

Predicting hospital accounting costs

by Joseph P. Newhouse, Shan Cretin,
and Christina J. Witsberger

Two alternative methods to Medicare Cost Reports that provide information about hospital costs more promptly but less accurately are investigated. Both employ utilization data from current-year bills. The first attaches costs to utilization data using cost-charge ratios from the previous year's cost report; the second uses charges from current year's bills. The first

method is the more accurate of the two, but even using it, only 40 percent of hospitals had predicted costs within plus or minus 5 percent of actual costs. The feasibility and cost of obtaining cost reports from a small, fast-track sample of hospitals should be investigated.

Introduction

The Health Care Financing Administration (HCFA), the Congress, the hospital industry, and many others wish to know as soon as possible how the ongoing changes in the Medicare prospective payment system (PPS) affect hospital inpatient costs. Recent program changes have included the final transition to national rates, adjustments to rural and metropolitan rates, and a change in indirect medical education payments; future changes might include bringing capital costs into the rate.

Quantifying the effect of such changes on costs is important for at least three reasons:

- If changes cause hospital costs to fall, as appears to have been the initial effect of the entire PPS program, Government will want to share in at least some of the savings. If those costs are known earlier, the sharing can begin sooner. The recent debate over re-basing is a case in point.
- On the other side of the coin, if rates are set such that hospitals incur losses on Medicare patients, access to hospital care for Medicare beneficiaries may be jeopardized. Earlier knowledge of the situation will permit more rapid adjustment.
- If changes in the program or technological change differentially affect costs in different diagnosis-related groups (DRG's), recalibration of DRG weights will be necessary. Partly because of lags in the availability of cost data, HCFA used charges to recalibrate DRG weights in 1986. Subsequently a debate has ensued over the wisdom of using charges rather than accounting costs. Cotterill, Bobula, and Connerton (1986) have shown that there is little difference between costs and charges for 1981 data, but the same may not be true in the later period, when utilization was changing.

Thus, prompt and accurate data on costs are important to the operation of the PPS.

This research was supported by Grant No. 99-C-98489/9-03 from the Health Care Financing Administration. The views and opinions expressed are the grantee's, and no endorsement by the Health Care Financing Administration or the Department of Health and Human Services is intended or should be inferred.

Reprint requests: Joseph P. Newhouse, Division of Health Policy Research and Education, Harvard University, Parcel B, First Floor, 25 Shattuck Street, Boston, Massachusetts 02115.

Unfortunately, as is often the case, the requirements of promptness and accuracy conflict. The source of Government data on hospital costs is the Medicare Cost Report. This document traditionally served as the basis of reimbursement. It continued to serve as the basis for a portion of the reimbursement through fiscal year 1987 and is still used for exempt hospitals and units. Unfortunately, processing of cost reports is typically delayed, in part because it takes time to audit costs. In this article, we investigate two alternatives to waiting for cost reports.

Although marginal economic cost is theoretically preferable to average accounting cost as a basis for reimbursement, there are important practical difficulties in estimating it. As a result, we do not take up the issue of estimating marginal cost, and we confine ourselves to the narrower issue of promptness versus accuracy in obtaining average accounting cost.

Alternatives to the cost report

One alternative that is faster than waiting for audited cost reports is synthetic cost estimation. In this method, costs are disaggregated into quantity and unit price.

Quantity is projected from current-year utilization, estimates of which are available from claims or bills. These are processed more rapidly than cost reports are. Even with claims, however, there are processing lags. For example, the number of claims received at HCFA for PPS year 1 (October 1983-September 1985, depending on hospital fiscal year) by December 31, 1985, was about 10 million. Another million were received in the first 6 months of 1986, and another 200,000 in the last 6 months of 1986. One can, of course, estimate a model to impute missing claims if the lag process is stable; the RAND backcasting model is an attempt to do just that.

Unit price is estimated from past-year cost reports. More specifically, the estimates of unit price come from disaggregating hospital services into three types: regular room and care services; special care services, such as services for patients in the intensive or coronary care units; and ancillary services, such as operating room, pharmacy, laboratory, and radiologic services.

For the first two services, a cost per day can be found in a past cost report and inflated to the current

year. In our calculations, we excluded the cost of capital and of direct medical education, but they are sufficiently small components of cost that our estimates would not materially change by including them. For ancillary services, a cost can be defined by applying the relevant departmental cost-charge ratio from a past year to the ancillary charge on the claim.

Thus, synthetic cost per case equals:

$$\begin{aligned} & \text{Regular unit days}_t \text{ (cost per regular unit day}_{t-1} \cdot \\ & \text{inflation factor)} + \text{special unit days}_t \\ & \text{(cost per special unit day}_{t-1} \cdot \text{inflation factor)} + \\ & \sum_i \text{ancillary charges}_{i,t} \text{ (cost/charges)}_{i,t-1} \end{aligned} \quad (1)$$

where i indexes the relevant ancillary department in the given hospital and t indexes the year.

This method accounts for any change in real utilization between year $t-1$ and year t , such as the fall in admission rates and length of stay that was associated with the introduction of PPS, but it accounts for that change at a set of estimated prices.

When used with data from the current-year cost report (i.e., using t instead of $t-1$ subscripts and suppressing the inflation factors), equation (1) yields the estimate of accounting operating costs that is the standard we use in this article to judge the two alternatives.

Clearly, synthetic costs will not be useful if the estimated prices are not accurate. For example, if the reductions in length of stay are accompanied by an increase in the average intensity of a hospital stay, the per diem cost of regular and special units may increase at a faster rate than the index of input prices used as the inflation factor in equation (1) does. Moreover, these effects may occur differentially by type of hospital. One could, in principle, account for such effects by incorporating into equation (1) an estimated volume adjuster for unit price; we have not done so.

The second alternative we evaluate is deflated charges; the deflator is the median cost-charge ratio across all hospitals for 1984. We deflate only for purposes of centering the percentage error in predicting accounting costs; the correlation between accounting costs and charges is invariant to whether or how charges are deflated. Because we use the 1984 cost-charge ratio, which comes from the same year as the claims do, our centering is more accurate than one could achieve in practice because one will not have current-year data. Thus, the actual percentage error for this alternative will generally be greater than that shown here.

Methods

Patient bill file

Our analysis files were constructed from records of Medicare bills for inpatient, acute care hospital stays with discharge dates in fiscal year 1984 (October 1, 1983, through September 30, 1984). HCFA provided a 20-percent random sample of all bills received by

June 30, 1986. This sample contained 2.35 million bills drawn from an almost complete population (about 98 percent) of fiscal year 1984 bills. That it is not drawn from a complete population should not much matter for present purposes, because the issue is how well synthetic costs (and deflated charges) predict accounting costs in a reasonably representative sample of cases, not what the mean accounting cost at any hospital is.

To create the analysis sample, we excluded the following bills:

- About 147,000 bills from hospitals and other facilities exempted from PPS (psychiatric hospitals, rehabilitation hospitals, children's hospitals, alcohol and drug facilities, skilled nursing facilities and long-term care facilities, and hospitals outside the United States).
- About 295,000 bills from hospitals located in the four States exempted from PPS, or waiver States (New York, New Jersey, Maryland, and Massachusetts).
- About 6,000 PPS bills from hospitals that were all-inclusive providers and therefore did not report costs or charges in the same manner as other hospitals did.
- About 27,000 bills with unreliable data (negative or zero amounts for total charges, length of stay, reimbursement amount, covered charges, etc.).
- About 46,000 bills that could not be classified as PPS or non-PPS because of missing admission or discharge dates or because we did not know the hospital's fiscal year end date.
- About 800 bills from zero-weighted DRG's 469 and 470, which are not supposed to be paid under PPS until a valid DRG is assigned.
- Another 200 bills for kidney transplant cases (DRG 302), because kidney acquisition charges, which were supposed to be passthrough charges, were sometimes included and sometimes excluded from ancillary service charges.

The resulting file contained approximately 1.8 million bills. We then excluded bills for which the hospital stay was wholly or partially in the period before the hospital was on PPS. (Recall that a hospital began operating under PPS at the beginning of its fiscal year.) The resulting analysis file had 54 percent of the 1.8 million bills, or 980,556 bills.

Cost report files

The ratio of costs to charges for each hospital and the per diem costs were obtained from the Medicare Cost Report files for fiscal years 1983 (for synthetic costs) and 1984 (for accounting costs). The 1983 cost report files include usable cost reports from only about 68 percent of the hospitals and 52 percent of the bills that appeared in our bill sample in 1984, whereas we had usable 1984 cost reports for 97 percent of these hospitals and a similar percentage of bills. Bills that we could not associate with both 1983 and 1984 cost reports were dropped from our

sample. This reduced our file of 980,556 bills to a sample of 500,783 bills from 3,412 hospitals.

To adjust for inflation from 1983 to 1984, we inflated 1983 per diem costs at an annual rate of 6.2 percent for 1983 and an annual rate of 6.0 percent for 1984; these factors are the hospital market basket inflation rates. If the market basket inflation rates contain measurement error, it would impart a bias to our estimates. Because room and board and special unit charges represent about one-half of total revenue, the bias in our estimate of total cost is about one-half the measurement error; for example, if the true inflation rate were 4 percent rather than the 6-percent figure we used, we would have overestimated costs by 1 percent. Such an error, however, has little effect on the correlation between synthetic and actual costs or on our measures of goodness of prediction.

To estimate as precisely as possible, we calculated a monthly inflation rate by taking the 12th root of the annual rate (i.e., 1.062, or 1.06) and applied the monthly rate from the midpoint of the hospital's cost report year to the date of admission. For example, if the midpoint of the 1983 cost report year was June 1983 and an admission occurred on February 5, 1984, we inflated costs for 6 months of 1983 and 1 month of 1984.

Two additional problems arose in using the cost report data. First, some hospitals with otherwise complete cost reports submitted 1984 bills with charges in departments for which no costs or charges were reported in either the 1983 or 1984 cost report. This could reflect recently created departments or reorganizations. Second, some cost reports contained unbelievable data, either for one ratio of costs to charges or more or for one per diem cost or more. For example, some cost-charge ratios were on the order of 1,000, and others were on the order of 0.01. In some instances, the questionable number seemed to be a typographical error, such as a misplaced decimal point for either costs or charges. In other cases, no likely explanation could be detected.

In light of these probable errors, we set upper and lower limits on each ratio and per diem cost. These limits are described in the "Technical note." If a hospital reported a cost-charge ratio outside of our limits, we replaced the reported figure with the limit it violated. When the data were missing, we imputed values. Imputed values for missing per diem costs were based on regression equations that took into account hospital type (control), bed size, teaching intensity, and location (region and city size). Similar regressions for ancillary department cost-charge ratios had such poor predictive power that we simply imputed the overall (unweighted) median for the relevant department. For purposes of estimating accounting costs (1984 cost reports), we had to estimate one ancillary department ratio or more on about 11 percent of the bills and had to estimate a per diem cost on about 0.8 percent of the bills. For purposes of estimating synthetic costs (1983 cost reports), the corresponding figures were 16 percent and 2 percent.

When we test for the possibility of systematic (i.e., nonrandom) errors in the synthetic costs, we include dummy variables to indicate that we estimated data. Specifically, for both 1983 and 1984, we include a dummy variable (one for each year) to indicate that we estimated costs for all bills from that hospital, as well as a variable (one for each year) measuring the percentage of bills on which costs were imputed for those hospitals with less than 100 percent of bills estimated. Additionally, we tested the effects of imputations for missing data by limiting our sample to hospitals for which fewer than 25 percent of the bills had estimated data and, most stringently, to hospitals for which none of the bills had estimated data.

Other data sets

In addition to the patient bill and cost report files, we obtained hospital-level data from other data sets. We used these data in testing for nonrandom errors in the synthetic costs. These data came from the HCFA provider-of-service file, the HCFA provider-specific file, and the 1984 American Hospital Association (AHA) Survey of Hospitals. These data sources contained information on the hospital's bed size, number of residents per bed, metropolitan location, type of control, and the percentage of inpatient days paid for by Medicaid. These variables are discussed in more detail in the next section. Hospital data could not be linked with bills for 57 hospitals; thus, the tests for nonrandom errors were run on a sample of 3,355 hospitals.

Analytic methods

Our methods were designed to compare the operating costs per admission estimated from the 1984 cost reports (accounting costs) with the synthetic costs estimated from the 1983 cost reports, as described in equation (1). As noted previously, the formula for accounting cost per case in 1984 is similar to equation (1): All data in that equation for period $t-1$ are replaced with data for period t , and the inflation factor is suppressed (setting it equal to 1); that is, we used data from 1984 cost reports on the cost of regular and special unit days as well as 1984 cost-charge ratios. In addition, we gauged the accuracy of 1984 accounting costs by comparing them with charges. We first computed correlation coefficients between the accounting and synthetic costs and charges. We computed both weighted and unweighted correlations; in the weighted correlations, we weighted by the number of bills in our sample from that hospital. The number of bills at a hospital varied not only because of the number of admissions at the hospital and sampling error, but also because we included only the quarters of fiscal year 1984 that the hospital was on PPS. For example, a hospital that began PPS in July 1984 (i.e., one whose fiscal year began on that date) had only one quarter's worth of admissions in our data base.

In addition to the correlations, we computed the distribution of the error made by synthetic costs and deflated charges as a percentage of the accounting costs. The deflator for charges was .667, the ratio that made the percentage error for the median hospital equal to zero. (Without deflation it would be more difficult to compare the errors in synthetic costs and charges, because the latter error would be centered around a quite negative mean.)

Next, we tested whether errors at the hospital level were systematic or random by regressing the percentage errors for synthetic costs and charges on a series of descriptive variables for hospitals. In the regressions, each observation was weighted by the number of bills at the hospital. If errors are random, the coefficients of the descriptive variables should not differ significantly from zero. Use of the dependent variable in percentage form caused the variance to be approximately constant.

The explanatory variables included in this regression are as follows:

Bed size—This variable was obtained from the cost report, provider-of-service, or AHA file. It was entered into the regression as two separate linear spline functions, one for urban and one for rural hospitals. The urban hospital spline function consists of four connected linear segments: 1-100, 101-200, 201-400, and 401-620 beds.¹ A separate dummy variable was created for urban hospitals with 621 beds or more. The rural hospital function consisted of three connected lines: 1-50, 51-100, and 101-250 beds. A separate dummy variable was created for rural hospitals with 251 beds or more.

Teaching status—Information on the ratio of residents per bed was obtained from the provider-specific file, augmented by the cost report and AHA file. One dummy variable is used for hospitals with no house staff and another for a ratio of house staff to beds exceeding 0.5. Between 0 and 0.5, a linear spline function was used with a cutting point of 0.25.

Ownership of hospital—This is indicated by two dummy variables: proprietary (investor-owned) facilities and public (non-Federal and non-State) facilities. The excluded group represents voluntary hospitals, including community hospitals and church-run not-for-profit hospitals. These variables were derived from the AHA survey, augmented by the provider-of-service file.

Size of city in which hospital is located—This variable is categorized in terms of size of standard metropolitan statistical area (SMSA) and is treated as three dummy variables: small city (SMSA less than 250,000); medium city (SMSA from 250,000 to 1 million); large city (SMSA more than 1 million). The excluded group represents nonmetropolitan areas.

¹These cutting points reflect the following percentiles in the distribution of hospitals by bed size: rural = 20 percent, 50 percent, and 90 percent, if bill weighted; urban = 8 percent, 25 percent, 66 percent, and 90 percent, if bill weighted; rural = 50 percent, 80 percent, and 98 percent, if hospital weighted; urban = 27 percent, 54 percent, 85 percent, and 97 percent, if hospital weighted.

The size of the SMSA was obtained from the AHA file.

Region of country in which hospital is located—The nine Federal census regions were further divided based on a series of within-region regressions with hospital costs as a dependent variable and each State as a dummy variable. The following 21 subregions were created, using the criterion of grouping contiguous States with similar costs.

Northern New England—Maine, New Hampshire, and Vermont.

Southern New England—Connecticut and Rhode Island. Massachusetts is a waiver State.

We do not have 1983 cost reports for either Connecticut or Rhode Island hospitals, so this subregion does not appear in our regressions.

Middle Atlantic—Pennsylvania. New York and New Jersey are waiver States.

South Atlantic—Florida.

South Atlantic—District of Columbia.

South Atlantic—Rest: Georgia, North Carolina, South Carolina, West Virginia, Virginia, and Delaware. Maryland is a waiver State. This is the omitted region in the regression equation.

East North Central—Michigan.

East North Central—Illinois, Indiana, Ohio, and Wisconsin.

East South Central—Mississippi.

East South Central—Alabama, Kentucky, and Tennessee.

West North Central—Iowa, Kansas, Nebraska, North Dakota, South Dakota, and Minnesota.

West North Central—Missouri.

West South Central—Texas.

West South Central—Arkansas, Louisiana, and Oklahoma.

Mountain—Utah, Colorado, and Wyoming.

Mountain—Arizona, New Mexico, and Nevada.

Mountain—Idaho and Montana.

Pacific—California.

Pacific—Alaska.

Pacific—Hawaii.

Pacific—Oregon and Washington.

Location in one of these subregions was determined from the provider's State code, the first two digits of the provider number.

Inner-city location—A dummy variable was constructed indicating whether a hospital is located in the central city of an SMSA of more than 1 million. The central city also had to be one of the 100 largest cities in the United States. The city rank was obtained from the AHA file.

Percent of all inpatient days at hospital for which Medicaid was primary payer—This variable was obtained from the AHA file.

Interaction term between inner-city location and percent Medicaid days—These variables were defined previously.

Trauma center—A dummy variable was used to indicate whether the hospital was one of 108 fully qualified trauma centers. This information was obtained from a list provided by the National Study

Center for Trauma and Emergency Medical Services. Of the providers in our sample, 55 are trauma centers.

Case mix—A linear variable was entered up to the 90th percentile of case mix (a case mix of approximately 1.21). A dummy variable was used if the hospital exceeded the 90th percentile.

Quarter beginning PPS—A set of dummy variables indicating which quarter the hospital began operating under PPS was entered.

Estimated data—As described previously, two variables relating to missing or out-of-range per diem costs or cost-to-charge ratios on the cost report were also used. One is simply a dummy variable indicating that a per diem cost or ratio (such as laboratory or supplies) affecting every bill from the hospital had to be estimated. The second applies to hospitals that did not have estimation on every bill. It is a continuous variable indicating the percentage of bills at the hospital for which estimated cost report variables were used in calculating synthetic costs.

Results

The correlation (r) between synthetic and accounting costs in 1984 is 0.935 ($R^2 = 0.874$). This figure (r) is the correlation across hospitals when each hospital's values are weighted by the number of bills from that hospital. The unweighted correlation is slightly lower, 0.926. Because our conclusions are similar whether one uses weighted or unweighted results, we focus on the weighted results.

The correlation between charges and accounting costs in 1984 is 0.878; the R^2 is .770, or 10 points less than the R^2 with synthetic costs. One can also inquire about the effect of using synthetic cost rather than accounting cost to estimate accounting profit margins. The correlation between accounting profit margin and synthetic profit margin—i.e., (reimbursement - accounting [synthetic] cost)/accounting [synthetic] cost—is .746.

The distribution of the percentage error in the synthetic cost and deflated charges measured across 500,783 bills from 3,412 hospitals is shown in Table 1. When weighted by bills, only 43 percent (43 = 82.6 - 40.0) of the hospitals have synthetic costs within plus or minus 5 percent of accounting costs; 72 percent have costs within plus or minus 10 percent. A negative median (from -2 to -3 percent when weighted by bills) implies that accounting costs in 1984 fell more than predicted based on 1983 costs and 1984 utilization. This may reflect the incentives of the prospective payment system to reduce cost. Of course, not all errors are negative; approximately one-third of the hospitals (when weighted by bills) have positive errors.

Only 26 percent of hospitals have deflated charges within 5 percent of accounting costs (26 = 64.7 - 39.0), and only 48 percent have deflated charges within 10 percent of accounting costs. Thus, according to both measures of the goodness of prediction, charges are less accurate than synthetic costs in predicting accounting costs.

Table 1

Cumulative percentage of errors in synthetic costs and deflated charges as a percentage of hospital accounting costs: United States, 1984

Percentage error	Synthetic costs ¹		Bill-weighted deflated charge ²
	Bill weighted	Unweighted	
	Cumulative percent		
-15	10.4	9.1	21.6
-10	21.6	16.5	28.5
-5	40.0	29.2	39.0
0	62.6	46.7	50.3
5	82.6	65.6	64.7
10	93.1	79.6	76.0
15	97.2	88.1	85.6

¹Percent error is 100 (accounting cost - synthetic cost)/accounting cost.

²Percent error is 100 (accounting cost - .667 charges)/accounting cost.

NOTE: The range of percentage errors in synthetic costs is from -212 to +60 and in deflated charges is from -106 to +76.

SOURCE: Newhouse, J.P., Cretin, S., and Witsberger, C.J.: Calculated from data contained in: Health Care Financing Administration, Bureau of Data Management and Strategy: Data from the Medicare Statistical System.

The errors shown in Table 1 are not purely random. In Table 2 are shown the results of regressions of the percentage error in synthetic costs and in charges in 1984 on an intercept and the group of descriptive variables listed in the "Methods" section. If errors were purely random with a zero mean, the coefficients of the descriptive variables and the intercept would be zero.

We can firmly reject the hypothesis that errors are random. In the case of synthetic costs (column 1), the overall F statistic is 15; the intercept, far from being zero, is 24, with a standard error of 4. Virtually all the groups of dummy variables are significantly different from zero ($p < 0.01$); the one exception is city size.

The regression coefficients should be interpreted as showing the negative of the percentage error that results from using synthetic costs rather than accounting costs. Thus, for example, the coefficient of -3.2 for Pennsylvania in Table 2, column 1, indicates that synthetic costs overestimate accounting costs by 3.2 percent more in Pennsylvania than in the omitted region (South Atlantic other than Florida, Maryland, and Washington, D.C.).

In the case of charges, the errors are even more systematic (column 2). The R^2 rises from 0.19 to 0.44; the overall F statistic is 51. The intercept is 19, with a standard error of 8. Again, virtually all the groups of dummy variables are significantly different from zero ($p < 0.01$), the two of marginal significance being the estimated data dummies ($p < .02$) and PPS quarter ($p < 0.11$).

Not surprisingly, there is a large negative coefficient (-29) for proprietary hospitals in the regression with accounting costs minus charges as a dependent variable; this reflects the well-known, larger markups at such hospitals. However, the proprietary dummy has a significantly negative coefficient in the synthetic cost regression also (relative to both voluntary hospitals and public hospitals). This suggests that

Table 2

Results of regressions to explain the percentage errors from using synthetic costs and charges to estimate hospital accounting costs: United States, 1984

Explanatory variable	Dependent variable = accounting costs - synthetic cost		Explanatory variable	Dependent variable = accounting costs - charges	
	(1)	(2)		(1)	(2)
	Regression coefficient			Regression coefficient	
Intercept	24 (4)	19 (8)	Bed size—urban hospitals⁴		
			1-100 beds	-.07 (.03)	-.3 (.1)
Region¹			101-200 beds	-.02 (.01)	-.04 (.02)
Northern New England	7.1 (3.6)	5.3 (7.1)	201-400 beds	.002 (.005)	-.02 (.01)
Pennsylvania	-3.2 (1.1)	-18 (2)	401-620 beds	-.01 (.006)	.03 (.01)
Florida	-1.9 (1.4)	-23 (3)	621 beds or more (dummy)	-.86 (1.27)	-.45 (2.5)
District of Columbia	9.4 (3.0)	15 (6)			
East North Central—Michigan	3.5 (1.1)	2.5 (2.1)	Bed size—rural hospitals⁵		
Other East North Central	2.5 (.8)	7.5 (1.5)	1-50 beds	-.14 (.06)	-.57 (.12)
East South Central—Mississippi	-1.5 (2.4)	-5.9 (4.6)	51-100 beds	-.03 (.03)	-.14 (.05)
Other East South Central	-1.1 (1.0)	-12 (2)	101-250 beds	-.02 (.01)	-.08 (.02)
West North Central—Missouri	-2.8 (1.1)	-4.7 (2.2)	251 beds or more (dummy)	1.2 (1.9)	12 (4)
Other West North Central	3.7 (.9)	13 (2)	Trauma center	-1.8 (1.1)	5.5 (2.2)
West South Central—Texas	1.0 (.9)	5.9 (1.9)	Medicaid and inner-city location⁶		
Other West South Central	-1.5 (1.0)	-6.4 (1.9)	Percent Medicaid days	-.13 (.04)	-.35 (.08)
Arizona, Nevada, and New Mexico	-2.5 (1.6)	-8.2 (3.2)	Inner-city location	.47 (.86)	7.3 (1.7)
Idaho and Montana	4.1 (2.2)	6.6 (4.3)	Percent Medicaid x inner-city location	-.07 (.07)	-.96 (.14)
Colorado, Utah, and Wyoming	-.6 (1.3)	8.7 (2.6)	Quarter beginning prospective payment system⁷		
Hawaii	-44 (8.6)	30 (17)	Second	1.7 (.8)	.5 (1.5)
Alaska	6.9 (7.7)	13 (15)	Third	2.0 (1.0)	-1.9 (1.9)
California	-2.0 (1.0)	-5.9 (1.9)	Fourth	3.5	-1.6
Oregon and Washington	4.0 (1.1)	11 (2)			
Ownership²			Teaching status⁸		
m-2.9	-4.4		No teaching (dummy)		
Proprietary	-3.9 (.7)	-29 (1)	House staff to beds ratio <.25	(.7) -37 (6)	(1.3) -104 (11.5)
Public	.1 (.6)	4.9 (1.1)	House staff to beds ratio .25-.50	38 (10)	141 (20)
City size³			House staff to beds ratio >.50 (dummy)	-6.5 (3.3)	1.5 (6.8)
Small (less than 250,000)	-3.3 (3.6)	-5.3 (7.1)			
Medium (250,000-1,000,000)	-2.9 (3.6)	3.6 (7.0)			
Large (more than 1,000,000)	-3.3 (3.6)	-11 (7.1)			

See footnotes at end of table.

Table 2—Continued

Results of regressions to explain the percentage errors from using synthetic costs and charges to estimate hospital accounting costs: United States, 1984

Explanatory variable	Dependent variable =	
	accounting costs - synthetic cost (1)	Accounting costs - charges (2)
Regression coefficient		
Estimated data⁹		
1983 all claims estimated	-7.6 (1.2)	2.3 (2.5)
1983 percent claims estimated	-.03 (.01)	-.02 (.02)
1984 all claims estimated	-3.7 (1.8)	-9.0 (3.6)
1984 percent claims estimated	.02 (.01)	.03 (.02)
Case mix¹⁰		
Case-mix index ≤ 1.21	-.13 (.03)	-.21 (.06)
Case-mix index > 1.21 (dummy)	.11 (.61)	2.0 (1.2)
F on overall regression ¹¹	15	51
R ²	.19	.44
Dependent variable mean	-3.3	-53

¹Omitted region is South Atlantic except Florida and Washington, D.C. The F test for the 19 regional dummies is 9.1 ($p < .01$) in the synthetic cost regression and 26.9 ($p < .01$) in the charges regression.

²Omitted group is voluntary. The F test on the 2 control dummies is 16.0 ($p < .01$) in the synthetic cost regression and 247 ($p < .01$) in the charges regression.

³Omitted group is rural group. The F test on the 3 city-size dummies is 0.43 in the synthetic cost regression and 11.2 ($p < .01$) in the charges regression.

⁴The F test on the 5 urban hospital, bed-size variables is 6.0 ($p < .01$) in the synthetic cost regression and 17.4 ($p < .01$) in the charges regression. The F test on the 9 bed-size variables is 5.7 ($p < .01$) in the synthetic cost regression and 21.2 ($p < .01$) in the charges regression.

⁵The F test on the 4 rural hospital, bed-size variables is 6.9 ($p < .01$) in the synthetic cost regression and 29.9 ($p < .01$) in the charges regression.

⁶The F test on the 3 Medicaid and inner-city variables is 6.1 ($p < .01$) in the synthetic cost regression and 45.9 ($p < .01$) in the charges regression.

⁷The F test on the 3 quarter dummies is 6.5 ($p < .01$) in the synthetic cost regression and 2.0 ($p < .11$) in the charges regression.

⁸The F test on the 4 teaching variables is 10.5 ($p < .01$) in the synthetic cost regression and 27.2 ($p < .01$) in the charges regression.

⁹The F test on the 4 estimated data variables is 13.7 ($p < .01$) in the synthetic cost regression and 2.9 ($p < .02$) in the charges regression.

¹⁰The F test on the 2 case-mix variables is 10.4 ($p < .01$) in the synthetic cost regression and 5.8 ($p < .01$) in the charges regression.

¹¹ $p < .01$.

NOTES: Standard errors are shown in parentheses. Dependent variables are 100 (accounting cost - synthetic cost)/accounting cost and 100 (accounting cost - charges)/accounting cost. The mean of accounting cost is \$2,785. Sample size is 3,355.

SOURCE: Newhouse, J.P., Cretin, S., and Witsberger, C.J.: Calculated from data contained in: Health Care Financing Administration, Bureau of Data Management and Strategy: Data from the Medicare Statistical System; American Hospital Association: Annual Survey of Hospitals.

proprietary hospitals reduced costs from 1983 to 1984 to a greater degree than other hospitals did (that is, the overprediction of costs using 1983 cost report data was greater for proprietary hospitals). The quantitative effect of additional cost reduction is 4 percent.

Also noteworthy are the negative coefficients in column 2 on percentage Medicaid days and percentage Medicaid days interacted with the inner-city variable. These results imply that hospitals in the inner-city with a high proportion of Medicaid patients cross-subsidize their charity load with high charges.

We also examined the sensitivity of these results to errors that we made in imputing costs, an issue that must be faced when implementing the synthetic cost method with cost reports but one that is not inherent in the method of synthetic costs per se. To do so, we reestimated equations for those hospitals in which imputed data applied to 25 percent or less of the bills, about three-quarters of the original sample, and also for hospitals with no estimated data, a sample about one-third as large as the original sample.

These regressions (results not shown) are little different from the regressions in Table 2. Hence, our conclusions about systematic bias are little affected by the data we estimated. In particular, the F statistics are all still significant at the 1-percent level. Not having to impute, however, does mean that our estimates are more accurate. The bill-weighted correlation between synthetic and accounting costs rises from 0.935 to 0.951 in the subset of hospitals with less than 25 percent estimated data and rises still further, to 0.957, with no estimated data. (R^2 is 0.916.) The corresponding values for the correlation between accounting costs and charges are 0.876 and 0.883, respectively. The gain in accuracy comes at a cost of a smaller sample, of course. Because our conclusions are invariant to the estimated data, we have not investigated further the possible bias from using estimated data.

Discussion

Our results suggest that using synthetic costs as a proxy for accounting costs is problematic. Although the R^2 between predicted and accounting cost is 0.87, less than one-half of the hospitals have a predicted cost per case within 5 percent of the 1984 value. There are both bias and systematic error in synthetic costs; that is, the difference between accounting and synthetic costs varies by subgroup. Charges or charges deflated by a median cost-charge ratio are even less satisfactory as a proxy for accounting costs than are synthetic costs. However, before dismissing charges, one might consider that the accuracy of data in cost reports may fall because they are no longer used for reimbursement. If so, charges or deflated charges would become a more attractive option. These conclusions are not materially affected by our having to estimate or impute data that are missing from cost reports.

It might be thought that we picked a particularly difficult time period for predicting cost. After all, 1984 was the first year of implementation of the prospective payment system, and costs could be expected to have been volatile. The problem with this line of argument is that it is precisely in such periods that one wants an accurate estimate of cost. If

utilization is relatively stable (except for a general inflation factor), the cost from past years' cost reports, adjusted for inflation, ought to be relatively accurate.

What alternative is there to using synthetic costs or charges if one wants cost estimates quickly? One possibility is to place a sample of hospitals on a fast track for cost reporting. We have not investigated the operational problems that such a fast-track sample might pose, nor have we done any statistical analysis to estimate standard errors at varying levels of sample size. We suggest that an assessment of the usefulness of a small sample be carried out. It seems to us that a relatively small sample of hospitals from the current year is more likely to be useful for policy purposes than projecting costs from current utilization and past cost reports on a more complete sample of hospitals.

In choosing a fast-track sample, however, one faces a tradeoff. In order to get data most rapidly, one should use hospitals whose fiscal year begins in October (i.e., coincides with HCFA's). However, we know from Carter and Ginsburg (1985) that this set of hospitals differs somewhat from the universe of hospitals in its responses to PPS. Hence, adjustments or weighting would seem desirable.

The desirability of a fast-track sample is reinforced by the lags in the receipt of claims data noted in the "Introduction." The missing claims are likely to contain a disproportionate number of outlier cases, which traditionally take more time to move through the system. Therefore, projections of current use from claims either must be estimated from censored data, with attendant possibilities for error, or will not be timely. Furthermore, the complete claims file is so large (10 million records) that it is expensive and difficult to use, and using samples will introduce sampling error.

For some analyses, however, merging data from a sample of the bill file and the cost report will continue to be necessary. These include DRG-level analyses and certain hospital analyses in which simulated changes in policy are evaluated. If such policy changes involve DRG- or other case-level variables, such as outlier payments, then the aggregated hospital data contained in the cost report will not be sufficient.

Absent a fast-track sample, our findings let the analyst decide whether the more rapid estimates that can be obtained by the synthetic cost method are worth the time saved relative to waiting for audited cost reports.

Technical note: Imputations for missing data

The limits for cost-charge ratios were as follows:

- For hospitals with less than 100 beds, upper limit = 100; lower limit = .01.
- For hospitals with 100 beds or more, upper limit = 3; lower limit = .01 for supplies, anesthesiology, oxygen therapy, and other; lower limit = .20 for other departments (operating room, laboratory,

radiology, drugs, blood, physical therapy, occupational therapy, and speech therapy).

- Exception: For all hospitals, cost-charge ratios > 200 or = zero were treated as missing and set to the median instead of being set to the limits.

Missing cost-charge ratios (and the exception just noted) were set to overall sample medians, as shown in Table 3.

Table 3
Median cost-charge ratios, by hospital department: United States, 1983 and 1984

Department	1983 cost report	1984 cost report
Operating room	.88	.78
Anesthesiology	.64	.63
Blood	.97	.90
Drugs	.49	.45
Radiology	.68	.72
Laboratory	.64	.63
Supplies	.60	.54
Physical therapy	.80	.82
Occupational therapy	.95	.92
Speech therapy	.99	.97
Oxygen therapy	.51	.48
Other	.42	.40

Lower and upper limits for per diem costs were \$50 and \$850, respectively, for routine care; \$100 and \$1,800 for special care. Values outside these limits were treated as missing and replaced by a regression-model estimate.

These models had the following explanatory variables:

- Eight region dummies.
- Two control dummies—government and proprietary; voluntary omitted.
- Five bed-size category dummies— < 50, 50-99, 200-299, 300-499, 500 or more; 100-199 omitted.
- Three city-size dummies—small city (< 250,000), medium city (250,000-1,000,000), large city (> 1,000,000); rural omitted.
- Three teaching dummies—residents-beds < .25, residents-beds > .25; nonteaching omitted.

The mean of the dependent variable, the R^2 (is the percent of variance explained), and the number of hospitals in the sample for these regressions are shown in Table 4.

Table 4
Statistics for regression models to impute missing values

Dependent variable	Mean of dependent variable	R^2	Number of hospitals in sample
1984 routine care per diem cost	\$178	.32	4,999
1984 special care per diem cost	444	.29	3,493
1983 routine care per diem cost	142	.45	3,531
1983 special care per diem cost	403	.32	2,411

References

- Carter, G. M., and Ginsburg, P. B.: *The Medicare Case Mix Index Increase: Medical Practice Changes, Aging and DRG Creep*. RAND Pub. No. R-3242-HCFA. Prepared for Health Care Financing Administration. Santa Monica, Calif. The RAND Corporation, Mar. 1985.
- Cotterill, P., Bobula, J., and Connerton, R.: Comparison of alternative relative weights for diagnosis-related groups. *Health Care Financing Review* Vol. 7, No. 3 HCFA Pub. No. 03222. Office of Research and Demonstrations, Health Care Financing Administration. Washington. U.S. Government Printing Office, Spring 1986.