The Lewin Group

Comparing Hospital Costs: Adjusting for Differences in Teaching Status and Other Hospital Characteristics

Prepared for:

Bridges to Excellence

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I. INTRODUCTION

Hospitals differ in fundamental ways that affect their cost structures and financial status. For example, it is well established that patient care costs at teaching hospitals are higher than costs at non-teaching hospitals, even after adjusting for observed severity of illness. Although not necessary related to their cost structures, another way in which hospitals differ is in their provision of care to indigent populations who do not have the resources to cover the cost of their care. These hospitals attempt to cover the cost of uncompensated care using higher reimbursements from private payers, a phenomena know as cost shifting. Such examples do not necessarily suggest inefficiencies or poor performance on the part of hospitals, but, instead, represent the provision of costly services that often benefit their communities.

Third-party payers and administrators are increasingly focused on hospital costs, and on comparing hospitals' relative level of efficiency as a means to identify better performing hospitals. In many of these instances, hospitals' costs per case are primarily compared on a case-mix adjusted basis to establish tiered hospital payment models and/or preferred hospital networks. Most of the current methodologies used to measure relative efficiency look at resource use as measured, for example, by average length of stay and readmission rates. There is a likelihood that, without adding certain adjustment factors, the costs associated with the societal mission of a hospital may not get adequately accounted for in the construction of its relative efficiency. This could result in these hospitals being classified as inefficient and losing market share, thus straining their financial abilities to serve their communities.

The Lewin Group was commissioned by Bridges to Excellence to determine whether such adjustments are warranted and, depending on a hospital's characteristics, how they might be created. In this paper, we estimate the impact on hospital costs of the following hospital characteristics:

- Teaching intensity;
- Academic Health Center status;
- Share of care provided to poor populations;
- Cardiac specialty facility status; and
- Payer mix (as an indicator for need to cost shift);

In addition to determining the potential need for hospital-wide adjustment factors for the categories noted above, we were asked to determine whether these adjustments would vary by specific conditions and procedures, including community-acquired pneumonia; coronary artery by-pass graph (CABG); percutaneous coronary interventions (PCI); and acute myocardial infarction (AMI). We examine, for example, whether the relationship between hospital costs and teaching intensity differs between cardiac cases and all discharges.

We estimated a series of adjustment factors through an application of The Lewin Group's Hospital Efficiency Model. In general, the regression-based model works by recognizing that certain characteristics of hospitals are associated with higher (lower) costs. We then estimate a set of parameters that reflect the relationship between these characteristics and per-case hospital costs. Core aspects of the Efficiency Model were originally developed in the early 1990s for the

U.S. Department of Health and Human Services and the Association of American Medical Colleges. Since then, the model has been continually refined in step with improvements in hospital cost reporting and comments from numerous reviewers. Versions of the model have been used in projects evaluating the adequacy of state Medicaid payments and in studies published in *JAMA* and *Health Affairs*.[1]

The work presented in this paper should be viewed as an initial step towards the development of a set of adjustment factors for possible use in hospital cost comparisons. Our overall cost estimates are based on total all-payer costs as reported in Medicare hospital cost reports. In contrast, we used Medicare cost data at the discharge level to estimate the condition- and procedure-specific models. The value of the Medicare data is that they are publicly available, include a large number of cases, and cover almost all hospitals. Private payers of health care benefits, however, are the primary end users of the study findings, and our results may change when our model is applied to comparable data for privately insured populations. If possible, our findings therefore should be validated using data from a large national health insurer(s).

Hospitals with societal missions are subsidized in a variety of ways, including charitable donations by various organizations, implicit contracting cross-subsidies by plans, and other means. The types of adjustment factors presented in this paper could support these payer activities. The issue of how and when adjustments for teaching and other hospital missions should be used to determine provider payments is a subject of on-going debate[2] and beyond the scope of this paper. The purpose of this paper is to provide initial estimates of the contribution of specific hospital characteristics to patient care costs. Individual payers will ultimately need to determine how to use these adjustments in developing their payment policies for hospitals.

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[1] See Koenig et al. "Estimating the Mission-related Costs of Teaching Hospitals." *Health Affairs,* Nov/Dec 2003, Vol 22:6; and Mechanic, Coleman, and Dobson. "Teaching Hospital Costs: Implications for Academic Missions in a Competitive Market." *JAMA*, September 1998, Vol 280:11.

[2] see Stuart Guterman. "Financing Teaching Hospital Missions: A Context" and Joseph P. Newhouse "Accounting For Teaching Hospitals' Higher Costs And What To Do About Them" in *Health Affairs*, November/December 2003; 22(6).

II. STUDY APPROACH

We develop a set of potential payment adjustment factors by estimating the relationship between hospital costs and hospital characteristics using The Lewin Group Efficiency Model. These relationships are estimated using regression analysis, which allows us to estimate the independent effect of a specific characteristic on costs. For example, teaching hospitals tend to treat sicker patients, on average, than non-teaching hospitals. Our regression model allows us to control for the severity of patients so as to not confound the effect of teaching status with other factors not related to teaching.

The Lewin Group Efficiency Model does not define efficiency in the traditional economic sense - e.g., producing a given level of output or an outcome at the lowest cost. Instead, efficiency is measured in terms of average cost per case. Our adjustment factor for teaching, for example, represents an average increase in cost per case for each incremental increase in teaching intensity. The impact of teaching on the cost of economically efficient providers could be different from this average effect. This feature of the model, however, is desired. It is consistent with the way Medicare and many other payers reimbursement providers. By basing payment on average costs (or charges), such systems provide incentives for high cost providers to improve efficiency, while rewarding low cost providers.

In conducting our analysis, we worked with an Advisory Group to complete the study. The Advisory Group reviewed an initial draft of this paper and provided comments. We have incorporated these comments into this paper and discuss them where appropriate.

A. Data

Our primary source for hospital financial data was the Hospital Cost Report (HCR). The HCR includes hospital-specific information on total (all payer) costs, total discharges (Medicare and non-Medicare), total Medicare disproportionate share payments, total Medicare outlier payments, and total patient days spent in intensive care units. Hospitals are required to submit annual cost reports to receive reimbursement from Medicare.

We obtained cost report data from the Healthcare Cost Reporting Information System (HCRIS) dataset, Release 2.0 (July 15, 2004). This database includes cost reports from fiscal year 1996 through 2004 received through June 2004. We extracted hospital fiscal year (FY) 2002 cost reports for use in this study. For this release of HCRIS, FY 2002 is the most recent and complete cost report year, with over 96 percent of hospitals reporting. After excluding hospitals in Alaska, our dataset consisted of cost reports from 4,317 short-term acute care hospitals. Hospital fiscal years vary, with over 80 percent of hospitals' 2002 fiscal year ending on either December 31, 2002, September 30, 2002, or June 30, 2003. To adjust for different reporting periods, we standardized hospital costs to the 2002 federal fiscal year.

We combined cost report data with information from the Inpatient Impact File, which is made available each year by the Centers for Medicare and Medicaid Services (CMS). The Impact File includes data on the hospital DRG case-mix index, wage index, urban/rural status, and intern- and resident-to-bed ratio. In addition, we estimated models using data from the 2002 Medicare Provider Analysis and Review (MedPAR) file, as described below. The MedPAR file includes charges, payments, and clinical information for all Medicare discharges in a given federal fiscal year. In 2002, the file included information for over 12 million Medicare discharges at short-stay hospitals. We used the MedPAR file because the discharge-level information allowed us to estimate the model over selected sets of cases (e.g., cardiac patients).

B. Hospital Characteristics, Conditions, and Procedures

In Table 1, we show the hospital characteristics for which we develop adjustment factors and how each characteristic is measured. To identify AHC hospitals, we used the set of integrated teaching hospitals identified by the American Association of Medical Colleges (AAMC). The AAMC defines an integrated teaching hospital as one in which a majority of clinical chiefs of staff are also department chairs in the affiliated medical school.

Among teaching hospitals, AHC hospitals represent some of the top institutions in terms of biomedical research and the availability of sophisticated clinical services, such as burn care services, Level I trauma care, and medical/surgical and neonatal intensive care. The infrastructure needed to provide these services has been referred to in the literature as standby capacity.[3] Communities benefit from AHC hospitals' capacity for treating special, complex cases, although maintaining this capacity is costly. We included an indicator for AHC status in our regression model, which is intended to capture the additional patient care costs associated with standby capacity and other mission-related activities, not captured by the teaching intensity measure.

Table 1. Hospital Characteristic with a Potential Impact on Cost per Case

Hospital Characteristic	Measurement (Source)
AHC status	Teaching hospitals that are integrated with a medical school (AAMC)
Teaching intensity	Intern and residents to bed ratio (HCR)
Disproportionate share (DSH) levels	Medicare DSH payments (HCR)
Payer mix	Medicaid days as percent of total hospital days (HCR)
Cardiac Care Specialty Hospital	Hospital with 2/3rds or more of their discharges in cardiac Diagnosis Related Groups (Lewin)

Notes: AAMC=Association of American Medical Colleges; HCR=Hospital Cost Report, CMS=Centers for Medicare and Medicaid Services,

We measure teaching intensity using the intern and resident to bed (IRB) ratio. This is the traditional variable used in measuring the impact of teaching intensity on hospital costs. AHC

[3] Koenig et al. "Estimating the Mission-related Costs of Teaching Hospitals." *Health Affairs,* Nov/Dec 2003, Vol 22:6.

hospitals tend to have high IRB ratios. Therefore, we expect the IRB ratio and AHC status to be correlated and measure some of the same underlying cost drivers. However, as previously discussed, it is most appropriate to view the AHC status indicator as capturing the additional costs associated with the non-teaching missions pursued by AHC hospitals, such as research.

Our hospital cost regression models include measures of Medicare disproportionate share (DSH) payments to hospitals. DSH payments are intended to support those hospitals that provide a disproportionate amount of care to the poor. The current formula used by Medicare to calculate the disproportionate share patient percentage is based on the amount of care provided to patients who receive Medicaid and SSI benefits. According to the National Association of Public Hospitals and Health Systems, Medicare DSH payments alone finance 6 percent of uncompensated care provided by public hospitals. The determination of Medicaid DSH payments to hospitals is more complex than Medicare DSH and varies from state to state. DSH payments represent a significant source of revenues to hospitals to cover the costs of uncompensated care provided to the poor and uninsured.

Although the cost regression models explicitly include DSH payments as an explanatory variable, this primarily is intended to capture differences in severity and, therefore, patient care costs, across DSH and non-DSH patients. In contrast, a payer mix adjustment could be used to credit hospitals that have a higher proportion of low-paying patients and, therefore, rely on cost-shifting to maintain their financial performance. We discuss this adjustment later in the paper.

In addition to producing hospital-wide adjustments for the categories noted above, we were asked to provide adjustment factors for the conditions and procedures presented in Table 2. We identified these conditions using corresponding codes from the International Classification of Diseases, 9^{th} Revision, Clinical Modification (ICD-9-CM). To identify acute myocardial infarction and pneumonia cases, we only reviewed the principal diagnosis on a claim.

Table 2. Special Adjustments for Selected Conditions and Procedures

Conditions/Procedure	IDC-9 CM
Community-acquired pneumonia	480.xx – 486.xx, 487
Coronary artery by-pass graph (CABG)	36.1x
Percutaneous Coronary Interventions (PCI)	36.01, 36.02, 36.05, 36.06, 36.07
Acute myocardial infarction (AMI)	410.x1

In our analysis, we examine whether the relationship between costs and selected hospital characteristics (Table 1) differ for selected conditions and/or procedures (Table 2) as compared to all cases. Because Table 2 includes AMI and specific cardiac surgical procedures, a patient could have both an AMI and receive a CABG or PCI. Therefore, we separated cardiac patients into five mutually exclusive categories:

1. AMI Only;
2. AMI with a CABG;
3. AMI with a PCI;
4. CABG without AMI; and
5. PCI without AMI.

By creating these five mutually exclusive categories, we are able to produce adjustment factors that can be applied to individual cases.

C. Regression Models

We estimated two sets of models: (1) all-payer models; and (2) Medicare models. Each model is estimated using hospital-level data, and we weight by the number of discharges. For the Medicare models, we aggregated cases within each hospital to develop a hospital-level database.

The all-payer model, which uses total hospital costs and discharges to construct a cost per case, is our primary model of interest, because it uses our most aggregate measure of cost and includes privately-insured patients. The findings from the all-payer models produce our base adjustment factors. The Medicare models allow us to estimate a set of adjustment factors for the specific conditions and procedures noted in Table 2, through the use of the discharge-level MedPAR file.

In developing adjustment factors for the conditions/procedures, we used a simple approach to make the results from the Medicare model applicable to all cases. Using the MedPAR data, we ran the model over all Medicare patients, and then ran separate models for those Medicare discharges associated with each condition or procedure. We then compared the relationship between hospital costs and variables of interest across the models to determine if, for example, AHC status has a different impact on costs overall as compared to costs for specific conditions. To illustrate how we did this suppose, for example, that we found that AHC status is associated with 5 percent higher costs across all Medicare cases, and for AMI cases it is associated with a 10 percent increase in Medicare costs. In addition, suppose that in the all-payer model we found that AHC status was associated with 8 percent higher costs. Given these facts, we would estimate an AHC adjustment factor for AMI cases of 16 percent (i.e., (10/5) * 8).

We crosswalk our results from the diagnosis/procedure-specific Medicare models to the all-payer models to make our results applicable to private payers, which are the primary end users of the study findings . We recognize that our results may differ when our models are directly applied to a private-payer or all-payer dataset. Therefore, the work presented in this paper should be viewed as an initial step towards the development of a set of adjustment factors for use in hospital cost comparisons.

In Table 3, we list the variables included in the all-payer and Medicare models. The model should control for cost drivers that are beyond the control of hospitals. These include factors such as the severity of patients treated (i.e., hospital case mix) and local area wages. The variables included in the models are grouped into three broad categories: (1) Medicare payment variables; (2) Additional case mix measures; and (3) Other variables. The first category includes those variables that drive Medicare payment. Medicare pays on these factors because they are found to drive cost differences across hospitals and/or they represent important missions that the Medicare program supports for policy reasons (e.g., DSH, teaching).

In our all-payer model, we include a number of additional variables to better account for the all-payer case mix of a hospital. Based on comments we received from the Advisory Group, we tested the impact of excluding some of these variables on our findings. These findings are discussed in the next section.

Table 3. Variables Included in Regression Model

Category	Variable	Comment
Medicare payment factors	Medicare case-mix index	
	Outlier payments	As % of total payments, tested impact of excluding
	Wage index	
	Intern and resident to bed ratio	
	Urban/rural status	
	Medicare DSH payments	As % of total payments
Additional case-mix measures (included only in all-payer models)	Medicare days, Medicaid days	As % of total days
	Nursery days	As % of total days
	Cardiac care unit days	As % of total days, tested impact of excluding
	Burn care days	As % of total days
	ICU days	As % of total days, tested impact of excluding
	Nursing facility days	As % of total days, tested impact of excluding
	SNF days	As % of total days
	Surgical care days	As % of total days, tested impact of excluding
Other	Hawaii indicators	
	Hospital beds	Tested impact of excluding
	Cardiac Specialty hospital indicator	
	Academic health center (AHC) hospital indicator	

III. FINDINGS

In this section, we present our findings beginning with models based on the cost report data. In all models, we used a log-log specification, where the dependent variable and all continuous variables are in log form. In some cases, we added a 1 to the variable before taking the log, if some of the values for the variable are zero. The interpretation on these coefficients is as an elasticity. For example, a coefficient of 0.5 indicates that a 10 percent change in the explanatory variable would change cost per case by roughly 5 percent. For dummy variables (i.e., 0-1 indicator variables), the interpretation is similar. A coefficient on the AHC indicator of 0.15 shows that AHC hospitals have costs per case that are approximately 15 percent higher than non-AHCs.

A. Findings from the All-payer Models

In Table 4, we present means and standard deviations for the hospitals included in the all-payer models. The statistics are shown for the 3,802 hospitals included in our all-payer models. We lost some hospitals from HCRIS because of incomplete data either from the hospital cost report or the Medicare PPS Impact File. The means reported in Table 4 were calculated using a weighted average, where the weight is equal to the number of discharges.

For hospitals in our database, approximately 43 and 14 percent of inpatient days are for treatment of Medicare and Medicaid patients, respectively. The remaining 43 percent of total days include care for patient with private insurance, coverage from other governmental payers, or patients without insurance. Although they represent roughly 2-3 percent of hospitals, discharges at AHC hospital account for 9 percent of all discharges for hospitals in the database, which suggest their large size. With respect to the specific conditions and procedures, 10 percent of all discharges are pneumonia cases, 4 percent are AMI cases, 2 percent receive a CABG, and 3 percent receive a PCI.

Table 4. Descriptive Statistics Based on FY 2002 Hospital Cost Report Data (Hospitals = 3,802)

Variable	Mean	Standard Deviation
Annual Cost	$6,536	$2,162
Case Mix Index	1.47	0.26
Medicare Operating Wage Index	1.02	0.16
Medicare Disproportionate Share Payments*	0.08	0.08
Medicare Inpatient days**	0.43	0.15
Medicaid Inpatient days**	0.14	0.11
Intern- and resident-to-bed ratio	0.12	0.21
Urban indicator	0.85	0.35
Hawaii indicator	0.00	0.06
Academic Hospital Center indicator	0.09	0.28
Medicare Outlier payments*	0.05	0.06
Intensive Care Unit days**	0.08	0.05
Coronary Care Unit days**	0.02	0.03
Nursing Facility days**	0.02	0.23
Surgical Care days**	0.01	0.02
Total hospital beds	322	239
Community-acquired pneumonia discharges***	0.10	0.03
Coronary Artery Bypass Graft discharges***	0.02	0.02
Percutaneous Coronary Interventions discharges***	0.03	0.03
Acute Myocardial Infarction discharges***	0.04	0.02

Source: The Lewin Group analysis of Medicare hospital cost reports
Notes: The means are weighted by the number of discharges.
* Indicates as a percentage of total payments; ** As percentage of total hospital inpatient days;
*** As a percentage of total discharges

In Table 5, we present our regression model results for four all-payer models. The first and second columns show the results from the fully specified models (i.e., they include the variables listed in Table 3). In Model 1, we included only Medicare DSH payments obtained from the hospital cost reports. In Model 2, we also added Medicaid DSH payments obtained from recently available data from the Centers for Medicare and Medicaid Services. The DSH payment variable is intended to proxy for the amount of care provided to the uninsured and underinsured and capture broad severity differences between these patients and others.

In Models 3 and 4, we excluded outliers and specific case-mix measures. We included Medicare outlier payments and special care unit days (e.g., intensive care unit days) to capture differences in the severity of illness of patients across hospitals. Members of the Advisory Group, however, raised concerns about whether some of our case-mix measures were capturing unobserved sources of inefficiency (e.g., hospital errors causing more ICU and CCU days). We tested the sensitivity of our findings to the inclusion of outliers and special care unit days.

As shown in Table 5, neither measure of DSH is statistically significant in Model 1 and 2. We believe that the Medicaid DSH variable is poorly measured for two reasons. First, different states have different formulas for calculating these payments and some states (e.g., Tennessee) do not make such payments at all. Second, data were not available for each hospital for the same year and some states (e.g., Georgia) did not report these data. (This factor also accounts for the smaller sample sizes for the second model, since states for which we did not have data had to be excluded.) We only include Medicare DSH payments in the other models presented in this paper.

Across all models, the IRB and AHC variables have a high degree of statistical significance ($p<0.0001$). However, exclusion of ICU days, CCU days, SCU days, and nursing facility days results in a significant decrease in the IRB coefficient and an increase in the AHC coefficient. Because the coefficients on IRB and AHC move in different directions, it is difficult to interpret the relationship between teaching status, hospital inefficiency, and our case-mix measures. The findings certainly do not support the simple hypothesis that teaching hospitals are inefficient and that our additional case-mix measures are capturing this inefficiency. Moreover, the overall explanatory power of Models 3 and 4 is slightly lower than the fully specified models, as measured by the adjusted R-square. Because of their contribution to capturing case-mix differences across hospitals, we focus our discussion in the remainder of this paper on the results from Model 1.

Table 5. Coefficients from All-payer Model using FY2002 Hospital Cost Report Data

	Fully Specified		Excl. Outliers	Excl. Outliers, ICU, CCU, SCU, NF
Dependant Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Medicare DSH	-0.027	-	0.0002	0.011
Medicare + Medicaid DSH	-	0.012	-	-
Teaching Intensity (IRB)	0.184*	0.195*	0.153*	0.149*
Academic Health Center	0.150*	0.160*	0.165*	0.169*
Adj R-Sq	0.707	0.724	0.692	.690
Observations	3802	3773	3802	3802

Source: The Lewin Group analysis of Medicare hospital cost reports
Notes: Although not all are shown, all variables reported in Table 1 were included in the model unless otherwise indicated.
* Significant at 0.01 level.

One question we addressed was whether to include (logarithm of) the number of beds in the model (Note: the models presented in Table 5 do not include a beds variable). There are two effects one might expect the number of beds to have. First, there may be economies of scale in hospital services, which might lead hospitals with more beds to be less costly on a per-patient basis. Second, large hospitals may have standby capacity, in the form of expensive equipment or facilities that are needed for only a few patients, but when needed are critical. In this second case, what would be observed from including beds as an explanatory variable would not be a "bed effect" but a "standby capacity effect." It is possible that both effects exist, and without information on standby facilities, we can only observe the sum of the effects in the beds coefficient. Furthermore, there is substantial overlap between "larger hospitals" and "teaching hospitals," which would cause the beds coefficient to pick up variation that more properly belongs in the IRB and AHC coefficients. It is quite possible that these effects are much larger than the economies-of-scale effect alone.

To address these issues, we partitioned the data set into quartiles based on the number of beds. The coefficient on the beds variable was negative for the lower two quartiles, and positive for the upper two quartiles. This is consistent with economies of scale, combined with standby facility-, IRB-, and AHC-related costs in the larger hospitals. However, the beds variable was not statistically significant in three of the four quartiles (p=0.1999, p=0.3189, p=0.3374). On the other hand, the beds variable was statistically significant (p=0.0149) in the full data set. These results suggest that any independent effect of beds is "washed out" by other effects correlated with size. Finally, bed size is not related to payments in hospital payment systems. For these reasons, we decided not to include a beds variable in the models presented in this paper.

B. Findings from the Medicare Models

In Table 6, we present means for select variables used in our Medicare models. The means reported in Table 6 were calculated using a weighted average, where the weight is equal to the number of discharges. The means follow the expected pattern. The severity and cost of pneumonia cases is below the average for all cases, while the cardiac cases fall above the average. As much as 11 percent of Medicare payments for beneficiaries who received a CABG was for outlier payments. It is also worth noting that the average Medicare case-mix index constructed from the MedPAR file (1.46) matches the average Medicare case-mix index derived from hospital cost reports (1.47, see Table 4).

Table 6. Descriptive Statistics for Medicare Models (Based on 2002 MedPAR file)

	All MedPAR Cases	Pneu-monia	AMI Only	AMI with CABG	AMI with PCI	CABG w/o AMI	PCI w/o AMI
Case Mix Index	1.46	1.31	1.58	5.72	2.91	5.20	2.18
Average Cost	$7,650	$6,844	$8,129	$34,165	$15,503	$27,935	$11,505
Medicare Outlier Payments	0.05	0.04	0.04	0.11	0.05	0.09	0.03
Hospitals	3578	3521	3459	974	1140	988	1149

Source: The Lewin Group analysis of 2002 MedPAR file

We present our Medicare model findings for key variables in Table 7. We estimated 7 models using the MedPAR data. Model M1 included all cases in the MedPAR file. Each subsequent model includes only those discharges with a specific condition or procedure. Model M2 includes pneumonia cases, and Models M3 through M7 cover the AMI and procedure cases.

There are important differences between Model M1 and Model 1 (see Table 5). Model M1, which is based on the MedPAR data, has higher explanatory power than Model 1. This in large part is the result of the better measures available to capture the case-mix of hospitals (e.g., the Medicare case-mix index, Medicare outlier payments). In addition, the estimated effects of teaching intensity and AHC status are smaller in the Medicare model. The results from Model M1 suggest that every 10 percent point increase in the IRB ratio is associated with a 10 percent increase in costs, as compared to an 18 percent increase found in Model 1. Similarly, Model M1 suggests that AHC hospitals' costs are roughly 10 percent higher than non-AHC hospitals, after controlling for IRB, while Model 1 estimates this effect to be 15 percent.

In general, the explanatory power of the models falls as we consider specific types of cases. This is, in part, due to the smaller sample sizes in these models. The explanatory power of Model M7, which includes non-AMI patients that received a PCI, is the lowest at 0.22. This means that the model explains 22 percent of the variation in hospital cost per case.

Medicare DSH is statistically significant in all models, although the interpretation on this variable is unclear. For the all-payer model, we argued that the DSH variable captures severity of illness differences between uninsured and underinsured patients and other patients. The models presented in Table 7, however, only include Medicare cases. So, this argument would not seem appropriate here, and we do not create adjustment factors for Medicaid DSH payments. Cardiac specialty hospitals appear to be able to perform CABGs at less cost than other hospitals.

Table 7. Coefficients from Discharge-level Analysis of 2002 MEDPAR Data

Dependant Variable	All Cases	Pneu-monia	AMI Only	AMI with CABG	AMI with PCI	CABG w/o AMI	PCI w/o AMI
Model	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**
Medicare DSH	0.228*	0.269*	0.497*	0.459*	0.306*	0.470*	0.215**
Teaching Intensity (IRB)	0.097*	-0.022	0.295*	0.175*	-0.069	0.076	-0.201*
Academic Health Center	0.101*	0.080*	0.077*	0.041**	0.082*	0.082*	0.092*
Cardiac Specialty Hospital	-	-	-0.027	-0.091*	-0.011	-0.135*	-0.012
Adj R-Square	0.764	0.641	0.651	0.593	0.328	0.528	0.219
Observations	3578	3521	3459	974	1140	988	1149

Source: The Lewin Group analysis of the 2002 MEDPAR file
Notes: * Significant at 1% level, **Significant at 10% level.

C. Development of Adjustment Factors

We used the results presented in Table 5 and Table 7 to develop a set of adjustment factors. These adjustment factors may be used by health plans and others in crediting hospitals for pursuing valuable but costly missions when comparing costs across different types of hospitals. The results for our all-payer model (Model 1) could be used directly as cost adjustment factors. The results related to specific conditions or procedures obtained from the Medicare models, however, need to be crosswalked to the all-payer model.

As indicated above, we used a simple approach to make the results from the Medicare population-based models applicable to an all-payer population. We calculated a ratio based on the effects estimated in Models M2 through M7 and Model M1. These ratios were then applied to the results from the all-payer model (Model 1). For example, to calculate the adjustment factor for teaching intensity for AMI only cases, we first calculated the ratio (0.295/0.097). We obtained these values using the coefficients from Model M3 (Table 7) and Model M1 (Table 7) for the IRB variable. This ratio was then multiplied by the coefficient from the IRB variable from Model 1 (Table 5). The resulting adjustment factor is equal to 0.56 (=0.184*(0.295/0.097)). For statistically insignificant variables, we assumed no impact of the variable on hospital costs. Recall that the teaching intensity and cardiac specialty hospital indicator variables entered the regression models as either a zero or one. In addition, the dependent variable in the regression models was the logarithmic value of cost per case. Consequently, we took the exponential of the AHC and specialty hospital estimated effects to create adjustment factors for these hospital characteristics. The resultant adjustment factors are presented in Table 8.

Table 8. Estimated Adjustment Factors

Dependant Variable	General	Pneu-monia	AMI Only	AMI with CABG	AMI with PCI	CABG w/o AMI	PCI w/o AMI
Medicare DSH	0.00	-	-	-	-	-	-
Teaching Intensity (IRB)	0.18	0.00	0.56	0.33	0.00	0.14	-0.38
Academic Health Center	1.16	1.13	1.12	1.06	1.13	1.13	1.15
Cardiac Specialty Hospital	-	-	1.00	0.91	1.00	0.87	1.00

Source: The Lewin Group
Notes: If a variable was not significant in the regression model, we set the adjustment factor equal to zero (0.00).

The values presented in Table 8 can be applied to the case-mix adjusted cost per case of a hospital to adjust that hospital's costs. The application of the teaching intensity adjustment is different than the AHC and cardiac specialty hospital indicators. This difference exists because the teaching intensity variable (IRB) is a continuous variable, which was entered into our regression equations in logarithmic form. To use the teaching intensity adjustment factor, we divide case-mix adjusted costs by (1+IRB Ratio) raised to the power of the adjustment factor. To use the other adjustment, we only need to divide costs by the adjustment factor (e.g., for AHC status divide cost per case by 1.16 for overall costs).

Consider, for example, Hospital A with an IRB ratio equal to 0.2 and case-mix adjusted costs per case of $6,350 (also assume that this hospital is not an AHC or cardiac specialty hospital). Also suppose that we are comparing the cost of Hospital A to a non-teaching hospital (Hospital B) in the same geographical area with costs of $6,000 per case (also assume that this hospital is not a specialty hospital). The calculation is as follows:

Table 9. Using the Adjustment Factors: Example 1

	Hospital A	Hospital B
Case-mix Adjusted Costs	$6,350	$6,000
Teaching Intensity Adjustment	$(1 + 0.2)^{0.18} = 1.033$	$(1 + 0.0)^{0.18} = 1.00$
Adjusted Costs	$6,147	$6,000

In Table 10, we provide a more complex example where Hospital 1 is an AHC hospital and this is being compared to a non-teaching hospital. In addition, the example also includes a space for us to include the Medicare wage index. Hospitals in different geographical areas could face different labor markets and, thus, labor costs. If so, it is important to standardize for these cost differences. In the example, we assume that the hospitals being compared come from the same general geographical area. So their labor costs as measured by the Medicare wage index do not vary. In this case, we entered a 1.000 for both hospitals to reflect this. The calculation used to derived the All Cases adjusted costs for Hospital 1 is (Note: a calculator is available from the authors.):

$$\$7,200 / [(\text{Wage Index})^{0.710} * (1+\text{IRB Ratio})^{0.180} * 1.162^{\text{AHC Indicator}}]$$

$$=\$7,200 / [(1.000)^{0.710} * (1.250)^{0.180} * (1.162)^{1}]$$

$$= \$7,200 / [1.041*1.162]$$

$$= \$5,952$$

As can be seen from the example, the adjustment factors can make a large difference. The Case-mix adjusted costs for the hospitals differed by $1,200 ($7,200 - $6,000). However, applying the adjustment factors bring the costs more inline, such that across all cases the AHC hospital has roughly the same cost per case as the non-teaching hospital.

Table 10. An Example: Comparing an AHC to a Non-Teaching Hospital

Hospital 1	Input Values	All Cases	Pneu-monia	AMI only	AMI w/ CABG	AMI w/ PCI	CABG w/o AMI	PCI w/o AMI
Case-Adjusted Cost	$7,200							
Medicare Wage Index	1.0000	0.710	0.762	0.661	0.540	0.472	0.474	0.270
IRB Ratio	0.2500	0.180	0.000	0.560	0.330	0.000	0.140	-0.380
Academic Health Center*	1	1.162	1.127	1.116	1.062	1.127	1.127	1.150
Cardiac Specialty Hospital**	0	1.000	1.000	1.000	0.914	1.000	0.869	1.000
Cost per Case: Predicted value		$5,952	$6,389	$5,694	$6,298	$6,389	$6,192	$6,815
Hospital 2	**Input Values**	**All Cases**	**Pneu-monia**	**AMI only**	**AMI w/ CABG**	**AMI w/ PCI**	**CABG w/o AMI**	**PCI w/o AMI**
Case-Adjusted Cost	$6,000							
Medicare Wage Index	1.0000	0.710	0.762	0.661	0.540	0.472	0.474	0.270
IRB Ratio	0.0000	0.180	0.000	0.560	0.330	0.000	0.140	-0.380
Academic Health Center*	0	1.162	1.127	1.116	1.062	1.127	1.127	1.150
Cardiac Specialty Hospital**	0	1.000	1.000	1.000	0.914	1.000	0.869	1.000
Cost per Case: Predicted value		$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
Hospital 1 - Adjusted Costs		$5,952	$6,389	$5,694	$6,298	$6,389	$6,192	$6,815
Hosptial 2 - Adjusted Costs		$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
Percent Difference		-0.8%	6.5%	-5.1%	5.0%	6.5%	3.2%	13.6%

*If AHC then input value equals 1, otherwise it equals 0.

**If a hospital is a cardiac specialty hospital then the input value equals 1, otherwise it equals 0.

The adjustments above do not include a payer mix adjustment. The payer mix adjustment would be used to credit hospitals that have a higher proportion of low-paying patients (i.e., uninsured and Medicaid patients). These hospitals rely on cost-shifting to maintain their financial performance. Recent changes to the Hospital Cost Report require hospitals to report uncompensated care costs. However, these data are unavailable from the 2002 hospital cost reports. Therefore, we have no direct way of measuring the pressure a hospital faces to cost-shift other than through their Medicaid patient loads.

To develop a payer mix adjustment, we could use state-level Medicaid payment-to-cost ratios and the percent of each hospital's costs accounted for by Medicaid patients as proxied by Medicaid days obtained from hospital cost reports. From this information, we could estimate the additional payments require to make a hospital financially "whole." For example, suppose a hospital faces a Medicaid payment-to-cost ratio (PCR) of 0.90 and 10 percent of its patient days are Medicaid. This hospital's losses on Medicaid patients account for 1 percent of it total costs, and it would need to cost-shift to other payers for this amount (1 percent = (1-0.9) * 0.1).

The Medicare Payment Advisory Commission most recently published Medicaid payment-to-cost ratios at the state level for 1999.[4] In using our approach, it is important to use estimates of Medicaid payment-to-cost (P-C) ratios at the state or other aggregate level. Hospital-specific measures of Medicaid P-C ratios reflect hospital cost efficiency as well as the overall adequacy of Medicaid payments. Unfortunately, updated values for the Medicaid P-C ratios are unlikely to be available. Therefore, plans should use this as a rough estimate of the cost-shifting requirements of a hospital.

[4] The American Hospital Association no longer makes these data available. See Appendix A for the 1999 values from MedPAC 2001 Report to the Congress.

IV. CONCLUSIONS

In this paper, we present estimates of the impact of specific hospital characteristics on costs per case. We find significant impacts of teaching intensity, AHC status, and cardiac specialty hospital status on hospital costs. In addition, these effects differ when considering all cases, pneumonia cases, or specific cardiac cases. Using our findings, we develop a set of adjustment factors that could be used by private payers and others when comparing costs across hospitals. The adjustments allow payers to credit hospitals that pursue costly missions.

The work presented in this paper should be viewed as an initial step towards the development of a set of adjustment factors for use in hospital cost comparisons. In estimating the adjustment factors for cases with specific conditions or that received certain cardiac surgical procedures, we used Medicare data. In addition, our all-payer model, which we used to develop a general set of adjustment factors, was based on hospital cost report data that include costs from Medicare and Medicaid cases. Because our results may change when our models are applied to a privately-insured population, the findings should be validated using data from a large, national health insurer. To ensure the results are robust, there should be a sufficient number of cases from each hospital. Moreover, these cases should be representative of the types of cases treated by a hospital.

APPENDIX A: HOSPITAL PAYMENT-TO-COST RATIOS FOR MEDICAID

All Hospitals	96.7
Alabama	96.2
Alaska	83.3
Arizona	78.6
Arkansas	86.0
California	93.1
Colorado	94.9
Connecticut	69.8
Delaware	87.8
Florida	83.3
Georgia	91.1
Hawaii	78.8
Idaho	90.5
Illinois	74.6
Indiana	98.0
Iowa	90.3
Kansas	64.5
Kentucky	84.5
Louisiana	89.0
Maine	94.2
Maryland	103.9
Massachusetts	75.0
Michigan	99.8
Minnesota	88.4
Mississippi	107.2
Missouri	85.8
Montana	85.0
Nebraska	97.1
Nevada	100.6
New Hampshire	73.9
New Jersey	90.0
New Mexico	111.0
New York	104.6
North Carolina	93.0
North Dakota	95.6
Ohio	93.6
Oklahoma	70.2
Oregon	92.8
Pennsylvania	77.2
Rhode Island	104.6
South Carolina	91.1
South Dakota	90.9
Tennessee	74.0
Texas	106.1
Utah	110.4
Vermont	86.7
Virginia	102.0
Washington	95.5
West Virginia	89.2
Wisconsin	77.6
Wyoming	86.8

Note: Payment-to-cost ratios cannot be used to compare payment levels because the mix of services and cost per unit of service vary across payers. They do, however, indicate the relative degree to which payments from each payer cover the costs of treating its patients. Operating subsidies from state and local governments are considered payment for uncompensated care, up to the level of each hospital's uncompensated care costs. Data are for community hospitals and reflect both inpatient and outpatient services. Values for individual states reflect reported data only. Totals for all hospitals are calculated using reported as well as imputed data (about 35 percent of observations), which corrects for under-representation of proprietary and public hospitals relative to voluntary institutions. Most Medicare and Medicaid managed care patients are included in the private payers category. The costs allocated to Medicare and Medicaid include HCFA's allowed and non-allowed costs.

Source: MedPAC analysis of data from the American Hospital Association Annual Survey of Hospitals. MedPAC Report to The Congress: Medicare Payment Policy, March 2001