Michael Shwartz
David W. Young
Richard Siegrist

The Ratio of Costs to Charges: How Good a Basis for Estimating Costs

This study evaluates the accuracy of costs derived from the ratio of costs to charges (RCCs), using costs based on relative value units (RVUs) as the "gold standard." We found that RCC-calculated costs were not a good basis for determining the costs of individual patients. However, when examining average costs per diagnosis-related group (DRG), RCCs performed better. For almost 70% of the DRGs, average RCC calculated costs were within 10% of average RVU-calculated costs. RCCs were even more reliable for comparing the relative cost of patients in a DRG in one hospital to the average cost of patients in that DRG in a group of hospitals. Charges, or an overall hospital RCC (as opposed to the departmental RCCs we used in most of our analyses), were not a good basis for determining relative hospital costs.

Most health policy analysts, and many making managerial decisions, estimate hospital costs by hospital charges or by using ratios of costs to charges (RCCs) to "adjust" charges. As Finkler (1982) discussed, charges usually are not a good proxy for costs because, for a variety of competitive and other reasons, the mark-up on items differs. Estimating costs using departmental RCCs adjusts for differences in mark-ups across departments, but assumes the same mark-up for all items within a department. For this reason, RCCs do not provide an adequate basis for determining the cost of an individual item in a given department.

However, a patient typically consumes many different items in many different departments. If overestimates of cost on some items are balanced by underestimates on others, RCCs may provide a reasonable method for determining a patient's actual total costs. And, even if this balancing is imperfect at the individual patient level, it may be adequate when patient costs are averaged over some subgroup of interest, such as a diagnosis-related group (DRG).

Over the past 10 years, there has been a large increase in the use of sophisticated hospital cost accounting and management information systems. In most cases, costs in these systems are estimated using relative value units (RVUs). Under the RVU approach, each item consumed in a department is assigned a value that reflects its relative costliness compared to a departmental baseline cost. The cost of a patient's hospitalization can be estimated by summing the RVUs of the items used by the patient in each department, multiplying the resulting total by the department's cost per RVU, and then summing the resulting cost totals over all departments in which the patient received services. The RVU method generally is considered more accurate than the RCC method because it directly incorporates relative cost information on each item consumed,

Michael Shwaflz, Ph.D., *is professor of health care and operations management, and* ***David W. Young, D.B.A.,*** *is professor of accounting and control, both in the School of Management, Boston University.* ***Richard Siegrist, M.B.A., C.P.A., M.S****., is president, HealthShare Technology, Inc., and adjunct lecturer on management, Harvard School of Public Health. Address correspondence to Dr. Shwartz at School of Management, Boston University, 621 Commonwealth Ave., Boston, MA 02215.*

Inquiry 32: 476—481 (Winter *1995/96).*
0046-9580/95/3204—0476$1 .25

and thus does not depend on the assumption that errors cancel each other out.

Although one may question the validity of costs derived from an RVU-based system, most hospital managers consider RVUs to be the most accurate approach to costing currently available. Indeed, hospitals using RVU-based systems have invested heavily in terms of both capital expenditures and management staff time to obtain the most accurate cost measures possible for their own internal information needs" (Ashby 1993). For this reason, cost data from hospitals with these systems are believed to be as accurate as the current state of technology allows. The Prospective Payment Assessment Commission (ProPAC) (Ashby 1993), justifying use of RVUs to evaluate RCC-based cost estimates from the Medicare Cost Report (MCR), stated that RVUs "represent the best available 'standard' against which to assess the accuracy of MCR cost measures.

The purpose of this study was to evaluate the accuracy of costs derived from RCCs, using RVU-estimated costs as the "gold standard." RCC-estimated costs were compared to RVU-estimated costs for three types of analyses: 1) estimating individual patient costs; 2) estimating average costs per DRG; and 3) comparing the average cost of patients in a DRG in a particular hospital to the average cost of patients in that DRG in a group of hospitals.

Methods

We collected cost data on all patients discharged from seven hospitals that use a sophisticated hospital cost accounting and management information system developed by Transition Systems, Inc. (TSI). The TSI system is used at more than 350 hospitals worldwide. Data were from fiscal year 1988 at six hospitals (and in three hospitals included some part of 1987), and from calendar year 1989 at one of the hospitals. Of the seven hospitals in our study, two are on the West Coast, one in the Southwest, one in the Midwest and three in New England. Six are teaching hospitals, ranging from 350 to more than 700 beds. The nonteaching hospital has less than 200 beds.

In the TSI system, the following approach is used to estimate patient-level costs. First, all billable procedures in the hospital are grouped into intermediate products, the key building blocks in the system. Then, intermediate products are mapped into intermediate product departments. Hospitals differ both in how they define intermediate products, and in how they map them into departments. In this study, we mapped intermediate products in each hospital into a common set of 42 departments, corresponding to the revenue centers used by the Massachusetts Rate Setting Commission (six routine accommodation departments, seven special accommodation departments, and 29 ancillary departments).

Within each department, each intermediate product is assigned a relative weight for up to nine cost categories (variable labor, variable supplies, variable other, fixed direct labor, fixed direct equipment, fixed direct facilities, fixed direct other, variable indirect, and fixed indirect). The methods for assigning weights, which vary both across hospitals and within any hospital over time, are described in more detail in Shwartz, Young, and Siegrist (1994). By multiplying each relative weight by the annual volume of the intermediate product and summing the results over all intermediate products in the department, we can determine the total relative weight units expended by the department in each cost category.

Each expense account and payroll job code from the general ledger and payroll file is assigned to one of the nine cost categories. Since each expense account and payroll job code also is associated with a department, total departmental expenses can be broken into the major cost categories. Thus, the cost per RVU in each cost category in each department for a given year can be calculated by dividing the total annual expenses in the cost category in the department by the total RVUs in that cost category. The total cost of each intermediate product then can be calculated by multiplying its RVU weight for each cost category by the category's cost per RVU and summing the results over the nine cost categories.

From the patient bill, we determine the quantity of each intermediate product used from the map of billable items into intermediate products. This is multiplied by the cost per intermediate product to determine patient-level RVU-calculated costs. Patient-level RCC-based costs are calculated by multiplying patient charges in each department by the departmental RCC. Departmental RCCs are calculated from the ratio of total annual department costs to total annual department charges.

This study compared costs derived from RVUs to costs derived from RCCs. Our focus was on RCC-to-RVU cost comparison within each hospital, and not differences in costs to treat the same type of patient at different hospitals.

Percentage of cases (patients or DRGs) where RCC-estimated costs are within different ranges of RVU-estimated costs

Unit of analysis	Ratio of RCC costs to RVU cost[a]							
	<.85	.85—<.90	.90—<.95	.95—<1.00	1.00—<1.05	1.05—<1.10	1.10—<1.15	≥1.15
Patient level	13.6	5.5	9.4	13.7	15.3	12.5	8.8	21.1
DRG level, intrahospital[b]	6.8	3.3	5.9	17.1	29.3	17.6	9.6	10.4
DRG level, hospital to group[c] (department RCC)	4.5	4.2	13.5	26.6	23.1	13.2	7.8	6.2
DRG level, hospital to group[c] (hospital RCC)	17.3	8.5	11.7	14.8	11.8	8.5	5.1	22.2

[a] The number in each cell is the average of the percentages in this ratio category at the seven hospitals.
[b] Distribution of the ratio RCC-estimated cost to RVU-estimated cost for each DRG.
[c] Distribution of the ratio (hospital RCC-estimated cost/group RCC-estimated cost) to (hospital RVU-estimated cost/group RVU-estimated cost) for each DRG.

Thus, the differences among the hospitals in defining intermediate products, estimating relative value units, and allocating overhead were of minor importance.

For the patient-level analyses, we focused on the distribution of the ratio of RCC-estimated costs to RVU-estimated costs for each patient. For the DRG-1evel analyses, we focused on the distribution of the ratio of average RCC-estimated costs to RVU-estimated costs for all patients within each DRG. We initially examined the distribution of the ratios for each of the individual hospitals across the categories shown in the table above. In this paper, we report the average of the percentage of cases in each category, averaging across hospitals. Averages were calculated by giving each hospital an equal weight, as opposed to a weight based on the number of discharges (in which case the larger hospitals would have dominated results).

Before calculating ratios, we eliminated all cases where RVU-estimated costs were less than $500, and, in the DRG-level analyses, all DRGs with fewer than 30 discharges. This left about 5,500 cases in one of the hospitals, between 10,000 and 15,000 cases in five of the hospitals, and more than 23,000 cases in the other hospital.

Results

Patient-Level Analyses

There was a very high correlation between RVU-based and RCC-based estimates of individual patient costs, .94 or larger in all hospitals. Charges and RVU-estimated costs also were highly correlated, .98 or larger, in six of the hospitals. The one hospital with a low correlation, .39, had implemented the system only recently.

A high correlation does not mean necessarily that RCC-estimated costs are good proxies for RVU-estimated costs for all purposes. As shown in the first row of the table, for example, for only about half of the patients on average (9.4% + 13.7% + 15.3% + 12.5% = 50.9%) was the RCC-based cost within 10% of RVU-based costs; for more than one-third of the patients (34.7%), the two cost estimates differed by more than 15%.

DRG-Level Analyses

The second row of the table shows the distribution of the ratio of RCC-estimated costs to RVU-estimated costs for all DRGs studied in each hospital. For almost half the DRGs (46%), average cost per DRG estimated using RCCs was within 5% of the average cost estimated using RVUs; for almost 70% of the DRGs, average RCC costs were within 10% of average RVU costs. Thus, RCCs were a much better basis for estimating the average cost of patients in a DRG than they were for estimating costs for an individual patient. However, as shown in Shwartz, Young, and Siegrist (1994), there was considerable variability across hospitals. At one extreme, for more than *75%* of the DRGs, RCC-estimated costs differed from RVU-estimated costs by less than *5%;* at the other extreme, for one hospital costs differed by more than 15% for almost 37% of the DRGs.

We examined those DRGs for which RCC-based average costs were more than 10% lower than RVU-based costs (i.e., costs were underpredicted by RCCs), and those DRGs where RCC costs were more than 10% higher than RVU-based costs (i.e., costs were overpredicted by RCCs). There were no DRGs that consistently showed up in either group across all hospitals. Also, it did not appear as

though RCC-based costs for procedure DRGs versus medical DRGs were consistently higher or lower across hospitals than RVU-based costs.

Hospital to Group Comparisons

The third row of the table shows results when a hospital-specific average cost per DRG was compared to the average cost per DRG over all seven hospitals, using both RCCs (hospital RCC cost/ group RCC cost) and RVUs (hospital RVU cost/ group RVU cost). On average, for 50% of the DRGs, estimates of relative costliness using RCCs were within 5% of the estimates using RVUs. That is, the ratio—hospital RCC cost/group RCC cost to hospital RVU cost/group RVU cost—was between .95 and 1.05. For 75% of the DRGs, RCC-estimates were within 10%. The effect of a 5% error can be illustrated as follows: if a hospital were 8% higher than the group average in a particular DRG using RCCs, it would be between 3% (1.08/1.05) and 14% (1.081.95) higher using RVUs. Again, there was some variability across hospitals. However, in all hospitals but one, estimates of the relative costliness of DRGs using RCCs were within 10% of estimates using RVUs for at least two-thirds of the DRGs.

As discussed earlier, RCC-estimated costs were derived from the departmental RCCs for the 42 departments. In many situations, however, only an overall hospital RCC is available. The last row of the table examines the accuracy of using an overall hospital RCC. It shows the ratio of relative costliness (i.e., how an individual hospital's cost for a DRG compares to the average cost of all seven hospitals for that DRG), using an overall hospital RCC to estimate costs compared to relative costliness estimated using RVUs. An overall hospital RCC was a much poorer basis for estimating relative costliness than departmental RCCs. If an overall hospital RCC were used, a 15% or greater error would occur in nearly 40% of the DRGs (versus 10% of the DRGs if departmental RCCs were used). If charges were used to estimate relative costliness, a 15% or greater error would occur for 44% of the DRGs.

Discussion

In most cases, analysts who undertake studies involving hospital "costs," and administrators or others who are interested in "cost" comparisons across groups of hospitals, use hospital charges or estimates derived from RCCs as proxies for costs. There have been almost no studies that provide any insights into the magnitude of error that, even on average, might be associated with these proxies.

In our study, 30% of the DRGs showed an error greater than 10% using RCC-estimated costs compared to RVU-estimated costs to determine average cost per DRG. From the standpoint of hospital administrators considering the financial impact of product-line or strategic decisions, a 10% error in cost estimation can be quite significant, relative to operating margins in most hospitals. Thus, investing in systems and approaches to more accurately determine costs could be of value to these hospitals. However, a 10% error in estimating the average cost per DRG for certain types of health policy analyses or health services research may be tolerable, especially considering the uncertainty of other estimates and the variety of other assumptions often made in these studies. For 70% of the DRGs in our study, the error made using department-level RCCs was 10% or less.

In the current competitive health care environment, there are a variety of reasons to compare a given hospital's cost for treating patients in a particular DRG to the cost of patients in that DRG in some larger group of hospitals. For example, managed care plans might make this comparison to identify low-cost hospitals with which to contract or high-cost hospitals to avoid. Hospital administrators might make this comparison to identify particularly efficient product lines that might be marketed aggressively to managed care plans. Similarly, management might identify areas of inefficiency, where interventions could be useful. Our analyses suggest that departmental-level RCC-estimated costs may be a reasonable basis for making these types of comparisons. For almost 80% of the DRGs, relative cost using RCCs were within 10% of relative cost using RVUs.

One other paper in the published literature (Schimmel, Alley, and Heath 1987) and one report (Ashby 1993) have compared RCC-estimated costs to RVU-estimated costs. The purpose of the paper by Schimmel, Alley, and Heath was to illustrate the value of RVU-estimated costs for hospital management. Thus, in comparing DRG-specific costs estimated each way, their focus was on those DRGs that illustrated a large disparity in cost measurement between the two methods. Since no comparisons were made across all DRGs, however, it is difficult to draw conclusions that pertain to a more representative sample of cases. Nevertheless, the

results of our study tend to confirm their results, namely that for some DRGs, there are large differences in costs estimated using RCCs and RVUs. For many other DRGs, however, the differences are not so great.

The ProPAC report (Ashby 1993) compared RCC-estimated costs from the Medicare Cost Report to RVU-estimated costs for 40 DRGs in 15 hospitals. In our analysis, we aggregated RVU-estimated costs to the department level and then calculated department-level RCCs. Thus, overhead estimation and allocation were similar for both sets of our cost estimates. In the ProPAC study, RCC estimates were based on Medicare cost estimation principles, which usually differ from those used internally by the hospital. Thus, one might expect RCC-estimated costs to differ more from RVU-estimated costs in the ProPAC study than in our study, but this was not the case. Ashby states, "there are five DRGs where the MCR methodology overstated the standard cost by more than 10%, while it understated costs by at least 2% for five others" (Ashby 1993, p. 6). This would suggest that for more than 80% of the DRGs (33/40), RCC-estimated costs were understated less than 2% and overstated less than 10% compared to RVU-estimated costs, somewhat smaller errors than we found. The reasons for this are not clear, but may reflect the particular DRGs chosen for analysis. Also, ProPAC found that a hospital-level RCC performed better than a department-level RCC, a different result from ours. This likely reflects differences in the specific questions examined in the ProPAC study (which tended to aggregate results across the 40 DRGs) compared to ours (which focuses on the distribution of results across DRGs).

There are several important limitations to this study. First, our sample included only a small number of hospitals. Second, the hospitals in the study were not a random selection of all hospitals using the TSI system. Out of 10 hospitals initially asked to participate in the study, based on expectations about likely interest, the seven hospitals in the study were the ones that provided data within our time frame. Thus, it is not clear the extent to which results from these hospitals can be generalized to any population of hospitals. Nevertheless, the variability of results across hospitals (Shwartz, Young, and Siegrist 1994), suggests that these hospitals do represent a relatively wide range of system users.

Third, RVU-estimated costs were the gold standard for our comparison. When trying to estimate "true" economic costs, RVUs suffer from many of the same problems as RCCs (Finkler 1982). Nevertheless, there is little doubt that most hospitals, even unsophisticated ones, believe that RVUs provide a better basis for estimating costs than RCCs. Hospitals using the TSI system (and other similar RVU-based systems) pay a substantial amount of money to install and operate the system, and they use data from it to make important operational and strategic management decisions. Thus, from a practical perspective, RVUs provide a reasonable basis for a "gold" standard.

Finally, there are differences among hospitals in the definitions of intermediate products and intermediate product departments, in the methods used to derive RVUs, and in the approach to cost allocations. Further, the methods to determine RVUs change over time within different departments at different hospitals, as managers become more sophisticated users of the TSI system. Finally, the bases for estimating RVUs and changes in RVUs are not well documented. For purposes of comparing costs across hospitals, comparability in the cost accounting methodologies is important (Young 1988). However, our purpose was not to undertake interhospital cost comparisons. Rather, we sought to examine within each hospital the relationship of costs determined in two different ways: using RVUs and using RCCs. The effects of differences in cost accounting are less important when comparing the ratio of RCC-estimated costs to RVU-estimated costs among hospitals than when comparing actual costs (estimated using either RCCs or RVUs) among hospitals.

Despite the limitations mentioned, we believe that our results are important for managers, policymakers, and researchers. This is the first study to provide a systematic comparison across all DRGs of the relationship of RCC-estimated costs to RVU-estimated costs. Our results suggest that RCC-estimated costs may not be a good basis for making certain hospital-level management decisions based on profitability considerations. Also, for some health policy and health services research studies where especially accurate estimates of cost are important, our findings suggest the need for some caution. However, for other policy and research analyses, and for cross-hospital cost comparisons, the magnitude of error in RCC-based cost estimation is likely to be within an acceptable range.

This project was supported in part by grants from the Robert Wood Johnson Foundation and from the Institute for Accounting Research and Education at the Boston University School of Management. We would like to thank Julie Sinclair, M.B.A, for her work as a research assistant; Gerry Coffman, MS., for his excellent computer programming; and two anonymous reviewers for useful comments. We are grateful to TSI, Inc., for its participation in the project, and particularly grateful to the hospitals that were most cooperative in providing the data.

Ashby, J. 1993. The Accuracy of Cost Measures Derived from Medicare Cost Report Data. Intramural Report 1-93-01, Prospective Payment Assessment Commission, Washington, D.C.

Finkler, S.A. 1982. The Distinction Between Cost and Charges. *Annals of Internal Medicine* 96(1): 102—109.

Schimmel, V.E., C. Alley, and A.M. Heath. 1987. Measuring Costs: Product Line Accounting versus Ratio of Cost to Charges. *Topics in Health Care Financing* 13 (4): 76-86.

Shwartz, M., D.W. Young, and R. Siegrist. 1994. The Ratio of Costs to Charges: How Good a Basis for Estimating Costs? Working Paper No. 94-09, School of Management, Boston University.

Young, D.W. 1988. Cost Accounting and Cost Compari-sons: Methodological Issues and Their Policy and Management Implications. *Accounting Horizons* 2 (1): 67—76.