Product-Line Evaluation of Graduate Medical Education Program Costs

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Summary

This article reports the results of an innovative application of traditional multivariate approaches to estimating hospital costs in order to support product-line evaluation of graduate medical education (GME) program costs among the clinical departments and teaching facilities of a nationwide, federal multi-institutional system. Department-level data for 1988, 1989, and 1990 were used to estimate a multiple regression model of total costs per disposition for the specialties of medicine, surgery, obstetrics/gynecology, orthopedics, psychiatry, and pediatrics. Systemwide and facility-specific GME program costs per disposition were estimated for each specialty on the basis of dependent variable scores predicted by the regression model. Measures of case-mix intensity, facility bed size, department staff size, clinical specialty, GME status, teaching intensity, operating efficiency, and regional variation each made statistically significant contributions to the explained variance in total costs per disposition, and yielded an adjusted R^2 of .701. Estimates of total costs and GME costs per disposition revealed substantial variation among clinical specialties, both systemwide and within specific facilities. The results of these techniques, their usefulness for enhancing executive ability to evaluate costs of GME programs as product lines, and their implications for public policy regarding hospital payments are discussed.

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As national health care expenditures continue to climb toward 18 percent of the Gross National Product by the end of this decade, hospital executives are under enormous political and economic pressure from national leaders, the competitive marketplace, and private sector consumers and payers to reduce "inefficiency" in hospital operations. As executives strive to guide their institutions through this turbulent period of grave financial risk deriving from declining occupancy rates, reduced payments, increasing contractual losses, and unacceptable returns on equity, they are increasingly considering reductions in product lines to trim or eliminate unprofitable services (Eastaugh 1992). To enhance effectiveness of product-line decisions, executives must have readily interpretable and managerially relevant methods of evaluating hospital costs that facilitate the comparison of costs among subsets of programs and institutions, account for cost variance due to justifiable treatment requirements, and focus managerial evaluation on variance arising from nontreatment sources.

This article reports the results of an innovative application of traditional multivariate approaches to investigating hospital costs in order to support strategic product-line evaluation of graduate medical education (GME) costs among the clinical departments and teaching facilities of a federal nationwide multi-institutional system. The results of these multivariate techniques, their usefulness for managerial decision-making, and their implications for public policy will be discussed.

Review of Previous Research

The literature regarding hospital costs reflects an extensive but relatively discontinuous pattern of research efforts that have left the research community at a point far from consensus on basic issues of methodology, model specification, variable operationalization, and research strategy (Thorpe 1988; Vita 1990; Custer and Wilkie 1991). This is particularly evident in research regarding the costs of GME. There is extensive evidence that teaching hospitals incur higher costs than nonteaching facilities, even when the influence of case-mix differences and costs of faculty and resident salaries are taken into account (Eastaugh 1987).

The increased lengths of stay, greater use of diagnostic testing, increased use of supplies, equipment, and drugs, and lower levels of patient care productivity associated with the more aggressive diagnostic and therapeutic orientations of teaching programs have been documented extensively. However, complex interrelationships involving the joint products of education, patient care, and research that are inseparably intertwined in GME (Eastaugh 1987) have presented significant conceptual and methodological difficulties to researchers who have sought to assign costs to GME through traditional cost-accounting techniques (Koehler and Slighton 1973) or to estimate the costs of GME using multivariate analysis (Thorpe 1988).

Multivariate research efforts to deal with the "conceptually insolvable" problem of unambiguously assigning costs to the joint products of GME (Koehler and Slighton 1973) generally have focused on determining an appropriate estimate of teaching costs on which to base adjustments to diagnosis-related group (DRG)–based payments to teaching hospitals under the Medicare Prospective Payment System (PPS). These studies, conducted at the facility level of analysis among large samples of hospitals, generally have estimated GME costs on the basis of a multiple regression coefficient associated with a measure of "teaching intensity"—most commonly, the ratio of residents to operating beds (Anderson and Lave 1986), regarding which, potentially serious methodological issues have been raised (Custer and Wilkie 1991).

Multivariate estimates of hospital costs in general, and teaching program costs in particular, that have been used by the Health Care Financing Administration (HCFA) to adjust hospital payments under PPS have been criticized as flawed due to omitted variable bias arising from incomplete model specification, errors in variable measurement, and other methodological limitations (Anderson and Lave 1986; Thorpe 1988; Custer and Wilkie 1991). The HCFA model of hospital costs bases payment under PPS on national average costs per case adjusted for DRG, local wage index, census region, GME intensity, disproportionate share of indigent patients, and outlier cases (Thorpe 1988). This parsimonious model of hospital costs has come under increasing criticism for its inability to account adequately for the majority of variation in hospital costs per discharge (Pope 1990); its imprecision in excluding possibly justifiable sources of cost variation related to treatment, rather than inefficiency (Feder, Hadley, and Zuckerman 1987); its unfairness in reallocating payments among hospitals, based on incomplete adjustment formulae (MacKenzie et al. 1991); and its potentially harmful effects on quality and access arising from the excessive risk the PPS is placing on many hospitals (Siegel et al. 1992). HCFA payment adjustments for teaching program costs have also been criticized for their inability to distinguish GME costs that reflect unavoidable investments in advancing medical knowledge from those that reflect unnecessary cost-increasing behavior by teaching facilities (Welch 1987). There is increasing consensus that, to be equitable, PPS payments should reflect a blend of national average costs and hospital-specific costs to account for the influence of justifiable factors that current policy ignores (Stefos, LaVallee, and Holden 1992).

The inability of previous research efforts to adequately deal with wide variation in hospital costs appears to be leading policymakers and health care executives to an impasse that could have serious effects on the quality and accessibility of hospital services, *without* effectively controlling costs (Longest and Detre 1991). Without managerially interpretable methods for distinguishing between justifiable cost variances and those that may reflect inefficiency, hospital executives may be forced to limit the kinds of patients they admit and the services they provide to those that experience small variation between institutional costs and mean-based payments. We simply must develop new investigative approaches that grapple with observed variation within and across hospitals, enable the comparison of costs among programs and institutions, and identify areas of possible managerial intervention to reduce inefficiency without needless reduction to the mean.

Methods

Unit of Analysis

A major goal of the present study was to demonstrate the feasibility and usefulness of modeling hospital costs at the clinical department level of analysis. Substantial differences in disease processes, patient acuity, equipment, procedural and organizational aspects of technology, resource consumption, and clinical practice requirements among the major clinical specialties are well documented (Stefos, LaVallee, and Holden 1992). There is considerable evidence that variations in costs across specialties are not completely explained by DRG-based indicators of patient diagnosis or severity (Feinglass, Martin, and Sen 1991). It is thus possible that simplifying assumptions of homogeneity of costs and production functions across clinical specialties, which have been required by studies conducted at the facility level, may have excluded important sources of cost variation (Anderson and Lave 1986).

Sample and Data

Data were collected for 1988, 1989, and 1990 for the departments of medicine, surgery, obstetrics/gynecology, orthopedics, psychiatry, and pediatrics within the 37 community and general hospitals of a nationwide, military health care delivery system. A major component of the U.S. Department of Defense direct health care system that serves a total beneficiary population exceeding 9 million, the hospitals in the multi-institutional system studied are located throughout the United States and include 30 short-term acute care community hospitals and 7 tertiary-level medical centers. Hospitals in the sample are accredited by the Joint Commission on Accreditation of Healthcare Organizations and are comparable to their private sector counterparts in terms of their range of services and patient mix. The community hospitals range in size from 8 to 216 beds, with an average operating bed size of 104. Medical centers range in size from 341 to 748 operating beds. Systemwide average daily workload exceeds 4,600 beds occupied, 925 admissions, 86 live births, and 51,000 clinic visits.

Annual data were collected for clinical departments within each hospital from a variety of centralized cost, workload, and patient accounting systems. Each department's data for each year were treated as separate observations or cases, consistent with other studies that have involved data for multiple years (Hadley and Schwartz 1989; Farley and Hogan 1990). To control for time-related changes in the data, a dummy-coded variable was included to reflect the year to which each case referred (Farley and Hogan 1990). The exclusion of cases due to missing data and the absence of certain departments at some smaller hospitals yielded a sample size of 630 cases.

Operationalization of Variables

The project involved the specification and estimation via multiple regression of a general model of hospital costs that included the major determinants of costs identified by previous research. The variables in the model and their operational definitions are summarized in the Appendix.

The dependent variable was total annual costs per department divided by total annual discharges per department. The fact that all health care providers, including teaching staff and attending physicians, are salaried members of the system permitted the unambiguous inclusion of physician costs in the dependent variable (Eastaugh 1987). Total costs for each department included total annual costs of salaries, supplies, and equipment; costs of clinical support services incurred by each department; and overhead costs of plant, depreciation, energy, and administration allocated to each department.

Independent variables in the model reflected the categories of scale of operations, product mix, operational efficiency, and factor prices, under which hospital cost determinants generally have been classified (Carr and Feldstein 1967). Scale of operations was operationalized by measures of facility and department size. Product-mix variables included illness severity, teaching status, teaching program size or "intensity," and clinical specialty. Operational efficiency was measured by the effect of length of stay, net of the other variables. Regional variation in factor prices was operationalized by a categorical measure of regional location. A dummy-coded (0, 1) variable representing year was used to control for possible cross-year effects on costs.

The nonavailability of more precise factor price variables and measures of patient socioeconomic mix required assumptions of homogeneity with regard to these theoretical determinants of costs. These assumptions were supported by the standardized salary scales and the centralized personnel and materiel management systems present in this federal multi-institutional system. Relative homogeneity of socioeconomic status among eligible beneficiaries of the system permitted the assumption of homogeneity in patient socioeconomic mix.

Analytic Methods

The analysis was conducted in two phases. First, techniques of hierarchical multiple regression were used to test hypotheses that each independent variable specified in the model makes a unique contribution to explaining variance in costs per disposition, over and above the variance it shares with other independent variables in the model. The hierarchical analysis involved comparison of a series of reduced and full regression models that estimated the increase in R^2 that resulted when each independent variable was added to a regression equation containing all other independent variables. The increment in R^2 was interpreted as an unambiguous estimate of the variance in the dependent variable "uniquely attributable" to each predictor, net of all other variables in the model (Pedhazur 1982).

The second phase of the analysis used dependent variable–predicted scores for each case that were estimated in terms of dollars per disposition by the full regression model as a basis for estimating the costs of GME by clinical specialty, systemwide and at each teaching facility. These estimates were developed as follows. First, a predicted score for cost per disposition was obtained from the full regression equation for each of the 630 cases in the sample. Next, predicted score means were calculated by clinical specialty for departments with and without GME programs. The difference in means between teaching and nonteaching departments within each of the six clinical specialties was interpreted as the average cost per disposition attributable to GME by specialty across all teaching facilities. To calculate GME costs by specialty at each teaching facility, predicted scores for each teaching department were averaged for the three years studied. GME costs per case at each department were estimated as the difference between the average annual predicted cost per case for each teaching department and the mean predicted cost per case for nonteaching departments in its clinical specialty.

Results

Descriptive statistics that summarize relevant characteristics of teaching and nonteaching departments in the sample are provided in Table 1. The higher average cost per disposition, greater case-mix intensity, longer average length of stay (LOS), and larger department and facility size of teaching departments were consistent with findings reported by other studies conducted among national samples (Anderson and Lave 1986; Thorpe 1988) and supported the generalizability of the present study.

Table 1
Descriptive Statistics for Teaching and Nonteaching Departments

	Departments					
	Teaching (N = 105)		Nonteaching (N = 525)		Total Sample (N = 630)	
Variable	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Total cost per disposition	$3,935	$1,861	$2,089	$1,433	$2,396	$1,660
Case-mix index	1.18	.41	.740	.278	.81	.35
Facility bed size	458	143	104	79	163	161
Department FTEs	1,166	734	230	197	386	493
Average LOS per department	8.6	6.3	4.4	3.6	5.1	4.5
Annual disposition per department	3,736	2,264	1,174	1,075	1,601	1,650

Note: Annual averages based on 1988–1990 data.

Tests of Model Specification

Table 2 presents results of hierarchical multiple regression analyses that evaluated the degree to which the model of hospital costs was appropriately specified. As indicated in Table 2, each of the independent variables (except year) accounted for a statistically significant increase in the explained variance in costs per disposition, net of all other independent variables in the model. The full regression equation yielded an R^2 of .712 and an adjusted R^2 of .701. This was evidence of an appropriately specified model with relatively strong goodness of fit that compares favorably with the findings of other studies. It is not appropriate to make inferences regarding the relative importance of independent variables in the model. These results are simply evidence that, as a group, the independent variables specified were consistent with previous model-building, explained 70 percent of the variance in cost per disposition in the sample, and provided an acceptable basis for estimating GME costs, controlling for the effects of the variables in the model.

Estimation of GME Costs by Clinical Specialty

Table 3 presents the estimated mean costs per disposition by clinical specialty and teaching status based on dependent variable scores predicted by the full regression model. The considerable variation in costs observed among clinical specialties, in terms of total costs per disposition for the sample as a whole, total costs per case among teaching and nonteaching departments, and GME costs per case supports the appropriateness of modeling hospital costs at the department level. These findings are clear evidence that differences among clinical specialties have substantial cost-influencing effects, net of case-mix intensity, size, average LOS, teaching status, program "intensity," and region.

Table 2
Hypothesis Tests of Effects on Cost per Disposition Uniquely Attributable to Independent Variables (N = 630)

Effect Tested	R^2 Full Model	R^2 Reduced	Variance Uniquely Explained	df1	df2	*F*	*p*
Year	.7121	.7103	.0018	2	606	1.84	.1594
Case-mix index	.7121	.6766	.0355	1	606	74.64	.0000
Facility bed size category	.7121	.6638	.0483	4	606	25.43	.0000
Department staff size:							
a. FTE	.7121	.7029	.0092	1	606	19.36	.0000
b. FTE squared	.7121	.7043	.0078	1	606	16.40	.0001
Clinical specialty	.7121	.6910	.0210	5	606	8.88	.0000
Residents per bed	.7121	.7080	.0041	1	606	8.69	.0033
GME category	.7121	.6863	.0258	1	606	54.20	.0000
Average LOS per department	.7121	.6940	.0181	1	606	38.16	.0000
Region	.7121	.6923	.0198	6	606	6.94	.0000

Table 3
Estimated Total Costs and GME Costs per Disposition by Clinical Specialty

Clinical Specialty	Mean Estimated Total Costs per Disposition among Clinical Departments			
	(a) Sample	(b) Teaching	(c) Nonteaching	(d) GME Costs
Medicine	$2,360 N = 111	$3,857 N = 21	$2,011 N = 90	$1,846
Surgery	$2,675 N = 111	$4,446 N = 21	$2,257 N = 90	$2,209
Obstetrics/gynecology	$1,976 N = 110	$2,405 N = 15	$1,908 N = 95	$ 497
Orthopedics	$2,502 N = 106	$3,852 N = 21	$2,169 N = 85	$1,683
Psychiatry	$3,446 N = 89	$6,721 N = 12	$2,936 N = 77	$3,785
Pediatrics	$1,568 N = 103	$2,720 N = 15	$1,372 N = 88	$1,348

Estimation of GME Costs by Department and Facility

Estimated GME costs per disposition by clinical specialty within the teaching facilities of the system studied are presented in Table 4. As shown, estimated GME costs per case varied considerably within each specialty across the seven teaching facilities. For example, in the specialty of medicine, GME costs per case ranged from a high of $2,637 per case at facility F to a low of $926 at facility E. And, among teaching departments of surgery, GME costs per case ranged from $3,480 at facility C to $919 at facility E. For obstetrics/gynecology, the low of $-584 indicates that GME costs at facility G were $584 less than the average estimated costs per case of all nonteaching departments of obstetrics/gynecology.

The estimates of GME costs presented in Table 4 take into account the influence of the independent variables in the model. These GME cost estimates thus provided a managerially useful basis for investigating reasons—*other* than those influences accounted for by the model (such as case-mix index, size, or even GME)—that explain the wide variation in costs within specialties among the teaching facilities.

Estimated GME Costs per Resident

Table 5 presents estimates of GME costs per case, resident, clinical department, and teaching facility. These estimates were calculated by dividing the estimated GME costs per case for each department, reflected in Table 4, by the average number of residents within that department for the three years studied. The estimated GME costs per case per resident provided an indicator of teaching program productivity as an additional basis for managerial comparison of teaching program performance within specialties and across facilities. As indicated in Table 5, GME costs per case per resident also varied considerably among clinical specialties and across facilities.

When related to the output of GME, in terms of residents being trained, GME costs per case indicators of department and facility performance changed considerably. For example, facility A, which tended to be highest or among the higher-cost facilities in terms of GME costs per case across specialties (Table 4), demonstrated a more preferable performance profile in terms of teaching program productivity (Table 5). Indeed, for the departments of medicine

Table 4
Estimated Average GME Costs per Disposition by Specialty at Each Teaching Facility

Teaching Facility	Clinical Specialty					
	Medicine	Surgery	Obstetrics/ Gynecology	Orthopedics	Psychiatry	Pediatrics
A	$1,834	$1,314	$1,225	$3,837	$6,528	$2,706
B	1,449	1,135	*	417	3,598	*
C	2,220	3,480	1,093	1,812	*	1,514
D	2,587	3,310	*	3,768	3,793	*
E	926	919	79	−83	*	608
F	2,637	2,041	673	684	1,222	998
G	1,256	1,266	−584	1,346	*	915

*No GME program in specialty at facility.

Table 5
Average Estimated GME Costs per Disposition per Intern/Resident, by Specialty at Each Teaching Facility

Teaching Facility	Clinical Specialty					
	Medicine	Surgery	Obstetrics/ Gynecology	Orthopedics	Psychiatry	Pediatrics
A	$ 29	$ 39	$ 86	$288	$230	$166
B	82	71	*	52	186	*
C	69	103	73	147	*	134
D	89	89	*	314	292	*
E	42	34	4	**	*	48
F	96	61	32	59	62	65
G	47	72	**	86	*	62

*No GME program in specialty at facility.
**Cost per intern/resident not calculated; cost per disposition < average nonteaching department costs.

and surgery, in which facility A averaged more than twice the numbers of residents present in the next largest programs, GME costs per case per resident were substantially less than or closely comparable to those of facility E, which had the lowest GME costs per case across all specialties. These results were consistent with economies of scale in teaching programs that others have suggested in their criticism of the residents-to-bed measure of teaching "intensity" used by HCFA (Custer and Wilkie 1991).

Discussion

This study sought to extend current knowledge by developing an innovative methodological approach to estimating GME costs that retained the benefits of multivariate analysis but provided a more managerially useful basis for evaluation of teaching programs as product lines than previous estimation techniques based on the interpretation of multiple regression coefficients for specific predictor variables. The results of previous studies—which have concluded that in general, GME costs tend to increase by a certain percentage (whose size has been the focus of continuing scholarly criticism and policy debate) with every percentage increase in the ratio of residents per beds—are of limited practical usefulness to health care executives under intensifying pressure to streamline their portfolio of product lines and to reallocate resources and refine performance monitors among programs in competition for increasingly scarce resources. The estimation of GME costs, on the basis of dependent variable scores predicted by a regression model that was first subjected to commonly accepted tests of specification adequacy and consistency with the general body of other research, provided a remarkably adaptable basis for providing managerially useful information that supported comparative analysis of teaching programs by clinical specialty and among teaching facilities. GME cost estimates based on predicted scores retained the advantage of statistically controlling for the effects of the independent variables in the multiple regression equation but enabled us to avoid methodological issues related to reliance on regression coefficients of individual variables in the model. This alternative approach was also able to avoid issues of regression coefficient instability due to moderate to strong multicollinearity among independent variables.

The focus of the present study was on estimating costs of GME as a product line in a manner that permitted comparison of departmental and institutional performance among facilities and within clinical specialties, while taking into account the influence of factors that are known to influence costs. The results of the present research provided executive decision-makers with readily interpretable information about observed cost variance that could not be dismissed as "justifiable" by facility or departmental appeals to traditional arguments of "sicker patients," "larger size," "specialty-specific technology," or even "GME costs." By highlighting the presence of department- and facility-specific variation in estimated costs within the GME product line that were based on predicted scores that statistically controlled for these sources of treatment-related cost variance, the present methodology enabled executive decision-makers to focus their strategic product-line evaluation on cost variation arising from nontreatment sources that might be amenable to managerial intervention. Possible determinants of higher-cost programs that were not captured by the regression model might range from unique research activities, whose costs exceeded the norm for teaching facilities as a group but were not measured by the present analysis, to cost-increasing differences in management practices, facility disfunction, or clinical practice style.

These results were not, in themselves, considered to be a sufficient basis for program realignment, reduction, or other major product-line modifications. However, they did provide a stimulus for corporate- and facility-level investigation into the reasons *why* teaching programs at specific facilities were more costly than programs within the same specialty at other facilities. They also provided a more precise basis for allocating resources, setting expenditure expectations, and reviewing productivity monitors among the specialties involved than would be available from research conducted at the facility level. Finally, these results provided a means of enhancing dialogue between system executives and teaching program directors regarding the "managerial content of clinical practice" (Schneller 1991), which was aimed at reducing cost variance not due to unique clinical requirements.

The findings of the present study also have implications for public policy regarding hospital payment. As previously indicated, there is growing concern that current HCFA payment policies have not been able to adequately address the issue of widespread variation in hospital costs. The present findings have demonstrated the feasibility of estimating hospital costs per case using the clinical department as the unit of analysis. The regression results related to clinical department category, and the wide variation in estimated costs per case among clinical specialties, with regard to the sample as a whole, costs of teaching and nonteaching departments, and costs attributable to GME were evidence of substantial variation in costs among the six clinical specialties studied. These findings are highly consistent with differences that are known to exist in the technology, resource requirements, division of labor, and treatment patterns of the major clinical specialties of contemporary medicine. The present findings seem to be clear evidence that assumptions of homogeneity among clinical specialties, required by studies at the facility level of analysis, may have contributed to serious model underspecification in the basis on which national payment policies for hospitals have been developed. Imprecision in HCFA cost estimates that exclude this possibly important source of cost variance may have serious negative effects on hospital performance. Future studies of hospital costs cannot safely rely solely on DRG-based measures of patient severity to account for clinical influences on costs but must find ways to account more precisely for the potentially important influences of specialty-specific differences on variation in hospital costs.

Additional research is needed to replicate the present study among a sample of hospitals that may be more generalizable. Although consistency of sample characteristics and findings with the general body of research in this area were reassuring, the use of a federal system in the present study was a recognized limitation on the generalizability of its findings, particularly with regard to specific cost estimates. Although the actual cost estimates of the present study may be sample-specific, the techniques employed could be adapted readily to analyze costs of GME or other product lines within or among institutions.

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Appendix
Operationalization of Variables

Variable	Operational Definition
Dependent Variable	
Total cost/dispositions	Total annual costs/total annual dispositions per department
Independent Variables	
A. Scale of operations	
1. Department size	Annual full-time equivalents (FTEs) in department
2. Hospital size	Categorical variable set representing facility bed size (five categories, binary coded 1, 0)
B. Product mix	
1. Illness severity	Department case-mix index (DRG), based on aggregated inpatient diagnoses reflected in dispositions
2. Teaching status	Categorical variable (1 = yes, 0 = no)
3. Teaching intensity	Ratio of resident per bed for each department
4. Clinical specialty	Categorical variable set representing department specialty (six categories, binary coded 1, 0)
C. Efficiency	Average length of stay based on annual dispositions per department
D. Regional variation	Categorical variable set representing regional location (seven categories, binary-coded 1, 0, to reflect Northeast, Southeast, Midwest, Southwest, Northwest, far West, and Hawaii)
E. Year	Categorical variable set identifying data for 1988, 1989, 1990 (three categories, binary-coded 1, 0)

Note: A squared term of FTE was also included to examine the possibility of economies of scale between department size and costs (Carr and Feldstein 1967).

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