patients. The present findings suggest that a similar policy could be safely estab-
lished for pancreatic resection and esophagectomy without concern that patients would have to travel too far for their surgical care.

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Study concept and design: Birkmeyer, Goodman.

Acquisition of data: Birkmeyer, Goodman.

Analysis and interpretation of data: Birkmeyer, Siewers, Marth, Goodman.

Drafting of the manuscript: Birkmeyer.

Critical revision of the manuscript for important intellectual content: Birkmeyer, Siewers, Marth, Goodman.

Statistical expertise: Siewers.

Obtained funding: Birkmeyer.

Administrative, technical, or material support: Marth, Goodman.

Study supervision: Birkmeyer, Goodman.

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REFERENCES


