Preliminary
Case-mix Analyses

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Pre-requisites to Case-mix Adjustment

- What services should be in the bundle?
- How frequently or at what dose should each service in a bundle be reimbursed?
  - Historical use
  - Specification of appropriate care
- What is the unit of payment (month vs. session)?

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These questions need to be answered before developing a final case-mix adjustment.

Since a bundle has not yet been selected, we have performed preliminary analyses for two of the example bundles to help us address these questions.

Case-mix

- **How should utilization be measured?**
  - **Historical payments (dollars)**
  - **Units of service (e.g., dose or frequency)**
- **How should payments be adjusted?**
  - **Baseline patient characteristics**
  - **Case-mix measures that are updated over time**
  - **Prior utilization for each patient**
  - **Other issues**
- **Should separate models for each component (disaggregated) or an aggregated model be used?**
- **Should there be separate adjustments for each dialysis modality (HD, PD)?**

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Payment based on dose or frequency allows prices to be set externally for each service. For example, the new prices applied to selected injectable medications as of January 1, 2005, could be applied in conjunction with historical utilization data to simulate MACs under current payment policies. Updated case-mix measures or prior utilization history have the potential to better predict current costs. However, they also have the potential of themselves being consequences of the dialysis-related treatment delivered, creating the possibility of undesirable incentives in the payment system (rewarding facilities for poor outcomes reflected in worsening case-mix measures or for high prior service utilization). Component models could help to establish the clinical face validity of the results, but at the cost of increased complication in explaining that the final case-mix adjustment results from a weighted average of the coefficients from the component models. Because MACs for separately billable services are available at the patient level while costs for CR services are available only at the facility level, a two component approach that combines the coefficients from a patient-level case-mix model for the components of the expanded bundle with the coefficients from the facility-level case-mix model for CR costs could be undertaken. Finally, separately billable costs are considerably lower for PD than for HD. Therefore, setting separate payment levels and case-mix adjustments by modality will better reflect costs, whereas an expansion of the "composite rate approach" of paying both modalities at the same rate and with the same adjustments would provide an economic incentive to deliver PD.

Post-implementation Issues

- **What issues are likely to arise upon implementation?**
  - **Potential substitutes for services in the bundle**
  - **Substitution of services by non-dialysis providers**
  - **Data collection for case-mix adjustment**
  - **Other issues**
- **How should the payment system be updated without itemized bills?**
- **How should we assure quality (delivery) of care without itemized bills?**

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The choice of services to include in the demonstration bundle will itself create new economic incentives. If some services included in the bundle have close substitutes that remain separately billable (e.g., other injectable drugs that can treat the same condition), facilities will have an incentive to use the latter. Similarly, if non-dialysis providers can continue to bill separately for a service in the bundle (i.e., would not have to do it under arrangement with a dialysis facility), there would be an incentive to provide the service outside the dialysis setting. Other issues arise relative to data collection. Once services are bundled, itemized patient-level data on utilization will no longer appear on the claims. Reporting of certain elements related to use of services or outcomes can be required by CMS to help monitor the care process and ensure that services are not being inappropriately reduced under prospective payment. However, since payment will no longer depend directly on the quantities of these services provided, the accuracy of such reporting may be impaired.

Primary Objectives of Preliminary Case-mix Analyses

- **Explore face validity of data**
- **Describe amount of variation in payments**
- **Describe amount of variation that occurs among:**
  - **Facilities**
  - **Patients within facilities**
  - **Months within patients**
- **Inform the selection of:**
  - **Components of the bundle (services)**
  - **Unit of payment (month vs. session)**
  - **Modality (HD, PD)**
  - **Case-mix measures**

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These preliminary case-mix models are only exploratory. They are intended to demonstrate the types of analyses that can be performed and inform selection of the bundle. For example, it may be useful to the Board to have a general idea of the amount of variation involved in alternative bundles and whether case-mix models perform similarly in explaining the costs of broader or narrower bundles.

Priorities for Future/Final Case-mix Analyses

- Identify analysis inclusions/exclusions (e.g., types of patients, cutoffs for acceptable values)
- Develop specific case-mix adjustment factors
- Evaluate methods of controlling for variation not due to case-mix (e.g., control variables)
- Develop final case-mix models
- Provide a full risk/impact analysis
- Address payment options for outliers

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The models presented today are merely first cuts intended to illustrate some of the possibilities. All of the claims data have been used (i.e., no exclusions of outliers or implausible values) along with a broad set of patient demographics and comorbidities. Final models may impose some exclusions on the data and certainly will involve fewer patient variables, selecting those with the best combination of explanatory power/face validity/objectivity of measurement. Once a bundle is chosen and a more refined and/or expanded case-mix model has been estimated, impact analyses will be performed to assess the risks faced by dialysis facilities participating in the demonstration and to examine the extent to which outlier payments may be able to limit such risks.

Payment Data

- Medicare allowed charge (MAC) for separately billable services included in example bundles 1A and 1C
- CMS paid claims for 2003
  - Dialysis facility claims (type 72)
  - Other outpatient institutional claims
    - Hospital outpatient departments
    - Home health agencies
    - Hospice
  - Carrier claims
    - Laboratories
    - Physician offices
    - Suppliers / DMERC

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Only patient months with between 1 and 20 paid hemodialysis-equivalent dialysis sessions are included in all analyses.

DMERC = Durable Medical Equipment Regional Carrier.

Potential Case-mix Measures

Broad variety of factors considered for preliminary analyses:

- **Demographics: age, sex, race, ethnicity**
- **Duration of RRT (e.g., 1st month, 2nd month, etc.)**
- **Body size measures (at start of RRT): BSA, low BMI**
- **Laboratory values: hematocrit (at start of RRT)**
- **Functional status and health behavior (e.g., inability to ambulate, drug dependence)**
- **Comorbidities: 36 individual conditions (e.g., specific types of heart disease, cancer, anemia, infection)**
- **Prior hospitalization**
- **Type of month (e.g., hospitalized, died)**
- **Prior EPO dose response**

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A broad variety of patient demographics and comorbid conditions is considered for the preliminary case-mix analyses. In developing a final case-mix adjustment, each of these factors and other potential factors, such as prior utilization, would also be evaluated using other criteria (e.g., relative subjectivity/objectivity of the measure).

Prior EPO dose response was measured using the ratio of the average EPO dose to the average hematocrit reported on dialysis facility claims during April – June 2002.

Patients missing data for one or more of these case-mix measures are not included in the preliminary analyses.

Caution: when many comorbidities are included, as in this model, the individual coefficients for each comorbidity might be less interpretable (multi-collinearity).

Comorbidity Measures

- Identified using:
  - ME form (at start of RRT)
  - Diagnoses from claims (inpatient, outpatient, SNF, hospice, home health, physician)
- Current measures based only on claims, which were more predictive of payments for separately billable services than measures based on ME form
- Duration of most relevant claims history likely to vary with the type of condition
  - Longer time window (e.g., 1-5 years) for chronic conditions (e.g., heart disease, diabetes)
  - Shorter time window (e.g., 1-6 months) for acute conditions (e.g., infection, GI bleeding)

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For some case-mix measures, only the Medical Evidence Form was available. This includes inability to ambulate, inability to transfer and smoking.

Basic Modeling Approach (1)

- **Regression**
  - **Explains variation using available case-mix measures**
- **Dependent variable**
  - **Log-transformed payments per session or payments per month used to better satisfy assumptions of regression model (less skewed)**
  - **Conversion to dollar scale for interpretability (+/- s.d. approximates multiplicative % effect). Conversion to dollar scale does not account for budget neutrality.**
- **Additional analysis: mixed model**
  - **Distinguishes unexplained variation across facilities, patients, and months**
  - **Based on a 2% random sample of facilities**

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Regression models were based on all patient months with available case-mix measures.

A linear model of payments per session or payments per month (not log-transformed) could also be used.

Sensitivity analyses that included facility characteristics (facility identifiers) were also performed. This was done in order to determine how payments varied across patients within facility types (within facility). Results from the sensitivity analyses (i.e., case-mix coefficients) were similar to those reported in these slides.

The mixed model includes both fixed effects for case-mix measures (as covariates) and random effects (intercepts) for both individual patients and individual facilities. It is in this sense that it is a "mixed effects" model. It utilizes the fact that we have repeated observations for both patients and facilities, but does require substantially more resources to estimate. Estimation of the mixed model for a larger sample was not computationally feasible. Mixed model results were similar based on multiple 2% random samples.

Basic Modeling Approach (2)

- **Unit of analysis: patient month ($/session or $/month)**
- **Aggregated model for separately billable services was used (vs. disaggregated)**
  - **Aggregated model:**

    $Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_p X_{pi} + \text{error}$

    Mixed model error term: $\alpha_{\text{facility } j} + \gamma_{\text{patient } i} + \varepsilon_{\text{month } i}$
  - **Disaggregated model:**

    $Y_{ki} = \beta^{(k)} X_i$ **component k of bundle**

    E.g.: $EPO_{ij} = \beta_0^{(EPO)} + \beta_1^{(EPO)} X_{1i} + \beta_2^{(EPO)} X_{2i} + \text{error}$

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The unit of analysis is based on the way that data are reported, not upon whether we are predicting payments per session versus payments per month.

The disaggregated model is shown to indicate that separate models could be built for each component of a bundle.

Analyses Presented

- Face Validity (Model 1)
- Effect of Payment Outliers (Model 1 vs. 1T)
- Scope of the Bundle (Model 2 vs. 3)
- Unit of Payment (Model 3 vs. 5)
- Modality (Models 3 vs. 7)
- Other types of risk adjustors
    - Type of month (Model 3 vs. 4)
    - Prior EPO dose response (Model 3 vs. 3E)

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Models

Model	Separately billable (SB) bundle components	Payments per month or per session	Adjust for type of month	Adjust for prior EPO dose response	Modality	Exclude possible outliers*	Number of patient months
1	EPO & iron	session	N	N	HD	N	1,943,552
1T	EPO & iron	session	N	N	HD	Y	1,924,131
2	EPO, iron, vitamin D & related labs (1A)	session	N	N	HD	N	1,943,552
3	Selected injectables & all ESRD labs (1C)	session	N	N	HD	N	1,943,552
3E	Selected injectables & all ESRD labs (1C)	session	N	Y	HD	N	1,943,552
4	Selected injectables & all ESRD labs (1C)	session	Y	N	HD	N	1,943,552
5	Selected injectables & all ESRD labs (1C)	month	N	N	HD	N	1,943,552
6	Selected injectables & all ESRD labs (1C)	month	Y	N	HD	N	1,943,552
7	Selected injectables & all ESRD labs (1C)	session	N	N	PD	N	121,573
8	Selected injectables and all ESRD labs (1C)	month	N	N	PD	N	121,573

***Excluded months in which payments exceeded the 99th percentile.**

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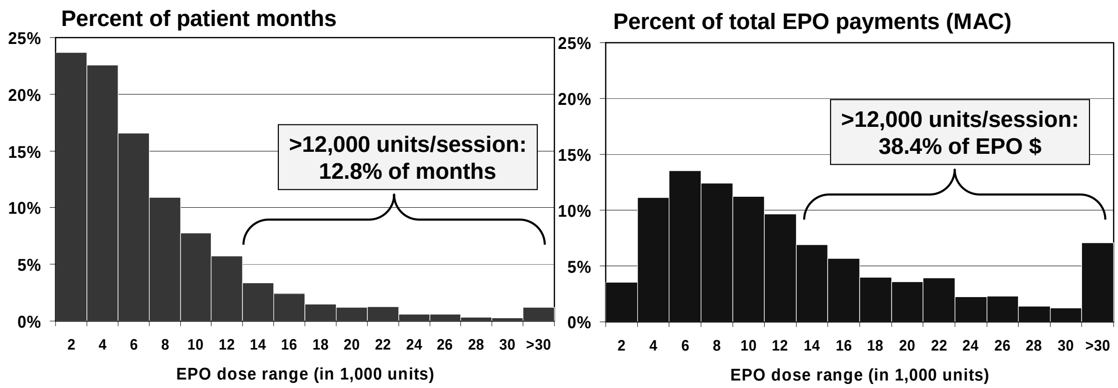
A description of each of the primary models is included in a single table for reference.

Although EPO and iron do not constitute one of the example bundles (since they do not include laboratory services, they do not meet the MMA minimum guideline for the bundle), models of EPO and iron will be used to assess the face validity of the results and to consider the potential impact of outliers on the explanatory power of case-mix models.

Two of the example bundles that are being discussed (bundles 1A and 1C) will be compared to each other so that we might consider the implications of expanding the bundle to include additional services.

One of the example bundles (1C) will then be used to compare alternative units of payment, modalities and types of risk adjustors. The selection of this particular example bundle (1C) to make these comparisons was somewhat arbitrary. We expect that the results of these comparisons will be generally similar for other example bundles that include the same principal components (bundles 1A, 1B, and 1D).

Percent of Months and Total EPO Payments by EPO Dose*



*Hemodialysis patient months only. N=2,467,523.

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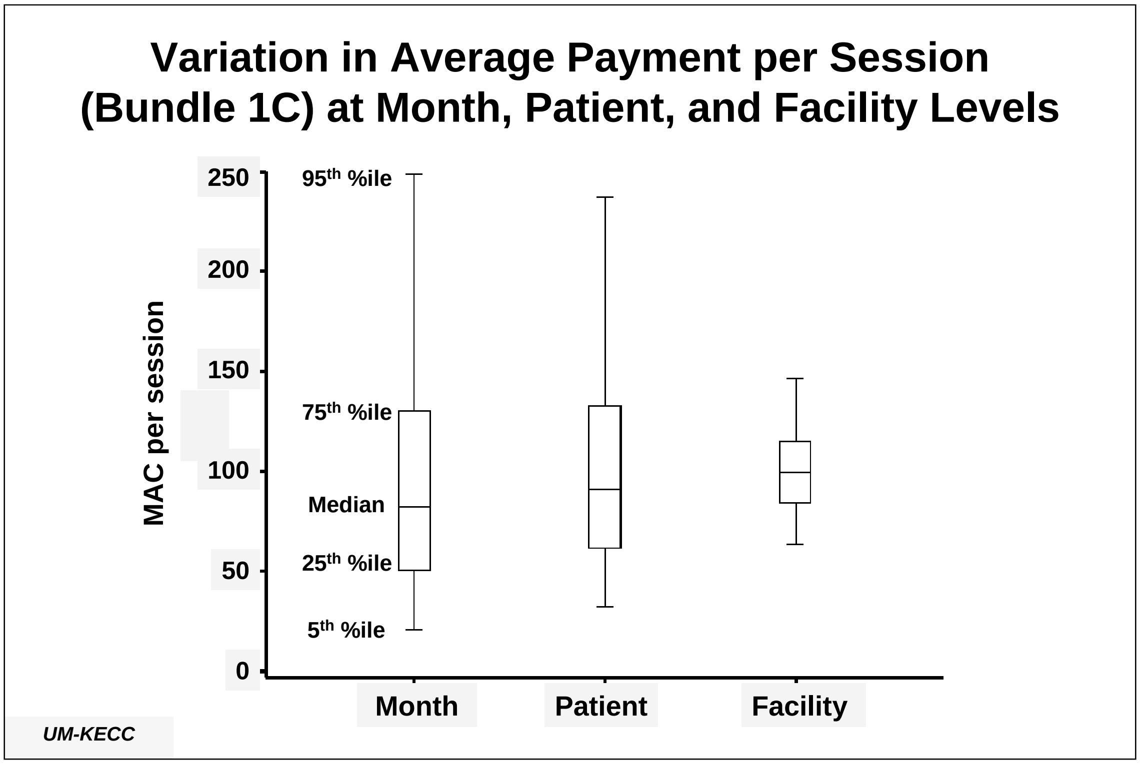
A relatively small percentage of hemodialysis patient months in which high doses of EPO are provided account for a relatively large percentage of total payments for EPO. Determining whether high EPO doses (or high utilization of other services) is clinically “appropriate” may be relevant to both developing the case-mix adjustment and to determining the level of payment.



Includes hemodialysis patient months with 1 to 20 dialysis sessions.

The range of average payments per session we observe at the month, patient and facility levels are shown without case-mix adjustment. Payments (MAC) for EPO, iron, vitamin D and other selected injectables and all ESRD laboratory services are included (bundle 1C). Includes n=2,467,523 patient months, n=265,681 patients and n=4,285 facilities.

Three boxplots are used to illustrate the magnitude of the variation in payments at the month, patient and facility levels. The boxes indicate the range for the middle 50% of values, with the upper and lower edges of each box representing the 75^{th} and 25^{th} percentiles, respectively. The horizontal line appearing near the middle of each box represents the median payment per session. The vertical lines extending above and below each box indicate the range for the middle 90% of values (i.e., between the 95^{th} and 5^{th} percentiles).

As might be expected, there is less variation in payments at the patient level than at the month level, and there is less variation in payments at the facility level than at the patient level. While the middle 50% of average payments per session range from $51 to $130 across months, the middle 50% of average payments per session range from $84 to $115 across facilities.

However, note that this figure should not be used to distinguish the relative magnitude of the variation in payments that we attribute to each of these three sources (month, patients and facilities). The variation in payments per month (the 1^{st} boxplot on the left, above) reflects not only variation over time for individual patients, but also variation both across patients and across facilities. Similarly, variation in payments per patient (the middle boxplot above) reflects both variation across patients and variation across facilities. A mixed effects model will later be used to distinguish between these three sources of variation in payments so that we can compare the relative amount of variation that we attribute to each source.

Face Validity

- **Focus on EPO and iron (anemia management) to enhance clinical interpretability**
- **Higher use of EPO and iron (10% or more) observed for:**
  - **Initial months of RRT**
  - **Females, especially ages 18-44**
  - **Larger patients (based on BSA)**
  - **Lower baseline HCT**
  - **Comorbidities: infections, bleeding conditions, anemias and hematologic cancers**
  - **Months following a hospitalization**
- **Relatively small effects (<10%) observed for:**
  - **Age**
  - **Race/ethnicity (except Pacific Islander)**
  - **Most functional status and health behavior measures**

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Note: This is narrower than the minimum MMA mandated bundle

The relationship between specific case-mix measures and the average payment per session for EPO and iron, the two major injectables used to manage anemia, is used to assess the clinical face validity of the data used for preliminary case-mix models.

In describing the results for individual case-mix measures that are used to explain variation in EPO and iron payments, the focus is on the magnitude of the multiplier rather than the p-value because of the large sample size.

Magnitude and Source of Variation in Payments Without Case-mix Adjustment

Model	0
N	1,943,552
Bundle	1C
Unit of payment (log of)	payment/session
Modality	HD
Includes case-mix measures?	No
Average payment	$101.37
R^2	0
Variation in payments (SD):	
Predicted	0
Unexplained (error)	$81.60
Correlation of prediction errors for current month vs.:	
Previous month	--
11 months ago	--
Source of unexplained variation (SD) from mixed model:	
Facility	$16.35
Patient	$47.91
Month	$40.39

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This table reports several statistics for an example bundle without case-mix adjustment.

In addition, this table illustrates the format that will be used in later tables to evaluate alternative bundles, units of payment, types of risk adjustors and other issues. The statistics in these tables can be used to describe:

-Overall explanatory power of the case-mix adjusted model (R-squared)

-Magnitude of the case-mix adjustment (standard deviation of predicted payments)

-Magnitude of the unexplained variation in payments (standard deviation of prediction errors)

-Consistency of unexplained variation in payments over time (correlation of prediction errors)

-Source of unexplained variation in payments (standard deviation of unexplained variation in payments across facilities, patients and months based on a mixed effects model)

This information will help us to address questions such as:

-Does the scope of the bundle affect the explanatory power of the model?

-Does the scope of the bundle affect whether patients have consistently higher or lower payments than expected based on available case-mix measures?

Using a mixed effects model, we can decompose the total variation in monthly payments into three specific types of variation occurring across facilities, patients and months. First, the magnitude of the typical variation in monthly payments across facilities can be described. Controlling for the average facility, the typical patient-to-patient variation that occurs within a facility can be described. Controlling for the average patient, the typical month-to-month variation that occurs over time for individual patients can also be described. The magnitude of each type of variation is reported as a standard deviation. In subsequent tables, we will see how much of these specific types of variation remains unexplained by available case-mix measures, which we expect to primarily explain the variation that occurs among patients rather than the variation that occurs among facilities or among months. All mixed effects models were performed using a 2% random sample of facilities (due to computational limitations).

NOTE: For a brief description of each of the statistics listed above, please see the addendum to the case-mix presentation (attached).

Effect of Case-mix Adjustment

Model	0	3
N	1,943,552	1,943,552
Bundle	1C	1C
Unit of payment (log of)	payment/session	payment/session
Modality	HD	HD
Includes case-mix measures?	No	Yes
Average payment	$101.37	$101.37
R^2	0	7.43%
Variation in payments (SD):		
Predicted	0	$22.24
Unexplained (error)	$81.60	$77.73
Correlation of prediction errors for current month vs.:		
Previous month	--	0.73
11 months ago	--	0.38
Source of unexplained variation (SD) from mixed model:		
Facility	$16.35	$15.94
Patient	$47.91	$42.65
Month	$40.39	$40.43

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This table shows the magnitude (in dollars) of a case-mix adjustment based on this preliminary model and the extent to which available case-mix measures reduce the amount of unexplained variation in payments. The unexplained variation is reduced from $82 to $78 when adding case-mix measures to the model. This can be mostly seen as a reduction in the patient-to-patient variation. Another way to say this is that compared to a flat payment of $101, case-mix adjustment would lead to a variable payment of $101 +/- $22. Note that the current system includes variable payments of $101 +/- $82.

The unexplained variation is relatively consistent within patient across months. That is, patients high last month (or 11 months ago) are likely to be high in the current month. The mixed model summarizes this as variation among patients.

Results from the mixed effects model are based on a 2% random sample of facilities.

Effect of Payment Outliers

Model	1	1T
N	1,943,552	1,924,131
Bundle	Anemia mgmnt (EPO & iron only)	
Unit of payment (log of)	payment/session	
Modality	HD	
Adjusts for type of month?	No	
Excludes outliers?	No	Yes
Average payment	$72.74	$69.03
R^2	6.83%	8.97%
Variation in payments (SD):		
Predicted	$18.40	$17.12
Unexplained (error)	$67.47	$54.37
Correlation of prediction errors for current month vs.:		
Previous month	0.77	0.78
11 months ago	0.40	0.38

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Outliers were defined as months with EPO and iron payments exceeding the 99th percentile. The 99th percentile corresponds to payments of $320 per session (including co-pay) or more for EPO and iron combined.

When excluding these potential outliers, the sample size goes down by 1%, the average payment goes down, and the explanatory power of the case-mix model improves, as the R-squared value increases from 6.83% to 8.97%. At the same time, the magnitude of the unexplained variation decreases from $67 to $54. That is, based on a model that includes these potential outliers, monthly payments typically vary +/- $67 per session after accounting for case-mix. Based on a model that excludes these potential outliers, monthly payments typically vary only +/- $54 after accounting for case-mix. Months with extremely high payments therefore appear to influence both the explanatory power of the case-mix model and the dollar amount of the typical variation in payments not explained by the model.

Scope of the Bundle

Model	2	3
N	1,943,552	
Bundle	1A	1C
Unit of payment (log of)	payment/session	
Modality	HD	
Adjusts for type of month?	No	
Excludes outliers?	No	
Average payment	$93.74	$101.37
R^2	6.76%	7.43%
Variation in payments (SD):		
Predicted	$19.86	$22.24
Unexplained (error)	$72.92	$77.73
Correlation of prediction errors for current month vs.:		
Previous month	0.76	0.73
11 months ago	0.40	0.38
Source of unexplained variation (SD):		
Facility	$15.78	$15.94
Patient	$41.09	$42.65
Month	$40.25	$40.43

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Bundle 1A, which includes EPO, iron, vitamin D and related laboratory services, is expanded in Bundle 1C to include other selected injectables and all other ESRD labs. Average payment per session increases from $93.74 to $101.37.

Does the scope of the bundle affect the explanatory power of the model? The explanatory power is relatively similar for these two example bundles, ranging from 6.76% to 7.43%. The magnitude of unexplained variation is also approximately the same for both bundles.

The correlation of prediction errors over time suggests that patients have consistently higher or lower payments than predicted by the model. This result is also similar for both bundles.

We further explored the source of the unexplained variation using a mixed effects model that was performed for a 2% random sample of facilities. Based on this model we observe the following:

-Facilities typically vary by +/- $16 in ways we can not predict using the case-mix model.

-In terms of the risk to the facility, the patient-to-patient variation is most important. For the average facility, payments for individual patients typically vary by +/- $41 to $43.

-For the average facility and the average patient, months typically vary by +/- $40.

Expanding a bundle that includes EPO, iron, vitamin D and related laboratory tests (1A) to include additional injectables and labs (1C) does not have a substantial effect on the performance of preliminary case-mix models. This suggests that the choice between a narrow versus a broad set of injectables and laboratory services to include in an expanded bundle could be made using criteria other than case-mix adjustment.

Unit of Payment

Model	3	5
N	1,943,552	
Bundle	1C	
Unit of payment (log of)	payment/session	payment/month
Modality	HD	
Adjusts for type of month?	No	
Excludes outliers?	No	
Average payment	$101.37	$1,178.53
R^2	7.43%	4.54%
Variation in payments (SD):		
Predicted	$22.24	$191.76
Unexplained (error)	$77.73	$870.82
Correlation of prediction errors for current month vs.:		
Previous month	0.73	0.75
11 months ago	0.38	0.40

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This table compares alternative units of payment (per session or per month) based on preliminary case-mix models for an example bundle that includes selected injectables and all ESRD laboratory tests (bundle 1C).

For both the per-session model and per-month model, the unit of analysis is the patient month. The models differ according to whether we are trying to explain variation in the average payment per outpatient dialysis session during the month (per-session model) or variation in the total payments for injectables and labs during the month (per-month model). The per-month model was not adjusted for the number of dialysis sessions provided during the month.

There is greater explanatory power (R-squared) with the per-session model (R-squared of 7.43%) than the per-month model (4.54%). Available case-mix measures are therefore able to explain more of the variation in payments per session than the variation in total payments per month.

Note that when adjusting for the “type” of month (e.g., hospitalized, transplanted, or died during the month; Model #6), the R-squared value for the per-month model increases from 4.54% to 5.83%, but is still lower than the R-squared value of 7.43% for the per-session model shown above.

Modality

Model	3	7
N	1,943,552	121,573
Bundle	1C	
Unit of payment (log of)	payment/session	
Modality	HD	PD
Adjusts for type of month?	No	
Excludes outliers?	No	
Average payment	$101.37	$42.23
R^2	7.43%	0.34%
Variation in payments (SD):		
Predicted	$22.24	$5.35
Unexplained (error)	$77.73	$91.88
Correlation of prediction errors for current month vs.:		
Previous month	0.73	0.20
11 months ago	0.38	0.02

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The average payment for injectables and laboratory services is substantially lower for PD patients ($42.23/session) than for HD patients ($101.37/session). This is likely to partially reflect the lower use of certain drugs by PD patients and the tendency for PD patients to be administered certain drugs orally (which is not reimbursed by Medicare) rather than by injection. Dialysis modality was assigned to individual patient months, so one patient can contribute data to both the HD and PD results in different months.

Available case-mix measures explain very little of the variation in payments for PD patients (0.34%).

Patient month payments are much less consistent within patient for PD patients than for HD patients (the correlation from month to month is lower for PD patients).

Other Types of Risk Adjustors: Type of Month (e.g., transplant, die, hospital)

Model	3	4
N	1,943,552	
Bundle	1C	
Unit of payment (log of)	payment/session	
Modality	HD	
Adjusts for type of month?	No	Yes
Excludes outliers?	No	
Average payment	$101.37	$101.37
R^2	7.43%	8.34%
Variation in payments (SD):		
Predicted	$22.24	$23.56
Unexplained (error)	$77.73	$77.17
Correlation of prediction errors for current month vs.:		
Previous month	0.73	0.73
11 months ago	0.38	0.38

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This table demonstrates the effect of a different type of potential risk adjustor based on certain events that occur during the month and interrupt treatment at the dialysis facility. Model 4 includes additional covariates that are indicators for the following events:

-Hospitalization

-Kidney transplant

-Death or withdrawal

-Modality switch (between HD and PD)

-Transfer between outpatient dialysis facilities

-Training

-Multiple events

-Unexplained low number of sessions (e.g., includes months with skipped sessions)

Note that this list of events does not include the starting month of dialysis, which is already included as part of the adjustment for duration of RRT.

There is a relatively modest improvement in the explanatory power of the per-session model when adjusting for the “type” of month, as the R-squared increases from 7.43% to 8.34%. The magnitude of the unexplained variation in payments decreases slightly from $77.73 to $77.17. Relatively large effects (well above a 10% increase in payments/session) were observed for certain types of months, however, such as months with a kidney transplant or a hospitalization.

The impact of adjusting for the “type” of month is similar for the per-month model (based on a comparison of Models 5 and 6).

Other Types of Risk Adjustors: Measure of Prior EPO Dose Response

Model	3	3E
N	1,943,552	
Bundle	1C	
Unit of payment (log of)	payment/session	
Modality	HD	
Adjusts for type of month?	No	
Excludes outliers?	No	
Includes prior EPO dose?	No	Yes
Average payment	$101.37	$101.37
R^2	7.43%	15.48%
Variation in payments (SD):		
Predicted	$22.24	$32.10
Unexplained (error)	$77.73	$74.39
Correlation of prediction errors for current month vs.:		
Previous month	0.73	0.69
11 months ago	0.38	0.32

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An alternative type of risk adjustor is based on a measure of each patient's prior dose response to EPO. Prior EPO dose response was measured using the ratio of the average EPO dose to the average hematocrit reported on dialysis facility claims during April – June 2002. For patients who recently started RRT, the mean value was imputed by the overall average. For months in which this ratio exceeded the 99th percentile, the ratio at the 99th percentile was used. This measure was included in a separate model so that we might consider the potential contribution of this type of risk adjustor to the overall explanatory power of the case-mix model.

This single added covariate doubles the r-squared, reduces the unexplained variation, and increases the variation in predicted payments.

Key Outstanding Questions for Case-mix Adjustment

- **Adjust for prior EPO dose response for each patient? Or prior utilization?**
- **Use average payment based on current practice or clinically "appropriate" practice (e.g., inclusion or exclusion of extreme values)?**
- **What other potential risk adjustors should be collected for the demonstration?**
- **How to define and pay for outliers?**
- **Pre-requisites / post-implementation issues (see slides at beginning of this presentation)**

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The preliminary case-mix analyses that were presented are intended to help us address key questions such as the following (referred to earlier as pre-requisites for developing a final case-mix adjustment):

-What services should be in the bundle?

-What is the unit of payment (month vs. session)?

Addendum to Case-mix Presentation

Brief Overview of Key Statistics for Preliminary Case-mix Models

The **R-squared statistic** measures the overall explanatory power of a case mix model. The R-squared can range from zero to one. A model that perfectly predicts resource use would have an R-squared of one (1.0). A model that predicts the same (or average) level of resource use for all patients would have an R-squared of zero.

The **standard deviation of predicted payments** measures the extent to which a model predicts variation in resource use. This statistic has a value that can range from zero to the standard deviation of actual resource use. A model that perfectly predicts resource use would have a standard deviation for the predicted value that is equal to the standard deviation of actual resource use. A model that predicts no variation in resource use would have a standard deviation for the predicted value equal to zero.

The **standard deviation of prediction errors** (the difference between predicted and actual resource use) measures the extent to which a model fails to predict variation in resource use. It is, in a sense, the complement of the previous statistic. It also has a value that can range from zero to the standard deviation of actual resource use. A model that perfectly predicts resource use would have a standard deviation for the prediction errors equal to zero. A model that predicts no variation in resource use would have a standard deviation for the prediction errors that is equal to the standard deviation of actual resource use.

The **correlation of the prediction error** in the current month with prediction errors in prior months measures the extent to which a model systematically over- or under-predicts resource use for a given patient across time. These statistics have a value that can range from negative one (-1) to positive one (+1). If the difference between actual and predicted resource use varies randomly from month-to-month for a given patient, the correlation will be close to zero. If the difference is nearly the same across months the correlation will be close to one.

The **source of the unexplained variation** attempts to distinguish three different types of prediction error. The prediction error attributed to the facility measures the differences among facilities that are not explained by case-mix. This statistic has a value that could range from zero to the standard deviation of resource use (per session) calculated at the level of the facility. Such facility differences are likely due to either different practice patterns or to unexplained differences in case-mix. The prediction error attributed to the patient measures the extent to which a model systematically under- or over-predicts resource use for the patients *within* a given facility. The prediction error attributed to the month measures the extent to which a model systematically under- or over-predicts resource use for a given patient (in a given facility) *across* months.