Teaching Status and Resource Use for Patients with Acute Myocardial Infarction: A new look at the indirect costs of graduate medical education

I. Steven Udvarhelyi, MD, Terry Rosborough, MD, Richard P. Lofgren, MD, MPH, Nicole Lurie, MD, MSPH, and Arnold M. Epstein, MD, MA

Abstract: To investigate whether the process of graduate medical education increases costs in teaching hospitals by causing longer lengths of stay and greater resource use, we compared lengths of stay, hospital charges, and the use of cardiovascular procedures for patients with acute myocardial infarction admitted to the teaching and nonteaching services of a university-affiliated community hospital.

After adjusting for severity of illness and demographic characteristics, patients on the teaching services had a mean length of stay that was shorter by 0.6 days ($p = 0.04$) and mean charges that were $2,060 lower ($p = 0.15$) than for patients on the nonteaching service. Patients on the teaching service also had 15 percent (95% CI: −26, −4) fewer cardiac catheterizations and 9 percent (−18, 0) fewer procedures for myocardial revascularization (angioplasty or cardiac bypass surgery).

These findings suggest that graduate medical education per se may not directly increase the use of health care resources and that the cost differences between teaching and nonteaching hospitals may be largely a consequence of other factors. These factors may include epiphenomena of teaching such as a specialized organizational structure, specialized patient care services, and continuing medical education for the nursing and medical staffs. They may also include factors not related to teaching such as differences in patients' severity of illness and sociodemographic characteristics. (*Am J Public Health* 1990; 80:1095–1100.)

Introduction

Medicare is currently providing teaching hospitals with supplementary payments to compensate them for the indirect costs of graduate medical education. However, as the government focuses on controlling costs these payments have become controversial.[1] Other third party payers also are concerned about the contribution of graduate medical education to rising health care costs.[2] There is little question that teaching hospital costs are greater than those of nonteaching hospitals. It is commonly thought that a substantial portion of this difference in costs is attributable to the educational process engendering greater resource use, both in terms of longer lengths of stay and increased use of diagnostic and therapeutic services.[2–10] Implicit in the scrutiny of the indirect costs of graduate medical education is an assumption that they may represent inefficiency or waste in health care.

Despite the prevailing belief that graduate medical education increases the use of medical services, this view is not universally accepted.[11] The findings of previous studies of this issue may be questioned for at least two reasons:

- Most of them evaluated the costs of graduate medical education for patients cared for prior to the focus on cost containment which became prominent after the introduction of prospective payment for Medicare.[2–10] The traditional academic concern to "be complete" has probably been modified by growing interest in cost-effectiveness and efficiency during the 1980s.
- Second, some investigators argue that the indirect costs of graduate medical education are merely a consequence of differences in severity of illness between patients cared for in teaching and nonteaching hospitals.[12–15] Even authors who argue that severity of illness does not account for the cost differential between teaching and nonteaching hospitals acknowledge that adjusting for severity of illness and/or case-mix substantially decreases the magnitude of the cost differential.[3–5]

The present study re-examines the issue of indirect costs of graduate medical education and focuses specifically on whether a graduate medical education program fosters greater use of medical services and longer lengths of stay by comparing the teaching and nonteaching services of a single institution.

Methods

We compared lengths of stay, total hospital charges, and the use of cardiovascular procedures for patients treated for acute myocardial infarction in 1985 on the teaching and nonteaching services of a single hospital. We chose myocardial infarction as the "tracer" because it is a common disease, clinical indicators of disease severity are easily identifiable through chart review, and there are costly, disease-specific procedures for the diagnosis and treatment of coronary artery disease.

Setting

Our data derive from Abbott Northwestern Hospital, a private, secondary and tertiary care hospital with 780 beds staffed for adult patients. The hospital is affiliated with the University of Minnesota Medical School but has its own accredited internal medicine residency training program with 12 interns or residents in each year of a three-year program. Abbott Northwestern is not a member of the Council of Teaching Hospitals, and is considered a minor teaching hospital.

Description of the Training Program

The medical service was organized with a teaching and a nonteaching service, although there was no physical separation of the two services and all patients used the same nursing stations, ancillary services, etc. Attending physicians

From the Department of Medicine (Division of General Medicine, Section on Health Services and Policy Research), Brigham and Women's Hospital; Department of Health Care Policy, Harvard Medical School; Department of Health Policy and Management, Harvard School of Public Health, Boston, MA; Department of Medicine, University of Minnesota; Department of Medicine, Hennepin County Medical Center; and Medical Education Office, Abbott Northwestern Hospital, Minneapolis, MN. Address reprint requests to Arnold M. Epstein, MD, Department of Health Care Policy, Harvard Medical School, 25 Shattuck Street, Parcel B, 1st Floor, Boston, MA 02115. This paper, submitted to the Journal August 31, 1989, was revised and accepted for publication February 12, 1990.

admitted their patients to either the teaching or the nonteaching service, based on their own discretion, although beds on the teaching service were occasionally not available since the teaching service had a limited capacity. The attending physicians received the same reimbursement regardless of whether a patient was on the teaching or nonteaching service, so that there was no financial incentive involved in choice of service. Patients admitted to the nonteaching service were cared for solely by the private attending physicians, except in the rare case of medical emergencies, such as cardiac arrests, when residents were the only available physicians. Patients admitted to the teaching service were still the responsibility of the private attending physicians, although much of the decision-making was delegated to the teaching service ward teams. These teams were each comprised of an intern, a second- or third-year resident, a third-year medical student, and one of four internists who comprised the full-time teaching faculty. In their supervisory roles, the private attending physicians maintained routine contact with the teaching service ward teams through progress notes and informal meetings. The full-time teaching faculty conducted formal, bedside rounds after each admitting day (three hours per week per ward team), and each ward team had an additional two hours of teaching rounds per week with a separate "teaching-only" attending. These "teaching-only" faculty included internists and medical subspecialists who were not part of the full-time teaching faculty but who were part of the clinical teaching faculty of the University of Minnesota Medical School. Patient care on the teaching service was also supervised on a daily basis by three chief residents (in their 4th postgraduate year) assigned to the eight ward teams.

Facilities for Cardiac Care

Abbott Northwestern hospital had 73 critical care beds, 95 telemetry beds, a cardiac catheterization suite, and operating rooms for open heart surgery. Approximately 1,300 open heart surgeries and 900 percutaneous coronary angioplasties were performed each year at this hospital. The medical director of the critical care units was an internist who was not a cardiologist, and there were no standard orders or operating procedures that confined or limited the type of care that cardiac patients received. Patients could be cared for in the critical care units without a cardiologist attending and without a consultation from a cardiologist. Likewise, cardiac catheterization was performed under the direction of each individual cardiologist and not a catheterization laboratory director.

Patient Selection

We identified all patients discharged with a diagnosis of acute myocardial infarction (AMI) in 1985 from computerized discharge abstracts and reviewed the charts of these individuals. Of 325 patients with a discharge diagnosis of AMI we excluded 99 patients who had been transferred from another acute care facility because information concerning severity of illness could not be obtained consistently. We excluded 41 of the remaining 226 patients because chart review did not confirm a diagnosis of AMI (an elevated serum creatine kinase with a positive MB fraction, or sudden death within 24 hours of admission). Five patients with confirmed AMIs were excluded because complete information was not available for determining severity of illness. The final study cohort of 180 patients therefore included all patients directly admitted to the hospital in 1985 with a confirmed diagnosis of AMI for whom accurate severity of illness information was available. In analyses of hospital charges we included only 177 patients because charge data were not available for three patients.

Data Collection

Data were collected from chart review, computerized discharge abstracts, and the accounting office. All charts were reviewed by one of us (ISU) to collect information on age, race, sex, whether the attending physician was a cardiologist, and, if the attending was not a cardiologist, whether the patient was seen by a cardiologist in consultation. To assess the general severity of acute medical illnesses, each patient was classified by a modified APACHE II score.[16] Because age was a separate variable in our analyses we excluded points for age from the APACHE II score. We recorded the number of diagnoses listed on the discharge summary as an approximation of comorbid disease. To assess the severity of cardiac illness we noted whether each patient had a history of a previous AMI, whether there was evidence of congestive heart failure on admission, and whether during the hospitalization there was recurrent chest pain, shock, cardiac arrest, sustained ventricular dysrhythmia, or severe conduction system disturbance (2nd or 3rd degree atrioventricular block or severe bradycardia).

From the discharge abstracts and the accounting office, we obtained data on primary and secondary payor, mortality, length of stay, total hospital charges, and the use of the following cardiovascular procedures: percutaneous coronary angioplasty, coronary artery bypass surgery, cardiac catheterization, Swan-Ganz catheterization, temporary pacemaker placement, and echocardiograms. We used hospital charges as an estimate of costs. Unit charges were identical on the teaching and nonteaching services and therefore total hospital charges should be a good proxy for relative costs even if they are not equivalent to absolute costs. Because angioplasty and bypass surgery may be viewed as different methods of myocardial revascularization these two outcomes were also combined to form a composite variable. Three patients had coronary angioplasty fail and therefore had bypass surgery as well. These patients were counted as having only one episode of myocardial revascularization.

Data Analysis

Our primary goal was to compare procedure use, length of stay, and total charges between the teaching and nonteaching services. To adjust for potential confounding due to differences in severity of illness and demographic characteristics, we performed a two-stage analysis using propensity scores as described by Rosenbaum and Rubin.[17,18]

A "propensity score," defined as the probability of being on the teaching service as a function of the confounding variables, was calculated for each patient. Patients were then stratified by propensity score and outcomes were compared using the techniques for stratified data described below.

We used a logistic regression model to calculate the propensity scores as a function of 11 potential confounders: age, sex, type of insurance (health maintenance organization or other), history of previous myocardial infarction, APACHE II score, recurrent chest pain, congestive heart failure, atrioventricular block or bradycardia, shock, cardiac arrest or sustained ventricular dysrhythmia, and the number of comorbid diagnoses. There was a linear relationship between age and the probability of being on the teaching service, so age was used as a continuous variable in the model. Interaction terms added little to the predictive ability of the model and were excluded. The patients were then grouped into five strata on the basis of the probabilities

derived from the logistic model. For example, as a function of their severity of illness and other characteristics, patients in the lowest stratum had on average a 23 percent chance of being on the teaching service while patients in the highest stratum had a 78 percent chance of being on the teaching service.

Summary estimates of differences in hospital charges, lengths of stay, and procedure use between the teaching and nonteaching service were calculated using weighted averages across the five strata based on propensity scores. These summary estimates are therefore average differences that are adjusted for differences in patients' severity of illness and demographic characteristics.

Average differences in mean length of stay and charges were estimated by weighting each stratum specific difference by the inverse of the variance of the difference.[19] Average differences in median length of stay and charges were estimated by weighting each stratum specific difference in median length of stay or charges by the number of observations in that stratum, thereby producing a standardized median difference.[19] A stratified Wilcoxon rank sum test was used to test significance since length of stay and charges did not have normal distributions.[20]

Adjusted differences in procedure and mortality rates were calculated as standardized rate differences, again using the number of observations in each stratum as the weight, because several strata had marginal totals of zero.[19] Ninety-five percent confidence intervals (CI) for these standardized rate differences were based on the chi-square test statistic.[19]

To determine whether differences in resource use between the teaching and nonteaching service could be due to differences in the number of patients on each service who had a cardiologist as their attending physician, or to differences in the frequency of consultation by a cardiologist on each service, we controlled for these factors in a separate analysis. In this analysis we added dichotomous variables representing the specialty of the attending physician (cardiologist or not) and whether a patient had a cardiology consultation (yes or no) to the logistic regression model defined above, producing a second propensity score model based on 13 potential confounders. Patients were again divided into five strata on the basis of propensity scores and the above noted techniques for stratified analysis were employed to calculate weighted averages for procedure rates, length of stay and charges.

To assess the importance of outliers, we repeated our analyses excluding four patients (all on the teaching service) who had a length of stay greater than the 1985 Medicare outlier limit, which was 35 days.

The 95 percent CI for all univariate comparisons were based on the chi-square statistic[21] for categorical variables and Student's t-distribution[21] for continuous variables.

Results

Patient Characteristics

The number of patients admitted to the teaching and nonteaching services, their clinical characteristics, and the percentages enrolled in health maintenance organizations, cared for by a specialist in cardiology or seen by a cardiologist in consultation, are indicated in Table 1.

Although age and sex distributions were similar for the two groups, patients on the teaching service were generally more ill. Specifically, they had more comorbid diagnoses and more frequently had congestive heart failure on admission, recurrent chest pain, and cardiac arrest or sustained ventricular dysrhythmia.

Severity of Illness and Resource Use

The univariate associations of severity of illness with procedure use, length of stay, total charges, and mortality are presented in Table 2. Generally, the severity of illness indicators were well correlated with resource use and therefore seem to be reasonable covariates to use when controlling for severity of illness in our analyses. The patterns of procedure use, length of stay, charges and mortality conform to conventional clinical wisdom.

Resource Use and Teaching Status

Procedure rates, length of stay, hospital charges, and mortality on the teaching and nonteaching services are presented in Table 3. Patients on the teaching service had significantly fewer cardiac catheterizations and underwent myocardial revascularization less frequently. However, they had more frequent use of echocardiography. These differences persisted after adjustment for severity of illness and demographic characteristics. There was no difference in the

TABLE 1—Patient Characteristics

Characteristics	Teaching (N = 95)	Nonteaching (N = 85)	% Difference* (95% CI)
	mean ± SD		
Age (years)	73 ± 11	71 ± 14	2 (−1.7, 5.7)
APACHE II Score**	6.0 ± 4.4	5.8 ± 4.6	0.2 (−1.1, 1.5)
Number of comorbid diagnoses	7.4 ± 6.2	5.8 ± 4.5	1.6 (0.0, 3.2)
		% (N)	
Male	57 (54)	59 (50)	−2 (−16, 12)
History of myocardial infarction	28 (27)	28 (24)	0 (−13, 13)
Recurrent chest pain	51 (48)	41 (35)	10 (−5, 25)
Atrioventricular block or bradycardia	7 (7)	7 (6)	0 (−7, 7)
Cardiac arrest or sustained ventricular dysrhythima	25 (24)	16 (14)	9 (−3, 21)
Congestive heart failure on admission	75 (71)	52 (44)	23 (9, 37)
Shock	5 (5)	8 (7)	−3 (−10, 4)
Health maintenance organization members	37 (35)	40 (34)	−3 (−17, 11)
Cardiology attending	11 (10)	26 (22)	−15 (−26, −4)
Cardiology consult	55 (52)	45 (38)	10 (−5, 25)
Mortality	28 (27)	20 (17)	8 (−4, 29)

*differences are teaching minus nonteaching.
**the possible range is from 0 to 64, the actual range was from 0 to 23.

TABLE 2—Resource Use Related to Severity of Illness

Resource Use	Previous AMI		Recurrent Chest Pain		Congestive Failure		AV Block or Bradycardia		Cardiac arrest or Sustained Ventricular Dysrhythmia		Shock	
	present	absent	present	absent	present	absent	present	absent	present	absent	present	absent
Number	51	129	83	97	115	65	13	167	38	142	12	168
% Angioplasty	2	7	7	4	2	12	0	6	3	6	0	6
% Coronary bypass surgery	12	5	11	3	6	8	8	7	8	6	0	7
% Angioplasty or bypass surgery	12	10	16	6	7	17	8	11	8	11	0	11
% Cardiac catheterization	16	19	24	13	10	32	15	19	8	21	0	20
% Swan-Ganz catheterization	12	12	12	11	17	3	23	11	26	8	50	9
% Temporary pacemaker	6	11	11	8	12	5	31	8	26	5	25	8
% Echocardiogram	37	33	35	33	36	31	31	34	26	36	42	33
Mean length of stay (days)	10.1	10.5	12.5	8.6	10.7	9.8	6.9	10.6	7.4	11.2	6.2	10.7
($) Mean hospital charges	$11,038	10,065	12,943	8,143	10,942	9,277	11,673	10,234	10,807	10,221	10,658	10,317
% Mortality	35	20	27	23	34	8	62	22	79	10	92	20

use of Swan-Ganz catheterization or temporary pacemakers between the two services.

Before adjusting for severity of illness and demographic characteristics there were equivocal differences in length of stay between the two services; the teaching service had a higher mean length of stay but a lower median length of stay. After adjustment, the teaching service clearly had shorter lengths of stay. For hospital charges, patients on the teaching service tended to have higher charges before adjusting for severity and demographic characteristics, but this pattern reversed after adjustment for these factors.

The differences in length of stay and hospital charges persisted when outliers were excluded from the analysis. The adjusted mean length of stay for patients on the teaching service was 1.1 days shorter and the adjusted median length of stay was 0.5 days shorter ($p = 0.009$). Adjusted mean charges were $2,257 less and adjusted median charges were $1,653 less ($p = 0.07$).

The differences in resource use between the teaching and nonteaching services also persisted when we controlled for the specialty of the attending physician (cardiology or other) and whether a patient was seen in consultation by a cardiologist. The teaching service still had a lower use of cardiac catheterization, i.e., −11 percent (95% CI: −22, 0), and tended to have less myocardial revascularization, i.e., angioplasty −3 percent (95% CI: −8, 2); coronary bypass surgery −3 percent (95% CI: −11, 5); either −5 percent (95% CI: −13, 3). Controlling for these same variables minimized differences in lengths of stay and hospital charges. The teaching service had an adjusted mean length of stay that was 0.1 days shorter and an adjusted median length of stay that was 0.5 days shorter ($p = 0.09$). Adjusted mean charges were $16 higher on the teaching service, while adjusted median charges were $508 lower on the teaching service ($p = 0.46$).

Despite differences in resource use, in-hospital mortality on the two services was comparable. After adjusting for demographic characteristics and severity of illness, patients on the teaching services had a mortality rate that was 4 percent (95% CI: −10, 18) higher than for patients on the nonteaching service.

TABLE 3—Resource Use Related to Teaching Status

	Teaching (N = 95)	Nonteaching (N = 85)	crude difference*	adjusted** difference (95% CI)
	% (N)	% (N)	%	
Angioplasty	2 (2)	9 (8)	−7	−6 (−12, 0%)
Coronary bypass surgery	5 (5)	8 (7)	−3	4 (−11, 3)
Angioplasty or bypass surgery	6 (6)	15 (13)	−9	−9 (−18, 0)
Cardiac catheterization	11 (10)	27 (23)	−16	−15 (−26, −4)
Swan-Ganz catheterization	13 (12)	11 (9)	2	0 (0, 0)
Temporary pacemaker	9 (9)	9 (8)	0	−2 (−31, 27)
Echocardiogram	41 (39)	26 (22)	15	14 (0, 28)
Length of stay (days)				
mean ± SD	10.6 ± 7.8	10.2 ± 5.4	0.4	−0.6
median	9	10	−1.0	−1.2
p***			0.27	0.04
Hospital charges ($)				
mean ± SD	$10499 ± 9501	10164 ± 7611	335	−2060
median	$7544	7459	85	−1469
p***			0.73	0.15

*all differences are teaching minus nonteaching

**adjusted for: age, gender, insurer, previous MI, recurrent chest pain, congestive heart failure, AV block or bradycardia, cardiac arrest or sustained ventricular dysrhythmia, shock, APACHE II score, and number of comorbid diagnoses

***p-values are for differences between teaching and nonteaching services, based on the Wilcoxon rank sum test.

Discussion

Our data do not support the view that care on teaching services necessarily entails greater use of resources than care on nonteaching services, when adjusted for severity of illness. On the contrary, these data show that once adjustments were made for differences in severity of illness, patients on a teaching service had shorter lengths of stay and received a conservative type of care that used less cardiac catheterization and myocardial revascularization.

There may be several reasons why our results differ from those of previous investigators. First, our data were collected in 1985 and almost all previous studies have analyzed data collected prior to 1981.[2-10] We believe that emphasis on efficiency and "cost effectiveness" in academic medical centers is more common now than it was during the late 1970s and early 1980s. This may be especially true for the hospital we studied, since the Twin Cities has a very competitive health care market.

A second explanation may be that patients in teaching hospitals are more severely ill and much of this difference in severity may not have been controlled for by previous investigators using methods of DRG (diagnosis related group) case-mix adjustment. We used clinically relevant indicators of severity that were specific to one illness—acute myocardial infarction. The changes in patterns for length of stay and charges that we found before and after adjustment for severity of illness support the conclusion that there is significant variation in disease severity between teaching and nonteaching patients that may not be adequately controlled for by simple case mix adjustment.

A third explanation may be that the setting of our study allowed us to better isolate the effect of a teaching program on resource use. In our single hospital setting the primary difference between the teaching and nonteaching services was the presence of the teaching program and not other institutional or organizational characteristics. Results from previous studies which compared separate teaching and nonteaching hospitals may have been confounded by systematic differences between the two types of hospitals in terms of organization and other characteristics not directly related to teaching.[3,5,8,10] Even those previous studies which compared teaching and nonteaching services within a single institution may have been confounded by organizational differences since most studies evaluated physically separate patient care units.[2,4,6,7,9]

Certain characteristics of the decision-making process on the teaching services may also have influenced the pattern of procedure use we found. Before a patient on the teaching service underwent a procedure, the housestaff, teaching attending, private attending, and the cardiologist came to a working agreement on a treatment plan. It is possible that this interaction decreased utilization in a way analogous to mandatory second opinion programs.[23,24]

Nevertheless, there are several limitations to this study. First, patients were not randomly assigned to the teaching and nonteaching services and therefore differed in a variety of characteristics. It is possible that patients admitted to the teaching service were in other ways less "appropriate" candidates for procedures than patients on the nonteaching services. We did not have sufficient data to ascertain the appropriateness of, or indications for, individual procedures, but we did attempt to collect data on and control for those patient characteristics that correlated with and likely influenced patient management. Therefore, we feel that differences in procedure use between the two services are unlikely to be related to the severity of acute cardiac disease, and are more likely to be due to differences in practice style on the teaching and nonteaching services that are independent of disease severity. However, we cannot exclude the possibility that differences in unmeasured, clinically relevant characteristics between patients on the teaching and nonteaching services accounted for our results.

Second, it is possible that variations in the practice style of a few attending physicians accounted for our results. However, 71 attending physicians had patients in our study and the mean number of patients per attending physician was 2.5 (range 1–11).

A third potential problem with our findings is that the records on the teaching and nonteaching services may have contained systematically different amounts and detail of information regarding severity of illness. The physician-reviewer who abstracted all the charts did not note such a discrepancy, especially for the parameters of severity and utilization that we collected. Therefore we do not feel that our findings are an artifact of chart completeness.

Finally, we decided to study only one hospital and one disease in an effort to control for as many confounders as possible. This limits our ability to generalize our results to other settings and other diseases. An analysis of the management of other illness which have less stereotyped patterns of care or which have fewer options for very specialized procedures may show different results. While it is also possible that the teaching service we studied may be atypical and not representative of teaching services at other types of institutions, we feel that the nature of the internal medicine training program we studied was very similar to that of most university-based programs. It is also likely to be representative of those found in other nonCOTH (Council of Teaching Hospitals) minor teaching hospitals which in total comprise approximately 72 percent of all teaching hospitals in the country and have 19 percent of all residents.[25] These nonCOTH minor teaching hospitals would therefore receive approximately 20 percent of Medicare's payments for indirect medical education.[26]

Overall, this study suggests that graduate medical education does not universally lead to longer lengths of stay and greater use of medical resources. It may therefore be unwarranted to equate the cost differences between teaching and nonteaching hospitals with nonessential clinical expenditures generated by graduate medical education. This does not imply that teaching hospitals have the same costs as nonteaching hospitals. Graduate medical education may lead to "indirect" costs that are associated with teaching such as floor space devoted to conference rooms, larger medical libraries, and support for teaching faculty. The presence of graduate medical education may encourage teaching hospitals to have more active programs for nursing education and continuing education for staff physicians. Teaching hospitals may also require a more sophisticated organizational structure and higher level of technical support because of the academic mission which leads to caring for patients who require extraordinarily specialized and highly technical care. Previous studies have shown that hospitals which accept a large number of transfer patients have higher average costs per case than hospitals receiving few transfer patients.[27] Teaching hospitals may constitute a large percentage of such hospitals because of specialized services that attract referrals. Other reasons for higher costs in teaching hospitals may not be directly related to graduate medical education at all.

For example, there may be important differences in the socioeconomic characteristics of patients in teaching hospitals that increase resource use and bad debt.[28]

Medicare's supplementary payment to teaching hospitals to cover the indirect costs of graduate medical education is already controversial and has been reduced by 30 percent since 1983. Further reduction is now under serious consideration. Other payers are also questioning the high costs of care in teaching hospitals. The results of this study suggest that these costs may not be a function of unnecessarily longer lengths of stay and greater use of health care resources. We postulate that much of the higher costs noted in teaching hospitals may now come from the overhead expense of providing and developing specialized services or from differences in the patient populations of teaching and nonteaching hospitals that are not accounted for in DRG case-mix adjustments. In order to institute proper reform of reimbursement for graduate medical education, further work is needed to define more accurately the components of graduate medical education that currently influence health care costs.

ACKNOWLEDGMENTS

The authors wish to thank E. Francis Cook, ScD, Lee Goldman, MD, MPH, and Anthony Komaroff, MD, for providing helpful suggestions on earlier versions of this manuscript. We also wish to thank Nan Laird, PhD, for advice regarding statistical analysis.

Drs. Epstein and Lurie are Henry J. Kaiser Family Foundation Faculty Scholars in General Internal Medicine.

Presented in part at the national meeting of the Society of General Internal Medicine, Washington, DC, April 28–30, 1988.

REFERENCES

1. Lave JR: The Medicare adjustment for the indirect costs of medical education: Historical development and current status. Washington, DC: Association of American Medical Colleges, 1985.
2. Garg ML, Elkhatib M, Kleinberg WM, Mulligan JL: Reimbursing for residency training: How many times? Med Care 1982; 20:719–726.
3. Cameron JM: The indirect costs of graduate medical education. N Engl J Med 1985; 312:1233–1238.
4. Garber AM, Fuchs VR, Silverman JF: Case mix, costs, and outcomes: Differences between faculty and community services in a university hospital. N Engl J Med 1984; 310:1231–1237.
5. Frick AP, Martin SG, Schwartz M: Case-mix and cost differences between teaching and nonteaching hospitals. Med Care 1985; 23:283–295.
6. Jones KR: Predicting hospital charge and stay variation: The role of patient teaching status, controlling for diagnosis-related group, demographic characteristics, and severity of illness. Med Care 1985; 23:220–235.
7. Jones KR: The influence of the attending physician on indirect graduate medical education costs. J Med Educ 1984; 59:789–798.
8. Schroeder SA, O'Leary DS. Differences in laboratory use and length of stay between university and community hospitals. J Med Educ 1977; 52:418–420.
9. Martz EW, Ptakowski R: Educational costs to hospitalized patients. J Med Educ 1978; 53:383–386.
10. Goldfarb MG, Coffey RM. Case-mix differences between teaching and nonteaching hospitals. Inquiry 1987; 24:68–84.
11. Buchwald D, Komaroff AL, Cook EF, Epstein AM: Indirect costs for medical education—is there a July phenomenon? Arch Intern Med 1989; 149:765–768.
12. Horn SD: Measuring severity of illness: Comparisons across institutions. Am J Public Health 1983; 73:25–31.
13. Becker ER, Sloan FA: Utilization of hospital resources: The role of teaching, case mix, and reimbursement. Inquiry 1983; 20:248–257.
14. Detsky AS, McLaughlin JR, Abrams HB, L'Abbe K, Markel FM: Do interns and residents order more tests than attending staff? Med Care 1986; 24:526–534.
15. Horn SD, Sharkey PD: Measuring severity of illness to predict patient resource use within DRGs. Inquiry 1983; 20:314–321.
16. Knaus WA, Draper EA, Wagner DP, Zimmerman JE: APACHE II: A severity of disease classification system. Crit Care Med 1985; 13:818–829.
17. Rosenbaum PR, Rubin DB: The central role of the propensity score in observational studies for causal effects. Biometrika 1983; 70:41–55.
18. Rosenbaum PR, Rubin DB: Reducing bias in observational studies using subclassification on the propensity score. J Am Stat Assoc 1984; 79:516–524.
19. Kleinbaum DG, Kupper LL, Morgenstern H: Epidemiologic research: Principles and Quantitative Methods. New York: Van Nostrand Reinhold Co, 1982.
20. Kalbfleisch JD, Prentice RL: The Statistical Analysis of Failure Time Data. New York: John Wiley & Sons, 1980; 149.
21. Colton T: Statistics in Medicine. Boston: Little, Brown, and Co, 1974.
22. Hollander M, Wolfe DA: Nonparametric Statistical Methods. New York: Wiley, 1973; 114–119.
23. Martin SG, Schwartz M, Whalen BJ, D'Arpa D, Ljung GM, Thorne JH, McKusick AE: Impact of a mandatory second-opinion program on medicaid surgery rates. Med Care 1982; 20:21–45.
24. Gertman PM, Stackpole DA, Levenson DK, Manuel BM, Brennan RJ, Janko GM: Second opinions for elective surgery. The mandatory Medicaid program in Massachusetts. N Engl J Med 1980; 302:1169–1174.
25. Anderson G, Lave J, Russe C, Newman P: Providing hospital services: The changing financial environment. Baltimore: Johns Hopkins University Press, 1989.
26. Medicare prospective payment and the American health care system: Report to the Congress. Washington, DC: Prospective Payment Assessment Commission, 1989.
27. Jencks SF, Bobula JD: Does receiving referral and transfer patients make hospitals expensive? Med Care 1988; 26:948–958.
28. Epstein AM, Stern RS, Tognetti J, Begg CB, Hartley RM, Cumella E, Ayanian JZ: The association of patients' socioeconomic characteristics with the length of hospital stay and hospital charges within diagnosis-related groups. N Engl J Med 1988; 318:1579–1585.