Comparison of alternative relative weights for diagnosis-related groups

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During this study, we investigated the extent to which diagnosis-related group (DRG) relative weights based exclusively on charge data differ from DRG weights constructed according to the methodology used in deriving the original relative weights for the Medicare prospective payment system (PPS). The PPS operating cost weights were based on a combination of cost and adjusted charge information (Pettengill and Vertrees, 1982).

The results of this study reveal only minor differences between the two sets of weights. Interhospital differences in cost-to-charge ratios do not produce large, arbitrary differences between charge-based and operating cost weights. Whether the data are standardized for differences in capital and medical education costs also appears to make little difference.

Introduction

On October 1, 1983, the Health Care Financing Administration (HCFA) began the implementation of a new system for making Medicare payments to hospitals for inpatient services. The new system changed the method of payment for inpatient hospital services from a cost-based retrospective reimbursement system to a diagnosis-specific prospective payment system. Implementation of the new prospective payment system was preceded by nearly a decade of research and demonstrations by HCFA in order to develop the necessary elements required for such a system.

The first step in the research and development process was the development of a system that classified hospital cases into a manageable number of categories such that the cases within each category are clinically coherent and reasonably homogeneous in cost. After evaluating a number of different patient classification systems, HCFA selected a system called diagnosis-related groups (DRG's) that was developed at Yale University. In the DRG system, patients are grouped into 467 categories derived from a multistage process of clinical judgment and statistical analysis. The DRG system is designed for use with diagnosis and procedure information coded in the *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM) coding system. Under the prospective payment system (PPS), each Medicare discharge is classified into one of these mutually exclusive and comprehensive categories.

The second step in the process was the development of a set of relative weights that measure the relative costliness of each of the DRG case categories. Relative weights based on the average cost per case in each DRG, rather than the average charge per case, were chosen on the assumption that average cost weights better reflect relative resource use across case categories. The relative weights were developed using a sample of Medicare bills and Medicare Cost Reports from approximately 5,500 hospitals. The process of constructing relative cost weights involved classifying a sample of approximately 20 percent of all 1981 Medicare discharges into DRG's, computing an estimated cost for each discharge, standardizing the cost data to account for variations in input factor prices and variations in the level of hospitals' teaching activity, computing an average cost per DRG, and finally, deriving a measure of the relative costliness of each DRG called the relative cost weight.

The final step was the development of a hospital case-mix index (CMI) using the DRG classification scheme and cost weights developed in the first two steps. The CMI is a ratio that compares each hospital's expected average cost for the types of Medicare cases it treats to the national average cost per Medicare case. A critical test of the usefulness of the CMI (and its component parts) was the determination of the extent to which hospital CMI values are related to hospital average cost per case values. Various statistical tests supported the hypotheses that the resultant CMI is a significant factor explaining variation in average Medicare cost per case among the hospitals and that the CMI is proportionately related to Medicare cost per case. These findings provided strong indirect evidence that the CMI is a valid representation of the expected costliness of an individual hospital's Medicare patient mix (Pettengill and Vertrees, 1982). The results of each of these steps in the research and development process led HCFA to conclude that a prospective payment system for hospital inpatient services could be implemented using available Medicare data.

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Relative weights based on average costs

The original relative weights used in the Medicare prospective payment system (PPS) were based on standardized cost data for a sample of 1981 Medicare discharges. Average costs, rather than average charges, were used on the assumption that average cost weights better reflect relative resource use across case categories. In a fully competitive market, total charges (prices) for different case types would be equal to the minimum average costs of production and, from the perspective of economic efficiency, would provide suitable weights for the case categories. However, the market for hospital inpatient services was considered to depart sufficiently from the competitive norm to cast doubt on the use of charge data alone in the weight construction process (Pettengill and Vertrees, 1982). Given that most inpatient hospital services are covered by health insurance and that the hospital industry is dominated by nonprofit providers, markets for hospital inpatient treatment cannot be characterized as strongly price competitive. Further, past hospital reimbursement methods were thought to have encouraged hospitals to set prices to cross-subsidize between routine and ancillary services and among ancillary services.

As a result, average hospital charges for each case category were not considered to reflect efficient costs of production. Instead, an alternative approach was adopted that used a combination of charge and cost information. Routine costs, special care costs, and ancillary charges reported by hospitals for each case in a DRG category were adjusted, based on data from the Medicare Cost Reports and other data files, to account for the gross effects of hospital pricing policies, variations in factor input prices, and variations in the level of teaching activity. Though subject to their own limitations, the resultant set of cost weights were considered to better represent the efficient relative cost of treatment for a given DRG category than would relative weights based on unadjusted charges.

Purpose of this study

The purpose of this study was to investigate the extent to which DRG weights based on costs differ from DRG weights constructed exclusively from charge data, and to investigate the source(s) of any differences. Charge data have some potential advantages compared with operating cost data for constructing DRG relative weights. Weights based on charges would be more timely, because they would not require cost report data that is typically 2 to 3 years old before it becomes available for analytical purposes. Charge-based relative weights would also be simpler to construct, because a series of adjustments would not be required to convert charges to costs.

However, charge-based weights might be less reflective of true resource costs than cost weights are. Pettengill and Vertrees (1982) give two reasons for choosing cost data instead of charge data for the construction of DRG relative weights:

- Significant differences in cost-to-charge ratios among hospitals may result in large arbitrary differences between charge-based and cost-based weights.
- Charge-based weights that are not standardized for differences among hospitals in capital and medical education costs may differ significantly from operating cost weights.

The chief reason for including the cost-to-charge adjustment in computing relative weights is to compensate for possible distortions between costs and charges that are the result of the variety of pricing policies used by hospitals. For example, cross-subsidization by hospitals in their pricing of routine and ancillary services might be expected to make charge-based weights more compressed than the current set of operating cost weights. If relatively inexpensive, highly utilized services are priced to subsidize expensive, less frequently utilized services, charges for high (low) weight DRG's may underestimate (overestimate) true resource costs relative to the operating cost weights.

To assess the relative advantages and disadvantages of using charge data, we computed a set of charge-based relative weights and compared them with a comparable set of weights based on operating costs. Our analysis will not permit us to determine whether either set of relative weights is a good measure of the resources used to treat hospital inpatients; however, it will permit the evaluation of the differences between the two measures. We also investigated the sources of observed differences and estimated the relative importance of each source. Finally, we tested the hypotheses that a CMI developed from charge-based relative weights is a significant factor that explains the variation in average Medicare cost per case and that it is proportionately related to Medicare cost per case.

The following are provided in this article:

- Background information on the development of the original set of relative cost weights used in the Medicare prospective payment system.
- Data sources and methodology used in the construction of the charge-based relative weights and the major sources of differences between the methodologies used to construct the operating cost and charge-based relative weights.
- A comparison of the alternative sets of relative weights.
- A detailed analysis of the source(s) of any differences between the sets of weights.
- An assessment of the relationship between case-mix index values constructed from charge-based relative weights and hospital average cost per case values.
- A summary of the findings of this study.

Cost-based relative weights

The diagnosis-related group (DRG) weights used in the prospective payment system (PPS) were calculated by a complex methodology using data from the 1981 Medicare provider analysis and review (MEDPAR) file, the 1981 Medicare Cost Report abstract file, and the 1981 hospital wage index based on hospital wage information collected by the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor. The MEDPAR file contains Medicare stays for a 20-percent sample of Medicare beneficiaries discharged from short-stay hospitals. It also contains detailed charge data for each bill (including the number of days and charges for routine care and special care); separate charges for seven categories of ancillary services (pharmacy, radiology, laboratory, medical supplies, operating room, anesthesiology, and other ancillaries; a limited amount of clinical information, such as principal diagnosis and principal procedure; and selected demographic characteristics, such as age and sex.[1]

The Medicare Cost Report abstract file contains detailed cost report information for hospitals providing inpatient care to Medicare beneficiaries. The cost reports provide the basis for settling the amount of final Medicare payment in a given fiscal year. The cost reports contain information on operating costs, capital costs, medical education costs, and on aggregate cost-to-charge ratios for a number of different revenue centers. The 1981 Medicare Cost Report abstract file was supplemented with additional information, such as the number of Medicare discharges for each hospital in 1981, from other statistical files maintained in the central office of the Health Care Financing Administration (HCFA).

The 1981 hospital wage index used in the computation of relative weights was a county-level hospital wage index developed for HCFA by the BLS. The BLS constructed the hospital wage index by using compensation and employment data for hospital workers based on quarterly tax reports submitted by hospitals to State employment security agencies. The BLS file is used to adjust the cost and charge data for variations in area wages across hospitals.[2]

Constructing cost-based relative weights

The DRG relative weights are estimates of the relative resource intensity of each DRG. These weights are computed by estimating the average resource intensity per case for each DRG, measured in dollars, and dividing each of those values by the average resource intensity per case for all DRG's, also measured in dollars. The result is a set of relative weights, one for each DRG.

Computation of the DRG weights entailed several discrete steps. First, all cases from the 1981 MEDPAR file were assigned to a DRG classification category. Second, an estimate of the cost for each case was computed. This was accomplished by adding together for each case the following three components:

- The number of days the patient spent in a regular room (from MEDPAR) times the hospital's routine cost per day (from the Medicare Cost Report).
- The number of days the patient spent in a special care unit (from MEDPAR) times the hospital's special care cost per day (from the Medicare Cost Report).
- Ancillary charges for seven ancillary departments (from MEDPAR) times the relevant departmental cost-to-charge ratio (from the Medicare Cost Report).

This procedure was applied to approximately 2 millon records from hospitals for which adequate cost report data were available. Direct medical education costs and capital costs were removed from the estimated cost per case by using data from the Medicare Cost Report file. Direct medical education and capital costs were removed because, at least initially, they continue to be reimbursed on a retrospective basis under PPS. Costs in excess of the routine cost limits applicable in 1981 were also removed.

Third, the estimated cost per case was adjusted for estimated indirect teaching costs in order to standardize for variations in the level of teaching activity across hospitals. This is accomplished by dividing the estimated cost for each case in a given hospital by a teaching adjustment factor computed for that hospital. The teaching adjustment factor was developed from a multivariate analysis of hospital costs that indicated that teaching hospitals' expected costs per case differ by slightly less than 6 percent for each 10-percent difference in their resident-to-bed ratios (Pettengill and Vertrees, 1982). Hence, a teaching hospital with a resident-to-bed ratio of 0.2 would have its estimated costs per case reduced by a factor of approximately 12 percent.

Fourth, estimated costs per case were standardized for differences in area wages across hospitals. This is accomplished by deflating the labor share of the estimated cost of each case by the appropriate wage index value from the BLS hospital wage index. The labor share of the average Medicare case was estimated by HCFA's Office of Financial and Actuarial Analysis to be 0.7915. The nonlabor share, estimated to be 0.2085, was not adjusted (except for Alaska and Hawaii) because HCFA had no reliable measure of variations in prices of nonlabor inputs across hospitals.

Fifth, extreme values were excluded from each DRG category. Criteria for excluding statistical outlier cases were set at plus or minus three standard deviations of the geometric mean cost per case for each DRG. The geometric mean was used instead of the arithmetic mean because the distribution of cases within each DRG is skewed to the right. (Cost per case values can be extremely large, but cannot be less than zero.) Use of the geometric mean better enables the identification of unusually low and unusually high costs per case. Roughly 10,000 out of approximately 2 million cases (one-half of 1 percent) were excluded on the basis of these criteria.

The final step was the computation of the relative weights. This was accomplished by dividing the case-weighted, arithmetic mean cost per case for each DRG by the average cost per case for all DRG's, where the

[1]In contrast to the 1981 data, the 1984 data contain discharge information for 100 percent of all Medicare beneficiaries. In addition to the diagnosis, length of stay, and charge information contained in the 1981 data, the 1984 data contain additional diagnostic information on up to three surgical procedures and four secondary diagnoses.

[2]For a detailed discussion of the contents of these data sources and of problems of data quality, see Pettengill and Vertrees (1982) or Lave (1985).

average cost per case for all DRG's is defined as follows:

$$1/M \sum_{j=1}^{M} 1/N_j \sum_{i=1}^{n} N_{ij} C_i ,$$

where
M = number of hospitals
N_j = total number of cases in hospital j
N_{ij} = number of cases in DRG i and hospital j
C_i = arithmetic mean adjusted cost per case for DRG i.
n = number of DRG's.

This definition of the average cost per case for all DRG's is a hospital weighted mean of the case weighted mean of the adjusted cost per case for all DRG's. Weighting by hospital allows each hospital, regardless of its Medicare patient load, to exert an equal effect on the calculation of the average cost per case.

Evaluating cost-based relative weights

Prior to implementation of the PPS, an attempt was made to assess the validity of the resultant set of cost-based relative weights (Pettengill and Vertrees, 1982). A direct assessment was not possible, because no other independent measure of the relative structure of costs across DRG's was available. However, an indirect assessment was attempted by evaluating the relationship between hospital CMI values constructed from the cost-based relative weights and hospital average cost per case values. Finding that CMI values based on the relative weights are proportionately related to average cost per case values (e.g., a hospital with a 10-percent higher CMI value has a 10-percent higher average cost per case) would provide strong indirect evidence of the validity of the CMI and its component parts, the cost-based relative weights.

The relationship between hospital CMI values and hospital operating cost per case values was tested by estimating a single-equation, average cost function using 1981 Medicare Cost Report data from approximately 5,000 hospitals. The cost function assumed Medicare cost per case to be a function of case mix, teaching intensity, hospital wages in the local area, bed size, and size of standard metropolitan statistical area. Ordinary least-squares regression was used to estimate the coefficients of the independent variables.[3] The regression equation explained 72 percent of the variation in Medicare cost per case. More importantly, CMI values were found to be approximately proportional to operating cost per case values, as expected.

Additional sensitivity analyses were conducted to assess the stability of the estimated regression equation in response to potential classification errors, specification errors, and errors in the measurement of the dependent and independent variables. The results of these analyses led HCFA to conclude that the Medicare CMI constructed from cost-based relative weights provides a generally accurate representation of the expected costliness of an individual hospital's patient mix.

There are, however, some problems associated with the method used to construct the cost-based relative weights used in PPS. First, there is a 2-year or 3-year lag between the date of the Medicare Cost Report data and the date when the file becomes available for analysis. Second, the process of constructing cost-based weights is relatively data intensive. The original set of cost-based relative weights required data from five different Medicare files. In addition, a series of adjustments were required in deriving standardized operating costs. Pass-through costs, such as direct medical education and capital costs, were identified and removed from cost report data for each hospital. Also, charges were converted to costs for seven different ancillary departments from each hospital. Finally, costs were adjusted to account for differences in wage levels and indirect medical education costs across hospitals.

Having made all of these adjustments, the resulting set of relative weights may be compressed to some unknown extent. That is, the weights probably underestimate the cost of the high-weight DRG's and overestimate the cost of the low-weight DRG's. For routine and special care costs, compression results from the use of the average cost per day for all cases within a given hospital, irrespective of the DRG category. Thus, the operating cost weights do not reflect intra-DRG variations in the intensity of nursing and other routine and special care services among patients in different DRG's. The effect of this omission may bias the low-cost DRG categories upward and the high-cost categories downward.

Also, within each ancillary category, average cost-to-charge ratios are used for all cases within a given hospital, again irrespective of the DRG category. If within ancillary categories charges are set so that the less expensive services subsidize the more expensive services, then the cost of cases with above-average ancillary costs may be underestimated, and the costs of cases with below-average ancillary costs may be overestimated. Adjustments using departmental cost-to-charge ratios can only compensate for cross-subsidization that occurs across, not within, cost categories. Again, the effect may be to bias the low-cost DRG categories upward and the high-cost DRG categories downward.

Charge-based relative weights

As noted earlier, charge-based weights have some potential advantages over operating cost weights. Weights based on charges could be constructed without cost report data that are typically 2 to 3 years old before they become available for analysis. Charge-based relative weights are also simpler to compute,

[3]The cost function was specified as linear in logarithms. That is, the values of the dependent and independent variables (except city size) were transformed into logarithms before the cost function was estimated.

because adjustments are not required to convert charges to costs and to remove capital and medical education costs. However, it is possible that charge-based relative weights might be even less reflective of true resource costs than the operating costs weights are. Specifically, the omission of the cost-to-charge and pass-through cost adjustments could result in charge-based relative weights that differ markedly from cost-based relative weights. Also, cross-subsidization in the pricing of high-cost and low-cost services could make charge weights even more compressed than operating cost weights. (The compression of routine and special care costs noted earlier is very likely also to apply to charges for these services so that both the operating cost and the charge weights can be expected to suffer from this source of compression.)

To investigate these concerns, a set of charge-based relative weights (with no adjustment for cost-to-charge ratios and pass-through costs) were computed and compared with a comparable set of weights based on operating costs. The charge weights were constructed from calendar year 1981 Medicare provider analysis and review (MEDPAR) data, the same data set that was used in conjunction with the Medicare Cost Report abstracts to construct the original operating cost weights for the prospective payment system (PPS).

Constructing charge-based relative weights

A guiding principle in deriving the charge-based set of weights used in this analysis was that the methodology be as similar as possible to that used in deriving the original set of PPS relative weights. However, it was sometimes necessary to modify the procedures used in deriving the PPS relative weights. For example, the charge weights used in this analysis were restricted to the 358 diagnosis-related groups (DRG's) for which the 1981 MEDPAR contains a sufficient number of cases to yield reliable weights. For 109 low-volume DRG's, the 1981 MEDPAR file had to be supplemented with outside data from Maryland and Michigan, data that was not used in this analysis. For purposes of consistency, the cost weights used in this analysis were also restricted to the same 358 DRG's.

The cost weights computed for this analysis differ only slightly from the PPS relative weights published in the *Federal Register* (1983). The Pearson correlation coefficient between the cost weights computed for this analysis and the published weights is very high, .99. The small differences that do exist can be attributed to the following factors. First, the operating cost weights used in this analysis were computed for the 358 DRG's for which MEDPAR contained a sufficient number of cases, whereas the published weights incorporate data from Maryland and Michigan for 109 low-volume DRG's. Hence, values for the 358 common DRG's may differ because a different denominator is used in computing the relative weights in the two cases. Second, kidney acquisition costs were removed in computing the published weights, but were not removed in computing the cost weights for this study, because these costs were not on the files available for this analysis. Third, the operating cost weights were standardized by using slightly different wage indexes and indirect teaching factors than the published weights were. For the operating cost weights, we used the June 30, 1981, BLS wage index and a .05795 indirect teaching factor that was based on 1981 data, both of which are used for PPS payments. However, the published relative weights are based on the March 18, 1981, BLS wage index and a .06063 indirect teaching factor that was based on 1980 data. The main difference between the two wage indexes concerns the classification of certain metropolitan statistical areas as rural or urban, rather than the wage data themselves.

The chief differences between the cost weights and the charge weights developed in this study are as follows:

- Per diem costs (from the Medicare Cost Reports) were used in conjunction with length-of-stay information from the MEDPAR file in computing the routine and special care components of the operating cost weights, whereas routine and special-care charges (from the MEDPAR file) were used in computing the charge-based relative weights.
- Ancillary charges (from the MEDPAR file) were adjusted by the relevant ancillary department cost-to-charge ratio (from the Medicare Cost Report) in computing the ancillary component of the operating cost weights, whereas unadjusted ancillary charges were used in computing the charge-based relative weights.
- Pass-through costs have been removed from the operating cost weights, but not from the charge weights.

For the cost weights, capital and direct medical education costs were removed from routine, special care, and ancillary costs in exactly the same manner used in deriving the original PPS weights. The method is equivalent to estimating these costs as proportions of routine costs, special care costs, and ancillary costs and using those proportions to reduce the respective cost elements. The cost weights were also standardized for differences in indirect medical education costs, whereas the charge weights were not standardized.

The same standardization for wage differences was applied to both sets of weights. This standardization is the same as that used in developing the published weights except for the difference in wage indexes described earlier. The labor-related share was assumed to be .7915 of both costs and charges. This assumption was used because more accurate shares for charges are not available.

The same criterion used in computing the published weights was used to eliminate statistical outliers for both sets of weights. All cases outside of three standard deviations from the mean of the log distribution of costs or charges per case for each DRG

Table 1

Method of computation of estimated cost per case and of adjustments to estimated costs per case

Type of cost and adjustment	Cost weights			Charge weights
			Method of computation	
Total cost	Routine + special care + ancillaries			Routine + special care + ancillaries
Routine cost	Hospital-specific routine per diem cost (Cost report)	X	Case-specific routine length of stay (MEDPAR)	Routine accommodations charges (MEDPAR)
Special care cost	Hospital-specific special care per diem cost (Cost report)	X	Case-specific special care length of stay (MEDPAR)	Special care charges (MEDPAR)
Ancillary cost	Hospital-specific cost to charge ratios for 7 categories of ancillary services (Cost report)	X	Case-specific charges for 7 categories of ancillary services (MEDPAR)	Ancillary department charges (MEDPAR)
			Method of adjustment	
Pass-through adjustment	Capital and direct medical education costs were removed from routine, special care, and ancillary costs based on hospital specific estimates of the ratios of routine, special care, and ancillary capital and medical education costs to total, routine, special care and ancillary costs.			No adjustment
Indirect teaching adjustment	Indirect medical education costs were removed based on a hospital specific estimate of the teaching adjustment factor (1 + (.5795 × Residents/Beds)).			No adjustment
Wage adjustment	Area wage differences were removed based on an area-specific 1981 Bureau of Labor Statistics wage index applied to the labor share of the estimated cost per case.			Same adjustment

were eliminated from the calculation of the relative weights.

Once the arithmetic mean costs or charges per case were determined for each DRG, they were converted to relative weights by using the same definition for the mean costs or charges for all DRG's that was used in computing the PPS relative weights. The definition used is the hospital weighted mean of the case weighted mean of the standardized costs (charges) per case for all DRG's.

A summary of the major differences between the methodologies used in constructing both sets of weights is presented in Table 1. A comparison of the resultant sets of operating cost weights and charge-based weights will permit isolation of the impact of not adjusting for cost-to-charge ratios and pass-through costs in the construction of charge-based relative weights. However, it should be noted that the analysis will not permit determination of whether either set of relative weights is a good measure of the true resource costs of treating hospital inpatients. It will, however, permit an evaluation of the differences between the two measures and of the sources of any such differences.

Comparison of alternative relative weights

A comparison of the 1981 operating cost weights and the 1981 total charge weights is presented in this section. The results of the analysis indicate that relative weights based on 1981 MEDPAR data are largely invariant, regardless of the methodology used. A summary of the major findings is presented below.

First, the relative weights computed by each method are quite similar. As indicated in Table 2, the difference between relative weights based on operating costs and relative weights based on total charges is less than 5 percent for most of the DRG's.

Second, the structure of the relative weights across DRG's for each method are also very similar. The

Table 2

Number of diagnosis-related groups and number and percent distribution of cases, by percent by which charge weights differ from cost weights

Percent by which charge weights differ from cost weights	Number of DRG's	Number of cases	Percent distribution of cases
Total	358	1,845,267	100.0
15-20 percent less	0	0	0.0
10-15 percent less	0	0	0.0
5-10 percent less	12	98,232	5.3
0-5 percent less	136	976,883	52.9
0-5 percent more	160	674,720	36.6
5-10 percent more	41	84,993	4.6
10-15 percent more	8	9,960	0.5
15-20 percent more	1	479	0.0

NOTES: DRG's are diagnosis-related groups. MEDPAR is Medicare provider analysis and review. Data are based on the 358 DRG's for which sufficient information was available on the 1981 MEDPAR file to compute relative weights.

Spearman correlation coefficient, which measures the correspondence of the rank ordering of pairs of observations, and the Pearson correlation coefficient, which measures the correspondence of actual values between two sets of observations, are both greater than .99. A comparison of cost and charge weights for the top 25 DRG's in terms of frequency is presented in Table 3.

Third, the relative dispersion of costs or charges within a DRG are very similar for each method. When charge data are used, coefficients of variation for each DRG (the ratio of the standard deviation to the mean) are slightly higher than they would be if cost data were used. However, in general, the difference is less than 5 percent, with only a few coefficients of variation differing by as much as 10 percent. In some cases, the coefficients of variation are even lower when charge data are used. A comparison of coefficients of variation for the top 25 DRG's in terms of frequency is presented in Table 4.

Fourth, the dispersion of average costs or charges across DRG's are also very similar, as indicated in Table 5. The standard deviation of the charge-based weights is slightly larger than the standard deviation of the cost-based weights, which means that the charge-based relative weights are slightly less compressed than the cost-based relative weights. DRG's with high (low) relative weights are likely to be slightly higher (lower) if computed using charge data rather than cost data.

Finally, as indicated in Tables 6 and 7, hospital case-mix index values computed on the basis of charge-based weights are very similar to case-mix index values computed on the basis of cost weights. In Table 6 we observe, however, that large urban hospitals have higher case-mix index values using charge-based weights rather than cost-based weights. Small rural hospitals, on the other hand, have lower case-mix index values using charge-based weights. This finding is a consequence of the earlier finding that charge-based weights are slightly less compressed than the cost-based weights. Similarly, teaching hospitals have higher case-mix index values using charge-based weights rather than cost-based weights.

Table 3

Total number of cases, total charge weights, operating cost weights, and percent difference between the two weights for the top 25 diagnosis-related groups: 1981

Code number	Diagnosis-related group	Total number of cases[1]	Total 1981 charge weights[2]	1981 operating cost weights[2]	Percent difference
127	Heart failure and shock	76,628	1.0375	1.0400	−0.24
182	Esophagitis, gastroenteritis, and miscellaneous digestive diseases	73,963	.5951	.6174	−3.61
132	Atherosclerosis, age > 69 and/or C.C.	70,442	.8857	.9167	−3.38
39	Lens procedure	66,340	.5058	.5005	1.06
88	Chronic obstructive pulmonary disease	52,500	1.0829	1.0432	3.81
14	Specific cerebrovascular disorders, except transient ischemic attacks	51,869	1.3400	1.3508	−0.80
89	Simple pneumonia, age > 69 and/or C.C.	46,376	1.1270	1.1028	2.19
468	Unrelated OR procedure	44,282	2.1874	2.1034	3.99
122	Circulatory disorders with AMI (121 and 122 combined)	39,947	1.4141	1.5007	−5.77
294	Diabetes, age > 36	39,284	.7842	.8072	−2.85
140	Angina pectoris	36,711	.7356	.7545	−2.50
243	Medical back problems	36,328	.7240	.7554	−4.16
138	Cardiac arrhythmia and conduction disorders	29,228	.9163	.9295	−1.42
134	Hypertension	27,165	.6837	.7045	−2.95
15	Transient ischemic attacks	26,306	.6624	.6674	−0.75
96	Bronchitis and asthma, age > 69 and/or C.C.	26,214	.8077	.7994	1.04
467	Other factors influencing health status	25,158	.9637	.9795	−1.61
82	Respiratory neoplasms	24,586	1.1802	1.1413	3.41
320	Kidney and urinary tract infections	22,167	.8087	.8108	−0.26
130	Peripheral vascular disorders	21,569	.9453	.9635	−1.89
296	Nutritional and miscellaneous metabolic diseases	20,547	.9015	.8970	0.50
183	Esophagitis, gastroenteritis and miscellaneous digestive diseases	19,814	.5539	.5652	−2.00
174	G.I. hemorrhage, age > 69 and/or C.C.	19,134	.9405	.9282	1.33
395	Red blood cell disorders, age > 17	18,742	.7961	.7842	1.52
336	Transurethral prostatectomy	18,215	1.0049	1.0075	−0.26

[1]Total number of cases including statistical outliers. Statistical outlier cases were excluded from the computation of the relative weights reported in columns two and three.

[2]Based on the 358 DRG's for which sufficient information was available on the 1981 file to compute relative weights.

NOTES: C.C. is complication and/or comorbidity; OR is operating room; AMI is acute myocardial infarction; and G.I. is gastrointestinal. The 25 DRG's listed above accounted for 47.8 percent of total MEDPAR cases in 1981.

Table 4

Coefficients of variation for total charge weights and total operating cost weights for the top 25 diagnosis-related groups in terms of frequency: 1981

Code number	Diagnosis-related group	Total 1981 charge weights[1]	1981 operating cost weights[1]
127	Heart failure and shock	.9208	.8912
182	Esophagitis, gastroenteritis and miscellaneous digestive diseases	.8414	.8049
132	Atherosclerosis, age > 69 and/or C.C.	.8930	.8832
39	Lens procedure	.3752	.3576
88	Chronic obstructive pulmonary disease	.9821	.9390
14	Specific cerebrovascular disorders, except transient ischemic attacks	1.0428	1.0074
89	Simple pneumonia, age > 69 and/or C.C.	.9298	.8777
468	Unrelated OR procedure	1.1278	1.0714
122	Circulatory disorders with AMI (121 and 122 combined)	.6966	.6889
294	Diabetes, age > 36	.8566	.8167
140	Angina pectoris	.7199	.7262
243	Medical back problems	.7547	.7267
138	Cardiac arrhythmia and conduction disorders	.9495	.9392
134	Hypertension	.8868	.8600
15	Transient ischemic attacks	.8409	.8171
96	Bronchitis and asthma, age > 69 and/or C.C.	.8093	.7601
467	Other factors influencing health status	1.1511	1.0902
82	Respiratory neoplasms	1.0842	1.0534
320	Kidney and urinary tract infections	.8432	.7946
130	Peripheral vascular disorders	1.0576	1.0119
296	Nutritional and miscellaneous metabolic diseases	.9988	.9454
183	Esophagitis, gastroenteritis and miscellaneous digestive diseases	.8261	.8027
174	G.I. Hemorrhage, age > 69 and/or C.C.	.9115	.8780
395	Red blood cell disorders, age > 17	.8954	.8641
336	Transurethral prostatectomy	.5513	.5290

[1] Based on the 358 DRG's for which sufficient information was available on the 1981 Medicare provider analysis review to compute relative weights.

NOTES: C.C. is complication and/or comorbidity; OR is operating room; AMI is acute myocardial infarction; and G.I. is gastrointestinal. The 25 DRG's listed above accounted for 47.8 percent of total MEDPAR cases in 1981.

Table 5

Number of diagnosis-related groups, mean relative weight, and associated standard deviation for each method of computing relative weights, by type of weight

Type of weight	Number of DRG's[1]	Mean relative weight	Standard deviation
Operating cost weight	358	1.2186	0.8022
Total charge weight	358	1.2486	0.8745

[1] DRG = diagnosis-related group.

NOTES: Data are based on the 358 DRG's for which sufficient information was available on the 1981 Medicare provider analysis review file to compute relative weights. The means reported above are DRG weighted. Relatively low frequency, high-weight DRG's have a greater impact on the DRG weighted mean than on the hospital weighted mean of the case weighted DRG means used in the prospective payment system. As a result, the means reported above are greater than 1.

Nonteaching hospitals, on the other hand, have lower case-mix index values using charge-based weights. The distribution of hospitals by percent difference between charge-based and cost-based case-mix index values is given in Table 7. Only 94 out of a total of 5,501 hospitals would have observed more than a 3-percent difference in their case-mix index value had charges rather than costs been used in constructing case-mix indexes. No hospitals would have observed more than a 6-percent difference in their case-mix index values.

Table 6

Case-mix index values for operating cost weights and total charge weights, by type of hospital, bed size, and hospital teaching status

Type of hospital, bed size, and teaching status	Operating cost weights	Total charge weights
	Case-mix index values	
Urban hospital		
Group 1 (0-99 beds)	.9686	.9657
Group 2 (100-404 beds)	1.0486	1.0526
Group 3 (405-684 beds)	1.1094	1.1208
Group 4 (685 beds or more)	1.1447	1.1623
Rural hospital		
Group 5 (0-99 beds)	.9444	.9391
Group 6 (100-169 beds)	.9877	.9863
Group 7 (170 beds or more)	1.0258	1.0278
Teaching status		
Nonteaching hospitals	.9827	.9808
Teaching hospitals with residents to bed ratio under .25	1.0802	1.0879
Teaching hospitals with residents to bed ratio over .25	1.1410	1.1598

NOTE: Data are based on the 358 DRG's for which sufficient information was available on the 1981 Medicare provider analysis review file to compute relative weights.

Table 7

Number and percent distribution of hospitals, by percent by which charge-based case-mix indexes differ from cost-based case-mix indexes

Percent by which charge-based case-mix indexes differ from cost-based case-mix indexes	Number of hospitals	Percent distribution of hospitals
Total	5,501	100.0
5-6 percent less	0	0.0
4-5 percent less	0	0.0
3-4 percent less	24	0.5
2-3 percent less	38	0.7
1-2 percent less	531	9.7
0-1 percent less	2,290	41.6
0-1 percent more	2,161	39.3
1-2 percent more	340	6.2
2-3 percent more	85	1.5
3-4 percent more	24	0.4
4-5 percent more	6	0.1
5-6 percent more	2	0.0

NOTE: Data are based on the 358 DRG's for which sufficient information was available on the 1981 Medicare provider analysis review file to compute relative weights.

Interpretation of the results

Three adjustments made in constructing the operating cost weights were omitted in constructing the charge weights (the charge-to-cost adjustment and the standardizations for differences in capital and medical education costs). The similarity of the charge and the operating cost weights indicates that these adjustments have little effect on the structure of the relative weights. The chief difference between the two sets of weights is that the charge weights are less compressed than the operating cost weights. That is, the charge weights tend to be greater (less) than the operating cost weights for DRG's with relatively high (low) operating cost weights. In this section, we attempt to provide explanations for these results. In particular, we attempt to answer the following two questions:

- Why do interhospital differences in cost-to-charge ratios and pass-through costs produce relatively small differences between charge-based and operating cost weights?
- Why are the charge-based weights less compressed than the operating cost weights?

Similarity of alternative relative weights

If the charge-based and operating cost weights were identical, then the ratio of the charge-based to the operating cost weight would be equal to one for every DRG. Since the two sets of weights are very similar, the ratio does not vary greatly from one. As shown in Table 2, no DRG had a charge-based weight that was more than 10 percent less than the operating cost weight. In addition, no DRG had a charge-based weight that was more than 20 percent greater than the operating cost weight. These results imply that the ratio of the charge-based weight to the operating cost weight ranges from a low of approximately .90 to a high of approximately 1.20.

We examined why the charge-based and operating cost weights are so similar by investigating the relative constancy across DRG's of the ratio of total charges per case to operating cost per case. Comparing the charges-to-operating cost ratio is essentially equivalent to comparing the ratio of the two relative weights. These alternative comparisons yield equivalent results because the relative weights are constructed by dividing the mean operating cost or charges for each DRG by the mean operating cost or charges for all DRG's. Hence, for each DRG, the ratio of the charge-based to the operating cost weight is equal to the ratio of the mean charges per case to the mean operating cost per case multiplied by the ratio of the mean operating cost to the mean charges for all DRG's as shown below:

$$\frac{\text{Charge weight}_i}{\text{Cost weight}_i} = \frac{\text{Mean charge}_i/\text{Mean charge all DRG's}}{\text{Mean cost}_i/\text{Mean cost all DRG's}}$$

$$= \frac{\text{Mean charge}_i}{\text{Mean cost}_i} \times \frac{\text{Mean cost all DRG's,}}{\text{Mean charge all DRG's}}$$

The ratio of the mean cost for all DRG's to the mean charge for all DRG's is the same for each DRG. Therefore, variation across DRG's in the ratio of the two sets of relative weights is fully reflected in the ratio of the mean charges per case to the mean operating cost per case.

A hypothetical example is useful to show how the operating cost and charge-based weights can be very similar despite relatively large interhospital differences in the total charges-to-operating cost ratio. The critical determining factor is the degree of similarity among hospitals' case mixes. On the one hand, if the proportion of cases in each DRG were the same for all hospitals, inter-DRG differences in the total charges-to-operating cost ratio would disappear, and charge-based and operating cost weights would be identical no matter how much variation exists in the ratio among hospitals. On the other hand, if hospitals were completely specialized, each treating a different set of DRG's, the interhospital differences would appear as inter-DRG differences, and charge-based and operating costs weights would reflect these differences.

Consider the following examples shown in Table 8. In each case, there are two hospitals and two DRG's. Hospital X has a total charges-to-operating cost ratio of 2.0, and hospital Y has a total charges-to-operating cost ratio of 1.0. In case A, hospitals X and Y each treat one case in each DRG. In case B, hospital X

Table 8
Impact of hospital differences in charge-to-cost ratios on diagnosis-related group relative weights

	Case A						
	DRG 1			DRG 2			Hospital charge-to-cost ratio
Item	Cost	Charges	Cases treated	Cost	Charges	Cases treated	
Hospital X	$100	$200	1	$200	$400	1	2.0
Hospital Y	100	100	1	200	200	1	1.0
Mean cost or charge per case	100	150	—	200	300	—	—
DRG charge-to-cost ratio		1.5			1.5		

Mean cost per case for all DRG's: $600 ÷ 4 = $150
Mean charges per case for all DRG's: $900 ÷ 4 = $225
Relative cost weights: $100 ÷ $150 = .667 (DRG 1)
$200 ÷ $150 = 1.33 (DRG 2)
Relative charge weights: $150 ÷ $225 = .667 (DRG 1)
$300 ÷ $225 = 1.33 (DRG 2)

	Case B						
	DRG 1			DRG 2			Hospital charge-to-cost ratio
Item	Cost	Charges	Cases treated	Cost	Charges	Cases treated	
Hospital X	$100	$200	2	—	—	0	2.0
Hospital Y	—	—	0	$200	$200	2	1.0
Mean cost or charge per case	100	200	—	200	200	—	—
DRG charge-to-cost ratio		2.0			1.0		

Mean cost per case for all DRG's: ((2 × $100) + (2 × $200)) ÷ 4 = $600 ÷ 4 = $150
Mean charges per case for all DRG's: ((2 × $200 + 2 x $200)) ÷ 4 = $800 ÷ 4 = $200
Relative cost weights: $100 ÷ $150 = .667 (DRG 1)
$200 ÷ $150 = 1.33 (DRG 2)
Relative charge weights: $200 ÷ $200 = 1.00 (DRG 1)
$200 ÷ $200 = 1.00 (DRG 2)

NOTE: DRG is diagnosis-related group.

treats two cases in DRG 1 and no cases in DRG 2. Hospital Y treats no cases in DRG 1 and two cases in DRG 2. Hence in case A, both hospitals X and Y have the same proportion of their cases in each DRG. In contrast, in case B, hospital X has 100 percent of its cases in DRG 1, whereas hospital Y has 100 percent of its cases in DRG 2. In case A, the interhospital differences in the total charges-to-operating cost ratio (2.0 versus 1.0) disappear at the DRG level, where the ratio is 1.5 for both DRG's. In turn, the charge-based and operating cost weights are identical. In case B, the interhospital differences in total charges-to-operating cost ratios (again 2.0 versus 1.0) appear at the DRG level also and, indeed, the charge-based and operating cost weights differ significantly. In particular, in case B the charge-based weights fail to capture the differences in resource intensity between the two DRG's.

These are the examples of the extreme cases. Clearly, the high degree of correspondence between the empirically derived charge-based and operating cost weights provides strong circumstantial evidence that the 1981 data lie closer on the spectrum to case A than to case B.

To explore this issue empirically, we computed the mean and standard deviation of the total charges-to-operating cost ratio by using the 1981 MEDPAR cases on which the DRG relative weights were based: across all hospitals with cases in the data set, and across the 358 DRG's included in our analysis. These means can be expressed, respectively, as

$$1/M\Sigma_j(\Sigma_i(n_{ij}/n_j)R_{ij}) \text{ and } 1/N\Sigma_i(\Sigma_j(n_{ij}/n_j)R_{ij}),$$

where

R_{ij} is the total charges-to-operating cost ratio for DRG i and hospital j;

(n_{ij}/n_j) is the proportion of cases in DRG i and hospital j;

(n_{ij}/n_j) is the proportion of cases in DRG i and hospital j;

M is the total number of hospitals; and

N is the number of DRG's (358 in our study).

The standard deviations are of particular interest because they measure the extent of variation in the ratios across DRG's and hospitals.

These results are presented in Table 9, and they show the large reduction in variation that occurs when

Table 9

Means and standard deviations of hospital and diagnosis-related groups charge and cost ratios by cost category: 1981

Category	Hospital	Diagnosis-related group
Total charges / Operating cost	1.34 (.25)	1.44 (.0025)
Total charges / Total cost	1.23 (.20)	1.26 (.0013)
Total cost / Operating cost	1.10 (.09)	1.14 (.0005)

NOTE: Standard deviations are shown in parentheses.

the ratio is computed by DRG rather than by hospital. The standard deviation of the total charges-to-operating cost ratio is only one-hundredth as large on a DRG basis as on a hospital basis. This result illustrates that the effect portrayed in case A of Table 8 is operating in the 1981 data and appears to explain why the charge-based and operating cost weights are very similar.

Compression of alternative relative weights

The finding that the charge-based weights are less compressed than the operating cost weights implies that the ratio of the two sets of weights tends to increase in moving from low-weight to high-weight DRG's. That is, for low-weight DRG's, the charge-based weights tend to be less than the operating cost weights; and for high-weight DRG's, the charge-based weights tend to be greater than the operating cost weights.

As noted earlier, it is shown in Table 9 that the inter-DRG variation in the total charges-to-operating cost ratio is small relative to the interhospital variation (0.25 versus .0025). Nevertheless, some variation exists, and it holds the answer to the question of why the charge-based weights are less compressed than the operating cost weights. Our objective is to determine which of the adjustments made in constructing the operating cost weights accounts for these differences. Just as in the previous section, the issue is analyzed in terms of the total charges-to-operating cost ratio. The lesser compression of the charge-based weights implies that the total charges-to-operating cost ratio is positively correlated with the size of the operating cost weights.

This ratio can be expressed as the product of the following two ratios—the total charges-to-cost ratio and the total cost-to-operating cost ratio:

$$\frac{\text{Total charges per case}}{\text{Operating cost per case}} = \frac{\text{Total charges per case}}{\text{Total cost per case}} \times \frac{\text{Total cost per case}}{\text{Operating cost per case}}$$

The significance of this decomposition is that the component ratios reflect the adjustments for cost-to-charge ratios and pass-through costs whose effects we

Table 10

Regressions of cost and charge ratios on operating cost weights for diagnosis-related groups

Dependent variables	Constant	Coefficient of operating cost weights	R^2
(1) Total charges-to-operating cost ratio	1.40	.0351 (13.0)	.32
(2) Total cost-to-operating cost ratio	1.13	.0096 (6.38)	.10
(3) Total charges-to-total cost ratio	1.24	.0200 (9.24)	.19
(4) CCP (Total charges-to-total cost ratio with mean charge-to-cost ratios and DRG-specific cost proportions)	1.23	.0221 (11.8)	.28
(5) CCR (Total charges-to-total cost ratio with DRG-specific charge-to-cost ratios and mean cost proportions)	1.25	.0052 (3.69)	.03

NOTES: DRG is diagnosis-related group.
t-statistics are shown in parentheses. The number of observations in all 5 equations is 358—the number of DRG's used throughout this analysis.

are attempting to determine. By examining how each of these ratios varies across DRG's, we can assess the effect of each adjustment. The standard deviations reported in Table 9 indicate that the total charges-to-total cost ratio is approximately 2½ times more variable across DRG's than the total cost-to-operating cost ratio (.0013 versus .0005). This fact suggests that cost-to-charge differences may be more likely to explain the lesser compression of charge-based weights than differences in pass-through costs are.

However, the critical question is whether the total charges-to-total cost ratio or the total cost-to-operating cost ratio increases more rapidly in going from low-weight to high-weight DRG's. We analyzed this question by regressing each of the three ratios on the operating cost weights, and the results are presented in lines (1)-(3) of Table 10. The positive slope coefficients indicate that both the total charges-to-total cost and the total cost-to-operating cost ratios contribute to the lesser compression of the charge-based weights.[4] However, the fact that the coefficient of the total charges-to-total cost ratio is twice as large

[4]Indeed, the fact that the slope coefficient and the R^2 are largest in the total charges-to-operating cost equation (row 1) indicates that the combined effects are stronger than either individual effect. Because the effects are multiplicative, this result is expected.

as the coefficient of the total cost-to-operating cost ratio (.02 versus .0096) indicates that differences between total charges and total costs are more important in explaining the compression result than inter-DRG differences in the pass-through costs are.

As a final step in our analysis, we attempted to determine why the total charges-to-total cost ratio tends to be greater (less) for high (low) weight DRG's. Variations in the total charges-to-total cost ratio result from variations in either the total charges-to-total cost ratios of the nine cost categories or the proportions of costs in each of the nine cost categories:

$$\left(\frac{\text{Total charges per case}}{\text{Total costs per case}}\right)_i = \sum_{j=1}^{9} \left(\frac{\text{Total charges}}{\text{Total cost}}\right)_{ij} \times \left(\frac{\text{Cost in category}}{\text{Total cost}}\right)_{ij}$$

The subscript i represents the DRG, and the subscript j represents the cost category. The following nine cost categories are the ones used in constructing the relative weights:

- Routine.
- Special care.
- Operating room.
- Drugs.
- Laboratory.
- X-ray.
- Medical supplies.
- Anesthesiology.
- Other ancillaries.

The total charges-to-total cost ratio of a DRG may be greater than the average for all DRG's because its specific charge-to-cost ratios are higher than average, or because it has above average proportions of total cost in cost categories that, on average, have relatively high charges-to-cost ratios. The means for the nine charges-to-cost ratios and cost proportions across DRG's are reported in Table 11.

To isolate the separate effects of differences in charges-to-cost ratios and differences in cost proportions, we computed two additional total charges-to-total cost ratios for each DRG, letting only one source of inter-DRG variation occur at a time. First, we computed one set of charges-to-cost ratios (*CCP*) using the mean charges-to-cost ratios for each of nine cost categories and the DRG-specific cost proportions. Then, we repeated the process using DRG-specific charges-to-cost ratios and nine mean cost proportions (CCR). CCP_i is the sum for each DRG across cost categories of the product of the mean charge-to-cost ratio for each cost category (CC_j) and the DRG-specific cost proportion (CP_{ij}); and CCR_i is the sum for each DRG across cost categories of the product of the DRG-specific charge-to-cost ratio (CC_{ij}) and the mean cost proportion for each cost category (CP_j). Thus, *CCP* reflects only inter-DRG variation in the proportions of total cost in each of the nine categories, whereas *CCR* reflects only inter-DRG variation in the charge-to-cost ratios for each category.

Table 11

Means and standard deviations of the total charges-to-total cost ratios and cost proportions, by cost category: 1981

Cost category	Total charges / Total cost	Cost in category / Total cost
Total	1.26 (.0013)	1.00 —
Routine	1.05 (.0011)	.501 (.0123)
Special care	.88 (.0073)	.060 (.0036)
Operating room	1.19 (.0017)	.091 (.0069)
Drugs	1.92 (.0064)	.068 (.0007)
Laboratory	1.62 (.0018)	.088 (.0005)
X-ray	1.38 (.0013)	.048 (.0003)
Medical supplies	1.54 (.0042)	.052 (.0007)
Anesthesiology	1.60 (.0511)	.014 (.0001)
Other ancillaries	1.70 (.0056)	.078 (.0010)

NOTES: DRG is diagnosis-related group. The means reported above are DRG-weighted means of the case weighted means for 356 DRG's. Standard deviations are shown in parentheses.

By regressing *CCP* and *CCR* on the operating cost weights, we determined which source of variation plays a greater role in explaining the lesser compression of the charge-based weights. The results of these regressions are shown in Table 10, lines (4) and (5). The slope coefficient is much larger in the *CCP* equation than in the *CCR* equation (.0221 versus .0052). This result indicates that inter-DRG variation in the proportion of cost in each of the nine cost categories explains most of the variation in the total charges-to-total cost ratio across DRG's. This result is further supported by the fact that the R^2 is much larger in the *CCP* than in the *CCR* equation (.28 versus .03).

Because, as shown in Table 11, the ancillary services, on average, have higher charges-to-cost ratios than routine and special care costs, we can draw the following inference: The lesser compression of the total charge weights results from the fact that higher (lower) weight DRG's tend to have higher (lower) proportions of their total costs in cost categories with relatively high (low) charges-to-cost ratios. Thus, in explaining the degree of compression that is the result of variation across DRG's in overall charges-to-cost ratios, inter-DRG variation in the proportions of costs in the various categories is more important than inter-DRG variation in the charges-to-cost ratios of the individual cost categories.

As a final comment on the compression issue, it should be noted that we found the pattern of charges-to-cost ratios among the nine cost categories to be consistent with conventional beliefs about cross-subsidization. Ancillary cost categories have higher charges-to-cost ratios than the routine, special care, and operating room categories. Further, special care, which we might expect to be associated with high-weight DRG's, has the lowest charges-to-cost ratio. Other things being equal, we might expect DRG's with relatively high proportions of cost in special care to have lower charge-based weights than operating cost weights. However, other things are not equal. In particular, the relationship between the charge-based and operating cost weights for DRG's with above average proportions of special-care costs also depends on the correlations between the special-care proportion of cost and the other cost proportions.

We investigated this issue and found that the special-care proportion of total cost exceeds the DRG weighted mean of .06 for 123 of the 358 DRG's analyzed in this study. Eighty-four of the 123 DRG's had operating cost weights greater than 1.0. The charge-based weights are greater than the operating cost weights for 77 of these 84 DRG's. Thus, most relatively high-weight DRG's with an above average proportion of special-care cost fit the general pattern of lesser compression for the charge-based weights. For these DRG's, cross-subsidization of special care, as reflected in a relatively low ratio of charges-to-cost, does not result in compression of the charge-based weights relative to the operating cost weights. This result can only be explained by the existence of a positive correlation between the proportions of cost in special care and in the ancillary categories with higher charges-to-cost ratios. In other words, a high proportion of special-care cost does not generally compress the charge-based weight for a DRG because relatively high utilization of special care is accompanied by relatively high utilization of ancillaries, such as X-ray and laboratory services.

Relationship between cost and case-mix

An important step in the development of the original set of cost-based relative weights was an assessment of the relationship between hospital case-mix index values constructed from the cost-based relative weights and hospital average per case values. The relationship between case mix and cost per case was tested by estimating a single equation average cost function using 1981 Medicare Cost Report data from approximately 5,000 hospitals. The analysis supported the hypothesis that a case-mix index based on operating cost weights is a significant factor that explains variation in average Medicare cost per case among hospitals, and that such a case-mix index provides a valid representation of the expected costliness of an individual hospital's Medicare patient mix. In this section, we replicate the original analysis by using a case-mix index constructed from charge-based relative weights, rather than from operating cost weights, and compare the results with the original findings.

The evaluation of case mix and Medicare cost per case was based on the multivariate regression analysis of hospitals' 1981 operating costs per case. Cost per case is hypothesized to depend on the following independent variables:

- The charge-based Medicare case-mix index.
- A 1981 Bureau of Labor Statistics wage index.
- A measure of teaching activity (resident-to-bed ratio).
- Bed size.
- A set of locational dummy variables (three standard metropolitan statistical area size categories and one rural category).

With the exception of the location variables, all variables were transformed to logarithms in the estimated equation; and for these transformed variables, the regression coefficients are interpretable as elasticities (i.e., the coefficients are estimates of the percent change in the dependent variable resulting from a 1-percent change in the independent variable).

The estimated coefficients and associated *t*-statistics for the regression results based on charge-based and cost-based case-mix index values are given in Table 12. The coefficient values are quite similar for both sets of regression results. The case-mix coefficient and the teaching activity coefficient are slightly lower when the charge-based case-mix index is used, but they are not significantly different from the coefficients obtained using the cost-based, case-mix index (evaluated in a two-tailed test at the 5-percent level of significance). The other coefficient values remain essentially unchanged. More importantly, after controlling for other factors that influence hospital costs, the coefficient of the charge-based case-mix

Table 12

Regression results using charge-based and cost-based case-mix indexes in a single equation average cost function

Variable	Coefficient	*t*-Statistic
	Results using charge-based case-mix index	
Case-mix index	.969	23.4
Wage index	1.022	27.5
Resident to bed ratio	.545	11.9
Bed size	.117	23.8
Large city dummy	.109	7.8
Medium city dummy	.025	2.2
Small city dummy	.000	0.0
Constant	7.334	—
Adjusted R^2 = .72		
Standard error of estimate = .22		
	Results using cost-based case-mix index	
Case-mix index	1.012	23.3
Wage index	1.023	27.5
Resident to bed ratio	.580	12.7
Bed size	.119	24.4
Large city dummy	.109	7.8
Medium city dummy	.026	2.3
Small city dummy	.001	0.0
Constant	7.322	—
Adjusted R^2 = .72		
Standard error of estimate = .22		

index was not significantly different from 1.0 (evaluated in a two-tailed test at the 5-percent level of significance). Hence, the charge-based case-mix index is approximately proportional to the expected costliness of an individual hospital's Medicare patient mix, as was the case for the cost-based case-mix index. This result further supports the finding that there do not appear to be large, arbitrary differences between charge-based and cost-based weights or between case-mix indexes constructed from charge-based and cost-based weights.

Summary

The original relative weights used in the prospective payment system (PPS) were based on standardized cost data for a sample of 1981 Medicare discharges. Cost-based relative weights were used in the PPS on the assumption that they would better reflect differences in true resource costs among diagnosis-related groups (DRG's) than relative weights based on charges would. The extent to which relative weights based on costs differ from relative weights derived exclusively from charge data and the sources of any differences were investigated in this study. Also, the validity of a case-mix index developed from charge-based relative weights as a measure of the relative costliness of a hospital's Medicare cases was assessed.

The results of the analysis indicate that charge-based and operating cost weights based on 1981 MEDPAR data are very similar. A summary of the major findings is as follows:

- The difference between relative weights based on operating costs and relative weights based on total charges is less than 5 percent for most of the DRG's.
- The structure of the relative weights across DRG's for each method are nearly identical. The Spearman and Pearson correlation coefficients are greater than .99.
- The relative dispersion of costs or charges within a DRG are very similar, although for most DRG's the coefficients of variation using charge data are slightly higher than the coefficients of variation using cost data.
- The dispersion of average costs or charges across DRG's are also very similar. However, DRG's with high (low) relative weights tend to have slightly higher (lower) relative weights if computed using charge data rather than cost data, which means that the charge-based relative weights are slightly less compressed than the cost-based relative weights.
- Large urban hospitals and teaching hospitals tend to have slightly higher case-mix index values using charge-based weights rather than cost based weights, whereas small rural hospitals and nonteaching hospitals tend to have slightly lower case-mix index values using charge-based weights. This finding is a consequence of the finding that charge-based weights are slightly less compressed than the cost-based weights.

The results of the analysis support the use of charge data in constructing DRG relative weights. In particular, interhospital differences in cost-to-charge ratios do not result in large, arbitrary differences between charge-based and operating cost weights. Whether the data are standardized for differences in capital and medical education cost also appears to make little difference. These interhospital differences only affect the DRG relative weights if there is a high degree of specialization among hospitals in different groups of DRG's. Our results indicate that, in 1981, hospitals' case mixes were similar enough so that most interhospital effects disappear when the data are partitioned by DRG.

However, as noted previously, we found that charge-based weights are somewhat less compressed than cost-based weights. This result is contrary to the expectation that cross-subsidization by hospitals in their pricing of high-cost and low-cost services would make charge-based weights more compressed than operating cost weights. In seeking an explanation for the observed result, we found the pattern of charge-to-cost ratios among the cost categories used in constructing the relative weights to be consistent with the cross-subsidization hypothesis. However, the relative importance of these costs categories varies across DRG's in a way not accounted for by the cross-subsidization hypothesis. On the one hand, high-cost services such as special care have lower charge-to-cost ratios than ancillary services such as drugs and laboratory. On the other hand, high-weight DRG's with a relatively high proportion of special-care cost also have relatively high proportions of other ancillaries. The net effect of these relationships is to make the charge-based weights less compressed than the operating cost weights.

Finally, we analyzed the relationship between hospitals' case-mix index values constructed from the charge-based relative weights and average Medicare cost per case based on multivariate regression analysis of hospitals' 1981 operating costs per case. The charge-based case-mix index was found to be proportional to the expected costliness of an individual hospital's Medicare patient mix. This result further supports the study's major finding that there do not appear to be large differences between charge-based and cost-based weights or between case-mix indexes constructed from charge-based or cost-based weights.

Although the differences between charge-based and cost-based weights are small, our analysis does not necessarily imply that charges are a good measure of the resources used to treat hospital inpatients. However, it would appear that, based on our analysis, charge-based relative weights are a viable alternative to operating-cost weights constructed according to the methodology originally used in the PPS.

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