Case-Mix Adjustment for an Expanded Renal Prospective Payment System

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ABSTRACT

Medicare is considering an expansion of the bundle of dialysis-related services to be paid on a prospective basis. Exploratory models were developed to assess the potential limitations of case-mix adjustment for such an expansion. A broad set of patient characteristics explained 11.8% of the variation in Medicare allowable charges per dialysis session. Although adding recent hematocrit values or prior health care utilization to the model did increase explanatory power, it could also create adverse incentives. Projected gains or losses relative to prevailing fee-for-service payments, assuming no change in practice patterns, were significant for some individual providers. However, systematic gains or losses for different classes of providers were modest.

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Medicare's current payment methodology for outpatient, dialysis-related care is a blend of prospective and fee-for-service approaches. Medicare pays a predetermined composite rate for a specified set of services comprising the basic dialysis treatment. The composite rate is an example of a prospective payment system (PPS) under which providers receive a flat rate for a bundle of services. Generally in a PPS, payments vary across providers and patients as a result of only predetermined adjustments that account for factors such as local wage rates and patient characteristics related to the cost of care but beyond the provider's control. However, the composite rate bundle is far from all-inclusive. Therefore, the dialysis payment system retains a significant element of fee-for-service payment, as dialysis facilities and other providers bill separately for services not covered by the composite rate, primarily injectable medications and laboratory tests.

The Medicare Modernization Act of 2003 mandates that the Centers for Medicare and Medicaid Services (CMS) study the possibility of expanding the scope of prospective renal care payment to include many or all of the dialysis-related services now billed on a fee-for-service basis. This legislation requires CMS to conduct a demonstration project and to submit a report to Congress regarding policy options for such an expanded bundle.

Of separately billable services, erythropoietin (EPO), iron, and vitamin D comprise 95% of Medicare Allowable Charges (MAC) submitted by dialysis facilities. MAC represent the sum of the Medicare payment for a service and the amount for which the patient or the patient's secondary insurer is responsible. As is the case in any PPS, variation in patients' needs for care may create financial risk for providers and compromise access to care for more costly patients. To mitigate these concerns, case-mix adjustment increases payments to facilities treating more costly patients. If unacceptable risk remains after the implementation of a feasible case-mix adjustment system, policy makers may seek to supplement case-mix adjustment with additional

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measures, such as targeting higher payments for patients with unusually high costs ("outlier" cases).

The work presented here builds on prior research on case-mix adjustment for Composite Rate services.[1–3] This previous research underlies the basic case-mix adjustment for the Composite Rate that was implemented on April 1, 2005. A key difference between the case-mix adjustment research for Composite Rate services and the current research for separately billable services is the unit of analysis. Data on the actual costs of delivering Composite Rate dialysis services are unavailable at the patient level. Therefore, the previous research related facility-level costs to characteristics of the facility's patient population. For separately billable services, Medicare claims provide patient-specific proxies for resource use, allowing the estimation of the relationship between separately billable resource use and case-mix at the patient level. Hirth *et al.* estimated case-mix relationships for separately billable resource use,[1] but the analysis was performed at the facility level, only used case-mix variables measured at onset of ESRD, and did not explore prior healthcare utilization as a predictor. The authors concluded that there exists "adequate justification for further exploring the development of a case-mix adjustment system for consideration in conjunction with an expanded outpatient renal PPS".[1]

The selection of a case-mix adjustment model must balance several policy objectives (*e.g.*, maintaining transparency, avoiding the creation of adverse incentives or opportunities to exploit the payment system, and minimizing administrative burdens). Therefore, the purpose of this paper is to inform policy makers and dialysis providers about the current state of research on case-mix adjustment for an expanded bundle. This research illustrates the potential predictive accuracy and limitations of case-mix adjustment, but is not intended to propose a specific model.

First, we determine how accurately MAC can be predicted using available data. For each patient, MAC are predicted with error, and the magnitude of error reflects how facilities' revenues would change under a case-mix adjusted PPS. Some sources of prediction error are more problematic than others. For example, prediction errors arising from unmeasured patient characteristics that are stable over time will lead to persistent gains or losses for the facility treating the patient. Such gains or losses will tend to average out across a facility's patient population, but may remain substantial for small facilities or facilities drawing patients from atypical populations. Conversely, prediction errors arising from random fluctuations in utilization over time, or from discretionary practice patterns that could be modified in response to a PPS, may not create substantial financial risks.[4] Second, we highlight issues that must be resolved during the implementation phase. Third, we explore tradeoffs in moving from the preliminary models developed here to a more parsimonious model that may be desirable for use in the demonstration project or the payment system.

We posed three research and policy questions:

1. How much does resource utilization vary across patients, and how much of this variation can be explained by patient characteristics?
2. How much would Medicare payments to dialysis facilities change under a simulated, case-mix–adjusted expanded bundle? The simulated system leaves aggregate payments unchanged, but individual facilities could gain or lose revenue.
3. What are the practical tradeoffs involved in implementing case-mix adjustment, included feasibility, administrative burden, predictive power, and incentives?

RESULTS

Total MAC and MAC per dialysis session for items in the expanded bundle are reported in Table 1. These services account for $1.2 billion from July to December 2003, representing an average MAC of $97.36 per dialysis session. Drugs used for anemia management (EPO and iron) accounted for 73% of the total charge. Individual hemodialysis (HD) patients received varying levels of services. MAC were <$28.04 per session for 5% of patients and <$55.42 for 25% of patients, and were >$122.19 per session for 25% of patients and >$221.76 per session for 5% of patients (*i.e.*, the 5th, 25th, 75th and 95th percentiles, respectively).

Table 2 describes variables used in the ordinary least squares (OLS) regression models and indicates the set of predictor

Table 1. Bundle definitions: Total MAC and MAC/session for each bundle component from July through December 2003[a]

Item	Total $ (millions)	Total $ (millions) Capped	MAC/Session	SD
EPO[b]	$ 737	$ 717	$58.87	$51.33
Iron	$ 141	–	$11.52	$11.90
Vitamin D	$ 197	–	$16.03	$18.92
Other injectables[c]	$ 33	–	$ 2.65	$ 9.24
Labs[d]	$ 91	–	$ 7.48	$ 6.23
Other services[e]	$ 10	–	$ 0.81	$ 3.43
Total[f]	$1,209	$1,190	$97.36	$61.25

[a]EPO, erythropoietin; MAC, Medicare allowable charges. Outer fence definition: Average MAC/session < Q1 − (3 × IQR) or mean MAC/session > Q3 + (3 × IQR).
[b]EPO MAC/session is capped at $300/session.
[c]Includes injectables other than EPO, iron, and vitamin D that were built by dialysis facilities only. Items include darbepoetin alfa, levocarnitine, hepatitis B vaccine, flu vaccine, heparin sodium, filgrastim, alteplase recombinant, other antibiotics (cefazolin NA, ceftriaxone NA, ceftazidime), vancomycin, and other drugs.
[d]Includes laboratory services that were either billed by dialysis facilities or billed by freestanding laboratory suppliers and ordered by physicians who received Medicare capitation payments for treating ESRD patients.
[d]Includes services other than EPO, iron, vitamin D, other injectables, and labs that were built by dialysis facilities (*ie*, syringes and other supplies).
[f]Excludes patients with outliers for mean MAC/session for the bundle.

Table 2. Descriptive statistics for Medicare hemodialysis patients, July to December 2003 ($n = 231,742$)

Variable	Mean or Proportion	SD
Demographics		
age		
<18 yr	0.0014	–
18 to 44 yr	0.1172	–
45 to 59 yr	0.2240	–
60 to 69 yr	0.2390	–
70 to 79 yr	0.2756	
>80 yr	0.1427	–
18 to 44, female	0.0475	–
female	0.4703	–
race		
Asian	0.0220	–
black	0.3529	–
Native American	0.0145	–
white	0.5662	
other	0.0400	–
unknown/missing	0.0044	–
Hispanic ethnicity	0.1255	–
Time since start of RRT		
started RRT during month	0.0249	–
1 previous month of RRT	0.0355	–
2 previous months of RRT	0.0260	–
3 previous months of RRT	0.0287	–
4 previous months of RRT	0.0230	–
5 previous months of RRT	0.0226	–
6 previous months of RRT	0.0208	–
7 previous months of RRT	0.0204	–
8 previous months of RRT	0.0193	–
9 previous months of RRT	0.0181	–
10 to 12 previous months of RRT	0.0506	–
2nd year of RRT	0.1765	–
3rd year of RRT	0.1446	–
3 yr or more of RRT	0.3889	
Body size		
underweight[a]	0.0434	–
weight (kg)	76.1180	17.6316
Baseline hematocrit		
hematocrit (2728)	29.3339	5.4695
Functional status and comorbidities		
inability to ambulate (2728)	0.0269	–
inability to transfer (2728)	0.0079	–
current smoker/tobacco use (2728)	0.0517	–
alcohol dependence within 1 yr	0.0666	–
drug dependence within 1 yr	0.0250	–
cardiac arrest within 1 yr	0.0204	–
congestive heart failure within 1 yr	0.3735	–
cardiac dysrhythmias within 1 yr	0.2660	–
ischemic heart disease within 1 yr	0.3534	–
pericarditis within 1 yr	0.0128	–
cerebrovascular disease within 1 yr	0.2297	–
diabetes (primary or contributing) within 1 yr	0.2718	–
peripheral vascular disease within 1 yr	0.3388	–
chronic obstructive pulmonary disease within 1 yr	0.2241	–
AIDS within 1 yr	0.0160	–
HIV positive status within 1 yr	0.0125	–
aspiration and specified bacterial pneumonias within 6 mo	0.0247	–
hepatitis B within 1 yr	0.0391	–
other hepatitis from 1999 to 2002	0.1414	–
opportunistic infections within 6 mo	0.0083	–
pneumococcal pneumonia, emphysema, lung abcess within 6 mo	0.0141	–
septicemia/shock within 6 mo	0.1521	–
other infections within 6 mo	0.2725	–
gastro-Intestinal tract bleeding within 6 mo	0.0222	–
GI ulcer (no hemorrhage within 6 mo)	0.0354	–
esophogeal varices within 6 mo	0.0025	–
acquired hemolytic anemias within 1 yr	0.0160	–
hereditary hemolytic anemias from 1999 to 2002	0.0210	–
sickle-cell anemia from 1999 to 2002	0.0038	–
other anemias within 2 yr	0.0000	–
leukemia within 1 yr	0.0054	–
lung, upper digestive tract, and other severe cancers within 1 yr	0.0126	–
lymphatic system, head, and other major cancers within 1 yr	0.0005	–
lymphoma within 2 yr	0.0065	–
metastatic cancers within 1 yr	0.0130	–
multiple myeloma within 1 yr	0.0074	–
other cancers within 1 yr	0.0722	–
hyperparathyroidism within 1 yr	0.1714	–
monoclonal gammopathy within 1 yr	0.0083	–
myelofibrosis within 1 yr	0.0007	–
myelodysplastic syndrome	0.0132	–
age < 45 yr, with cardiovascular disease (cardiac arrest, congestive heart failure, cardiac dysrhythmias, pericarditis)	0.0426	–
age < 45 yr, with infection (aspiration and specified bacterial pneumonias, opportunistic infections, septicemia/shock)	0.0206	–
age < 45 yr, with sickle-cell anemia or leukemia or monoclonal gammopathy, myelofibrosis	0.0015	–
Previous hospitalization		
inpatient hospital admissions, previous month	0.2107	–
days in hospital, previous month	1.8971	4.1672

[a]Body mass index < 18.5.

Table 3. Comparison of SD of predicted and unpredicted variation using 6-month pooled data (July to December 2003)

Model	Case-Mix Adjustors	R^2 (%)	SD of Predicted MAC/Session	SD of Prediction Error
1	Demographics (age, race, sex)	2.81	10.27	60.38
2	Add time since start of renal replacement therapy	4.68	13.25	59.80
3	Add body size	5.52	14.39	59.54
4	Add baseline hematocrit	6.50	15.62	59.23
5	Add functional status and comorbidities (with 3 age–comorbid interaction terms)	11.75	21.00	57.54
5a	Add functional status and comorbidities and use more recent Hct measure (with 3 age–comorbid interaction terms)	16.06	24.55	56.12
6	Add previous hospitalization (with 3 age–comorbid interaction terms)	15.23	23.90	56.39

The standard deviation of MAC/session is $61.25.

variables used in each model. Model fit statistics appear in Table 3. The discussion will focus primarily on Model 5, which uses the broadest available set of patient characteristics, but no measures of prior healthcare utilization. Complete OLS results for Model 5 appear in Table 4.

Predicting Dialysis-Related Costs

The first five models explore the ability of different types of patient characteristics to predict MAC per session. Starting with patient demographics ($R^2 = 2.8\%$ in Table 3), predictive power increases with the addition of time after start of renal replacement therapy (RRT) ($R^2 = 4.7\%$), body size ($R^2 = 5.5\%$), baseline (start of RRT) hematocrit ($R^2 = 6.5\%$), and functional status and comorbidity indicators ($R^2 = 11.8\%$). The SD of MAC per session was $61.25 in the fee-for-service payment system that prevailed in 2003 (Table 3). On the basis of Model 5, the SD of predicted charges is $21.00, leaving the SD of the unpredicted variation at $57.54.[1] Total variance is the square of the SD of MAC per session, which equals the sum of the square of the predicted SD and the square of the unpredicted SD (*e.g.*, in Model 5: $\$61.25^2 = \$21.00^2 + \$57.54^2$). The SD of predicted MAC represents the variation in payments across patients if Model 5 were used as a case-mix adjuster. The unexplained variation implies that payments for many patients would change substantially relative to the existing fee-for-service system. The extent to which this unexplained variation in resource use has implications for patient care or for facilities' financial risk under an expanded bundle depends on the efficiency with which care is provided under the fee-for-service system, as well as on other factors discussed below.

Given that Model 5 uses a broad set of patient characteristics available in current CMS data, improving the predictive power of the model will require additional sources or types of information. Without the collection of additional patient data not currently available to CMS, two possibilities exist: The first is to supplement comorbidity data with more proximate laboratory measures, such as recent hematocrit values; the second is to use measures of prior utilization of other healthcare services that plausibly predict future use of separately billable services. Models 5A and 6 provide examples of these two approaches to enhance explanatory power. Model 5A is identical to Model 5 except that the baseline (start of RRT) hematocrit is replaced by the average hematocrit 6 to 8 mo prior, raising r^2 to 16.1% (*versus* 11.6% in Model 5). Model 6 adds the hospitalization measures to Model 5, raising R^2 to 15.2%.

Given the large sample size, it is not surprising that many patient characteristics had statistically significant relationships to MAC per session (Table 4). Furthermore, a number of these factors had substantial impacts on predicted costs. To highlight a few, costs were particularly high during the first 3 mo of dialysis ($27 to $33 higher per session than patients who had been receiving RRT for > 3 yr). Similarly, costs were elevated for patients suffering from infections, hematologic conditions, and bleeding disorders, with costs often >$20 higher per session than those of patients without these conditions. Many of these conditions plausibly increase the need for anemia management.

Facility Financial Risk

We simulated the impact on facilities' revenues by comparing payments they actually received from July through December 2003 to projected payments under a PPS using Model 5 to adjust for case-mix. Although this simulation holds average payments constant, individual facilities or types of facilities may gain or lose revenue. The model's prediction error (predicted payment minus actual payment) measures the gain or loss in revenue for each patient; facilities would gain or lose revenue for each patient for whom the prediction error is positive or negative, respectively. To assess the revenue impact, these gains and losses are aggregated across all dialysis sessions delivered by a facility, and across all facilities of a particular type.

Table 5 illustrates the distribution of the prediction errors from Model 5 averaged across all Medicare patients treated at each specific dialysis facility. The majority of facilities (54.8%) would experience a gain in MAC per session, whereas the remaining 45.2% would experience a loss. The simulated per-session gain or loss was <$15 for the majority (52.4%) of facilities. A smaller proportion of facilities (16.9%) would experience gains or losses >$30 per session.

Systematic revenue gains or losses for different classes of facilities were modest (Table 6). The largest simulated gain occurred in rural facilities, whose revenues per session would have risen by an average of $2.95 per session. Hospital-based facilities experienced the greatest simulated loss ($3.96 per session).

Table 4. Regression coefficients for case-mix adjusted bundle (Model 5)

Model 5 Mean MAC/session: $97.36 ($R^2$: 0.1175)			
	Coefficient ($/Session)	t	P
Demographics			
age			
<18 yr	6.69	1.89	0.0585
18 to 44 yr	6.06	9.42	<0.0001
45 to 59 yr	8.55	23.78	<0.0001
60 to 69 yr	4.85	14.23	<0.0001
70 to 79 yr	−3.76	−9.41	<0.0001
>80 yr	–	–	n/a
18 to 44, female	6.81	8.95	<0.0001
female	5.07	19.22	<0.0001
race			
Asian	−2.99	−3.74	0.0002
black	11.11	39.93	<0.0001
Native American	−4.70	−4.66	<0.0001
white	−1.15	−1.84	0.0657
other	2.85	1.65	0.0991
unknown/missing	–	–	n/a
Hispanic ethnicity	−5.67	−14.51	<0.0001
Time since start of RRT			
started RRT during month	26.99	10.76	<0.0001
1 previous month of RRT	32.51	16.95	<0.0001
2 previous months of RRT	33.28	14.6	<0.0001
3 previous months of RRT	19.50	8.83	<0.0001
4 previous months of RRT	8.31	3.11	0.0019
5 previous months of RRT	8.79	3.16	0.0016
6 previous months of RRT	−2.28	−0.76	0.4477
7 previous months of RRT	−5.91	−1.9	0.0573
8 previous months of RRT	−3.37	−1.04	0.2974
9 previous months of RRT	−6.54	−2.04	0.0416
10 to 12 previous months of RRT	−6.76	−6.44	<0.0001
2nd year of RRT	−6.92	−18.99	<0.0001
3rd year of RRT	−5.28	−13.49	<0.0001
3 yr or more of RRT (reference)	–	–	n/a
Body size			
underweight[a]	2.22	3.51	0.0004
weight (kg)	0.38	49.07	<0.0001
Baseline hematocrit			
hematocrit (2728)	−1.14	−51.09	<0.0001
Functional status and comorbidities			
inability to ambulate (2728)	2.03	2.33	0.02
inability to transfer (2728)	−2.37	−1.46	0.1439
current smoker/tobacco use (2728)	−3.57	−6.54	<0.0001
alcohol dependence within 1 yr	5.96	11.65	<0.0001
drug dependence within 1 yr	10.48	13.14	<0.0001
cardiac arrest within 1 yr	15.28	12.92	<0.0001
congestive heart failure within 1 yr	3.17	9.57	<0.0001
cardiac dysrhythmias within 1 yr	4.89	14.24	<0.0001
ischemic heart disease within 1 yr	−0.61	−1.83	0.0676
pericarditis within 1 yr	15.89	13.3	<0.0001
cerebrovascular disease within 1 yr	3.57	10.48	<0.0001
diabetes (primary or contributing) within 1 yr	−1.99	−4.79	<0.0001
peripheral vascular disease within 1 yr	4.00	12.76	<0.0001
chronic obstructive pulmonary disease within 1 yr	5.30	15.26	<0.0001
AIDS within 1 yr	4.44	3.86	0.0001
HIV positive status within 1 yr	10.07	8.11	<0.0001
aspiration and specified bacterial pneumonias within 6 mo	14.17	13.2	<0.0001

Table 4. Continued

Model 5 Mean MAC/session: $97.36 ($R^2$: 0.1175)			
	Coefficient ($/Session)	t	P
hepatitis B within 1 yr	1.21	1.59	0.1127
other hepatitis from 1999 to 2002	−3.73	−9.64	<0.0001
opportunistic infections within 6 mo	24.86	13.82	<0.0001
pneumococcal pneumonia, emphysema, lung abcess within 6 mo	15.36	11.42	<0.0001
septicemia/shock within 6 mo	18.81	40.33	<0.0001
other infections within 6 mo	7.53	20.06	<0.0001
gastrointestinal tract bleeding within 6 mo	27.93	26.09	<0.0001
GI ulcer (no hemorrhage within 6 mo)	12.00	14.26	<0.0001
esophogeal varices within 6 mo	38.31	12.53	<0.0001
acquired hemolytic anemias within 1 yr	7.61	6.76	<0.0001
hereditary hemolytic anemias from 1999 to 2002	10.61	12.55	<0.0001
sickle-cell anemia from 1999 to 2002	17.70	8.3	<0.0001
other anemias within 2 yr	87.23	1.57	0.1166
leukemia within 1 yr	12.77	6.42	<0.0001
lung, upper digestive tract, and other severe cancers within 1 yr	12.23	9.56	<0.0001
lymphatic system, head, and other major cancers within 1 yr	2.70	0.42	0.6728
lymphoma within 2 yr	11.54	6.78	<0.0001
metastatic cancers within 1 yr	10.80	8.52	<0.0001
multiple myeloma within 1 yr	21.36	11.3	<0.0001
other cancers within 1 yr	8.13	14.88	<0.0001
hyperparathyroidism within 1 yr	0.44	1.09	0.2776
monoclonal gammopathy within 1 yr	7.25	4.56	<0.0001
myelofibrosis within 1 yr	41.71	5.94	<0.0001
myelodysplastic syndrome	31.10	27.66	<0.0001
age < 45 yr, with cardiovascular disease (cardiac arrest, congestive heart failure, cardiac dysrhythmias, pericarditis)	11.19	12.66	<0.0001
age < 45 yr, with infection (aspiration and specified bacterial pneumonias, opportunistic infections, septicemia/shock)	10.80	8.57	<0.0001
age < 45 yr, with sickle-cell anemia or leukemia or monoclonal gammopathy, myelofibrosis	22.76	5.93	<0.0001

[a]Body mass index < 18.5.

DISCUSSION

This ongoing research can inform the development of a case-mix adjustment system for the upcoming demonstration of an expanded bundle for dialysis-related services, and possibly for broader implementation.

A number of available measures had strong associations with MAC per session, and case-mix adjustment could account for them. The predictive power of a model that included a broad set of patient characteristics (11.8% in Model 5; 16.1% in Model 5A) is modest, but comparable to studies that have explored risk adjustment for other clinical conditions. Other studies using similar, claims-based, diagnosis measures often explain 5% to 15% of the variation in medical costs.[11–13]

Two recent studies explain a higher percentage of cost variation than most of the prior literature and are particularly relevant to the current work. First, the model underlying the case-mix adjustment for Composite Rate dialysis services achieved an R^2 of 0.36. However, because of the lack of patient-level data on the costs of Composite Rate services, that model related average costs at the facility-level to average patient characteristics and a set of facility control variables (*e.g.*, hospital-based *versus* free-standing). The vast majority of the explanatory power of the Composite Rate model was derived from the control variables; the patient measures upon which payments are based added only about 0.02 to the R^2.[14] Therefore, the R^2 of 0.118 in Model 5 actually indicates a greater contribution of patient characteristics. Facility controls were excluded from the models reported here because they did not substantially improve the explanatory power (R^2 increased by about 0.01), and the case-mix coefficients were insensitive to their inclusion.

Second, the risk-adjustment model for the Medicare Part D prescription drug benefit achieved an R^2 of 0.23 with the inclusion of demographics, disability, metropolitan status, census region, and 130 clinical conditions.[15] The higher predictive power of the Part D drug model probably exists for two reasons. First, the number of case-mix measures used in the Part D model (>100) dwarfs the number in our models. A large number of adjusters may be feasible in the context of setting annual capitation rates paid to insurers, but would likely create onerous tracking and reporting requirements for dialysis facilities

Table 5. Number of facilities at each interval of prediction error (Model 5)

Range of gain or loss	*n*	%
−$30	355	8.77
−$29.99 to −$15	487	12.03
−$14.99 to $0	986	24.36
$0.01 to $15	1136	28.06
$15.01 to $30	755	18.65
>$30	329	8.13
Total	4048	100

filing monthly claims. Second, whereas almost all dialysis patients are chronic recipients of anemia management drugs, and vitamin D, and undergo various laboratory studies, many patients in the general Medicare population use few, if any, prescription drugs (19.4% had <$250 annual spending) compared to very high burdens faced by many others (30.7% spend >$2000 annually). Therefore, clinical measures that correlate with whether a general Medicare enrollee is in the "quite healthy" subset *versus* the "quite sickly" subset should explain a great deal of the variation in the data.

The data available for developing risk adjusters have limitations. Predictive accuracy improved by including measures related to recent hematocrit values or prior healthcare utilization. However, adjusting payments for these factors could create inappropriate incentives. Using recent hematocrit values would pay more to facilities that have worse outcomes. The baseline hematocrit measure in Model 5, although less predictive, is not a result of the care delivered by the dialysis facility. Similarly, paying dialysis units more after a hospitalization may encourage inappropriate admissions or even indirectly reward dialysis complications.

At the patient level, substantial unpredicted variation in MAC per session remained, even in the most predictive models. At the facility-level, some providers would experience large payment changes relative to the current system. Therefore, expanding the PPS to include additional injectable medications, laboratory tests, and other services may impose financial risk on some facilities and may compromise access to care for patients whose care is more costly than predicted. Payments for these additional services typically account for about 40% of Medicare payments to dialysis facilities (services already paid prospectively under the Composite Rate account for the other 60%). However, to the extent that providers respond to a new payment system by changing practice patterns, these simulated payment changes may represent an upper limit on the true risk in actual practice.

In terms of the redistribution of payments across classes of facilities, hospital-based dialysis units are the only class that, on average, would lose >$2 per treatment if paid under a case-mix–adjusted PPS rather than the existing system. Rural and small facilities are the only classes that, on average, would gain >$2 per treatment. Those classes that are relatively low users of services tend to gain under an expanded bundle, whereas those who are relatively high users tend to lose. A recent paper examined the percentage of patients who exceed hemoglobin targets and the percentage of patients above target whose EPO dose was appropriately reduced.[16] Dosing protocols appeared to vary substantially by dialysis chain and between hospital-based and free-standing facilities. This is consistent with the cost patterns demonstrated here, and suggesting that discretionary practice patterns are an important determinant of which classes of facilities gain or lose.

Importantly, the simulated gains and losses are relative to the existing fee-for-service system. As suggested earlier in the context of different types of prediction error, fee-for-service resource use that is higher or lower than predicted may or may not reflect variation in efficient levels of care. Indeed, one of the motivations for bundling more services into a PPS is to reduce the incentives for inefficient care. The upcoming expanded bundle demonstration will perhaps provide more information on whether changes in utilization follow the institution of a case-mix–adjusted PPS.

Reported dosing variations across chains and locations (hospital-based *versus* free-standing), including the finding that the most conservative practices occurred in a nonprofit chain, are consistent with the likelihood that discretionary practices respond to economic incentives.[16] To ensure that quality is maintained or enhanced under an expanded bundle, other policy options should be evaluated to address limitations of case-mix adjustment models. These include outlier payment mechanisms, pay-for-performance systems rewarding achievement of quality goals, and mixed payment models blending fee-for-service and prospective approaches. For example, a mixed payment system could provide a fixed payment for each patient that is smaller than the fixed payment under a fully prospective system, plus an incremental payment based on services delivered but at a lower rate than would prevail under a pure fee-for-service system. Such policy options could mitigate incentives to undertreat or avoid more costly patients.

Additionally, Medicare claims represent allowable charges, which are only a proxy for the actual cost of hiring the inputs required to deliver services. For example, if MAC exceed drug acquisition costs plus associated administration and documentation costs, charges would overestimate costs actually incurred by facilities. Conversely, if personnel costs associated with administering drugs and laboratory tests are higher for certain types of patients, this would not be directly reflected in the available charge-based data. Thus, MAC per session reflects factors that lead to some patients' using more services, but not factors that make caring for some patients the most costly *given* the amount of drugs and labs they use. Likewise, these historical data reflect prices and practices prevailing in 2003 in a different payment environment (fee-for-service) than the one being proposed (case-mix–adjusted PPS). Utilization in 2003 could be "re-priced" to reflect changes in Medicare payment rates since that time. However, practice patterns may also have changed in response to changes in the pricing of injectable medications that took effect in 2005 and may change further

Table 6. Impact analysis for case mix adjusted bundle (Model 5)

	Location		Type		Affiliation		Facility Size (# Medicare Dialysis Sessions)		
	Rural (n = 1039)	Urban (n = 3009)	Hospital-Based (n = 428)	Free-Standing (n = 3620)	Chain (n = 3116)	Nonchain (n = 932)	<5K (n = 1417)	5K to 10K (n = 1577)	>10K (n = 1054)
Actual MAC/session	$94.10	$98.16	$99.53	$97.06	$97.84	$95.80	$94.30	$95.94	$99.31
Predicted MAC/session	$97.05	$97.44	$95.57	$97.61	$97.51	$96.88	$97.16	$97.06	$97.66
Average predicted gain/loss	$ 2.95	−$ 0.72	−$ 3.96	$ 0.55	−$ 0.33	$ 1.08	$ 2.86	$ 1.12	−$ 1.65
Std Dev of predicted gain/loss	$19.57	$22.32	$37.68	$18.88	$18.83	$29.29	$15.52	$20.24	$29.33

under a PPS.[17] Therefore, CMS should update the models and monitor practice patterns. Under a PPS, payment would no longer depend on actual utilization, so monitoring may have to rely partly on data other than Medicare claims.

Some comorbidities may prove difficult to collect. Diagnoses reported on the Medical Evidence Report or Medicare claims may be incomplete or measured with error, and cannot directly measure severity. Furthermore, prevalence varies with the length of the "look-back" period (*e.g.*, diagnoses on claims filed in the last year *versus* the last two years). Ideally, the prevalence and severity of comorbidities identified for this model-building exercise would be comparable to what facilities would report under a bundled payment system. For subjectively defined conditions or conditions for which severity varies greatly, reporting could increase. Because the comorbidity measures accounted for nearly half of the explanatory power of Model 5, addressing reporting issues will be important. Further research could explore models that eliminate comorbidities that providers and policy-makers believe to be most problematic. Implementation would likely require facilities to collect and report case-mix measures on their claims. This requirement would create a new administrative burden for facilities, at least partially offsetting administrative efficiencies from not having to submit claims for each service.

A practical case-mix adjustment system would likely use fewer variables than were included in these models. Further research is required to develop a model that focuses on a smaller set of variables that can be measured most objectively, have the most predictive power, and are politically acceptable as payment adjusters (*e.g.*, race may not be an acceptable adjuster). CMS would have to balance the resulting burden of the reduction in data collection against the reduced explanatory power of a more parsimonious model.

In summary, the models presented here identify a variety of patient characteristics that have strong and significant relationships to the costs of separately billable, dialysis-related services. These services, primarily injectable medications and laboratory tests, may soon be included in an expanded bundle of dialysis-related services paid on a prospective basis. If so, such a case-mix model would become necessary to ensure access to care and mitigate financial risks to dialysis providers under prospective payment. However, despite the large number of significant predictors of costs, the predictive power of a feasible case-mix adjustment model is modest, and some providers would face substantial changes in their payments. Therefore, it may be useful for policy makers to develop mechanisms such as outlier payments for use in conjunction with a case-mix adjustment model.

CONCISE METHODS

Bundle Definition and Data Source

The dependent variable in our analyses is MAC for a bundle of services provided by dialysis facilities and their affiliates to individuals receiving chronic dialysis under Medicare's ESRD payment system. For most services in the expanded bundle, Medicare pays 80% of MAC, with the patient or the patient's secondary insurer being responsible for the remaining 20%. The main exception is laboratory tests, for which Medicare pays 100% of MAC, resulting in no patient obligation. Because MAC are based on quantity and type of services delivered, MAC serve as a patient-level cost measure. However, to the extent that allowable charges differ from the actual cost of the resources used to provide them (*e.g.*, drug acquisition costs and the cost of labor associated with drug administration), MAC would measure costs imperfectly.

The bundle selected for this research includes EPO, injectable iron, vitamin D, and other selected injectable medications, as well as selected, separately billable laboratory tests (those most commonly provided to dialysis patients). Details on the bundle definition appear under Services Included in the Expanded Bundle Definition. Although the bundle definition chosen by CMS for implementation may differ, the definition used here will likely capture most of the potential components of an expanded bundle.

MAC for services in this bundle were obtained from 2003 Medicare claims files for all HD patients with Medicare as the primary payer (231,742 patient-/facility-level observations). For HD patients who also received peritoneal dialysis during the study period, the number of HD-equivalent sessions was calculated by multiplying the reported number of peritoneal dialysis days by 3/7.

Patient Characteristics for Risk Adjustment

Measures of patient characteristics are derived from the ESRD Medical Evidence Report (CMS Form 2728) and/or Medicare claims. These characteristics include demographics (age, sex, and race), time after start of RRT, body size at start of RRT (weight in kg), malnutri-

tion (body mass index <18.5 kg/m^2), hematocrit, clinical comorbidities, and functional status. Although comorbidities reported at start of RRT on the CMS Form 2728 predict mortality,[5–7] there is also evidence of underreporting.[6–10] In addition, this form does not capture changes in patient condition after initiation of RRT. Therefore, clinical comorbidity measures were based on diagnosis codes reported on Medicare inpatient, skilled nursing facility, outpatient, hospice, home health, and physician claims covering a specified period of time. For acute conditions, these claims-based measures were limited to recent diagnoses (*e.g.*, during the previous 6 mo only). Longer periods were used for chronic conditions. Preliminary analyses tested several "look-back" periods (*e.g.*, diagnoses in the last year *versus* the last two years *versus* the last five years) to determine their ability to predict MAC. For each comorbidity, the look-back period with the strongest bivariate relationship to MAC was used in the subsequent multivariate models. Diagnoses reported on laboratory claims were not used because such diagnosis codes may represent a condition being evaluated rather than an established diagnosis. Interactions between key variables were also explored, and the focal model in this paper includes four interaction terms.

To explore the extent to which measures of prior health care utilization can enhance predictive power, we used the number of hospital admissions and hospital days in the prior month. Hospital utilization may reflect temporarily high care needs or the need to "catch up" for drugs or lab tests missed while the patient was hospitalized.

MAC per session were averaged over 6 mo to limit the effects of transient variations for a given patient. Such variations can arise from fluctuations in drug doses around long-run average doses or systematic scheduling of laboratory tests (*e.g.*, tests performed quarterly). These types of variations would be hard to predict on the basis of a set of relatively fixed patient characteristics. Furthermore, more expensive and less expensive months would offset each other, leading to little financial risk. Financial risk to facilities is a greater concern when the cost of caring for some patients *consistently* exceeds the cost predicted by the model.

Because the number of sessions during the observation period varied across patients, each observation was weighted by sessions. Patient characteristics that can vary across months (*e.g.*, some comorbidities, hospitalization) were summarized over a 6-mo period as an average of their values across months for which the patient had dialysis claims, weighted by the number of sessions in each month.

Potential Risk-Adjustment Models

Seven OLS regression models were estimated to predict MAC per session for the defined bundle of services. The first model included only patient demographics as explanatory variables. Each successive model added another set of measures. Models 5 and 5A are identical except for the hematocrit measure; Model 5 uses hematocrit at the start of RRT, whereas Model 5A uses the average hematocrit value 6 to 8 mo prior to the start of RRT.

For each dialysis facility, MAC in the fee-for-service system were compared with MAC predicted by the case-mix adjustment model. This analysis simulates the impact on revenues for individual dialysis providers as well as classes of providers (rural *versus* urban, hospital-based *versus* freestanding, chain *versus* independent, <5000 treatments annually *versus* 5000 to 9999 treatments *versus* $>10{,}000$ treatments). These simulations are static in the sense that they assume no changes in practices in response to the introduction of a PPS. Therefore, they are likely to represent an upper limit on the potential risk to facilities.

Services Included in the Expanded Bundle Definition

The expanded bundle definition that was used for the case-mix analyses primarily consists of injectable medications that are commonly provided to Medicare dialysis patients on an outpatient basis. These injectables include EPO (epoetin alfa, darbepoetin alfa), iron (iron dextran, iron sucrose, sodium ferric gluconate), vitamin D (calcitriol, doxercalciferol, paracalcitol), levocarnitine, alteplase (recombinant), vancomycin, hepatitis B vaccine, flu vaccine, cefazolin sodium, ceftriaxone sodium, ceftazidime, heparin sodium, filgrastim, and other injectables. Monthly MAC for epoetin alfa were capped at $300 per session (1.96% of months) to prevent individual outliers that represent highly unusual and potentially erroneous EPO doses ($>30{,}000$ units per session) from being overly influential in estimating case-mix coefficients. MAC for these injectable medications account for 91.61% of MAC for all services in the expanded bundle definition, with the EPO, iron, and vitamin D products alone accounting for 88.92% of total MAC.

The expanded bundle definition also includes a set of outpatient laboratory services that are billed for Medicare dialysis patients. Included are laboratory services that were either billed by dialysis facilities on Medicare outpatient institutional claims or billed by freestanding laboratory providers on Medicare carrier claims and ordered by physicians who received monthly Medicare capitation payments for treating ESRD patients. The expanded bundle definition therefore includes a relatively comprehensive set of dialysis-related lab tests covered by Medicare. Together, the laboratory services account for 7.56% of MAC. Many of these lab tests are related to the use of the separately billable injectables that are also included in the expanded bundle definition. Lastly, the remaining 0.83% of total MAC correspond to other types of services that were billed by dialysis facilities (*e.g.*, syringes and other supplies).

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DISCLOSURES

None.

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