Measuring Efficiency: The Association Of Hospital Costs And Quality Of Care

Are the goals of quality improvement and cost reduction complementary to or in competition with one another?

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ABSTRACT: Providers with lower costs may be more efficient and, therefore, provide better care than those with higher costs. However, the relationship between risk-adjusted costs (often described as efficiency) and quality is not well understood. We examined the relationship between hospitals' risk-adjusted costs and their structural characteristics, nursing levels, quality of care, and outcomes. U.S. hospitals with low risk-adjusted costs were more likely to be for-profit, treat more Medicare patients, and employ fewer nurses. They provided modestly worse care for acute myocardial infarction and congestive heart failure but had comparable rates of risk-adjusted mortality. We found no evidence that low-cost providers provide better care. [*Health Affairs* 28, no. 3 (2009): 897–906; 10.1377/hlthaff.28.3.897]

THE U.S. HEALTH CARE SYSTEM is facing challenges on two competing fronts: rising costs—which have seriously strained the government, private payers, and individuals—and concerns about quality. The Centers for Medicare and Medicaid Services (CMS) estimates that hospital costs increased 7.3 percent in 2007, and increases in hospital costs continue to outpace the overall increase in national health spending.[1] Yet recent research suggests that hospitalized patients often fail to receive care that is indicated for their condition.[2]

As we seek to improve care, it is vitally important to understand whether there is a relationship between an organization's quality of care and what that care costs. The relationship between quality improvement and cost reduction is complex, and it is not yet clear whether these two goals are complementary to or in competition with one another.[3] One might posit that low-cost hospitals are institutions with better management and therefore likely to have higher-quality care.

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There is some evidence that states with lower costs of hospital care per Medicare beneficiary tend to be states with the highest quality of care.[4] At the hospital level, Mary Deily and Niccie McKay found that more-efficient Florida hospitals had lower in-hospital risk-adjusted mortality rates than less-efficient hospitals have.[5] However, there is little empirical evidence to support this notion.

Although efforts to identify hospital costs have existed for some time, we have not been able to assess whether hospitals with lower costs provide higher-quality care, mainly because national data on hospitals' quality of care have been lacking. The Hospital Quality Alliance (HQA) program, led jointly by the CMS, the Joint Commission, and others, is a recently initiated effort to measure the quality of care provided in hospitals.[6] The HQA includes quality-of-care data from nearly every U.S. hospital and makes those data publicly available. This database provides an important opportunity to examine whether the costs and quality of hospital care are related.

In this study we identified hospitals with low risk-adjusted average costs and sought to determine their structural characteristics and nurse staffing levels. We also sought to determine whether the low-cost hospitals had better performance on HQA process indicators and lower risk-adjusted mortality rates than the hospitals with higher costs.

Study Data And Methods

■ **Data on hospitals' costs and resources.** We calculated hospital costs using data from the CMS Hospital Cost Reports (HCR) for fiscal year 2002. The FY 2002 data set is nearly complete, with 96 percent of hospitals reporting. We linked these data to the inpatient prospective payment system (PPS) Impact File, which is also provided by the CMS and has data on a hospital's Medicare case-mix, wages, urban/rural status, the ratio of interns and residents to beds (the IRB ratio, a measure of teaching intensity), and hospitals' outlier payments. We also supplemented these data with data from the Area Resource File, which provides demographic information about the county in which the hospital is located, including the total population, poverty rate, per capita income, and the percentage of residents who are age sixty-five or older. Finally, we linked the hospital-level data to the 2004 Medicare Provider Analysis and Review (MedPAR) file, which has patient-level data (including discharge status, demographic characteristics, and clinical diagnoses) for all fee-for-service Medicare beneficiaries.

■ **Data on quality of care.** To examine performance on quality metrics, we used data from the 1 September 2005 public release of the HQA program, which consist of performance scores for 4,048 acute care hospitals based on patients seen during calendar year 2004. Although the HQA now has data on twenty process measures, we limited our analyses to the ten that are known as the "starter set," because the Medicare Prescription Drug, Improvement, and Modernization Act (MMA) of 2003 only provides financial incentives for reporting these ten measures.[7] Therefore, although

most hospitals report data on these ten measures, a relatively small number also report data on the other ten. Finally, we linked each of the above sources of data with the annual survey of the American Hospital Association (AHA) to obtain information about hospital characteristics.

■ **Hospital cost models.** A relative cost index was calculated for each hospital as the ratio of its actual average cost per case for Medicare patients, divided by its predicted average cost per case for Medicare patients. We used regression models with hospital-level data to predict each hospital's average cost per case. These models took into account the Medicare case-mix index, the fraction of outlier payments to total payments, the IRB ratio, bed size, urban versus rural location, the ratio of adjusted disproportionate-share hospital (DSH) payments to total payments, and the Medicare wage index. The models were also adjusted for community-level characteristics, including county population, per capita income, poverty rate, and the proportion of the total population who were age sixty-five or older. The creation and use of these models have been described elsewhere.[8] This model incorporates factors that are likely beyond a hospital's control and that likely affect a hospital's cost of care, including caring for more severely ill patients (the case-mix index and outlier payments); structural features related to location (urban versus rural status, Medicare wage index, income in the community, and poverty rate); and the pursuit of costly missions such as teaching, research, and service to indigent populations (IRB ratio and DSH payments). Because there have been concerns that some hospitals might manipulate outlier payments, we "Winsorized" this variable (gave outliers the fifth- and ninety-fifth-percentile values) to ensure that a small number of hospitals with the highest (or lowest) outlier payments did not unduly affect our results.

Because costs in Alaska and Hawaii are much higher in ways that are not adequately captured by the Medicare Wage Index, we excluded hospitals from these two states.[9] We performed a series of sensitivity analyses for our relative cost models and found that the inclusion or exclusion of teaching status (using the IRB ratio or membership in the Council of Teaching Hospitals, or COTH), DSH and outlier payments, hospitals in Alaska and Hawaii, and community-level characteristics did not significantly affect our results.

Using these models, we created an index of relative costs: the ratio of actual costs to predicted costs, taking into account each hospital's particular characteristics. Thus, a relative cost index of 1.0 would indicate that a hospital's actual costs were the same as its predicted costs, given its characteristics and case-mix. A value of 1.1 would represent a hospital with costs 10 percent higher than expected for an average hospital with the same characteristics and case-mix.

■ **Hospital characteristics and structural features.** We examined the relationship between risk-adjusted hospital costs and three sets of hospital characteristics: nurse-to-census ratio (calculated by dividing the number of nurses on staff by the number of patient days in thousands), ownership (for-profit versus not-for-profit), and percentage of patients who had Medicare insurance. Given the financial

incentives under the CMS hospital PPS, we posited that hospitals would likely have lower costs if they had a higher percentage of Medicare patients (and, therefore, had more patients whose costs were prospectively paid) or if they were for-profit. We also hypothesized that lower-cost hospitals might have lower nurse-to-census ratios because of efforts to reduce expenditures.

■ **Hospital quality metrics.** For each hospital, we calculated a summary performance score for each of three conditions: acute myocardial infarction (AMI), congestive heart failure (CHF), and pneumonia. There were five performance indicators for AMI: aspirin at arrival, aspirin at discharge, beta-blocker at arrival, beta-blocker at discharge, and angiotensin-converter enzyme (ACE) inhibitor for left ventricular systolic dysfunction; two indicators for CHF: left ventricular function assessment, and ACE inhibitor for left ventricular systolic dysfunction; and three indicators for pneumonia: initial antibiotic timing, pneumococcal vaccination, and oxygenation assessment. To create summary scores for each condition, we used a methodology prescribed by the Joint Commission.[10] This approach suggests that the summary score be simply the number of times a hospital performed the appropriate action across all measures for that condition divided by the number of opportunities the hospital had to provide appropriate care for that condition. Composite scores were not calculated if a hospital did not have at least thirty patients for at least one of the measures of each condition.

■ **Hospital costs and mortality.** We examined the relationship between risk-adjusted hospital costs and risk-adjusted mortality rates for three subgroups of patients. In these analyses, we limited our analyses to those age sixty-five or older. The first subgroup comprised patients who had been discharged with a principal diagnosis of AMI (using the *International Classification of Diseases*, Ninth Revision [ICD-9] codes 410.x1); the second subgroup included patients discharged with the primary diagnosis of CHF (ICD-9 codes 398.91, 404.x1, 404.x3, and 428.0–428.9); and the third subgroup consisted of patients discharged with the primary diagnosis of pneumonia (ICD-9 codes 480–486). We excluded patients who were admitted as a result of a transfer from other inpatient acute care facilities. The MedPAR database also provided data on patients' age, race, sex, and up to nine comorbidities (such as diabetes mellitus) so that risk adjustment could be performed in our regression models using the Krumholz adjustment scheme, which the CMS has endorsed, for all three cohorts of patients (those admitted with AMI, CHF, or pneumonia).[11]

■ **Statistical analyses.** We used a combination of chi-square tests and t-tests, as appropriate, to compare various hospital characteristics with their quartile of risk-adjusted costs. We then used chi-square and analysis of variance (ANOVA) tests with the hospital as the unit of analysis to examine the two features we had hypothesized as likely to be correlated with lower risk-adjusted hospital costs: for-profit status and mean percentage of Medicare patients. We used correlation coefficients to examine the relationship between the hospital cost index and performance on the HQA summary scores as well as a hospital's nurse-to-census ratio. We subse-

quently built multivariable logistic models with patient discharges as the unit of analysis, to examine whether risk-adjusted hospital costs were independently associated with mortality, adjusting for patient characteristics and comorbidities as described above, and we accounted for clustering at the hospital level.[12]

Because we were concerned that a few hospitals with the highest or lowest costs might affect our analyses, we excluded twenty-four hospitals whose ratios of observed to expected costs were more than three standard deviations greater or less than the mean ratio.

Finally, to examine whether relationships between cost and quality were consistent across subsets of hospitals, we performed stratified analyses. We examined the relationship between costs and quality among urban and rural hospitals; those with and without medical intensive care units (ICUs); hospitals in each of the four census regions; and small, medium, and large hospitals. All analyses were conducted using SAS 9.1.

Study Findings

Of the 4,648 hospitals listed in the AHA survey as hospitals that care for medical and surgical patients, we were able to calculate average and predicted costs for 3,794 of them. We could not calculate hospital costs for 854 hospitals because either these hospitals were in Alaska or Hawaii, or some data elements for these hospitals were missing from the cost reports, the inpatient PPS Impact File, or the Area Resource File. The hospitals with missing data were generally comparable in their characteristics to hospitals where we had cost data, although the missing hospitals were slightly more likely to be small (52 percent versus 48 percent) and for-profit (18 percent versus 12 percent).

Among the 3,794 hospitals for which we could calculate risk-adjusted costs, approximately half had relative cost ratios of 0.9–1.1. Hospitals in the highest and lowest quartiles of costs were more likely to be small and less likely to have a cardiac ICU, compared to hospitals with closer-to-average costs (Exhibit 1). Hospitals in the lowest quartile of risk-adjusted costs were more often located in the South and less likely to have a medical ICU than other hospitals (Exhibit 1). Finally, hospitals in the lowest cost category had significantly shorter adjusted average lengths-of-stay compared with hospitals in other cost categories.

■ **Hospital costs and structural features.** Hospitals in the lowest quartile of risk-adjusted costs were more likely than hospitals in the highest quartile to be for profit (Exhibit 2). Similarly, hospitals in the lowest cost category had, on average, a higher fraction of Medicare patients than hospitals in the highest cost category. Finally, hospitals that had the lowest risk-adjusted costs had a lower nurse-to-census ratio than hospitals with higher costs. The relationship between hospital costs and each of these three structural features appeared to be monotonic: the lower the risk-adjusted costs, the higher the likelihood that the hospital was for profit, had a higher load of Medicare patients, or a had lower nurse-to-census ratio.

EXHIBIT 1
Characteristics Of Hospitals By Their Risk-Adjusted Costs Of Care

	Cost quartile (lowest to highest)							
	1 (0.58 to 0.91)[a]		2 (0.91 to 1.00)[a]		3 (1.00 to 1.11)[a]		4 (1.11 to 2.25)[a]	
Characteristic	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Bed size								
<100	365	43	236	27	241	28	348	42
100–400	405	48	497	57	509	59	426	51
>400	80	9	134	15	116	13	61	7
Census region								
West	132	16	140	16	147	17	128	15
Midwest	151	18	210	24	230	27	290	35
South	436	51	368	42	333	38	240	29
Northeast	131	15	149	17	156	18	177	21
Presence of CCU	292	35	412	48	424	50	314	39
Presence of MICU	603	73	755	89	728	86	700	87
Mean adjusted length-of-stay, days (SE)	5.9 (0.1)		6.1 (0.1)	0.1	6.2 (0.1)		6.2 (0.4)	0.4

SOURCE: Authors' analyses of data from the Hospital Cost Report, American Hospital Association annual survey, and Area Resource File.
NOTES: CCU is cardiac care unit. MICU is medical intensive care unit. SE is standard error. All results were statistically significant ($p < 0.001$).
[a] Range of observed to predicted costs.

■ **Hospital costs and performance.** We found a consistent, although small, relationship between risk-adjusted hospital costs and performance on the AMI and CHF quality indicators. Hospitals in the lowest cost quartile had, on average, lower AMI performance and lower CHF performance (Exhibit 3). There was no relationship between risk-adjusted hospital costs and performance on the pneumonia metrics. When we examined the average risk-adjusted costs by quartiles of quality performance, we found, not surprisingly, similar results. For example, hospitals in the top quartile of CHF performance had higher risk-adjusted costs than hospitals in the bottom quartile of CHF performance (cost index 1.03 versus 0.97, $p < 0.001$). Sim-

EXHIBIT 2
Relationship Of Risk-Adjusted Costs Of Care And Hospital Characteristics

Hospital cost quartile (lowest to highest)	Percent for profit	Average percent Medicare	Nurses per 1,000 patient days
1	25	48	5.3
2	17	46	5.7
3	14	45	5.8
4	10	44	6.4

SOURCE: Authors' analyses of data from the Hospital Cost Report, American Hospital Association annual survey, and Area Resource File.
NOTE: All results were statistically significant ($p < 0.001$).

EXHIBIT 3
Association Between Risk-Adjusted Cost Of Care And Hospital Quality Scores

Hospital cost quartile (lowest to highest)	Acute MI (N = 2,236)		Congestive heart failure (N = 2,807)		Pneumonia (N = 2,857)	
	Summary score	*p* value	Summary score	*p* value	Summary score	*p* value
1	88.9	<0.001	77.0	<0.001	76.9	0.68
2	90.7		82.7		77.1	
3	90.7		82.4		77.4	
4	90.8		81.7		77.4	

SOURCE: Authors' analyses of data from the Hospital Cost Report, American Hospital Association annual survey, and Area Resource File.
NOTE: MI is myocardial infarction.

ilarly, hospitals that were top performers in AMI had higher average costs than those in the bottom quartile (1.03 versus 0.99, $p < 0.001$).

■ **Hospital costs and mortality rates.** We found small and inconsistent relationships between hospital costs and mortality rates (Exhibit 4). Low-cost hospitals had thirty-day mortality rates that were comparable to those of high-cost hospitals for AMI and pneumonia.

Discussion

For most U.S. hospitals, the ratio of observed to expected costs of caring for Medicare patients varied from 0.57 (lowest) to 2.33 (highest), with approximately half of hospitals between 0.9 and 1.1, reflecting costs that were within 10 percent of their "expected" level given their patient population and mix. In our analyses, we found that hospitals with the lowest risk-adjusted costs were more often for-profit hospitals, had more Medicare patients, and had lower nurse-to-census ratios. We found no evidence that low-cost hospitals provided higher-quality care. Instead, they had slightly worse performance on process-based quality indicators for AMI and CHF and comparable risk-adjusted mortality rates.

EXHIBIT 4
Association Of Risk-Adjusted Costs Of Care And Thirty-Day Hospital Mortality Rate

Hospital cost quartile (lowest to highest)	Acute MI (n = 2,598)		Congestive heart failure (n = 2,960)		Pneumonia (n = 2,926)	
	Adjusted rate	*p* value	Adjusted rate	*p* value	Adjusted rate	*p* value
1	19.4	0.56	13.3	0.80	14.4	0.18
2	19.3		13.3		14.2	
3	19.2		13.2		14.2	
4	19.5		13.2		14.2	

SOURCE: Authors' analyses of data from the Hospital Cost Report, American Hospital Association annual survey, and Area Resource File.
NOTE: MI is myocardial infarction.

■ **Efficiency and quality.** Many have advocated calculating risk-adjusted costs as an indicator of "efficiency." Implicitly, this assumes that all hospitals produce the same output in terms of quality of care. Better management should lead to both lower costs and higher quality of care.[13] Our results do not, in aggregate, support this hypothesis. We found that, on average, hospitals with lower costs had marginally lower quality of care, although the magnitude of this association was small.

We did not have direct data on how hospitals manage their costs and how low-cost hospitals achieve their results. There may be tremendous heterogeneity in the approach hospitals take to reduce their costs. However, our results shed light on two possible mechanisms: lower nurse-staffing levels and reduced lengths-of-stay. The hospitals in the lowest quartile of adjusted costs had 20 percent lower nurse-to-census ratios compared to hospitals in the highest quartile of costs. Whether these lower staffing levels are a factor in the lower quality of care is unknown, although prior studies have shown worse outcomes in hospitals with lower nurse-staffing levels.[14] Second, we found that even after differences in patient-level factors were accounted for, the low-cost hospitals had, on average, about 5 percent shorter lengths-of-stay than hospitals in the highest quartile of risk-adjusted costs. We could not determine whether patients in low-cost hospitals are discharged too early or whether patients in high-cost hospitals are discharged unnecessarily late.

■ **Comparable studies.** Although there is an extensive economics literature on hospital costs, there has been almost no examination of the relationship between a hospital's costs and the quality of care it provides.[15] There is now tremendous interest in understanding this relationship, but we suspect that work has been limited by the lack of reliable data on quality for most hospitals and the ongoing debate about which quality measures are most appropriate. Others who have examined the relationship between costs and quality have focused on different metrics and had differing results: Katherine Baicker and Amitabh Chandra found that a state's overall performance on quality metrics was inversely related to its per capita Medicare spending.[16] Elliott Fisher and colleagues examined the intensity of clinical services use during episodes of care, including often in the last six months of life, and found that higher costs are associated with lower quality of care.[17] We are unaware of any prior national studies examining the relationship between inpatient costs and quality, although one evaluation in the Veterans Affairs (VA) system also found a positive relationship between quality measures and risk-adjusted costs, consistent with our findings.[18] The differences between our findings and those of Fisher or Baicker and Chandra are almost surely attributable to differing approaches to measuring costs and quality of care.

■ **Limitations.** There are limitations to our study. The data on hospital costs come from Medicare's Hospital Cost Reports, which are widely used by policymakers to understand hospital finances; however, these reports are not uniformly audited, so their precision and accuracy may be limited. Similarly, our models of hos-

pital costs could adjust only for limited and, in some instances, crude characteristics, such as case-mix index and teaching status. We did not have clinically rich data to adjust for more nuanced differences in case-mix. Although these limitations make our cost estimates less precise, they are unlikely to bias our results.

Our data limitations prevented us from detecting more subtle differences in quality and costs, such as particular hospitals that provide high-quality, low-cost care or hospitals that have improved costs and quality for a particular aspect of care. Moreover, the associations we found of lower-cost hospitals having shorter lengths-of-stay, lower use of ICUs, lower nurse-to-census ratios, higher proportions of Medicare patients, and greater likelihood of being a for-profit organization all support the validity of the data. Finally, our cross-sectional analysis only allowed us to assess an association between a hospital's costs and its structural features or quality of care; it did not allow us to identify a causal relationship.

We had little information about how hospitals managed to reduce costs beyond measures of hospital staffing and technological capabilities. We also did not have data on patients' subsequent hospital readmissions or outpatient costs, which would have allowed us to create a more complete picture of total hospital costs. Another limitation is that the data came from slightly different time periods, reflecting data availability as the different components of the analyses were carried out. Although this lack of overlap would reduce our ability to find a relationship across these parameters, this bias is likely small, given the relative stability in a hospital's costs or quality of care over a one- or two-year period. Our outcome measures were also limited: the HQA quality metrics and our risk-adjusted outcomes focused on three conditions, and although these are common conditions with extensive morbidity and mortality, they do not represent the full spectrum of hospital care. Furthermore, our risk-adjusted mortality data were limited by our use of administrative data, which are generally less precise in accounting for differences in patient-mix than clinical data are.

IN SUMMARY, WE EXAMINED THE AVERAGE risk-adjusted costs of caring for Medicare patients in U.S. hospitals and found a wide range of results across hospitals. Certain hospital characteristics, such as for-profit status and a higher percentage of Medicare patients, were associated with lower risk-adjusted costs. We found no evidence that low-cost hospitals provided better care, and although the relationship between costs and quality was marginal, low-cost hospitals typically had slightly worse quality for common medical conditions. As payers increasingly reward greater "efficiency" or lower costs, they need to exercise caution to ensure that they are not inadvertently encouraging worse care.

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NOTES

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