

A longitudinal comparison of charge-based weights with cost-based weights

by Grace M. Carter and Donna O. Farley

The diagnosis-related group weights that determine prices for Medicare hospital stays are recalibrated annually using charge data. Using data from fiscal years 1985 through 1987, the authors show that differences between these charge-based weights and cost-based weights are increasing only slightly. Charge-based weights are available in a more timely manner and,

based on temporal changes in the weights, we show that this is an important consideration. Charge-based weights provide higher payments than cost-based weights to hospitals with higher case-mix indexes, but have little effect on hospitals with low cost-to-charge ratios, high capital costs, or high teaching costs.

Introduction

The Health Care Financing Administration (HCFA) uses a prospective payment system (PPS) to pay for hospital stays of Medicare patients. The amount of the payment for a stay is proportional to the weight assigned to the diagnosis-related group (DRG) of the stay. The weight is intended to measure the average amount of resources required to treat a patient in a given DRG relative to the amount of resources required to treat patients in other DRGs. For example, patients in a DRG with weight 2 should cost twice as much to treat, on average, as patients in a DRG with weight 1.

We compare DRG relative weights computed from operating costs, as was done in the first PPS year (fiscal year 1984) with those computed only from charges. Operating costs are computed using hospital-specific cost report data to transform case-level data on charges and length of stay into an estimate of the cost of each case. Since fiscal year (FY) 1986, weights have been recomputed annually using the charges for each case.

Criteria for choice between bases

It is impossible to determine theoretically whether cost-based weights or charged-based weights are more accurate measures of the relative operating costs of DRGs. Cost-based weights may be more accurate for several reasons: They capture variation among hospitals in cost-to-charge ratios; they capture variation among departments within a hospital in cost-to-charge ratios; and they remove the costs of capital and the direct cost of medical education, which are paid on a passthrough basis and which therefore should not be counted in the relative weights. However, some of the variation among hospitals and among departments in cost-to-charge ratios is the result of variations in accounting methodology. Also, there exists variation among services in the same department in the cost-to-charge ratio, and this variation is not captured in the cost

estimate. Nevertheless, if other things were equal, then cost-based weights likely would be superior to charge-based weights as measures of relative resource use.

Other things are not equal, however. Cost-based weights would be based on data 1-2 years older than the data on which charge-based weights could be calculated because cost reports are not available for at least a year after the end of a fiscal year. If the relative intensity of DRGs changes rapidly, then the cost-based weights may be less accurate than more recent charge-based weights. Charge-based weights also have an advantage in that they are simpler to administer.

Another advantage of charge-based weights is that they have been found empirically to have greater dispersion than cost-based weights (Cotterill, Bobula, and Connerton, 1986; Rogowski and Byrne, 1990; Price, 1989). It is believed that, using the cost methodology, the resources needed by DRGs with high relative weights are underestimated and those with low relative weights are overestimated. Three reasons for this compression are usually given:¹ (1) Each hospital is assigned just one per diem for routine costs and one per diem for special care costs, yet per diem nursing costs almost surely vary by DRG. (2) A single cost-to-charge ratio is used within each ancillary department. Many believe that prices are set so that low-cost services subsidize higher cost services, even within a particular ancillary department. To the extent that this is true, then the cost-based weights of DRGs that use those low-cost services (which tend to be low-cost DRGs) will be overestimated and the cost-based weights of high-weight DRGs that use the higher cost services will be underestimated. (3) Errors in classification of cases into DRGs will tend to make the weights more similar than they should be. Pettengill and Vertrees (1982) used simulation to show the effect of varying amounts of classification error on weight compression.

The empirical finding that charge-based weights have more dispersion leads to the possibility that they are also more accurate measures of relative resource intensity. Most of the sources of compression for cost-based weights also affect charge-based weights, however.² Thus it might be that the increased dispersion

This research was supported by Cooperative Agreement Number 99-C-98489/9-06 between the Health Care Financing Administration and the RAND/UCLA/Harvard Center for Policy Research in Health Care Financing.

Reprint requests: Grace M. Carter, RAND, P.O. Box 2138, Santa Monica, California 90407-2138.

¹Lave (1985) has a particularly clear discussion of these points.

²Thorpe, Cretin, and Keeler (1988) used regression analysis to show that charge-based weights were also compressed in the first PPS year.

in charge-based weights occurs in the mid-range of the distribution and is the result of random error related to the variance across hospitals in the cost-to-charge ratios, rather than occurring at the extremes and being the result of compression. Rogowski and Byrne (1990), however, showed that the difference between cost- and charge-based weights calculated on fiscal year 1984 PPS data was not distributed randomly. Rather, it was concentrated at the extremes with charge-based weights being higher than cost-based weights for patients in high-weight DRGs and lower for patients in low-weight DRGs.

Study questions

Our study describes differences between charge-based weights and cost-based weights and the effect of these differences on HCFA and hospitals.

First, we examine how the form of the weights affects growth in the national case-mix index (CMI). The CMI for any set of cases is the average of the DRG weights; the national CMI is the case-weighted average of the weights for all cases. Under normal procedures for recalibration of the DRG weights, an increase in the CMI for the set of all Medicare cases will be translated into a proportional increase in the price that HCFA pays for the average case.

Next, we look at the extent to which cost- and charge-based weights have diverged during the period 1985-87. Cotterill, Bobula, and Connerton (1986) first compared cost- and charge-based weights calculated on 1981 data and found them to be very similar. Rogowski and Byrne (1990) used data from the first year of PPS and found less similarity. Price (1989) used a 1986 bill file and found even more divergence. These studies use the same basic methodology but differ in methodological detail and in sample selection rules. Therefore, although the studies clearly suggest the direction of change, they do not provide the magnitude of the divergence. We also use a similar methodology and offer the first study examining this issue using a 3-year longitudinal data base and exactly the same methodology in each year.

We then study the relative compression of cost- and charge-based weights. We repeat the analyses of previous researchers using data from 1985 through 1987.

How the form of the weights affects the distribution of payments among hospitals is examined next. We study how charge- and cost-based weights affect the CMI of groups of hospitals and individual hospitals. We also examine the relationship between the difference of the two CMIs and the level of the hospitals' CMI and three indicators of high charges: cost-to-charge ratio, capital costs, and direct cost of medical education. To the extent that charge-based weights increase the CMI of hospitals with high values of the cost-based weight CMI, it can be viewed as decompression of the weights and a desirable feature of charge-based weights. A priori, we would expect that charge-based weights are positively biased for DRGs that are over-represented at hospitals that have high charges relative to costs. Therefore, to the extent that charge-based weights

increase the CMI of hospitals with low value of the cost-to-charge ratio, high capital costs, or high teaching expenditures, it can be viewed as error in the weights and an undesirable feature of charge-based weights.

Finally, we look at how each set of weights changes over time. Charge-based weights allow HCFA to use more recent data to calculate weights than would be possible with cost-based weights. If 1985 weights are very similar to 1987 weights, then the value of this advantage will be much less than if the 1985 weights differ greatly from the 1987 weights.

Methods

Data

We used a 20-percent random sample of Medicare inpatient stays in short-term hospitals for fiscal years 1985, 1986, and 1987. To increase comparability with Rogowski and Byrne (1990), the sample excludes cases at exempt hospitals and units in PPS States and also excludes cases in Maryland and New Jersey, which were not covered by PPS. (HCFA includes cases from hospitals in all States in computing DRG relative weights.) Although New York and Massachusetts did not join PPS until FY 1986, their bills are included in the sample in all 3 fiscal years. Because of difficulties in determining costs, we also had to exclude the approximately 1.5 percent of all cases that were from "all-inclusive" providers.

To estimate costs, we used cost reports from PPS years 1, 2, 3, and 4. The cost report for PPS year 1 (PPS 1) covers the hospital's FY that began during Federal FY 1984, the first year of PPS. Later PPS years are defined similarly with PPS 2 being related to Federal FY 1985, etc.

The cost estimate was derived by determining the PPS year containing the day of discharge for each stay and using data from the cost report for that PPS year. However, in some cases, the appropriate cost report was not available. In these cases, we used the closest available preceding cost report. Missing cost reports were rare, except for FY 1987, in which the costs of less than 6 percent of the stays were based on an early cost report because the PPS 4 cost report was not available.

Estimating costs

The method used to estimate the cost of each case is similar to that used by HCFA in calculating the FY 1984 and FY 1985 DRG relative weights and is described in Newhouse, Cretin, and Witsberger (1989). Cost report data are used to generate ratios of operating costs to charges for each of 12 ancillary departments and to estimate the per diem cost of routine care and the per diem cost of care in a special care setting such as an intensive care unit or a coronary care unit. (The ratios exclude capital costs and direct costs of medical education.)

To estimate ancillary costs for a particular case, ancillary charges for that case in each of 12 departments are multiplied by the appropriate cost-to-charge ratio

and then summed. Per diem costs are calculated as the number of days spent in routine care times the routine care per diem plus the number of days spent in special care units times the special care per diem. The total cost of the case is the sum of ancillary costs and per diem costs.

Before calculating per diem cost, routine care and special care per diems were inflated (or deflated) according to the number of months from the center of the hospital's fiscal year until the month of admission. An annual rate of 6 percent was used for calendar year 1984 to be consistent with the work of Rogowski and Byrne (1990). Eight percent was used for calendar years 1985 through 1987; this is the annual rate of increase in routine care observed from PPS 2 to PPS 4.

Calculating weights

Costs and charges were standardized for differences in input prices, teaching, and disproportionate share. The standardized costs and charges were averaged within each DRG and fiscal year. We decided to use the same grouper for each fiscal year's data in order to increase comparability among the data for different years. The grouper used in FY 1988 (grouper 5) was chosen, as it was the latest grouper that was available to us at the time.

We omitted from the cost-based weight calculation cases that were outside three standard deviations of the distribution of the log of costs for the FY and DRG. Similarly, we omitted from the charge-based weight calculation cases that were outside three standard deviations of the distribution of the log of charges for the FY and DRG. Thus, different cases were used for each weight for each year. We also omitted all DRGs that did not have at least 10 sample cases in each of the 3 years.

Our analyses use a total of 417 DRGs. Table 1 shows the sample sizes that we used. Although the trimming procedure eliminated almost exactly the same number of cases from the charge-based weights and from the cost-based weights, the identity of many of the eliminated cases differed for the two weights. The total column of Table 1 gives the number of cases that were used to compute hospital CMIs.

The final step in calculating weights is normalization. We used two procedures to normalize the weights. In the first procedure, we divided the DRG-fiscal year average of costs (charges) by the case-weighted average of costs (charges) for the same fiscal year. Thus the case-weighted CMI equals 1 for each year and type of weight, and each year's weights are independent of other years' weights and are directly comparable. We call these weights the "relative cost-based weights" and the "relative charge-based weights."

The second procedure used for normalization is designed to test whether the actual normalization procedure that HCFA uses affects the comparability of cost- and charge-based weights and whether the use of charge- rather than cost-based weights affects the growth in the CMI. In this normalization procedure, we applied the 1985 cost-based weights to the 1986 file to

Table 1
Sample sizes used for calculating cost- and charge-based weights, by Federal fiscal year: 1983-87

Fiscal year	Sample		
	Total	Cost-based weight	Charge-based weight
1985	1,783,230	1,770,029	1,769,663
1986	1,818,108	1,804,839	1,804,530
1987	1,784,018	1,770,976	1,770,552

SOURCE: Carter, G.M., and Farley, D.O., RAND, Santa Monica, California, 1991.

calculate what the 1986 case-weighted CMI would have been if the 1985 cost-based weights had been in use. Then we normalized the 1986 cost-based weights to this CMI. Similarly, we applied the 1986 cost-based weights to the 1987 file to calculate what the 1987 case-weighted CMI would have been if the 1986 weights had been in use. Then we normalized the 1987 cost-based weights to this CMI. An analogous procedure was used for the charge-based weights. We call these weights the "CMI-adjusted" cost- and charge-based weights. This procedure is not exactly the same as the one in use at HCFA because the file HCFA uses to calibrate each new set of weights is always more than 1 year old. However, it seemed the best we could do with our 3-year time series.

Comparison with earlier studies

In reporting our analyses, we compare our statistics with earlier studies.³ In several cases, we chose elements of our methodology to match those of Rogowski and Byrne (1990) in order to increase comparability. Nevertheless, there are methodological differences that make it incorrect to interpret differences between their study of 1984 discharges and ours as being entirely the result of temporal factors.

Two methodological choices have large, but opposite, effects on measures of the similarity of cost and charge weights. We trimmed separately for the cost distribution and for the charge distribution, but Rogowski and Byrne excluded a case from the analysis if it was beyond three standard deviations in either distribution.⁴ We believe our method is a more accurate representation of how either system would be implemented. Using the trimming method from the earlier study increases the percentage of cases for which the charge-based weight is within 5 percent of the cost-based weight by approximately 8 percentage points.

The second methodological difference concerns sample selection. We include cases from New York and Massachusetts. These States were not covered by PPS in 1984 and thus were excluded from the Rogowski and

³Rogowski and Byrne (1990) reported the results of several different computations. We compare our findings with the analysis that they labeled "current," which corresponds most closely to the methodology that we use here.

⁴Cotterill, Bobula, and Connerton (1986) used the same trimming method as Rogowski and Byrne (1990); Price (1989) used the same one we did.

Table 2
National case-mix index (CMI) and standard deviations of the relative and CMI-adjusted weights, by Federal fiscal year: 1985-87

Year	Case-weighted standard deviations					
	Case-weighted CMI ¹		Relative weight ²		CMI-adjusted weight	
	Cost	Charge	Cost	Charge	Cost	Charge
1985	1.00000	1.00000	0.68056	0.72953	0.68056	0.72953
1986	1.04049	1.04273	0.67425	0.72433	0.70155	0.75527
1987	1.06547	1.06865	0.67508	0.72760	0.71925	0.77755

¹Mean CMI-adjusted weight.

²Mean = 1.000.

SOURCE: Carter, G.M., and Farley, D.O., RAND, Santa Monica, California, 1991.

Byrne study. These cases have much greater than average congruence between charges and costs. We repeated the 1985 calculations dropping these two States and the percentage of cases with weights within 5 percent declined from 70.4 percent to 65.7 percent. Thus, the inclusion of New York and Massachusetts increases the similarity between the cost and charge weights.

There were three other methodological differences that had smaller effects on the comparison of costs and charges. We defined our sample of DRGs as those with at least 10 cases per year, but Rogowski and Byrne used a more complicated rule. We used the 1988 grouper, they used the 1984 grouper. Because 1984 was the first year of PPS, when they limited their sample to PPS cases, they used only partial-year data for most hospitals.

Other studies probably have even more differences from ours than Rogowski and Byrne. Thus, although we report comparative data, these data should not be interpreted as measuring trends.

Analysis methods

In examining the divergence of cost- and charge-based weights and the amount of dispersion in the weights, we weighted the data by the number of cases in the cost-based weight calculation. Almost all calculations were also performed using charge-based weights, but the findings were virtually indistinguishable.

To compare cost- and charge-based weights, we examined the distribution of cases in DRG categories defined by the difference between the cost- and charge-based weights expressed as a percentage of the cost-based weight. Similar distributions were used by all previously published studies in this area.⁵ Although the entire distribution is of some interest, it is also desirable to have a summary measure. Picking a single range from this distribution, (e.g., the percentage of cases with cost- and charge-based weights more than 5 percent apart) appears to us to be somewhat arbitrary.

⁵Cotterill, Bobula, and Connerton (1986), Rogowski and Byrne (1990), and Price (1989). Price expressed the difference between the two weights as a percentage of the charge-based weight.

Thus, we prefer a continuous measure and, therefore, report the case-weighted average of the absolute value of the difference between cost- and charge-based weights. Because payments are roughly proportional to the DRG weight, this measure is roughly proportional to the fraction of dollars that would be redistributed across cases if one moved from one system of weights to the other.

To examine how cost- and charge-based weights affect hospital CMIs, we use both case-weighted and hospital-weighted analysis. To examine how important the weight methodology is to individual hospitals, we report the mean value of the absolute value of the percent difference between cost- and charge-based CMIs. When this statistic is calculated after weighting by the number of cases at each hospital, it is roughly proportional to the fraction of dollars that would be redistributed among hospitals if one moved from one system of weights to the other.

Results

Growth in the national index

Table 2 shows how growth in the national CMI (i.e., the case-weighted average DRG weight) is affected by the choice of charge-based weights rather than cost-based weights. This table presents the CMIs for the cost-based and charge-based weights, along with their case-weighted standard deviations for both relative and CMI-adjusted weights. (The relative weights average 1.000 for all years.)

Using the charge-based weights, the CMI increased by 4.273 percent from 1985 to 1986 and by about 2.5 percent from 1986 to 1987. The CMI of the charge-based weights increases somewhat more than CMI of the cost-based weights. By 1987, the CMI based on charge-based weights exceeded the CMI based on cost-based weights by three-tenths of 1 percent.⁶

⁶These CMIs differ from those used for payment purposes because they are based on the FY 1988 grouper and were standardized on different year files. In addition, our 1985 cases include New York and Massachusetts, whose rate of increase in the CMI from 1985 to 1986 was substantially higher than average. The 4.3 percent rate of increase shown here for 1985 to 1986 is higher than the actual rate of increase in the paid CMI (3.0 percent according to Carter, Newhouse, and Relles, 1990). The rate of increase from 1986 to 1987 is more similar (2.5 percent here versus 2.4 percent in the paid CMI).

Table 3
Percent differences between charge- and cost-based weights, by magnitude of weight and year: 1985-87

Weight percentiles ¹	Mean percent difference charge weight minus cost weight as percent of cost weights					
	1985	Relative weight			CMI-adjusted weight	
		1986	1987	1988	1986	1987
Cost weights:						
Top 25 percent	1.01	0.79	2.29	1.01	2.60	
Middle 50 percent	-1.95	-1.56	-2.25	-1.77	-1.96	
Bottom 25 percent	-2.50	-3.70	-4.03	-2.90	-3.75	
Charge weights:						
Top 25 percent	1.96	2.43	2.47	2.65	2.78	
Middle 50 percent	-1.66	-1.60	-1.91	-1.39	-1.61	
Bottom 25 percent	-3.97	-4.78	-4.81	-4.58	-4.52	

¹Case-weighted.

NOTE: CMI is case-mix index.

SOURCE: Carter, G.M., and Farley, D.O., RAND, Santa Monica, California, 1991.

Compression of weights

Previous studies found that cost-based weights were compressed relative to charge-based weights. We observe the same phenomenon in this study, as shown by the standard deviations of the weights presented in Table 2. In all 3 years, the standard deviations of the cost-based weights are smaller than those of the charge-based weights.

The argument that cost weights are compressed is based on the assumption that high-weight DRGs are undervalued and low-weight DRGs are overvalued. The larger standard deviation for charge-based weights than for cost-based weights might be in large part the result of increased variance in the middle range rather than the desired decompression. However, as shown in Table 3, the charge-based weights tend to be higher than cost-based weights for large weights and to be lower for smaller weights, yielding mean relative differences that are positive for the larger weights and negative for the smaller weights. This is the same pattern of differences found by Rogowski and Byrne (1990). This reveals clearly the relative decompression of charge-based weights.

Because surgical DRGs tend to have higher weights than medical DRGs, earlier studies found that surgical DRGs have higher charge-based weights. Although not reported in detail here, we also found that the mean charge-based weights for surgical DRGs were higher than mean cost-based weights and were lower than the mean cost-based weights for medical DRGs. For example, in 1985, the charge-based weights for three-quarters of the medical cases were lower than their cost-based weights, but only 40 percent of surgical cases had lower charge-based weights than cost-based weights.

The evidence on whether decompression is occurring over time is mixed. Because the standard deviations of either cost- or charge-based relative weights do not change over the years, these measures indicate no decompression in relative weights over time. The increases in the standard deviations of the CMI-adjusted weights are primarily the result of

differences in case mix rather than changes in the relative weights of similar cases. All the weights in each set of CMI-adjusted weights are multiplied by the same CMI, and this increases the magnitude of the standard deviation of the set of weights.

On the other hand, the magnitudes of differences between charge- and cost-based weights increase from 1985 to 1987, increasing faster for the top and bottom 25-percent weights than for the mid-range 50 percent. This indicates a trend of slowly increasing differences between the weights, with a good portion of the increases occurring in the larger and smaller weights. This suggests a slight decompression of the charge weights over time.

Trends

Correlations between the cost- and charge-based weights are very high. Within each year, the correlation between the cost- and charge-based weights exceed 0.997. These correlations are consistent with results of previous studies (Cotterill, Bobula, and Connerton, 1986; Rogowski and Byrne, 1990; Price, 1989).

This strong linear relationship between the weights does not reveal the degree of dispersion among the sets of weights. Despite the high correlation, substantial differences between the cost- and charge-based weights exist for some DRGs in each year.

Table 4 presents the distribution of cases among DRG categories defined by the relative difference between the cost- and charge-based weights. The relative difference for each DRG is calculated as the DRG charge-based weight minus the cost-based weight expressed as a percentage of the cost-based weight. Distributions are presented for both relative weights (i.e., weights with an average value of 1 in each year) and CMI-adjusted weights (i.e., weights with an average value that reflects each year's increase in the frequency of higher weighted cases). (It is not necessary to distinguish between the two sets of weights in examining correlations because the CMI-adjusted weight is a multiple of the same year's relative weight.) The results from the two sets of weights are quite

Table 4
Distribution of cases by the relative difference between charge- and cost-based weights, by Federal fiscal year: 1985-87

Charge weight	Percentage of year's cases				
	1985	Relative weight		CMI-adjusted weight	
		1986	1987	1986	1987
More than 15 percent less	0.0	0.1	0.0	0.1	0.0
11-15 percent less	3.2	4.9	5.1	3.1	4.8
6-10 percent less	14.8	16.7	16.6	18.5	18.5
1-5 percent less	42.7	39.9	39.5	36.5	36.9
Equal	5.9	5.1	5.2	7.8	7.8
1-5 percent more	21.8	21.6	21.6	22.3	21.7
6-10 percent more	11.2	10.8	10.8	10.8	9.8
11-15 percent more	0.3	0.9	1.1	0.9	2.4
More than 15 percent more	0.0	0.0	0.0	0.0	0.0
Redistribution percentage	4.29	4.47	4.54	4.47	4.56

NOTES: Redistribution percentage is the case-weighted mean absolute difference expressed as a percentage of the cost-weight case-mix index. CMI is case-mix index.

SOURCE: Carter, G.M., and Farley, D.O., RAND, Santa Monica, California, 1991.

Table 5
Comparison of differences in weights with results of other studies: 1985-87

Year	Number and percent of cases with absolute differences less than or equal to 5 and 10 percent			
	5 percent		10 percent	
	Number of cases	Percent of cases	Number of cases	Percent of cases
1985	1,247,354	70.4	1,708,427	96.4
1986	1,200,708	66.6	1,696,615	94.1
1987	1,173,972	66.3	1,658,672	93.7
Other studies and year studied				
Cotterill, Bobula, and Connerton (1981)	1,651,603	89.5	1,834,828	99.4
Rogowski and Byrne (1984)	680,818	71.9	914,006	96.6
Price (1986)	5,619,499	62.2	8,328,826	92.1

NOTE: All results based on a case-weighted average diagnosis-related group weight.

SOURCE: Upper panel source is Carter, G.M., and Farley, D.O., RAND, Santa Monica, California, 1991; lower panel sources as shown.

similar and indicate only a slight increase in the divergence of cost- and charge-based weights over this 3-year period.

The redistribution percentages are reported in the last line of Table 4. For each relative weight calculation, this value is merely the case-weighted average of the absolute value of the difference between the cost- and charge-based weights multiplied by 100. For the CMI-adjusted case, the same average absolute value is then divided by the average cost-based weight. In either case, the redistribution percentage represents the fraction of DRG weights that are redistributed when one moves from one weight system to another. The conclusion to be drawn from this statistic is similar to the conclusion from studying the entire distribution: The difference between cost- and charge-based weights increased only slightly from 1985 through 1987. For relative weights there is a 4.29 percent redistribution in 1985, increasing to 4.47 percent in 1986 and to 4.54 percent in 1987. Again, the magnitude of the redistribution is similar for each year's relative weights as for the same year's CMI-adjusted weights.

A summary of the relative difference between cost- and charge-based relative weights found in this study is given in Table 5, along with the findings of previous studies. Although, as discussed earlier, there are some

methodological differences among the studies, the results of all the PPS studies are roughly similar and consistent with the very small trend evident in our data. Our 1985 results are numerically similar to those of Rogowski and Byrne (1990), who analyzed 1984 weights. Price (1986 weights) found only slightly more divergence than we did for fiscal year 1986—and this difference is likely explainable by differences in methodology and case selection.⁷ All the PPS results show much more divergence between cost- and charge-based weights than did the analysis of 1981 data.

Individual hospital payments

Table 6 gives the distributions of hospitals according to categories defined by the difference between the hospital's charge- and cost-based CMIs, expressed as a percentage of the cost-based CMI. The first three

⁷Price based his analysis on all Medicare Provider Analysis and Review (MEDPAR) PPS cases plus Puerto Rico; we used only a 20-percent sample but omitted Puerto Rico because it was not on PPS during our time period. Price used only PPS 2 cost reports; we used whichever cost report corresponded to the day of discharge. Price used a 10-percent rate of inflation compared with our 8-percent; and different imputation methods were used for cases with out-of-range cost-to-charge ratios.

Table 6
Distribution of hospitals by difference between cost- and charge-based hospital case-mix index (CMI): 1985-87

Charge-based CMI	Percentage of hospitals				
	1985	Relative weight		CMI-adjusted weight	
		1986	1987	1986	1987
More than 6 percent less	0.3	0.4	0.5	0.4	0.5
5-6 percent less	0.3	0.6	0.9	0.5	0.6
3-4 percent less	5.1	5.3	6.4	4.2	4.7
1-2 percent less	47.8	46.3	49.5	39.1	40.6
Equal	32.3	33.8	29.0	36.8	34.1
1-2 percent more	13.6	13.1	13.1	18.3	18.5
3-4 percent more	0.5	0.4	0.6	0.5	1.0
5-6 percent more	0.0	0.0	0.0	0.0	0.0
More than 6 percent more	0.0	0.1	0.0	0.1	0.0
Redistribution percentage	1.04	1.06	1.18	0.97	1.06

NOTES: Redistribution percentage is the mean absolute difference between the charge- and cost-based CMIs expressed as a percentage of the cost-weight CMI. This statistic is hospital-weighted (see Table 7 for case-weighted values).

SOURCE: Carter, G.M., and Farley, D.O., RAND, Santa Monica, California, 1991.

columns of the table give the indexes based on the relative weights, and we discuss these findings first. Roughly one-third of hospitals would have their CMIs change by less than one-half of 1 percent by changing the basis for calculating DRG weights. More than 90 percent of hospitals would have their CMIs change by 2 percent or less.

The redistribution percentage, presented at the bottom of Table 6, is the percentage by which a hospital's revenue would change in going from cost-based weights to charge-based weights. Under relative weights, the typical hospital would have seen its revenues change by 1.04 percent in 1985 and 1.18 percent in 1987. This slight trend toward increased dispersion over time of cost- and charge-based weights is also visible in the whole distribution and is consistent with the findings of the DRG-level analysis.

It is clear from Table 6 that using charge-based weights rather than cost-based weights causes more hospitals to lose money than it causes to gain money. Because the CMI-adjusted DRG weights give higher average values to charge-based weights than to cost-based weights, all hospitals do relatively better with charge-based weights than cost-based weights under the CMI-adjusted weights than under the relative weights. The effect of adding the CMI adjustment to the relative weight distribution where most hospitals had negative values is to make the cost- and charge-based weights more similar than under the relative weights. This is most visible by comparing the redistribution percentages, which, for 1986, are 1.06 for relative weights and 0.97 for the CMI-adjusted weights; for 1987, the corresponding figures are 1.18 and 1.06. This is also visible in the whole distribution of hospitals. For example, in 1987, 91.6 percent of hospitals have cost-based and charge-based relative weight CMIs that differ by 2 percent or less, while 93.2 percent have CMI-adjusted CMIs that differ by 2 percent or less.

Because the CMI-adjusted weights are a closer approximation to the calculations used by HCFA, they probably represent the cumulative effect over a 3-year period of the use of charge-based weights rather than

cost-based weights more accurately than relative weights. On the other hand, the relative weights show what would happen in any one year in which HCFA changed the basis of the DRG-weight calculation.

As we show directly later, the asymmetry in the number of gaining and losing hospitals is the result of the fact that small hospitals tend to be worse off using charge-based weights and large hospitals tend to be worse off using cost-based weights. Consequently, if one examines Table 7, which gives the distribution of cases (rather than the distribution of hospitals shown in Table 6), one sees much greater symmetry in gainers and losers. About 98 percent of the cases go to hospitals whose charge-based CMI differs from its cost-based CMI by 2 percent or less. Virtually all cases go to hospitals with CMIs within 4 percent. This result holds for all 3 years and for both relative and CMI-adjusted indexes. The adjusted indexes have slightly different distributions that show more cases going to hospitals for which charge-based weights increase the CMI. The case-weighted redistribution percentage shows that the typical case goes to a hospital whose 1985 CMI would change by about three-quarters of 1 percent by changing weight bases. Again, there is a slight trend toward divergence of the cost-based and charge-based weights.

Hospital characteristics

The differences between charge- and cost-based CMIs for rural and urban hospitals by bed size, hospital-teaching status, and disproportionate-share status are presented in Table 8. Positive differences indicate that hospitals have higher CMIs using charge-based weights; negative differences indicate higher CMIs using cost-based weights.

Although mean differences by hospital characteristics in general are fairly small, usually less than 1 percent, clear patterns are observed across the characteristics. In all years and for both types of CMIs, the charge-based CMI is smaller than the cost-based CMI for rural hospitals and larger for urban hospitals. For example,

Table 7

Distributions of cases by difference between cost- and charge-based hospital case-mix index (CMI), by Federal fiscal year: 1985-87

Charge-based CMI	Percentage of year's cases					
	1985	Relative weight			CMI-adjusted weight	
		1986	1987	1988	1986	1987
More than 6 percent less	0.0	0.0	0.0	0.0	0.0	
5-6 percent less	0.0	0.1	0.1	0.0	0.1	
3-4 percent less	0.9	1.0	1.3	0.7	0.8	
1-2 percent less	32.5	31.1	35.0	23.4	24.3	
Equal	41.2	43.1	36.2	42.9	39.0	
1-2 percent more	24.7	24.3	26.7	32.2	34.4	
3-4 percent more	0.6	0.5	0.7	0.8	1.4	
5-6 percent more	0.0	0.0	0.0	0.0	0.0	
More than 6 percent more	0.0	0.0	0.0	0.0	0.0	
Redistribution percentage	0.76	0.74	0.85	0.75	0.86	

NOTE: Redistribution percentage is the case-weighted mean absolute difference between cost- and charge-based CMI, expressed as a percentage of the cost-based CMI.

SOURCE: Carter, G.M., and Farley, D.O., RAND, Santa Monica, California, 1991.

Table 8

Charge-based case-mix index (CMI) minus cost-based CMI, by bed size within urban and rural location: 1985-87

Hospital characteristic	Percent difference in case-weighted CMI					
	1985	Relative weight			CMI-adjusted weight	
		1986	1987	1988	1986	1987
All hospitals	0.00	0.00	0.00	0.22	0.30	
Rural:						
All rural	-0.77	-0.77	-0.88	-0.56	-0.59	
0-49 beds	-1.27	-1.26	-1.40	-1.03	-1.10	
50-99 beds	-0.94	-0.93	-1.07	-0.71	-0.77	
100-149 beds	-0.67	-0.68	-0.86	-0.47	-0.56	
150-199 beds	-0.57	-0.65	-0.76	-0.43	-0.46	
200 or more beds	-0.30	-0.32	-0.32	-0.11	-0.03	
Urban:						
All urban	0.22	0.19	0.22	0.41	0.51	
0-99 beds	-0.56	-0.58	-0.66	-0.37	-0.36	
100-199 beds	-0.23	-0.24	-0.36	-0.03	-0.07	
200-299 beds	0.07	0.01	0.01	0.23	0.31	
300-399 beds	0.18	0.16	0.18	0.38	0.48	
400 or more beds	0.65	0.64	0.74	0.86	1.04	
Teaching status:						
No teaching	-0.34	-0.35	-0.39	-0.14	-0.10	
Minor teaching	0.41	0.38	0.43	0.59	0.73	
Major teaching	0.95	1.04	1.10	1.25	1.40	
Disproportionate-share status:						
Yes	0.25	0.25	0.27	0.47	0.57	
No	-0.12	-0.13	-0.14	0.08	0.15	

SOURCE: Carter, G.M., and Farley, D.O., RAND, Santa Monica, California, 1991.

the 1985 charge-based CMI was 0.77 percent less than the same cost-based CMI for rural hospitals, but it was 0.22 percent greater for urban hospitals.

There also appear to be additive effects of hospital bed size and urban or rural location. The percent difference between charge- and cost-based CMIs increases with bed size for both rural and urban hospitals. For equivalent-size hospitals, however, the cost-based indexes for the rural hospitals are larger relative to the charge-based indexes than for urban hospitals.

Teaching status and disproportionate-share status also have substantial effects on differences in the CMIs. Hospitals with no graduate medical education program

have lower charge-based CMIs than cost-based CMIs. Minor teaching hospitals, defined as those with intern- or resident-to-bed ratios of less than 0.25, have an average charge-based CMI that exceeds their average cost-based CMI. For major teaching hospitals, those with ratios of 0.25 or higher, charge-based CMIs typically are more than 1 percent higher than cost-based CMIs. Disproportionate-share hospitals have higher indexes under charge-based CMIs than under cost-based CMIs.

Over the 3 years, the absolute magnitude of the difference between charge- and cost-based indexes increases slightly for both negative and positive differences. The case-mix adjustment is roughly

Table 9
Regression of charge-based case-mix index (CMI) minus cost-based CMI (1987 data)

Variable	Coefficients		
	Model 1	Model 2	Model 3
Cost-based CMI	0.0624 (0.0011)	—	0.0612 (0.0012)
Cost-to-charge ratio	—	-0.0165 (0.0009)	-0.0023 (0.0008)
Constant	-0.0636 (0.0010)	0.0055 (0.0007)	-0.0608 (0.0014)
R ²	0.366	0.060	0.367

NOTES: Regressions were hospital weighted. Standard errors are in parentheses.

SOURCE: Carter, G.M., and Farley, D.O., RAND, Santa Monica, California, 1991.

equivalent to adding, to the percent difference in each category, an amount equal to the percentage by which the charge-based CMI for all hospitals exceeds the cost-based CMI for all hospitals.

Index magnitude and high charges

Our last hospital-level analysis was motivated by a desire to compare the extent to which the decompression accomplished by using charge-based weights helped hospitals with high CMIs with the extent to which it helped hospitals with high charges relative to costs. To the extent that charge-based weights increase the CMI of hospitals with high values of the cost-based CMI, it can be viewed as the result of decompression of the weights and a desirable feature of charge-based weights. To the extent that charge-based weights increase the CMI of hospitals with unusually low cost-to-charge ratios (CCRs), it can be viewed as an undesirable feature of charge-based weights.

Table 9 reports three regressions where the dependent variable is the difference between the charge-based CMI and the cost-based CMI. The difference in the CMIs was calculated without the case-mix adjustment. The univariate models show that 37 percent of the variation among hospitals in the difference between the two CMIs is linearly related to the hospital's CMI,⁸ compared with only 6 percent for the CCR. The multivariate model includes both variables. It shows that adding the CCR to the model including only the CMI causes only a tiny increase in explanatory power and only slightly decreases the coefficient on the CMI. On the other hand, the coefficient of the CCR is reduced to 15 percent of its previous value.

We also investigated whether the charge-based CMI helped hospitals with two particular characteristics that we postulated might provide hospitals with an unfair

⁸We use the cost-based CMI without a case-mix adjustment as our measure of the CMI level. Because differences among hospitals in the CMI are much greater than differences between cost- and charge-based CMIs for the same hospital, we would get similar results if we used the charge-based CMI as the explanatory variable in these analyses. For example, in 1985, the case-weighted interquartile range of the cost-based CMI was .846 to 1.003. The hospital-weighted interquartile range is even larger.

advantage in PPS payments. The univariate correlation of the difference between the two CMIs with the fraction of total costs that are capital costs is not even statistically significant. The univariate R² of the difference between the two CMIs with the fraction of total costs that are direct medical education costs is only 7.7 percent. These data and Table 9 thus demonstrate that the charge-based weights are much more likely to benefit hospitals with high values of the CMI than to benefit hospitals with low values of the CCR, high capital costs, or high teaching costs. The data in Table 9 concern only the 1987 results. We did, however, perform similar analyses for the other 2 years, with similar results, which we do not report in detail here.

Changes over time

The final subject of our empirical analysis is how weights change over time. One would expect weights to change as new technology and cost-saving measures have a differential effect on various DRGs, and as coding improves. Charge-based weights allow HCFA to use more recent data to calculate weights than would be possible with cost-based weights. If 1985 weights are similar to 1987 weights, then the value of this advantage will be much less than if the 1985 weights differ from the 1987 weights.

We will compare the 1985 charge-based weights to the 1987 CMI-adjusted charge-based weights and also compare the 1985 cost-based weights to the 1987 CMI-adjusted cost-based weights. We chose the CMI-adjusted weights rather than relative weights for 1987 because the relative weights are affected by both the relative intensity of each DRG and the distribution of cases across DRGs.⁹ The normalization factor is the way that the recalibration calculation adjusts for temporal change in the distribution of cases.

Roughly speaking, the 1985 weights are as different from 1987 CMI-adjusted weights as cost-based weights are from charge-based weights in the same year. The first column of Table 10 compares 1985 charge-based weights with 1987 CMI-adjusted charge-based weights. The second column provides the same data for cost-based weights. From 1985 through 1987, charge-based weights diverged so that only 66.0 percent of 1987 cases were in DRGs where the 1985 weight was within 5 percent of the 1987 weight. This is almost identical to the 66.3 percent of 1987 cases in which the 1987 charge-based weight was within 5 percent of the 1987 cost-based weight. The redistribution percentage shows that using charge-based weights calculated on the 1985 file would have changed the payment of the typical case by 4.55 percent, compared with using the 1987 charge-based weights. The cost-based weights diverged about the same amount as the charge-based weights during this period.

⁹As is to be expected because of the change in case mix, the 1987 relative weights are almost all smaller than the corresponding 1985 weight. For both cost- and charge-based weights, more than 85 percent of 1987 cases went to DRGs where the 1987 relative weight was smaller than the corresponding 1985 weight.

Table 10
Comparison of 1985 weights with 1987
case-mix index (CMI) adjusted weights

1985 weight	Percentage of 1987 cases	
	Charge-based	Cost-based
More than 15 percent less	0.6	0.3
11-15 percent less	0.9	1.3
6-10 percent less	14.4	14.1
1-5 percent less	33.2	39.2
Equal	8.2	5.6
1-5 percent more	24.6	23.7
6-10 percent more	10.9	10.9
11-15 percent more	6.1	4.5
More than 15 percent more	1.0	0.5
Redistribution percentage	4.55	4.34

NOTES: Differences are expressed as a percentage of the 1987 weight. The redistribution percentage is the case-weighted average absolute value of the difference between the two weights, expressed as a percentage of the average 1987 weights.

SOURCE: Carter, G.M., and Farley, D.O., RAND, Santa Monica, California, 1991.

Conclusions

The purpose of DRG weights is to measure the operating costs for cases in each DRG relative to the average operating cost for all cases. Since 1986, HCFA has been using charges to calibrate the DRG weights, which offer the advantages of timely access to charge data and computational simplicity. However, it is not possible to determine theoretically whether cost-based weights or charge-based weights are more accurate measures of the relative operating costs of DRGs.

Lacking a theoretical foundation, empirical comparisons of differences in weights calculated using the two methods, and of their impacts on payment amounts and distributions, can provide information for PPS payment policy decisions. Of particular interest is information that may provide insight regarding the relative accuracy of the two methods. Findings that raise sufficient concern about bias in the charge-based weights might lend support to the use of costs rather than charges to calculate the DRG weights. Such a change should be considered in the context of other biases that might be introduced if cost-based weights were used instead of the charge-based weights.

We found that the weight methodology used affected the total amount of payment. From 1985 through 1987, the national CMI measured by charge-based weights grew 0.3 percent more than the national CMI measured by cost-based weights. Assuming annual PPS hospital payments of approximately \$400 billion, this translates into an expenditure from the Federal budget of roughly \$120 million. Because we cannot be sure theoretically which index is a more accurate measure of resource intensity, this study cannot aid in a judgment about the desirability of this transfer.

Within a given year, the two sets of weights distributed payments somewhat differently among cases and among hospitals. In FY 1987, the use of charge-based weights rather than cost-based weights resulted in a redistribution across cases of approximately 4.5 percent of DRG weight. It resulted in a change of 1.18 percent in the CMI of the average hospital and,

therefore, in its payment. Using charge-based weights rather than cost-based weights results in a decrease in the CMI for small hospitals and for rural hospitals and, therefore, in decreased payments to these hospitals. It results in an increased CMI and increased payments for teaching hospitals.

We found only a small trend toward increasing divergence of the charge- and cost-based weights during the period 1985-87. The use of charge-based weights rather than cost-based weights resulted in a redistribution across cases of approximately 4.29 percent of DRG weight in 1985, compared with 4.54 in 1987.

The slightly increased divergence of the two sets of weights caused a slight change in the effect of the weight basis on most hospital groups. We measured the amount of this effect in two ways: using relative weights (i.e., weights with an average value of 1 in each year) and CMI-adjusted weights (i.e., weights with an average value that reflects each year's increase in the frequency of higher weighted cases). Because the CMI-adjusted weights are a closer approximation to the calculations used by HCFA, they probably represent the cumulative effect over a period of years of the use of charge-based weights rather than cost-based weights more accurately than relative weights do. On the other hand, the relative weights show what would happen in any one year in which HCFA changed the basis of the DRG-weight calculation. Using CMI-adjusted weights multiplies the charge-based weight by a larger number than it multiplies the cost-based weight. Hence, it mitigates the effect of the use of charge-based weights for hospitals that do worse under charge-based weights than under cost-based weights and enhances the effect of the use of charge-based weights for hospitals that do better under charge-based weights than under cost-based weights. For example, the use of charge-based weights rather than cost-based weights caused an increase in the relative-weight CMI for major teaching hospitals of 0.95 percent in 1985 and 1.10 in 1987. If charge-based weights had been used for all 3 years, the 1987 CMI would be 1.40 percent higher than if cost-based weights had been used for all 3 years. Another example is rural hospitals with fewer than 50 beds, which have lower CMIs under charge-based weights than under cost-based weights, but the CMI-adjusted weights mitigated the reduction in their CMI under charge-based weights.

The differences between cost-based and charge-based weights that we measured are very similar to those of other studies from the PPS era. We demonstrated the sensitivity of statistics to modest changes in methodology and case selection. Given this sensitivity, the other studies do not contradict our finding that differences between the two weights have been subject to only small trends.

The effects of the weight basis found in all PPS studies are much larger than those found using the 1981 data base. We expect that the major reason that the 1981 findings differ is that there were substantial coding problems in the 1981 data base. The argument is analogous to Lave (1985), who showed that

misclassification on a data file will lead to weight estimates that are too similar to each other. Price (1989) showed that the proportion of charges devoted to ancillary services is a significant explanatory variable for the difference between charge-based weights and cost-based weights. Thus, insofar as the 1981 data base misclassified cases from DRGs with substantial use of ancillary services into DRGs with less use, it causes the cost-based weights to be more similar to the charge-based weights than on a file with more accurate coding.

This analysis of the reason for differential results between 1981 and PPS has implications for what one would expect to find when the grouper undergoes substantial changes. Fiscal year 1988 was the first large change in the grouper. Insofar as the changes to the grouper resulted in grouping cases into DRGs with more similar resource use, and insofar as the data we have used does not reflect the coding of these cases that we would expect to see when the 1988 grouper is used for payment, we would expect to see a greater divergence of cost-based weights from charge-based weights in 1988 than would be expected based on continuation of the empirical trend from 1985 to 1987.

Along with previous researchers, we found that charge-based weights are less compressed than cost-based weights. In addition, we found that the charge-based weights are much more likely to benefit hospitals with high values of the CMI than to benefit hospitals with low values of the cost-to-charge ratio.

We find a very small trend toward increasing decompression of the charge-based weights. Again, because of the possibility of changes in coding practices, 1988 may not be a continuation of the trend.

Finally, we found that DRG weights change over time. There is roughly the same amount of difference between cost-based weights calculated in the 1985 file and similar weights calculated in the 1987 file as there is between cost-based and charge-based weights calculated on the same file. Thus, the timeliness of charge-based weights is an important consideration in choosing the appropriate weight basis.

Acknowledgment

We would like to thank our RAND colleagues Daniel Byrne and Jeannette Roskamp Rogowski for

their help in determining the methodological differences between their study and ours. We also thank three anonymous reviewers for their comments on an earlier draft.

References

- Carter, G.M., Newhouse, J.P., and Relles, D.A.: How much change in the case-mix index is DRG creep? *Journal of Health Economics* 9(4):411-428, 1990.
- Cotterill, P., Bobula, J., and Connerton, R.: Comparison of alternative relative weights for diagnosis-related groups. *Health Care Financing Review* 7(3):37-51. HCFA Pub. No. 03222. Office of Research and Demonstrations, Health Care Financing Administration. Washington. U.S. Government Printing Office, Spring 1986.
- Lave, J.: Is compression occurring in DRG prices? *Inquiry* 22(2):142-147, Summer 1985.
- Newhouse, J.P., Cretin, S., and Witsberger, C.J.: Predicting hospital accounting costs. *Health Care Financing Review* 11(1):25-33. HCFA Pub. No. 03286. Office of Research and Demonstrations, Health Care Financing Administration. Washington. U.S. Government Printing Office, Fall 1989.
- Pettengill, J., and Vertrees, J.: Reliability and validity in hospital case-mix management. *Health Care Financing Review* 4(2):101-128. HCFA Pub. No. 03149. Office of Research and Demonstrations, Health Care Financing Administration. Washington. U.S. Government Printing Office, Winter 1982.
- Price, K.F.: Pricing Medicare's diagnosis-related groups: Charges versus estimated costs. *Health Care Financing Review* 11(1):79-90. HCFA Pub. No. 03286. Office of Research and Demonstrations, Health Care Financing Administration. Washington. U.S. Government Printing Office, Fall 1989.
- Rogowski, J.R., and Byrne, D.J.: Comparison and evaluation of alternative DRG weight recalibration methods. *Health Care Financing Review* 12(2):87-101. HCFA Pub. No. 03316. Office of Research and Demonstrations, Health Care Financing Administration. Washington, U.S. Government Printing Office, Winter 1990.
- Thorpe, K.E., Cretin, S., and Keeler, E.B.: Are the diagnosis-related group case weights compressed? *Health Care Financing Review* 10(2):37-46. HCFA Pub. No. 03276. Office of Research and Demonstrations, Health Care Financing Administration. Washington. U.S. Government Printing Office, Winter 1988.