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The Effects of Regionalization on Cost and Outcome for One General High-Risk Surgical Procedure

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Purpose
The effects of regionalization of tertiary care were studied by analyzing cost and outcome for pancreaticoduodenectomies in a state in which the majority of these high-risk procedures were performed in one hospital.

Methods
Using Maryland inpatient discharge data via a retrospective study, the authors compared cost and outcome data for a hospital with more than one half of the cases in the state to all other hospital providers as a group and with smaller groupings according to the volume of procedures performed.

Results
Hospital mortality, length of stay, and costs were significantly less at the high-volume regional medical center when compared with all other hospitals. Mortality and cost increased as volume decreased when hospitals were grouped according to volume.

Conclusions
An academic medical center, functioning as a high-volume regional provider, can deliver tertiary care services with improved outcomes at lower costs than community hospitals.

As the national debate on health-care reform intensifies, regionalization should be considered as a means to ensure the use of the most appropriate and cost-effective settings for tertiary care. Regionalization is defined as the delivery of care at a limited number of selected provider sites. Regionalization is an important consideration as a matter of public policy as well as an economic consideration under managed care, in which there are strong incentives to provide care at the lowest possible cost.

With the growth in patient care technology during the last 10 years and the abandonment of certificate-of-need requirements, community hospitals can offer most services once provided in tertiary care centers. In addition, community hospitals are perceived to provide these services at a lower cost than tertiary care centers. As a result, academic medical centers, which generally function as regional tertiary care providers, are particularly vulnerable to reform initiatives that could direct the delivery of inpatient care to low-cost providers.

This article provides a case study of hospital costs and

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outcomes of care for a high-risk general surgery procedure. The findings support the conclusion that a high-volume regional center can provide greater value as measured by both cost and outcome when compared with lower-volume centers in delivery of a selected service. The regional medical center in this study was an academic medical center; thus, the study also demonstrates that academic medical centers can be low-cost, high-quality providers of care.

METHODS

To evaluate the effect of regionalization on cost and outcome, a complicated, high-risk, general surgical procedure was identified for which there existed one high-volume regional provider and numerous lower-volume providers in the state of Maryland. Pancreaticoduodenectomy (the Whipple procedure) met these criteria with a statewide in-hospital mortality rate of 7.7% (as compared with an overall statewide in-hospital surgical mortality of 2.7%). Approximately 54% of all pancreaticoduodenectomies were done at one regional center (The Johns Hopkins Hospital); the remaining 46% were done at 38 other hospitals in the state.

Data for this study came from hospital discharges reported to the Maryland Health Services Cost Review Commission (MHSCRC) from 1988 through the first half of 1993. This database includes records of every discharge from all nonfederal, acute care hospitals in the state of Maryland—on average, 630,000 discharges per year. Each discharge record contains information on demographic characteristics, one primary and up to four secondary discharge diagnoses, one primary and up to two secondary procedures performed during that hospital stay, source of admission and payment, length of stay, hospital charges, and discharge status. Discharges of patients who underwent Whipple procedures were included if they had the ICD-9 code for pancreaticoduodenectomy in the primary procedure field of the discharge record.

Analysis of these data compared cost and outcome between the high-volume regional provider and all 38 other hospitals, where at least one Whipple procedure had been performed during the study period. The primary outcome of interest was in-hospital mortality, and rates were compared using the relative risk. In-hospital costs were estimated for each discharge from the total hospital charges reported to the MHSCRC. Because hospital charges are regulated strictly in Maryland, charges are a good approximation of real costs. Other measures that reflect both cost and outcome, such as length of stay and intensive care unit length of stay, also were compared in the two groups. These comparisons were done for all discharges and then again for those discharged alive.

Other factors that could potentially confound the comparison of the regional provider with other hospitals were selected from the database and included demographic factors, source of admission, source of payment, and comorbidity. Comorbidities that were listed as secondary discharge diagnoses were reviewed for their potential to affect survival and length of stay. These comorbidities included diabetes, essential hypertension, cardiovascular disease, pulmonary disease, and renal disease. Each discharge was coded for the presence of each comorbidity and the total number of comorbidities.

The statistical analysis for categorical variables, such as mortality, gender, and race, was conducted using the chi-square statistic. The mean of continuous variables, such as charges and length of stay, were compared using a t test after appropriate transformation to achieve a more normal distribution. Multivariate analyses were performed to adjust for potential confounding using multiple linear regression models.

Projections regarding potential savings of lives were estimated by applying the observed mortality rate from the high-volume regional provider to the patients cared for in the other 38 hospitals. A similar projection was done to estimate cost savings using the mean charge and length of stay for the regional provider applied to the group of lower-volume hospitals.

RESULTS

A total of 502 discharges from 39 hospitals of patients undergoing pancreaticoduodenectomies were analyzed from the MHSCRC database. One case had inconsistent data in the discharge record and was excluded, leaving 501 cases for analysis. More than one half of all pancreaticoduodenectomies (271 or 54.1%) were performed at The Johns Hopkins Hospital, the large-volume regional provider. The remaining 230 patients (45.9%) underwent operations at 38 other hospitals in the state, with a minimum of 1 case and a maximum of 20 cases at any one facility.

There were a number of differences between the group of patients treated at the high-volume regional provider compared with the group treated by the lower-volume providers (Table 1). Patients treated at the regional medical center were more likely to have been transferred from another hospital, have commercial insurance or "other" payment sources, have diabetes or hypertension listed as a secondary discharge diagnosis, and be white. Patients at low-volume hospitals were more likely to be black, have Medicaid or Medicare as a payment source, and have pulmonary disease as a secondary discharge diagnosis. The age distributions were similar, with a mean age of 61.5 years for the regional center patients and a mean age of 63.6 years for patients at the other hospitals.

Table 1. DEMOGRAPHIC CHARACTERISTICS, SOURCE OF PAYMENT, AND COMORBIDITY AMONG PERSONS UNDERGOING WHIPPLE PROCEDURES IN MARYLAND HOSPITALS*

	Regional Provider n (%)	38 Other Maryland Hospitals n (%)	p Value
Total discharges	271 (54.1%)	230 (45.9%)	
Source of admission			
Admitted from home	234 (86.3%)	217 (94.3%)	
Transfer from other hospital	37 (13.7%)	13 (5.7%)	0.003
Payment source			
Commercial insurance (including HMO)	119 (43.9%)	86 (37.4%)	
Medicare	122 (45.0%)	119 (51.7%)	0.01
Medicaid	10 (3.7%)	18 (7.8%)	
Other	20 (7.4%)	7 (3.0%)	
Gender†			
Male	144 (55.4%)	115 (52.3%)	0.50
Female	116 (44.6%)	105 (47.7%)	
Race†			
White	222 (85.4%)	151 (68.6%)	
Black	25 (9.6%)	62 (28.2%)	<0.001
Other	13 (5.0%)	7 (3.2%)	
Age			
<50 years	50 (18.5%)	35 (15.2%)	
50–59 years	45 (16.6%)	35 (15.2%)	0.69
60–69 years	93 (34.3%)	81 (35.2%)	
70+ years	83 (30.6%)	79 (34.4%)	
Mean age	61.5	63.6	0.07
Comorbidity‡			
Diabetes	48 (17.7%)	28 (12.2%)	0.09
Hypertension	53 (19.6%)	17 (7.4%)	<0.001
Pulmonary disease	41 (15.1%)	55 (23.9%)	0.01
Renal disease	4 (1.5%)	8 (3.5%)	0.15
Cardiac disease	51 (18.8%)	39 (17.0%)	0.59
Any comorbidity	149 (55.0%)	112 (48.7%)	0.19

* ICD-9 procedure code 52.7—radical pancreaticoduodenectomy (procedure code in primary location only).

† 21 subjects (11 at regional provider and 10 at other hospitals) were missing information on gender and race.

‡ ICD-9 diagnosis codes: diabetes (250.x), essential hypertension (401.x), pulmonary disease (491.x, 492.x, 493.x, 495.x, 507.x, 511.x, 514.x, 518.x), renal disease (584.x, 585.x, 591.x, 593.x, 596.x), and cardiac disease (396.x, 402.x, 410.x, 412.x, 413.x, 414.x, 415.x, 424.x, 426.x, 427.x, 428.x, 429.x).

Cost and outcome were significantly different for these two hospital groups (Table 2). Hospital mortality was six times higher ($p < 0.001$) among patients treated at low-volume facilities compared with the high-volume regional provider. This excess mortality remained after adjustment for age, gender, race, source of payment, source of admission, and comorbidity (Table 2). Mortality was associated strongly with volume (Table 3). Mortality rates increased monotonically with decreasing volume from 2.2% at the high-volume regional provider to 19.1% among those hospitals with five or fewer cases over this 5½ year period ($p < 0.001$).

In addition to a lower risk of mortality, the high-volume regional center was associated with a shorter length of stay and a lower total hospital charge (Table 2). Average length of stay was lower by 4.1 days for all discharges ($p = 0.04$) and by 5.4 days for live discharges ($p < 0.001$) at the high-volume regional provider compared with the other 38 hospitals. Mean stay in the intensive care unit also was 2 days shorter at the regional provider ($p < 0.001$). Total hospital charges were significantly lower at the regional provider, an average difference of $5,455 for all discharges ($p < 0.001$) and $6,727 for live discharges ($p < 0.001$). Adjustment for potentially confounding variables made little difference in these results (Table 2).

Time trends in length of stay, total charges, and case volume are particularly interesting in this comparison (Figs. 1–3). For length of stay, total charges, and case volume, the two groups were very close in 1988. After 1988, the length of stay declined steadily at the regional provider through mid 1993, whereas length of stay in the other 38 hospitals fluctuated by calendar year, but remained relatively constant. Hospital charges at the regional provider also dropped after 1988 and have remained stable since 1989. In contrast, the other 38 hospitals have shown a slow but steady rise in total charges,

Table 2. IN-HOSPITAL MORTALITY, LENGTH OF STAY, AND CHARGES AMONG PERSONS UNDERGOING WHIPPLE PROCEDURES IN MARYLAND HOSPITALS

	Regional Provider	38 Other Maryland Hospitals	Crude Difference	p Value	Adjusted Difference*	p Value
In-hospital mortality	2.2%	13.5%	11.3%	<0.001	11.4%	<0.001
Relative risk	1.0	6.1				
(95% CI)		(2.9, 12.7)				
Mean length of stay						
All discharges	23.0	27.1	4.1	0.04	4.2	0.05
Live discharges	22.5	27.9	5.4	<0.001	5.7	<0.001
Mean ICU length of stay						
All discharges	2.2	4.1	1.9	<0.001	1.7	0.004
Live discharges	1.8	3.8	2.0	<0.001	1.9	<0.001
Mean total charges						
All discharges	$26,204	$31,659	$5,455	<0.001	$5,011	<0.001
Live discharges	$24,478	$31,205	$6,727	<0.001	$6,758	<0.001

* Adjusted for age, race, gender, source of payment, source of admission, and comorbidity.

with an acute rise between 1992 and 1993. Case volume at both the regional provider and the other 38 hospitals increased from 1988 through 1991, with the regional provider remaining at 60 to 65 cases per year through mid 1993. Case volume at the other hospitals peaked at 55 in 1991 and declined thereafter.

The potential reductions in mortality and cost associated with this complex procedure were estimated based on the mortality rate, average length of stay, and charges observed at the high-volume regional provider. Table 4 demonstrates that 84.0% of mortality, 15.0% of total hospital days, and 17.2% of total hospital charges may have been eliminated had such procedures been conducted at the regional referral center.

DISCUSSION

This study demonstrates that for the high-risk surgical procedure studied, the high-volume regional medical center achieved superior outcomes at a lower cost. The most likely explanation of this result is that the regional medical center has a group of health-care providers with special expertise because of the large number of procedures performed. This includes not only the expertise of the attending surgical and anesthesia medical staff, but also the around-the-clock availability and experience of a team of house staff, nursing staff, and ancillary personnel who are experienced in caring for those patients. Other possible explanations include the following: experience-driven early detection and treatment of complications; the use of dedicated intensive care unit attending physicians; and the availability of specialty support services. Costs were lower for precisely the same reasons that outcomes were better. Because of the standardized approach of the experienced team, there was a lower use of intensive care unit resources; avoidance of excessive

Table 3. ASSOCIATION OF HOSPITAL SURGICAL VOLUME AND MORTALITY FOR PATIENTS UNDERGOING WHIPPLE PROCEDURES IN MARYLAND HOSPITALS

Hospital Volume	No. of Hospitals	Total Whipple Procedures	Deaths	Mortality Rate	Relative Risk
1-5 cases	20	42	8	19.1%	8.7
6-10 cases	9	63	9	14.3%	6.5
11-15 cases	6	69	9	13.0%	5.9
16-20 cases	3	56	5	8.9%	4.0
>20 cases	1	271	6	2.2%	1.0

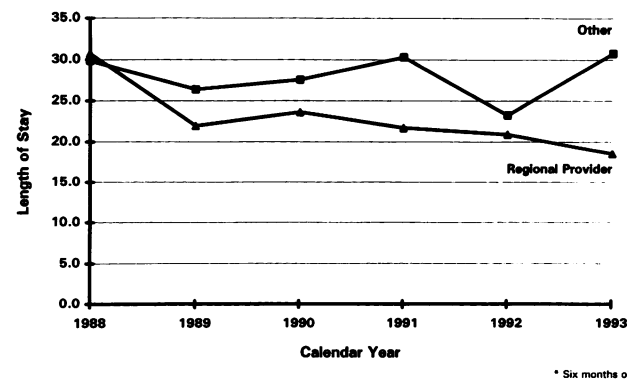

Figure 1. Average length of stay at regional provider and at other hospitals for patients discharged alive after undergoing Whipple procedure by calendar year from 1988 through the first 6 months of 1993.

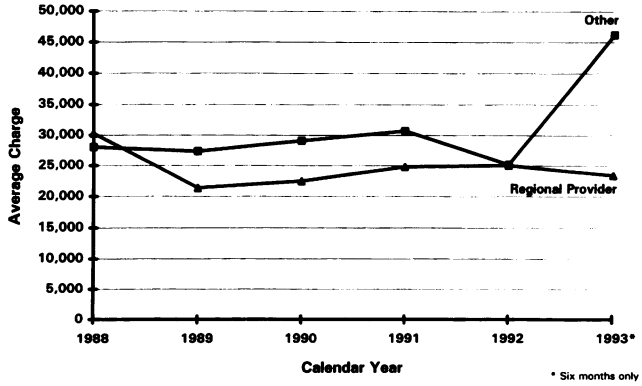

Figure 2. Average gross inpatient hospital charge at regional provider and at other hospitals for patients discharged alive after undergoing Whipple procedure by calendar year from 1988 through the first 6 months of 1993.

use of radiology examinations, laboratory tests, and hospital supplies; and an overall shorter length of stay.

This study has several important limitations. First, clinical outcome measurement was limited to in-hospital mortality because this was the only clinical indicator of outcome available in the state database. Ideally, complications, readmissions, functional status, quality of life, and survival after discharge should be examined to determine the most appropriate provider of care. Although these other outcome measures would provide a fuller picture of the consequences associated with this procedure, mortality is an important and objective criterion by which to study success. Second, information regarding patient severity on admission or indications for surgery was not available, which could influence course of treatment and outcome of care. Adjustment for comorbidities as defined by secondary discharge diagnoses, however, did not affect our results. Another limitation was the lack of information on diagnostic procedures performed before admission. Performing these on an outpatient basis or in a separate hospitalization would decrease in-hospital charges and affect cross-hospital comparisons. In the absence of outpatient data, and without means to link patient records across episodes of hospitalization, these important confounding factors could not be examined.

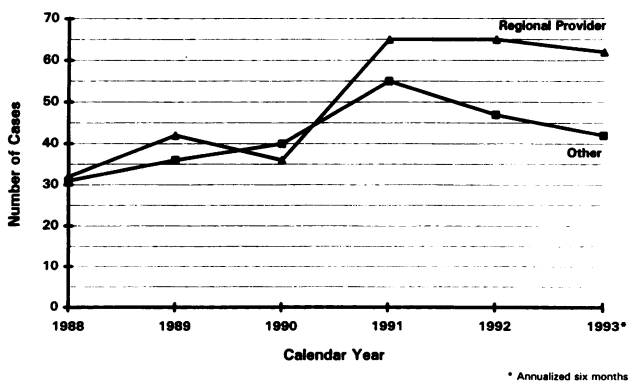

Figure 3. Total number of discharges at regional provider and at other hospitals of patients undergoing Whipple procedure by calendar year from 1988 through the first 6 months of 1993.

Table 4. POTENTIAL MORTALITY AND COST SAVINGS FOR WHIPPLE PROCEDURES IN MARYLAND HOSPITALS

	Mortality	Length of Stay	Costs
Total cases at 38 low-volume hospitals	230	230	230
Observed	31 cases	6225 days	$7,281,708
Expected if regional provider rate applied	5 cases	5289 days	$6,026,920
Potential savings	26 cases (84.0%)	936 days (15.0%)	$1,254,788 (17.2%)

The findings suggest that regionalization of care could have substantial impact on both the cost and outcome for patients undergoing this procedure. The relationship between volume of surgical services performed by surgeons and hospitals and positive outcomes of care has been well documented, highlighting the potential for regionalization of care.[1-8] In response, third-party payers have promulgated the development of "centers of excellence" or "institutes of quality" as a means to aggregate patients with providers with the best cost-outcomes profiles.[9-13] In this approach, patients are directed by their insurers to selected providers for these services. High-cost services that have been targeted in the centers of excellence approach include expensive high-volume procedures, such as coronary artery bypass surgery and the less frequently performed but even more expensive organ and bone marrow transplantations.

Although only a few surgical procedures have been targeted for regionalization, slightly more than one half of the approximately 31 million discharges from nonfederal short-stay hospitals in 1990 had operations performed.[14] Close to 4000 unique ICD-9 procedure codes exist to describe the operations performed.[15] Many of these surgical procedures are costly and carry a high risk of mortality, but have not yet been considered for regionalization in centers of excellence. Some reasons follow: a procedure may not be performed frequently enough to warrant the administrative costs of establishing a center; for some procedures, there are many different clinical indications, making it difficult to establish pre-admission approval of the surgery; treatment for many diagnoses includes surgical and nonsurgical interventions; diagnosis may be unknown until surgery is performed; and the

need for surgery may be an emergency and thus, may preclude the patient from being admitted to a center of excellence.

To benefit from the potential of enhanced survival and reduced costs, payers and providers will need to learn how to identify services for regionalization, establish regional centers, and triage patients to these centers. As opportunities for regionalization are identified, tertiary care and community-based providers must see that services are provided in the most cost-effective manner possible. This includes agreement on standardized care plans, prompt referral to appropriate specialty providers, availability and use of critical care transportation services, early discharge planning, use of home health care and subacute care facilities, and an overall commitment to cost control. Third-party concerns regarding outcomes, price, package pricing, single bill, and family amenities also must be addressed.

An important area of focus for clinical research is the identification of procedures most appropriately performed in regional centers and the development of specific clinical indications for referring patients to such centers. Third-party payers must commit to using these findings to develop policies and procedures that ensure their enrollees will receive care in the most appropriate setting. Regional centers also must increase their expertise in use of administrative databases to examine costs and outcomes of care. These are becoming increasingly available to the public and used by third parties and employers to compare provider performance and will play an increasingly important role in guiding policy development, despite their limitations.[16,17]

As more tertiary care shifts to fewer providers, cost for specific tertiary procedures may decrease as volume increases, but overall costs will increase at tertiary care centers and decrease at nontertiary care settings. Regional centers must document and explain this shift so that they are not penalized for providing high-cost specialty care, which is presumed to be their role. They also must be prepared to assess the impact of the shift to more tertiary care in terms of the need for ancillary support services, operating room time, intensive care unit beds, and similar factors. The impact of the shift of tertiary care on physician training also must be considered.

Academic medical centers, as part of their research and teaching mission, are particularly well suited to play leading roles in the development and implementation of analytical techniques to make use of available data resources to guide responsible policy development, provide leadership in understanding how to measure value as defined by cost and outcome, and educate purchasers of health-care services. Regional medical centers, and academic medical centers in particular, must begin to develop means to assess the cost and outcome of care to demonstrate the value of services provided. This includes the evaluation of performance to determine cost effectiveness, the identification of services that regional and academic medical centers are uniquely or specially qualified to provide, and the definition of the services these centers will supply within provider networks. Economic survival of academic medical centers will depend on ensuring an appropriate volume of patients to support these facilities and, in a broader public policy context, ensure a means to continue educating future physicians. Both academic medical centers and community hospitals must prepare for the review of costs and outcomes with consumers, third-party payers, and government agencies as all parties seek to ensure that services are provided in the setting that ensures accessible, high-quality, affordable care while meeting individual and societal needs.

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References

1. Luft HS, Bunker JP, Enthoven AC. Should operations be regionalized: the empirical relation between surgical volume and mortality. N Engl J Med 1979; 301:1364–1369.
2. Luft H. The relation between surgical volume and mortality: an exploration of causal factors and alternative models. Med Care 1980; 18:940–959.
3. Flood AB, Scott WR, Ewy W. Does practice make perfect? part I: the relation between hospital volume and outcomes for selected diagnostic categories. Med Care 1984; 22:98–114.
4. Flood AB, Scott WR, Ewy W. Does practice make perfect? part II: the relation between volume and outcomes and other hospital characteristics. Med Care 1984; 22:115–125.
5. Maerki SC, Luft HS, Hunt SS. Selecting categories of patients for regionalization: implications of the relationship between volume and outcomes. Med Care 1986; 24:148–158.
6. Hughes RG, Hunt SS, Luft HS. Effects of surgeon volume and hospital volume on quality of care in hospitals. Med Care 1987; 25: 489–503.
7. Hannan EL, O'Donnell JF, Kilburn H Jr, et al. Investigation of the relationship between volume and mortality for surgical procedures performed in New York state hospitals. JAMA 1989; 262:503–510.
8. Hannan EL, Kilburn H Jr, O'Donnell JF, et al. A longitudinal analysis of the relationship between in-hospital mortality in New York state and the volume of abdominal aortic aneurysm surgeries performed. Health Serv Res 1992; 27:518–542.
9. Renlund DG, Bristow MR, Lybbert MR, et al. Medicare-designated centers for cardiac transplantation. N Engl J Med 1987; 316: 873–876.
10. Wallace C. Centers for excellence: humana hopes to gain prestige as well as more hospital inpatients from its medical specialty centers. Mod Healthcare 1988; 18 (May 20):30–32.

11. Droste T. Marketing: "centers of excellence" name tag carries clout. Hospitals 1989; 63 (Jan 20):54.
12. Traska MR. In search of centers of excellence: here's what to ask before you send employees who need high-cost high-tech medical procedures to specialty centers. Business Health 1989; 7 (Sept):11–16.
13. Dragalin D, Plocher DW, Perkins D. Institutes of quality: Prudential's approach to outcomes management for specialty procedures. QRB Qual Rev Bull 1990; 16 (Mar):111–115.
14. Schneidman DS, ed. Socio-Economic Factbook for Surgery. Chicago: American College of Surgeons, 1993, p 46.
15. International Classification of Diseases—Clinical Modification. 9th Rev. Salt Lake City, UT: Med-Index Publications, 1993.
16. Luft HS, Hunt SS. Evaluating individual hospital quality through outcome statistics. JAMA 1986; 255:2780–2784.
17. Jencks SF, Williams DK, Kay TL. Assessing hospital-associated deaths from discharge data. JAMA 1988; 260:2240–2246.