Unrecognized redistributions of revenue in diagnosis-related group-based prospective payment systems

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The Medicare prospective payment system, which is based on the diagnosis-related group patient-classification system, identifies previously unrecognized redistributions of revenue among diagnosis-related groups and hospitals. The redistributions are caused by two artifacts. One artifact results from the use of labor market indexes to adjust costs for the different prices paid by hospitals in different labor markets. The other artifact results from the use of averages that are based on the number of hospitals, not the number of patients, to calculate payment rates from average costs. The effects of these artifacts in a sample data set have been measured, and it was concluded that they lead to discrepancies between costs and payments that may affect hospital incentives—the overall payment for each diagnosis-related group—and Medicare's total payment.

Introduction

The Federal Government has begun implementing the prospective payment system, which is designed to improve the efficiency of hospital care for Medicare patients. To achieve this goal, the prospective payment system will pay hospitals a fixed payment rate for each category of illness based on the diagnosis-related group patient-classification system. As a result of these fixed payment rates, hospitals are expected to control the costs of patient care through improved internal management of the resources they use to treat patients in each of the diagnosis-related groups.

In preliminary work using both hypothetical data sets and the New Jersey data sets, previously unrecognized discrepancies were observed between costs and payments that result when hospital payment rates are calculated according to the Medicare prospective payment system methods. Furthermore, it was found that similar discrepancies can be observed in the New Jersey prospective payment system, which uses similar methods to calculate hospital payment rates. In the absence of a precise definition from the literature, we call these discrepancies artifacts, because the discrepancies appear to produce arbitrary or artificial incentives.

In this article it is shown how these artifacts can be attributed to two distinct features of the prospective payment system rate-setting formulas: the use of labor market indexes to adjust payment rates for differences in hospital costs (the indexation artifact) and the use of hospital-weighted, rather than patient-weighted, average costs to calculate payment rates (the weighting artifact). In contrast, the New Jersey rate-setting formulas contain only the indexation artifact, and they are thus useful in illustrating the separate impact of the two artifacts. To measure the potential effect of the artifacts in actual data, simulated differences between payments and costs for a sample of 26 New Jersey hospitals are presented, using both the Medicare prospective payment system and the New Jersey rate-setting formulas to calculate hospital payment rates. Finally, the potential impact of the discrepancies between costs and payments in these simulations upon the incentive structure of the Medicare prospective payment system will be discussed.

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Background

Calculating prospective payment system (PPS) hospital payment rates is complex and is described in detail elsewhere (*Federal Register*, 48:171, 1983 and Grimaldi and Micheletti, 1983). What follows is a summary that highlights the problems described in this article.

Currently, PPS payment rates for an individual hospital are calculated by combining the hospital's costs, the costs of other hospitals in the same geographical region, and the costs of all the Nation's participating hospitals. Beginning in 1987 for most hospitals (and in 1986 for other hospitals), the calculation will no longer be adjusted for individual and regional hospital costs. A description of how payment rates will be calculated beginning in 1987 will be given here because it simplifies the summary and does not change the conclusions. The calculation depends only on the following values for each hospital: the number of discharges in each diagnosis-related group (DRG) category, the mean cost per discharge in each DRG category, and the index that describes the relative costliness of the hospital's labor market.

An example of payment-rate calculations under PPS

To illustrate the calculation, an example with only three hospitals that treat patients in only two DRG's will be used (Table 1). Hospital A is in a more costly labor market, as indicated by its labor market index, which is greater than one. Hospital C is in a less costly labor market, and hospital B is in a neutral

Table 1

Number of patients, average cost per patient, and labor market index for 3 hospitals treating patients in 2 diagnosis-related groups

Hospital	Total	DRG 1	DRG 2	DRG 1	DRG 2	Labor market index
		Number of patients		Average cost per case		
Total	200	150	50	—	—	—
A	100	75	25	$1,000	$1,000	1.5
B	65	50	15	500	1,000	1.0
C	35	25	10	250	1,000	0.5

NOTES: Data given are basic values used in the example to calculate payment rates.
DRG 1 = diagnosis-related group 1.
DRG 2 = diagnosis-related group 2.

Table 2

Adjusted average cost per case, hospital expected cost per case, and hospital case-mix index for 3 hospitals treating patients in 2 diagnosis-related groups

Hospital	DRG 1	DRG 2	Hospital expected cost per case	Hospital case-mix index
	Adjusted average cost per case			
A	$736.17	$ 736.17	$713.65	0.9968
B	500.00	1,000.00	705.63	0.9856
C	447.88	1,791.00	728.54	1.0176
Hospital average expected cost	—	—	$715.94	—
DRG expected cost	$609.40	$1,026.39	—	—
DRG relative cost weight	0.8512	1.4336	—	—

NOTES: Data given are intermediate values used in the example to calculate payment rates.
The names for some of these values differ from those in the *Federal Register* (1983).

DRG 1 = diagnosis-related group 1.
DRG 2 = diagnosis-related group 2.

labor market. To compare costs from different hospitals, it is first necessary to adjust their costs for the labor market differences. This is done by dividing each cost by the hospital's labor market index to calculate what the cost would have been if the hospital had paid national wage rates. (Because not all costs are due to labor, only 79.15 percent of the cost is divided by the labor market index and then added to the remaining 20.85 percent.) These adjusted costs are shown in Table 2.

Table 2 also shows the intermediate values that must be calculated before hospital payment rates can be calculated. Of special importance are the "case-mix indexes" (in the extreme-right column) and the "DRG relative cost weights" (last row). To calculate these numbers, the following intermediate values must be calculated, beginning with the "DRG expected costs" per discharge.

Diagnosis-related group expected costs are averages calculated by multiplying the number of each hospital's patients in each DRG (from Table 1) times the hospital's adjusted average cost for the DRG, adding the products together, and then dividing by the total number of patients in the DRG. The DRG expected costs are used to calculate hospital expected costs per case.

The hospital expected cost is calculated by multiplying DRG expected costs times the number of the hospital's patients in the corresponding DRG, adding these products together, and then dividing by the total number of the hospital's patients in all DRG's. This calculation produces an average cost for each hospital that is weighted according to the number of patients. To get the hospital average expected cost (for all hospitals), all hospital values are added together and divided by the number of hospitals. This calculation produces an average overall cost that is weighted by the number of hospitals and is one source of the redistributions that are the subject of this article (i.e., the weighting artifact). Weighting by hospital allows each hospital, regardless of its size and patient load, to exert an equal effect on the payment-rate calculation.

Each hospital's case-mix index is calculated by dividing each hospital expected cost by the average hospital expected cost. The hospital's case-mix index measures how costly the hospital's overall case mix is relative to other hospitals.[1] To calculate DRG relative cost weights (last row, Table 2), each DRG expected cost is divided by the hospital average expected cost. This step produces the DRG relative cost weights that are the widely quoted measures of how costly each DRG is in relation to other DRG's.[2]

[1]The values for participating hospitals are listed on pages 39847-39870 of the *Federal Register*, 1983.
[2]These values are listed on pages 39876-39886 of the *Federal Register*, 1983.

The preceding steps show how hospital case-mix indexes and DRG relative cost weights are calculated. The following steps show how national payment rates are calculated. First, each hospital's adjusted cost for each DRG (from the box in Table 2) is multiplied times the number of patients, the products are summed, and the total is divided by the total number of patients to give the hospital's adjusted cost per case in the first column of Table 3. Dividing these values by each hospital's respective case-mix index yields the hospital's standard cost per case, which equalizes each hospital's cost for differences in its own case mix compared with the average case mix. Adding and then dividing by the number of hospitals gives the average standard cost per case, which is in the last row of Table 3. This value is equivalent to the national payment rates that have been published in the *Federal Register* (48:171, 1983).

To calculate each hospital's payment rate for each DRG, each calculation must begin with the national payment rate (the number in the last row of Table 3). This number is multiplied times the hospital's labor market index (although only 79.15 percent of the value is multiplied by the labor market index and then added to the remainder). The result is then multiplied times the respective DRG relative cost weight. Multiplying by the DRG relative cost weight adjusts the national payment rate for differences in the costliness of each DRG. Multiplying by the labor market index is intended to translate the national payment rate, which is the amount that would be appropriate if the hospital paid national wage rates, into a payment that is appropriate for the hospital's labor market. The process of dividing the labor market index into hospital costs (going from Table 1 to the box in Table 2) and then multiplying the same index by national rates (Table 3) creates the second source of the redistributions that are the subject of this article (i.e., the indexation artifact).

These redistributions are described in Table 4, where the payment rates calculated in Table 3 have been used to determine the total payment received by each hospital for patients in each DRG. The redistributions can be separated into three effects. First, the overall payment for all patients does not equal the overall cost of care (the payment is $7,063 more than the cost). Second, the total payment in each DRG does not equal the total cost in that DRG (for DRG 1 the payment is $1,216 less, and for DRG 2 it is $8,279 more than the total cost of care). Third, each hospital's payment does not equal its cost. The payment is greater than cost in hospital A ($1,113) and hospital B ($6,559), and it is less than cost in hospital C ($609). It will be shown in the next section that the overall and DRG differences are due to the indexation and to the weighting artifacts described in this article. However, only part of each hospital difference is due to the artifacts. The other part is intentional and is due to the incentives that are meant to encourage each hospital to use internal resources more efficiently. There is currently no satisfactory way to measure how much of each hospital difference is due to the artifacts and how much is due to the intended incentive.

An example of the impact of the two artifacts

The model for the Medicare prospective payment system is the New Jersey DRG-based prospective payment system that began in May 1980 for 26 New Jersey hospitals. An important feature of the rate-setting methods of both systems is that payment rates are calculated using indexes to standardize average costs (*Federal Register*, 48:171, 1983 and Grimaldi and Micheletti, 1983). The most conspicuous use of indexes in Federal programs is for the purpose of making *intertemporal* comparisons of purchasing power. For example, Social Security benefits are indexed according to the Consumer Price Index to ensure that the purchasing power of beneficiaries does not diminish over time due simply to inflation. However, the use of indexes in the rate-setting methodologies of both New Jersey and Medicare is for the purpose of making *interspatial* comparisons of hospital costliness. In this sense, the rate-setting methodologies resemble the problem of comparing gross national products, which requires price adjustments so that products from one nation can be compared with those from other nations. However, the literature appears to be inconclusive about the best method for using indexes to make interspatial comparisons (Dreschler, 1973 and Diehl, 1978). Furthermore, there are no other known Federal programs that make payments on the basis of costs that are standardized to remove regional differences in labor costs. Therefore, it is believed that the problems described here may be unique to these new payment programs and, furthermore, that a solution may have to be developed especially for them.

Both the Medicare prospective payment system and the New Jersey DRG-based prospective payment system use labor market indexes in similar ways to calculate standardized costs. However, an important difference between the two rate-setting methods is that New Jersey calculates payment rates that are weighted according to the number of patients in each DRG, and Medicare calculates payment rates that are weighted according to the number of hospitals. To illustrate how discrepancies between costs and payments can be separated into an artifact due to indexation and an artifact due to hospital weighting, consider a simple example consisting of three hospitals that treat patients in only two DRG's. Furthermore, assume that two sets of rates are calculated for each hospital. The first set is calculated according to the New Jersey rate-setting formulas and is thus patient weighted. The second set is calculated according to the same formulas, but hospital weighting is substituted for patient weighting. The only adjustment made in the rate-setting formulas is for the hospital's labor market.

Table 3
Calculation of payment rates in the example

Hospital	Adjusted cost per case	Case-mix index [1]	Standard cost per case	Labor market index [2]	DRG 1		DRG 2	
					DRG cost weight [1]	Payment rate	DRG cost weight [1]	Payment rate
A	$736.17	0.9968	$738.53	1.5	0.8512	$863.44	1.4336	$1,454.21
B	615.38	0.9856	624.37	1.0	0.8512	618.62	1.4336	1,041.88
C	831.78	1.0176	817.39	0.5	0.8512	373.80	1.4336	629.56
Average standard cost per case	—	—	726.76	—	—	—	—	—

[1] From Table 2.
[2] From Table 1.
NOTE: DRG = diagnosis-related group.

Table 4
An example of redistribution effects

Hospital	DRG 1			DRG 2			Total profits
	Payments	Costs	Profits	Payments	Costs	Profits	
Total	$105,034	$106,250	– $ 1,216	$58,279	$50,000	$ 8,279	$7,063
A	64,758	75,000	– 10,242	36,355	25,000	11,355	1,113
B	30,931	25,000	5,931	15,628	15,000	628	6,559
C	9,345	6,250	3,095	6,296	10,000	– 3,704	– 609

NOTES: As used here and elsewhere in this article, the term "profits" is simply the difference between payments and costs.
DRG 1 = diagnosis-related group 1.
DRG 2 = diagnosis-related group 2.

Tables 5-7 demonstrate how the effect of the indexation artifact can be separated from the effect of the hospital weighting artifact. Table 5 shows that the artifacts do not exist under special conditions. Part A of Table 5 shows the average cost of DRG 1 and DRG 2, adjusted for the labor market index of each hospital. (To simplify the calculations in Tables 5-7 100 percent of hospital costs were adjusted by the labor market index, not 79.15 percent). When using a patient-weighted system like that for New Jersey to calculate payment rates, these averages are the payment rates. Calculation of hospital-weighted payment rates is shown in Part B of Table 5. The format and the methods used here are identical to those used in Table 3.

Parts C and D of Table 5 show the redistribution effects resulting from the two different sets of payment rates. The format and methods used here are identical to those in Table 4. When the labor market indexes have the same ratios as the average cost per case of each hospital, as in this example, there are no discrepancies between total costs and payments and thus no redistributions. However, these conditions almost certainly never occur.

Table 6 shows that the indexation artifact can be separated from the hospital-weighting artifact by allowing each hospital to have a neutral labor market index value of 1.0. When patient-weighted rates are used under these special conditions, hospital A loses $30,500 but hospital B gains $6,167 and hospital C gains $24,333. However, total payments equal total costs for both DRG's, and there is no discrepancy between overall costs and payments. When hospital-weighted rates are used, hospital A loses $39,716, hospital B loses $133, and hospital C gains $19,768. The discrepancy between total costs and total payments is a loss of $11,239 for DRG 1 and a loss of $11,842 for DRG 2. The discrepancy between overall costs and payments is loss of $23,081 which can be attributed solely to the use of hospital-weighted rates rather than to patient-weighted rates.

Table 7 shows how the discrepancies in Table 6 are affected by introducing labor market indexation into the examples. Unlike the examples in Table 5, the labor market indexes in Table 7 do not have the same ratios as the average costs per case in each hospital. When patient-weighted rates are used, hospital A loses $21,000, hospital B gains $1,500, and hospital C gains $12,800. The discrepancy between total costs and total payments is a loss of $3,000 for DRG 1 and a loss of $3,700 for DRG 2. The overall discrepancy is a loss of $6,700 that can be attributed solely to indexation, because the same example in Table 6 produced no discrepancy when all index values were equal to 1.0. When hospital-weighted rates are used, hospital A loses $27,754, hospital B loses $2,355, and hospital C gains $10,562. The discrepancy between total costs and total payments is a loss of $8,254 for DRG 1 and a loss of $11,293 for DRG 2. The overall discrepancy is a loss of $19,547. The example in Table 6 shows that the discrepancy due solely to the hospital-weighted artifact is a loss of $23,081, and the example in Table 7 shows that the overall discrepancy due solely to the indexation artifact is a loss of $6,700.

Table 5
An example of no discrepancies between payments and costs

Part A. Calculation of patient-weighted payment rates

Hospital	Labor market index	DRG 1 Number of patients	DRG 1 Average cost per case	DRG 1 Adjusted cost per case	DRG 2 Number of patients	DRG 2 Average cost per case	DRG 2 Adjusted cost per case
A	1.5	60	$750	[1] $500	25	$3,000	$2,000
B	1.0	50	500	500	15	2,000	2,000
C	0.5	40	250	500	10	1,000	2,000
Averages	1.0	—	—	[1] 500	—	—	2,000

Part B. Calculation of hospital-weighted payment rates

Hospital	Adjusted cost per case	Case-mix index	Standard cost per case	Labor market index	DRG 1 DRG cost weight	DRG 1 Payment rate [2]	DRG 2 DRG cost weight	DRG 2 Payment rate [2]
A	$941.17	1.0913	$862.43	1.5	0.5798	$750	2.3190	$3,000
B	846.15	0.9811	862.45	1.0	0.5798	500	2.3190	2,000
C	800.00	0.9276	862.44	0.5	0.5798	250	2.3190	1,000
Averages	—	—	862.44	—	—	500	—	2,000

Part C. Profits using patient-weighted rates

Hospital	DRG 1 Payment rate [1]	DRG 1 Payments	DRG 1 Costs	DRG 1 Profits	DRG 2 Payment rate [1]	DRG 2 Payments	DRG 2 Costs	DRG 2 Profits	Total profits
Total	—	$80,000	$80,000	$0	—	$115,000	$115,000	$0	$0
A	$750	45,000	45,000	0	$3,000	75,000	75,000	0	0
B	500	25,000	25,000	0	2,000	30,000	30,000	0	0
C	250	10,000	10,000	0	1,000	10,000	10,000	0	0

Part D. Profits using hospital-weighted rates

Hospital	DRG 1 Payment rate [2]	DRG 1 Payments	DRG 1 Costs	DRG 1 Profits	DRG 2 Payment rate [2]	DRG 2 Payments	DRG 2 Costs	DRG 2 Profits	Total profits
Total	—	$80,000	$80,000	$0	—	$115,000	$115,000	$0	$0
A	$750	45,000	45,000	0	$3,000	75,000	75,000	0	0
B	500	25,000	25,000	0	2,000	30,000	30,000	0	0
C	250	10,000	10,000	0	1,000	10,000	10,000	0	0

[1] Patient-weighted averages.

[2] Hospital-weighted averages.

NOTES: DRG 1 = diagnosis-related group 1. DRG 2 = diagnosis-related group 2.

Table 6

Discrepancies between payments and costs due to hospital weighting

Part A. Calculation of patient-weighted payment rates

Hospital	Labor market index	DRG 1 Number of patients	DRG 1 Average cost per case	DRG 1 Adjusted cost per case	DRG 2 Number of patients	DRG 2 Average cost per case	DRG 2 Adjusted cost per case
A	1.0	60	$750	$ 750	25	$3,000	$ 2,000
B	1.0	50	500	500	15	2,000	2,000
C	1.0	40	250	250	10	1,000	2,000
Averages	1.0	—	—	[1] 533.33	—	—	[1] 2,300

Part B. Calculation of hospital-weighted payment rates

Hospital	Adjusted cost per case	Case-mix index	Standard cost per case	Labor market index	DRG 1 DRG cost weight	DRG 1 Payment rate [2]	DRG 2 DRG cost weight	DRG 2 Payment rate [2]
A	$1,411.76	1.0966	$1,287.40	1.0	0.5554	$478	2.3953	$2,063
B	846.15	0.9800	862.42	1.0	0.5554	478	2.3953	2,063
C	400.00	0.9234	433.18	1.0	0.5554	478	2.3953	2,063
Averages	—	—	861.33	—	—	478	—	2,063

Part C. Profits using patient-weighted rates

Hospital	DRG 1 Payment rate [1]	DRG 1 Payments	DRG 1 Costs	DRG 1 Profits	DRG 2 Payment rate [1]	DRG 2 Payments	DRG 2 Costs	DRG 2 Profits	Total profits
Total	—	$80,000	$80,000	$ 0	—	$115,000	$115,000	$ 0	$ 0
A	$533.33	32,000	45,000	– 13,000	$2,300.00	57,500	75,000	– 17,500	– 30,500
B	533.33	26,667	25,000	1,667	2,300.00	34,500	30,000	4,500	6,167
C	533.33	21,333	10,000	11,333	2,300.00	23,000	10,000	13,000	24,133

Part D. Profits using hospital-weighted rates

Hospital	DRG 1 Payment rate [2]	DRG 1 Payments	DRG 1 Costs	DRG 1 Profits	DRG 2 Payment rate [2]	DRG 2 Payments	DRG 2 Costs	DRG 2 Profits	Total profits
Total	—	$68,761	$80,000	$ – 11,239	—	$103,158	$115,000	$ – 11,842	$ – 23,081
A	$478.41	28,705	45,000	– 16,295	$2,063.15	51,579	75,000	– 23,421	– 39,716
B	478.41	23,920	25,000	– 1,080	2,063.15	30,947	30,000	947	– 133
C	478.41	19,136	10,000	9,136	2,063.15	20,632	10,000	10,632	19,768

[1] Patient-weighted averages.
[2] Hospital-weighted averages.
NOTES: DRG 1 = diagnosis-related group 1. DRG 2 = diagnosis-related group 2.

Table 7

Discrepancies between payments and costs due to indexation

Part A. Calculation of patient-weighted rates

Hospital	Labor market index	DRG 1 Number of patients	DRG 1 Average cost per case	DRG 1 Adjusted cost per case	DRG 2 Number of patients	DRG 2 Average cost per case	DRG 2 Adjusted cost per case
A	1.2	60	$750	$ 625.00	25	$3,000	$ 2,500
B	1.0	50	500	500.00	15	2,000	2,000
C	0.8	40	250	312.50	10	1,000	1,250
Averages	1.0	—	—	[1] 500.00	—	—	[1] 2,100

Part B. Calculation of hospital-weighted rates

Hospital	Adjusted cost per case	Case-mix index	Standard cost per case	Labor market index	DRG 1 DRG cost weight	DRG 1 Payment rate [2]	DRG 2 DRG cost weight	DRG 2 Payment rate [2]
A	1,176.47	1.0947	$1,074.70	1.2	0.5639	$559	2.3686	$2,348
B	846.15	0.9804	863.07	1.0	0.5639	466	2.3686	1,957
C	500.00	0.9249	540.60	0.8	0.5639	373	2.3686	1,565
Averages	—	—	826.12	—	—	466	—	1,957

Part C. Profits using patient-weighted rates

Hospital	DRG 1 Payment rate [1]	DRG 1 Payments	DRG 1 Costs	DRG 1 Profits	DRG 2 Payment rate [1]	DRG 2 Payments	DRG 2 Costs	DRG 2 Profits	Total profits
Total	—	$77,000	$80,000	$ − 3,000	—	$111,300	$115,000	$ − 3,700	$ − 6,700
A	$600.00	36,000	45,000	− 9,000	$2,520.00	63,000	75,000	− 12,000	− 21,000
B	500.00	25,000	25,000	0	2,100.00	31,500	30,000	1,500	1,500
C	400.00	16,000	10,000	6,000	1,680.00	16,800	10,000	6,800	12,800

Part D. Profits using hospital-weighted rates

Hospital	DRG 1 Payment rate [2]	DRG 1 Payments	DRG 1 Costs	DRG 1 Profits	DRG 2 Payment rate [2]	DRG 2 Payments	DRG 2 Costs	DRG 2 Profits	Total profits
Total	—	$71,746	$80,000	$ − 8,254	—	$103,707	$115,000	$ − 11,293	$ − 19,547
A	$559.06	33,544	45,000	− 11,456	$2,348.08	58,702	75,000	− 16,298	− 27,754
B	465.89	23,294	25,000	− 1,706	1,956.73	29,351	30,000	− 649	− 2,355
C	372.71	14,908	10,000	4,908	1,565.38	15,654	10,000	5,654	10,562

[1] Patient-weighted averages.
[2] Hospital-weighted averages.
NOTES: DRG 1 = diagnosis-related group 1. DRG 2 = diagnosis-related group 2.

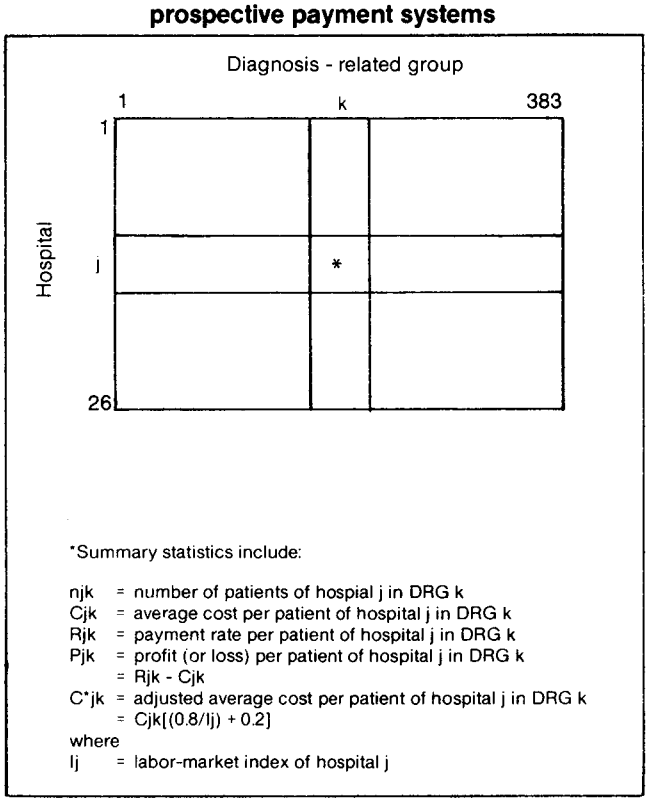
However, the overall discrepancy due to the combination of both artifacts in Table 7 is a loss of $19,547, which suggests that the artifacts have an interaction effect—i.e., the artifacts are not simply additive.

Methods

To demonstrate that the artifacts in the hypothetical example are real, two simulations of the prospective rate-setting process were performed by using actual hospital cost data. The goal of these simulations was to generate payment rates, and subsequently profits and losses, for every DRG and hospital combination in the data base. The data consisted of hospital-specific summary statistics for 26 New Jersey hospitals that participated in the State's DRG-based prospective payment system in 1980. Figure 1 shows the matrix used to perform each simulation, along with the summary statistics for each cell of the matrix. Our sample of 26 hospitals and 383 DRG's yielded 9,369 observations, including empty cells. Each observation contained the number of patients treated and the average variable cost per discharge for each DRG. The data were collected in 1978, which was before the new classification system with 467 DRG's came into use. The data included only those patients who were actually classified into DRG's in 1978, and length-of-stay outliers were excluded. Finally, each hospital's labor market adjustment factor was included.

Figure 1

Matrix for simulating the structure of costs, payments, and profits of the New Jersey and Medicare prospective payment systems



The data were used to create two sets of payment rates—one using the New Jersey methods and one using Medicare prospective payment system methods. Two minor modifications were made to the New Jersey methods to make the New Jersey simulations comparable to the Medicare simulations (Ignizio, 1983). Several modifications were made in the Medicare methods. Medicare adjusts the costs of each hospital for the following effects: case mix, teaching intensity, labor market, and urban or rural location within nine regions of the country. Teaching intensity and urban or rural location were not available, therefore, adjustments were not made for these effects in our simulations. The labor market index for each hospital was calculated by New Jersey from employee wage data. This index represents the relative costliness of each individual hospital, whereas the index used by Medicare represents the relative costliness of a labor market, which means that several hospitals may share the same labor market index. Also, we set the labor-related component of each hospital's costs to 80 percent for simplicity, rather than 79.15 percent as is done by Medicare. Finally, since all of the sample hospitals are from the same State, it was not necessary to calculate separate regional payment rates. Instead, we calculated payment rates that were equal to 100 percent of the standard payment rate for all hospitals. Therefore, our rates are comparable to those that will be calculated by the Medicare prospective payment system after fiscal year 1987 (excluding adjustments for capital costs, the costs of medical education, Medicare Part B costs, FICA taxes, budget neutrality, and outlier payments). Total payments were then calculated for each hospital for every patient in the sample—i.e., as if the simulation was for an all-payer system. This was necessary because we did not have payment-source information in our data base.

Results

Table 8 presents the 10 DRG's with the largest total revenue losses or gains in each simulation. Using New Jersey patient-weighted rates, DRG 121—acute myocardial infarction in the original DRG system with 383 categories—lost the most revenue ($23,495) and DRG 231—diseases of the pancreas with surgery—gained the most revenue ($1,682). Although these losses and gains are relatively small, they, nevertheless, indicate that the artifacts created an implicit revenue redistribution from some DRG's to other DRG's. The magnitude of this revenue redistribution between DRG's was much greater when hospital-weighted rates were used. As shown in Table 8, DRG 121 again lost the most revenue ($225,595), and DRG 46—neoplasm of lymphatic tissue with age less than 16—lost the least revenue ($63). Of particular interest is the fact that every DRG in the Medicare PPS simulation lost revenue.

Table 8

Number of patients, total hospital costs, payments, and profits for 10 diagnosis-related groups with greatest gains or losses

Diagnosis-related group	Number of patients	Hospital costs	Hospital payments	Hospital profits
Using New Jersey patient-weighted rates				
121	4,466	$ 8,684,914	$ 8,661,419	$ – 23,495
348	2,377	5,206,028	5,191,013	– 15,015
124	3,902	4,236,067	4,222,317	– 13,750
278	9,776	5,087,198	5,075,899	– 11,300
318	14,006	3,076,364	3,065,688	– 10,675
5	737	867,209	868,131	922
80	293	285,488	286,414	925
352	1,196	828,440	829,412	972
346	1,011	1,023,300	1,024,820	1,520
231	191	461,574	463,256	1,682
Using Medicare prospective payment system hospital-weighted rates				
121	4,466	$ 8,684,914	$ 8,459,319	$ – 225,595
132	4,634	5,369,015	5,232,687	– 136,328
348	2,377	5,206,028	5,070,050	– 135,978
278	9,776	5,087,198	4,957,081	– 130,117
11	1,552	4,818,531	4,697,508	– 121,023
309	95	39,179	38,377	– 802
63	49	24,814	24,219	– 595
383	14	14,171	13,776	– 395
82	47	8,268	8,051	– 217
46	3	3,577	3,514	– 63

Table 9 shows the DRG's with the greatest average losses and gains on a per patient basis in the simulations. Using New Jersey patient-weighted rates, DRG 368—burn of 2d or 3rd degree, more than 20 percent of body—lost the most revenue per patient ($25), and DRG 46 gained the most revenue per patient ($10). Using Medicare PPS hospital-weighted rates, DRG 138—valvular heart disease with valve operation or other major operation—lost the most revenue per patient ($132), and DRG 273—false labor—lost the least revenue per patient ($4).

Table 10 shows the aggregate impact of the artifacts on total hospital payments and profits when patient-weighted rates and hospital-weighted rates were used. Total losses for all hospitals were $413,608, or approximately 0.17 percent of total costs for all hospitals when the New Jersey patient-weighted rates were used, and $6,225,743, or approximately 2.51 percent of costs, when Medicare PPS hospital-weighted rates were used. It is important to note that Table 10 does not show the effect of the artifacts on the profits or losses of individual hospitals, because there is currently no readily available way of separating hospital payments into an incentive component and an artifact component.

Table 9

10 diagnosis-related groups with the greatest average gain or loss per patient

Diagnosis-related group	Average loss or gain per patient
Using New Jersey patient-weighted rates	
368	$ – 25
314	– 21
120	– 17
138	– 16
127	– 14
80	3
22	4
186	4
231	9
46	10
Using Medicare prospective payment system hospital-weighted rates	
138	$ – 132
127	– 129
131	– 93
368	– 93
101	– 83
318	– 6
378	– 6
114	– 6
82	– 5
273	– 4

Table 10

Number of patients, total hospital costs, payments, and profits for all diagnosis-related groups

Hospital	Number of patients	Hospital costs	Hospital payments		Hospital profits	
			New Jersey patient-weighted rates	Prospective payment system hospital-weighted rates	New Jersey patient-weighted rates	Prospective payment system hospital-weighted rates
Total	293,010	$247,555,135	$247,141,527	$241,329,392	$ −413,608	$ −6,225,743
1	16,408	14,294,460	14,532,243	14,158,139	237,783	−136,321
2	16,184	17,749,091	15,076,774	14,608,150	−2,672,317	−3,140,942
3	6,715	5,249,474	5,466,879	5,342,633	217,405	93,159
4	8,145	7,036,346	7,222,254	7,065,168	185,908	28,822
5	8,068	5,571,230	6,331,584	6,188,232	760,354	617,002
6	17,683	16,943,013	15,616,296	15,185,369	−1,326,717	−1,757,644
7	17,621	16,310,674	15,158,490	14,836,507	−1,152,184	−1,474,167
8	23,551	15,186,280	17,832,628	17,512,807	2,635,322	2,326,527
9	10,393	7,941,051	8,909,497	8,670,414	968,446	729,363
10	5,430	3,750,328	4,046,029	3,958,004	295,701	207,676
11	7,460	6,318,708	6,346,631	6,208,017	27,923	−110,690
12	10,327	9,341,845	8,269,258	8,103,041	−1,072,588	−1,328,805
13	11,522	8,713,070	8,830,504	8,720,309	117,434	7,239
14	13,773	8,423,409	11,641,071	11,313,463	3,217,608	2,890,054
15	19,158	17,069,964	16,359,841	15,911,408	−710,123	−1,158,556
16	9,815	7,168,152	7,934,743	7,824,838	766,592	656,686
17	11,498	12,427,937	11,580,775	11,258,631	−847,161	−1,169,305
18	3,808	3,015,505	3,604,652	3,538,993	589,147	523,488
19	7,322	5,600,366	6,156,885	6,117,812	556,520	517,446
20	3,323	2,567,055	2,852,716	2,800,853	285,661	233,798
21	27,309	25,291,573	22,155,176	21,579,214	−3,136,397	−3,712,359
22	9,379	7,819,630	7,827,298	7,649,163	7,668	−170,467
23	13,206	11,520,268	11,052,874	10,694,112	−467,394	−826,156
24	6,223	5,396,163	5,253,940	5,174,787	−142,222	−221,376
25	5,095	4,532,186	4,509,115	4,445,950	−23,071	−86,236
26	3,594	2,317,357	2,573,425	2,553,378	256,068	236,022

Discussion

The current method of calculating payment rates in the new Medicare prospective payment system (PPS) leads to previously unrecognized redistributions of revenue among diagnosis-related groups (DRG's) (Table 8) and hospitals (Table 10). If the data are representative of the national data used to calculate current payment rates, the redistributions will be large in some cases. It is believed that these effects are important. They will change the size and perhaps the direction of hospital incentives, change the overall payment for each DRG, and change the Medicare aggregate payment to all hospitals for all DRG's.

The examples described in here explain the reasons for the redistributions. They result from two artifacts. One artifact can be traced to the use of labor market indexes to adjust costs for the different prices paid by hospitals in different labor markets. The other artifact can be traced to the use of hospital weights to calculate payment rates from average costs. The two artifacts interact to produce complex effects.

The redistributions of revenue due to the artifacts can be positive or negative. Size and direction depend on the relationships among four factors: the labor market indexes used to adjust hospital costs, the average cost for each DRG in each hospital, the number of patients for each DRG in each hospital, and the method of weighting average costs. Therefore, size and direction change when different data are used to calculate payment rates, and the conclusions derived from the examples in this article must be interpreted cautiously when they are used to evaluate actual payment systems, such as those used by New Jersey and Medicare. Although the size and direction of the redistributions depend on the data, their existence cannot be eliminated by selecting alternative indexes, different definitions of allowable costs, or patient classification systems other than the one based on DRG's.

Do these redistributions matter? It is believed that they could contradict some of the stated goals of the Medicare prospective payment system. Consider the overall discrepancy between combined costs and combined payments for the whole system. In a Report to Congress (Office of the Secretary, 1982) the Secretary of Health and Human Services described 10 goals, including one stating that the system must ". . . continue to assure beneficiary access to quality care." Sample data from one State suggests that the discrepancies could be large enough to have important effects on this goal. If the combined payments for the whole system are substantially less than costs, hospitals may not be able to provide quality care without increasing their debt or shifting the unpaid cost from Medicare to other payors. If, on the other hand, the combined payments for the whole system are substantially more than costs, Medicare might have to reduce all its payment schedules to meet the legislative mandate for budget neutrality. Although this would balance Medicare's budget, it would not correct the DRG-to-DRG and hospital-to-hospital discrepancies that are described below.

The overall discrepancy can be thought of as a combination of all the separate discrepancies for the individual DRG's, some of which are large, some small, some positive, and some negative. To the extent that DRG discrepancies of different size and direction cancel each other, the combined discrepancy is reduced in size. This means that there will be some individual DRG discrepancies that are larger than the overall discrepancy when they are expressed as ratios of their respective costs. Therefore, the artifacts will exert proportionately greater effects in some individual DRG's than they will in the system as a whole.

One possible effect of these DRG discrepancies is a skewing of the Nation's hospital system to oversupply or undersupply services for some patients in some DRG's. To understand how this could happen, consider how economic considerations might affect decisions about distributing hospital resources to different types of patients. Before the Medicare prospective payment system, there were few constraints. Medicare paid practically all costs for all hospitalized patients who were covered by Medicare, regardless of the type of disease they had, and thus there were few economic reasons for the hospital industry as a whole to oversupply or undersupply care to patients based on the type of disease they had. Under PPS, however, there will be relatively large discrepancies between overall payments and costs for patients in some DRG's. If overall payments are higher than costs for some DRG's, more hospitals will be tempted to expand or to start services for patients in that DRG than if payments equalled costs. If overall payments are lower than costs for other DRG's, more hospitals will be forced to reduce or to terminate services for patients in those DRG's.

The net result could be a redistribution of programs and services, making it easier for patients with some types of problems and harder for those with other types of problems to find the hospital care they have come to expect. This does not mean that the current distribution of services is ideal. It does mean, however, that the changes that will be encouraged by the DRG-to-DRG discrepancies will be arbitrary or artificial ones with no relation to conscious policy decisions.

The overall discrepancy also can be thought of as a combination of the separate discrepancies from the individual hospitals. Because there are many more hospitals than DRG's, there likely will be even greater variation in the proportionate size of the hospital-to-hospital discrepancies than there are in the DRG-to-DRG discrepancies. The effects on individual hospitals, therefore, may be the most pronounced effects that are observed.

The effects on individual hospitals will occur through an alteration of the incentives that the hospitals face. The Medicare prospective payment system is designed to adjust for factors that affect hospital cost but are beyond the hospital's ability to control in the short run, for example, differences in patient case mix and differences in personnel costs resulting from different area wage rates. The system also is designed to

adjust for factors that affect costs but should be supported because of their social value, for example, some of the costs associated with training health care personnel. If these adjustments work as intended, the payments will have been adjusted for undesirable differences, and each hospital will face equal incentives even though each hospital does not receive the same payment.

It is believed that the hospital-to-hospital discrepancies that are described here will present hospitals with unequal incentives and thus may further frustrate the intention of the prospective payment system. Because of these discrepancies, some hospitals might receive payments that are too high and some, payments that are too low. Some hospitals, therefore, may face financial pressures that are less intense and others, financial pressures that are more intense than were intended when the system was created. The size and the importance of these effects, however, can be measured only by looking for the suspected discrepancies in the data used to calculate actual payment rates.

Although two sources of revenue redistribution have been identified and defined here, no completely satisfactory solution has yet been found. The solution involves trying to meet competing objectives. Based on work that has been done to date, it is not possible to develop a solution that will maximize all objectives. However, a technique known as goal programming that has been used by Ignizio (1983) to find satisfactory solutions for problems with multiple competing objectives may provide the most promise.

The discrepancies presented here are based on a static analysis of the Medicare and New Jersey systems. A dynamic analysis of the impact of these discrepancies would require time-series data, which were not available. The potential impact of these discrepancies depends on which model of hospital behavior one believes will apply to hospitals faced with fixed payment rates. Under an assumption of cost-minimizing behavior, hospitals will attempt to reduce costs on a DRG-by-DRG basis so as to maximize the difference between costs and payments. This may encourage shifts in the hospital's case mix away from unprofitable DRG's towards those that are more profitable. Unprofitable DRG's in one hospital might be profitable at another hospital, and shifts in the case mix of individual hospitals would not necessarily result in changes in the aggregate case mix of all hospitals. The DRG discrepancies presented in this article, however, suggest that aggregate changes should occur under the assumptions of cost-minimizing behavior, because some DRG's appear to be unprofitable for most hospitals. Whether or not an aggregate shift in hospital case mix is desirable is beyond the scope of this article. However, the DRG-by-DRG discrepancies presented here suggest a method for identifying which DRG's are likely to be the biggest winners and losers.

A reasonable alternative to the cost-minimizing model of hospital behavior is a break-even model, in which hospitals respond to fixed payment rates by using the profits from winning DRG's to subsidize the losses from losing DRG's. Of course, hospitals that are overall losers will need to reduce (or shift) costs in some manner that may or may not be DRG-specific. Under such a model, shifts in case mix would be unlikely in hospitals that were net winners and more likely (although not necessary) in hospitals that were net losers. Therefore, aggregate shifts in case mix might occur, but not in a manner that was directly related to the DRG discrepancies. Shifts in aggregate case mix would more directly depend on the response of hospitals that are overall losers. These hospitals could attempt to become net winners by reducing costs in their unprofitable DRG's or by reducing costs over all DRG's, neither of which would suggest a change in case mix. On the other hand, these hospitals might attempt to stop admitting patients in unprofitable DRG's, which would change case mix.

Regardless of which model of hospital behavior one chooses to accept, the overall discrepancy between total costs and total revenues suggests that the Medicare prospective payment system is likely to reduce the Federal Government's total payments for Medicare even if no changes in case mix occur. This is primarily due to hospital weighting, which reduces the impact of high-cost, high-volume hospitals during the calculation of payment rates. Of course, hospital weighting could lead to an overall discrepancy in which total payments were greater than total costs. This would occur whenever high-volume hospitals were also low-cost hospitals—that is, whenever economies of scale were obtained. However, the existence of economies of scale in the sample was not identified, either on a DRG-by-DRG basis or on an aggregate hospital-by-hospital basis. In fact, high-volume hospitals tended to be high-cost hospitals in our data, even on a DRG-by-DRG basis, that is, after controlling for case mix. Therefore, as long as high-volume hospitals continue to be high-cost hospitals, hospital weighting, considered separately from all other adjustments, will tend to reduce the Federal Government's total payments under PPS below total allowable costs.

The indexation artifact appears to have a much smaller impact on the redistribution of revenue than the weighting artifact based on our simulations. The overall discrepancy using New Jersey payment rates is 0.17 percent, which is due solely to the indexation artifact. The overall discrepancy using Medicare PPS rates is 2.51 percent, which is due to the combination of the hospital-weighting and indexation artifacts that have been shown not to be simply additive. Unlike the discrepancies due to hospital weighting, which appear to be consistent with the goal of controlling Federal expenditures, the discrepancies due to indexation appear to be true artifacts. The process of indexing allowable costs, aggregating these indexed costs into payment rates, then indexing the payment rates by the inverse of the original index to allow for geographical variations in wage rates does not appear to have a basis in economic theory similar to the economies-of-scale justification for hospital weighting.

It is understandable why these problems were not recognized when the system was designed. The indexation artifact is unique to prospective payment pro-

grams. Although other Federal programs adjust for differences in area wage rates, the purpose typically is to compare prices in different time periods, not to reimburse. These other programs do not readjust standard costs to calculate payments that reflect differences in local wages, as is done in the Medicare prospective payment system. Moreover, the method chosen for adjustment seems logical. Each hospital's cost for each DRG first is divided by its labor market index to calculate the standard payment rate and then is multiplied by the same index to calculate the hospital's own payment rate for the DRG. The problem surfaced only when it was noticed that overall payments did not equal costs when an evaluation of the demonstration project in New Jersey that led to the Medicare prospective payment system was done (Williams et al., 1984). Because PPS is in its first year, there has been little opportunity for the same observation to be made for the national system.

It also is easy to understand why the problem was not recognized earlier in New Jersey. Though similar to the Medicare prospective payment system, the New Jersey system includes different features that complicate payment calculations and tend to obscure the problem (Grimaldi and Micheletti, 1982). Unlike the Federal system, the New Jersey system includes all payers, which requires complex calculations to meet different contractual agreements. Also, the New Jersey system allocates the cost of uncompensated care to payers, it makes different provisions for the cost of financing capital, it has more generous provisions for excluding patients whose costs are different from average costs, and it uses a method for weighting average costs that appears to lead to smaller discrepancies.

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