
Is Case-Mix Adjustment Necessary for an Expanded Dialysis Bundle?

Richard A. Hirth, Ph.D., Robert A. Wolfe, Ph.D., John R.C. Wheeler, Ph.D., Erik C. Roys, M.A., Philip J. Tedeschi, Ph.D., Alyssa S. Pozniak, and Glenn T. Wright

Congress has required CMS to expand the Medicare outpatient prospective payment system (PPS) for dialysis services to include as many drugs and diagnostic procedures provided to end stage renal disease (ESRD) patients as possible. One important implementation question is whether dialysis facility case mix should be reflected in payment. We use fiscal year (FY) 2000 cost report and patient billing and clinical data to determine the relationship between costs and case mix, as represented by several patient demographic, diagnostic, and clinical characteristics. Results indicate considerable variability in costs and case mix across facilities and a significant and substantial relationship between case mix and facility cost, suggesting case mix payment adjustment may be important.

INTRODUCTION

Currently, the Medicare outpatient PPS pays a fixed amount for a limited bundle of routine, dialysis-related services, known as the composite rate (CR). Dialysis facilities are allowed to bill Medicare separately for other covered services furnished to ESRD patients. Congress has required CMS to develop an expanded PPS for outpatient dialysis services that includes as many drugs and diagnostic procedures provided to ESRD patients as possible (Section 422(c)

of Public Law 106-554, the Medicare, Medicaid, and the State Children's Health Insurance Program (SCHIP), Benefits Improvement and Protection Act of 2000 [BIPA]). One objective of the BIPA is to determine the appropriateness of creating a more comprehensive dialysis bundle that would include routinely furnished drugs and diagnostic procedures that are currently billed separately from the CR. Under a new system, the bundle of services covered by the PPS would then be expanded to include as many of the services provided to these patients as possible.

For services included in the current CR, previous studies have found only weak evidence that case mix plays a large role in determining dialysis facility costs (Dor, Held, and Pauly, 1992; Hirth et al., 1999). From a policy perspective, the lack of a strong relationship between case-mix factors and CR costs reduces the motivation for developing a case-mix adjustment mechanism to ensure access to quality care for patients with costly characteristics and to provide equitable reimbursement for the facilities that treat them. However, these previous studies have had access to only a limited range of case-mix descriptors. Further, the relationship between case mix and the costs of providing separately-billable services has not been studied yet. The vast majority of separately-billable costs are incurred for the delivery of drugs, with recombinant human erythropoietin (EPO) alone accounting for almost three-quarters of payments for items billed separately by dialysis units. The need for

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drugs and prescribed dosages varies among patients. If these variations are systematic (i.e., can be predicted by observable patient characteristics), a case-mix adjustment system may be possible. Indeed, incorporation of these separately billable costs into an expanded PPS bundle may make such a system necessary to minimize incentives to avoid treating patients with high expected drug usage or who incur other high costs.

The objectives of this study were to: (1) characterize costs and Medicare payments per dialysis treatment for CR services and separately-billable components under the existing dialysis payment system; (2) characterize the extent of variation in these costs and payments across dialysis providers; and (3) determine the relationship between patient characteristics and these costs and payments.

Accomplishing these objectives would help to establish the utility of a case-mix adjustment for an expanded ESRD outpatient PPS, to identify the case-mix factors that are predictive of costs and payments, and to estimate the percentage of variation in spending accounted for by such an adjustment system.

DATA

This study relies on three primary sources of data. First, the Medicare cost reports with cost reporting periods, ending in calendar year 2000, were obtained for each Medicare certified, freestanding dialysis provider. These reports provide the only comprehensive data on the costs incurred by dialysis units. They have been used in previous research (Dor, Held, Pauly, 1992; Hirth et al., 1999) to estimate statistical cost functions, assessing the impact of dialysis modality mix, patient case mix, facility size, location, and practice patterns on Medicare-allowable costs

for CR services. Hospital-based facilities, which comprise 18 percent of dialysis facilities nationally (Forum of ESRD Networks Clearinghouse Office, 2000), were excluded from the present study because their cost reports have a different format without certain data fields, which would impede comparability of the data. In addition, only a small number of FY 2000 cost reports for hospital-based facilities are currently available from CMS. Efforts are underway to obtain more complete data on hospital-based facilities. A potential weakness of the cost report data is that the level of auditing is not high because it is not used to determine payment amounts for individual facilities. However, the two models for total facility costs (Dor, Held, Pauly, 1992; Hirth et al., 1999) had excellent explanatory power, which suggests that reporting errors were not substantial, since reporting errors would tend to reduce explanatory power. Further, several fields in the cost report have been verified against independent data sources with high levels of agreement (e.g., facility-reported numbers of Medicare dialysis sessions correspond closely to Medicare sessions in the billing data discussed later.

Second, CMS standard analytical files (SAFs) of Medicare-paid claims provide the means to detail Medicare spending on dialysis-related care for Medicare-eligible ESRD patients. The data available from CMS billing are limited by the rules of eligibility for Medicare. Medicare eligibility begins 3 months after the onset of ESRD — unless that patient is already entitled to Medicare based on age or other disability; Medicare remains the secondary payer for up to 30 additional months for patients with employer-sponsored health insurance. Another limitation of the billing data is that itemization is not available for patients currently enrolled in a Medicare health maintenance organization (HMO). The outpatient

SAF provides the primary source of information about current payments received by dialysis facilities for treatment of ESRD patients. The data used here are limited to services provided between July 1, 2000 and December 31, 2000 to take advantage of changes made by CMS in the format of the SAFs from Version H to Version I. Version H recorded payments only for the claim as a whole, but it did not indicate which items were paid by Medicare. Nor did it indicate the amount of Medicare reimbursement for paid items. In contrast, the new Version I format identifies payments by the HCFA Common Procedure Coding System (HCPCS) code and revenue center. Thus, Version I allows an accurate disaggregation of Medicare payments for specific services without affecting the allocation of total spending to patients. Outpatient dialysis claims were identified as all claims for dialysis patients with the provider type code for dialysis facilities (code 72: clinic—hospital based or independent renal dialysis facility). Identifying dialysis claims via provider type, rather than the presence on the claim of at least one item with a dialysis revenue center, yields a more complete set of dialysis-related claims. For example, a claim including only ancillary services such as EPO, other drugs, or laboratory tests may not indicate any dialysis revenue center, but it would be correctly identified as dialysis-related, based on the type of provider.

Third, the only available source of comorbidity data for all ESRD patients was the End Stage Renal Disease Medical Evidence Report (CMS Form 2728) database. Form 2728 provides information on the cause of ESRD and about 20 comorbidities for the first ESRD treatment and selected baseline pre-ESRD laboratory measures, including creatinine, albumin, and hematocrit. In 1995, the reporting of this form was expanded from Medicare-eli-

gible patients only to all ESRD patients. The comorbidity measures were added to the form at that time. The primary weaknesses in the Form 2728 data are a lack of completeness in many of the forms and the fact that comorbidities are only reported at the start of ESRD. The reported comorbidities are not the primary purpose of the form, which is to establish Medicare eligibility on the basis of chronic renal failure. Thus, there is little incentive to report comorbid conditions completely. Comparisons to the Dialysis Morbidity and Mortality Study (DMMS) (U.S. Renal Data System, 1999) and abstractions of medical records (Ashby et al., 1998; U.S. Renal Data System, 1999; Roys et al., 1999; Wolfe, Ashby, and Port, 2000; and Longenecker et al., 2000) have verified underreporting. Nonetheless, comorbidities reported on this form have been found to be useful predictors of mortality, suggesting that the most salient comorbidities are reported (Wolfe et al., 2000); Ashby et al., 1998; Roys et al., 1999). Because completion of this form is required only at the onset of ESRD, there is no followup reporting of newly developed comorbidities or of cured, former comorbidities.

Additional sources of data include the CMS hospital wage index and the database used to generate CMS unit-specific reports for each dialysis facility. The hospital wage index applicable for FY 2000 is used to adjust for area labor costs (*Federal Register*, 1999). The unit-specific report database was the source of demographic information and the primary cause of renal failure for each facility's set of patients.

The analysis sample of dialysis facilities was derived from all freestanding facilities with cost reports for FY 2000 ($n=2,498$). Several facilities with implausible values for costs per session (less than \$50 or more than \$400) were excluded. Patient demographic and comorbidity data were linked

to the facility at which they were treated on January 1, 2000 for prevalent patients or on day 91 of chronic dialysis for patients incident during FY 2000. These matching protocols follow those employed in unit-specific performance reports prepared annually by the (University of Michigan Kidney Epidemiology and Cost Center, 2002). Facilities with fewer than 10 patients with available medical evidence forms were excluded to improve reliability of the comorbidity data. For payment analyses, each analysis (dependent) variable was restricted to facilities with values less than the 99th percentile in order to reduce the influence of outliers in the highest 1 percent. Finally, facilities that did not appear in the 1999 CMS Annual Facility Survey (U.S. Renal Data System, 1999) and those with missing data for key variables were excluded. The final analysis sample included 2,115 facilities (85 percent) with a subsample of 748 facilities that provided only in-center hemodialysis was also analyzed (Table 1). Billing data were summarized at the facility level for all patients for whom Medicare was the primary payer for the dialysis session.

METHODS

Measures

We report results describing the relationship between patient case mix and several measures of dialysis facility cost and payment per hemodialysis (HD)-equivalent session. All dialysis modalities are included in the analysis: HD, peritoneal dialysis (PD), HD and PD training. Due to reporting conventions in billing data, PD treatments are measured in days and are reimbursed an amount that is three-sevenths of the rate paid for HD treatments. Therefore, reported counts of PD treatments were multiplied by three-sevenths to

produce HD-equivalent sessions. In the cost reports, PD treatments are reported in weeks. Therefore, reported treatment weeks were multiplied by three to yield HD-equivalent sessions. In these analyses, we measure costs as reported in the cost reports and payments received by dialysis facilities as Medicare-allowable charges as reported in patients' bills. Medicare-allowable charges are the sum of Medicare payments from the billing data (80 percent of allowable charges) and patient obligations or copays (20 percent of allowable charges). To the extent that some patient obligations are not collected from patients or their secondary insurers, Medicare-allowable charges would overestimate payments actually received by facilities. However, to the extent that patients with private insurance pay higher rates than Medicare-allowable charges, the average payment received by facilities would be underestimated by focusing on dialysis sessions delivered to Medicare primary payer patients. These measures are listed in Table 1, which summarizes the distribution of cost and payment per session by facility. Per-treatment total facility cost and total facility payments, Medicare payment, and patient copay, were separated into CR and separately-billed services. Separately-billed services were further disaggregated into EPO and non-EPO. For all freestanding facilities in the analysis sample, we report results for the measures of cost and payment previously discussed. For those freestanding facilities providing only in-center HD services, we report results for a subset of these measures.

Patient case mix is measured by an extensive set of variables. Table 2 lists these variables, along with some results to be discussed later. Included on the list are the usual demographic characteristics: age, sex, and race. The next set of variables describes the main disease-related characteristics of

**Table 1
Distribution of Cost and Payment Per Dialysis Session, by Dialysis Facility: Fiscal Year 2000**

Facility	Mean	Percentile							
		1st	5th	25th	50th	75th	95th	99th	
Freestanding (n=2,115)									
Total Cost Per Session	\$199.11	\$139.34	\$157.58	\$178.62	\$195.25	\$214.34	\$257.63	\$297.56	
Total Paid Per Session	202.08	164.07	173.30	189.00	200.59	213.70	235.14	257.04	
Composite Rate Cost	141.16	93.63	106.53	122.33	136.40	153.73	191.21	234.38	
Composite Rate Paid	125.02	117.27	117.74	118.75	123.33	129.71	138.78	140.02	
Separately-Billable Cost	57.95	28.62	38.37	48.83	57.24	65.95	80.87	93.29	
Separately-Billable Paid	77.06	42.15	51.37	63.98	75.14	87.86	110.43	129.77	
Separately-Billable Cost: EPO	43.11	24.32	28.00	35.59	42.12	49.23	61.86	71.84	
Separately-Billable Paid: EPO	53.74	27.45	33.60	43.63	52.15	61.57	80.48	96.75	
Separately-Billable Cost: Non-EPO	14.83	—	0.39	11.24	14.78	18.62	25.82	33.91	
Separately-Billable Paid: Non-EPO	23.32	7.33	11.08	17.03	21.87	28.15	40.37	52.91	
HD-Only (n=748)¹									
Total Cost Per Session: HD-Only Facilities	199.17	145.71	158.04	178.95	195.34	214.38	256.19	290.92	
Total Paid Per Session: HD-Only Facilities	200.44	162.76	172.60	187.98	199.71	211.10	231.29	252.83	
Composite Rate Cost Per Session: HD-Only Facilities	140.60	95.81	107.02	120.33	135.00	153.34	192.32	230.99	
Composite Rate Paid: HD-Only Facilities	123.78	117.32	117.73	117.77	122.04	128.30	138.69	140.02	
Separately-Billable Cost: HD-Only Facilities	58.57	32.07	38.49	49.72	58.05	66.79	80.07	90.88	
Separately-Billable Paid: HD-Only Facilities	76.66	42.15	51.75	63.77	74.57	87.36	108.31	125.47	

¹ HD-only facilities are defined as those facilities that reported no costs for training or outpatient peritoneal dialysis.

NOTES: EPO is erythropoietin. HD is hemodialysis.

SOURCES: Centers for Medicare & Medicaid Services: Cost data are from the Medicare Cost Reports 2000 and represent Medicare-allowable costs. Payment data are from the Standard Analytical Files, Version I, July 2000-December 2000 and represent Medicare-allowable charges.

Table 2
Distribution of Outpatient Characteristics, by Dialysis Facility: Calendar Years 1995-2000

Characteristic	Percentile		
	10th	50th	90th
Number of Medicare Dialysis Patients	29	68	141
Average Age	57	61	67
< 20 Years	0	0	1
> 65 Years	31	47	63
Female	38	48	57
Asian/Pacific Islander	0	0	7
Black	2	29	81
Native American	0	0	3
Hispanic	0	0	33
Average Number of Years of Prior ESRD Therapy	2	3	5
<1 Year of ESRD	13	21	33
≥1 Year and <2 Years of ESRD	6	11	19
≥2 Years and <3 Years of ESRD	4	9	15
Employer Coverage	5	16	33
Medicaid	11	26	49
Receiving EPO before ESRD	8	24	46
Diabetes (Insulin) as Primary Diagnosis	9	20	33
Diabetes (No Insulin) as Primary Diagnosis	11	22	37
Hypertension as Primary Diagnosis	15	27	42
Other/Unknown Primary Diagnosis	8	17	27
Comorbid Conditions			
Diabetes, Not as Primary Diagnosis	0	6	13
Cardiac Arrest	0	0	3
Congestive Heart Failure	15	29	47
Ischemic Heart Disease	6	20	38
Myocardial Infarction	0	6	16
Cardiac Dysrhythmia	0	3	12
Pericarditis	0	0	3
Peripheral Vascular Disease	3	11	25
Cerebrovascular Disease, CVA, TIA	2	7	15
Cancer	0	3	9
Acquired Immunodeficiency Syndrome	0	0	1
Human Immunodeficiency Virus	0	0	2
Unable to Ambulate	0	2	7
Unable to Transfer	0	0	3
Using Tobacco	0	5	13
Alcohol Dependence	0	0	5
Drug Dependence	0	0	3
Clinical Measures			
Mean Serum Albumin	3	3	3
Mean Serum Creatinine	7	8	10
Mean BUN	78	89	101
Mean Hematocrit (for Patients with No EPO Use before ESRD)	26	28	30
Mean GFR	6	7	9
Mean Weight (KGs, Ages ≥20 Years Only)	69	74	79

NOTES: n=2,115 freestanding facilities. ESRD is end stage renal disease. EPO is erythropoietin. CVA is cardiovascular accident. TIA is transient ischaemic attack. BUN is blood urea nitrogen. GFR is glomerular filtration rate. KGs is kilograms.

SOURCE: Centers for Medicare & Medicaid Services: Data from the ESRD Medical Evidence Report (CMS Form 2728) for the period 1995-2000.

the patient, including primary diagnosis, other (non-Medicare) insurance coverage, and duration of ESRD. Each of these variables is available for the census of patients treated at the facility. Characteristics of a facility's patients based on CMS 2728 (and, hence, unavailable for patients incident prior to 1995) include 17 variables. These

variables indicate the percentage of patients for whom a particular comorbid condition is present and average values for six continuous measures (laboratory values and weight), all measured at the beginning of chronic dialysis treatment. At the facility level, the fraction of patients with each comorbidity was computed, based on Form

Table 3
Percent of Variance Explained in Per Session Payments and Cost Components, by Dialysis Facility: Fiscal Year 2000

Facility	Average Value	<i>R</i> ² Values for Covariates Controlling for			
		Wage Index	Modality and Training Percent	Case Mix	Total <i>R</i> ² Value
All FreeStanding (n=2,115)					
Total Cost Per Session	\$199.11	4	1	10	15
Total Paid Per Session	202.08	7	0	10	17
Composite Rate Cost	141.16	6	0	9	15
Composite Rate Paid	125.02	60	0	10	70
Separately-Billable Cost	57.95	0	2	17	19
Separately-Billable Paid	77.06	0	0	12	13
Separately-Billable Cost: EPO	43.11	0	1	15	16
Separately-Billable Paid: EPO	53.74	0	0	11	11
Separately-Billable Cost: Non-EPO	14.83	1	2	8	11
Separately-Billable Paid: Non-EPO	23.32	0	1	9	11
Hemodialysis-Only (n=748)¹					
Total Cost Per Session	199.17	5	—	14	19
Total Paid Per Session	200.44	7	—	16	23
Composite Rate Cost	140.60	7	—	15	23
Composite Rate Paid	123.78	61	—	8	69
Separately-Billable Cost	58.57	0	—	23	23
Separately-Billable Paid	76.66	0	—	18	18

¹ Hemodialysis-only facilities are defined as those that reported no costs for peritoneal dialysis training or outpatient peritoneal dialysis.

NOTES: EPO is erythropoietin. The overall average amount is calculated per session for each component. Successive columns correspond to models with more predictive factors added successively and their incremental explanatory power, as identified by the column headings incremental explanatory power. Some columns may not add to the total because of rounding.

SOURCES: Centers for Medicare & Medicaid Services (CMS): Cost data are from the Medicare Cost Reports 2000 and represent Medicare-allowable costs. Payment data are from the Standard Analytical Files, Version I, July 2000-December 2000, and represent Medicare-allowable charges. Wage index data are from the *Federal Register*, 2000. Case mix covariates are from CMS Form 2728 for the period 1995-2000.

2728 for patients receiving treatment at each facility in calendar year 2000. The comorbidity measure at the facility level is, thus, not a measure of the comorbidity of all the patients receiving dialysis at each facility, but represents instead the comorbidity level of patients incident after 1995 when reporting of comorbidity data began on Form 2728. One-half of all facilities in this study have baseline comorbidity information for at least 62 percent of their patients. In addition to the measures of patient case mix displayed in Table 2, the analyses include six variables that reflect the facility's mix of dialysis modalities: HD, HD training, PD, and PD training. The training treatments are further classified into those paid at \$20 above the CR (HD training and continuous cycling PD training) versus \$12 above the CR (continuous ambulatory PD

training). Finally, our analyses control for the wage rates prevailing in the metropolitan area of the facility and for urban versus rural classification.

Analytical Approach

The results discussed in the following section are in two parts. The first describes the distribution of cost and patient characteristics across dialysis facilities, using percentiles (Tables 1 and 2). This presentation gives a sense of the extent of variation in cost and case mix across facilities.

Second, linear regression analyses were used to evaluate the relationships of average patient demographic and comorbidity measures to per session costs and payments at the facility level (Table 3). As previously mentioned, the dependent variables

in these analyses were the average levels of cost (2000 cost report) and payments (July-December 2000) per HD-equivalent dialysis session for several categories of services.

Analyses of per session dialysis facility costs and Medicare payments were performed using linear regression analysis. These analyses show how the average cost or payment per session differs from case mix and other predictors measured at the facility level.

For each dependent variable, we estimated a series of linear models. The first model includes just the area wage index as a predictor. The second model includes the set of six variables defining modality and training. The third model adds all of the variables describing patient case mix, including demographics, main treatment characteristics, comorbidities, and clinical measures. The first two models include those factors (wages and modality mix) that are likely to be accounted for by a new payment system even if case-mix adjustment is not implemented. Thus, our approach is to determine the extent to which adding measures of patient case mix helps to explain variation in dialysis cost and payment beyond the variation explained by factors that would be incorporated in ratesetting regardless of the implementation of case-mix adjustment.

RESULTS

Table 1 describes the distribution of costs and payments per dialysis session across dialysis facilities. Considerable variability is evident in the data, both for CR and separately-billable services. For example, the 95th percentile of reported costs for CR services is \$191.21 versus \$106.53 at the 5th percentile. Similarly, the 95th percentile of reported costs for separately-billable services is \$80.87 versus \$38.37 at the 5th percentile.

Table 2 describes the distribution of outpatient characteristics across dialysis facilities. For each characteristic, the table reports the value at the 10th, 50th, and 90th percentiles of facilities. Clearly, there are substantial differences in case mix across facilities. For example, the average patient age was 57 at the 10th percentile of facilities versus age 67 at the 90th percentile of facilities. There are also substantial reported differences with regard to other factors, including duration of ESRD, race, and the availability of other insurance at onset of ESRD (private or Medicaid). The 10th percentile of facilities has only 13 percent of patients starting ESRD treatment within the last year versus 33 percent at the 90th percentile of facilities. Similarly, the percentage of black patients is 2 percent at the 10th percentile of facilities versus 81 percent at the 90th percentile. The distribution of Medicaid coverage ranges from 11 percent at the 10th percentile of facilities to 49 percent at the 90th percentile. Only 8 percent of patients received EPO before ESRD at the 10th percentile of facilities versus 46 percent for 90th percentile of facilities.

There also exists substantial variability in primary diagnosis across facilities. For each of the diagnosis categories, there is roughly a three-fold difference in percent of patients from the lowest 10th to the 90th percentile. In terms of the prevalence of comorbidities, there is particularly wide variability in cardiac arrest, heart disease, peripheral vascular disease, and cerebrovascular disease.

Given the substantial variation in both costs and case mix, a case-mix adjustment system would have potential value in an expanded outpatient PPS bundle. Table 3 summarizes our analyses of the extent to which the variation in patient case mix documented in Table 2 is related to dialysis facilities' costs and payments described in

Table 1. The table shows the R^2 values for the series of models previously discussed in the methods section. The R^2 statistic measures the fraction of the variation in per session costs or payments that can be attributed to the predictive factors in the model. A higher value of R^2 indicates that the costs or payments are more accurately predicted by the values of the predictor measures. We focus on the R^2 statistics to emphasize the overall explanatory power of case mix, rather than on the estimated coefficients for any particular case-mix factor. The table also shows the average value for total per treatment cost and payment plus several important components of cost and payment.

The average cost per session across all 2,115 freestanding dialysis facilities is \$199.11, while the average payment is \$202.08. Hence, on average, dialysis treatment is slightly profitable for providers as a whole (assuming that providers collect patient copays). The CR accounts for roughly 70 percent of total cost or \$141.16. For CR services, the facilities are paid an average of \$125.02. In contrast, separately-billable services cost an average of \$57.95 while associated payments are \$77.06. Hence, as has been noted elsewhere (Medicare Payment Advisory Commission, 2002), while the CR payment does not cover CR costs, the separately-billable payment exceeds separately-billable costs by enough to more than make up the shortfall.

Among separately-billable services, almost three-quarters of the cost arises from the use of EPO, which costs an average of \$43.11 per treatment and generates an average payment of \$53.74. Non-EPO services also generate payments in excess of costs.

Total facility per treatment cost for the 2,115 freestanding facilities' models, including area wage index and modality,

explain roughly 5 percent of variation in costs across facilities. Once the patient case-mix measures are added, the explanatory power of the model triples to 15 percent. However, for per treatment costs associated with separately-billable services, inclusion of case mix boosts the explanatory power from 2 to 19 percent.

Among components of the separately-billable services, case mix is especially important in explaining variation in EPO costs. Without case-mix measures, the R^2 is just 1 percent. Inclusion of the case-mix measures raises the R^2 to 16 percent.

Table 3 summarizes the results of our analyses of the 748 dialysis facilities providing in-center HD only. The average per treatment cost and payment amounts for these facilities are very similar to those for all freestanding facilities. The product of HD-only facilities is somewhat more homogeneous than that for all freestanding facilities. Hence, one source of variation in cost is eliminated and, not surprisingly, the relative explanatory power of case mix appears even higher for these facilities. The R^2 for total per treatment cost increases nearly four-fold, from 5 to 19 percent. For separately-billable services, case mix explains 23 percent of the variation in cost across dialysis facilities.

DISCUSSION

The necessary conditions for the development of a case-mix adjusted payment system for ESRD include: (1) demonstrated variability in costs and case mix across facilities; (2) a significant and substantial relationship between case mix and facility cost; and (3) an economically feasible system for collecting data, measuring case mix.

The analyses presented in this article document the existence of substantial variability in measures of both costs and patient case mix across dialysis facilities.

The extent of cost and case-mix variability indicates that the failure to adjust for case mix in an expanded outpatient renal PPS could place facilities at substantial financial risk. Any resulting underpayment of facilities that treat high-cost patients could eventually encourage facilities to avoid such patients altogether.

We find that these case-mix measures do explain a substantial fraction of the variation among facilities in per session costs and payments. As a group, they explain a greater fraction of the variation in costs and payments than the wage index and dialytic modality, factors almost certain to be adjusted for by an expanded PPS. Certain variables in the model (e.g., race/ethnicity); coefficients of individual variables are not reported here to focus on overall predictive value of the models, though predictive of costs, may not be considered appropriate for case-mix adjustment. Although three of the four race/ethnicity variables (Asian, black, Native American) are significant at the 5 percent level relative to the reference group (white persons), race/ethnicity contributes only a small proportion of the explained variation in costs per session (R^2 of the full model including race is 0.147; R^2 excluding the race variable is 0.131). Thus, about 90 percent of the model's explanatory power can be attributed to other factors.

This analysis demonstrates the feasibility of at least beginning to build a case-mix adjustment system, using existing administrative data; limitations and suggestions for further research are discussed later. The multivariate models reported here are intended primarily to show that certain groups of predictors (wage index, dialysis modality, and case mix) have the potential to explain variation in costs and payments. The R^2 values reported here are interpretable for such purposes. However, for a

variety of technical reasons, the detailed results from these models should be interpreted with great caution. Notably, correlated measures of patient conditions are included in the models and such redundancies can make the interpretation of individual predictive factors difficult. For example, the list of comorbidities includes a variety of cardiac conditions which are positively and significantly correlated with each other. In these analyses, a comprehensive list of potential predictors of costs and Medicare payments was considered, with no attempt made to develop parsimonious models for these outcomes. Thus, the coefficients of specific predictive factors (not reported here) should be interpreted recognizing the potential for multicollinearity among the factors.

Limitations and Opportunities for Further Research

Ideally, case-mix measurements would be based on accurate, objective, current measures of all relevant patient characteristics (with appropriate severity scales for comorbidity measures) for all patients treated at each facility. While accurate, current, and objective demographic and treatment-related data were available for all patients, comorbidity data were restricted to patients with a medical evidence form (CMS 2728). In addition, clinical conditions indicated in billing data from hospitals, physicians, and other non-dialysis providers should be studied to determine the extent to which these baseline comorbidity data change over time. An alternative source of current comorbidity data could be based on annual administration of Form 2728. However, that would raise other issues due to the possibility that certain comorbidities may themselves be outcomes of the quality of dialysis care

received; that is not an issue with the current Form 2728's administration at the start of dialysis.

Another issue that must be faced before implementing a case-mix adjustment system is the potential that the expanded PPS and any associated case-mix adjustment system could change practice patterns or reporting practices. For example, adding EPO to the prospective bundle would likely reduce dosages relative to the existing system under which EPO can be billed separately. Facilities may choose to administer EPO subcutaneously, which involves discomfort for the patient, but might involve a lower dose than the intravenous route of administration that is prevalent today (Hynes et al., 2002). Both the average payment level in an expanded PPS and the design of a case-mix adjustment system must anticipate, or at least monitor and adjust for, any such changes in practice patterns. Likewise, the completeness of comorbidity reporting will undoubtedly rise if these data are used to set payments. This will necessitate some recalibration of the adjustment formula to account for the new data collection environment. In addition, each case-mix indicator should be evaluated in terms of its potential for "gaming." Factors that are especially subjective, amenable to manipulation, or difficult to verify in an audit, should require substantial justification before they are included in a case-mix adjustment formula. Further, other factors for which data are not currently available, might account for a portion of the remaining, unexplained variation in costs. If such factors can be identified, efforts to collect additional case-mix data on a systematic basis might be justified.

Our study was limited to services currently billed by dialysis providers. To the extent that services now billed by other types of providers (e.g., most separately-

billable laboratory tests, vascular access procedures) are included in an expanded service bundle, further analyses, relating case mix to existing billing data, will be necessary. Finally, as a refinement to the models presented here, it would be useful to estimate separate models for HD and PD patients to determine if each dialysis modality requires a unique case-mix adjustment system.

Overall, we conclude that there is adequate justification for further exploring the development of a case-mix adjustment system for consideration in conjunction with an expanded outpatient renal PPS.

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Reprint Requests: Richard A. Hirth, Associate Professor, University of Michigan School of Public Health, Department of Health Management and Policy, 109 S. Observatory, Ann Arbor, MI 48109-2029. E-mail: rhirth@umich.edu