

Prometheus Payment Model

Application to Hip and Knee Replacement Surgery

**Amita Rastogi MD, MHA, Beth A. Mohr MS,
Jeffery O. Williams BS, Mah-Jabeen Soobader MPH, PhD,
Francois de Brantes MS, MBA**

© The Association of Bone and Joint Surgeons® 2009

Abstract The Prometheus Payment Model offers a potential solution to the failings of the current fee-for-service system and various forms of capitation. At the core of the Prometheus model are evidence-informed case rates (ECRs), which include a bundle of typical services that are informed by evidence and/or expert opinion as well as empirical data analysis, payment based on the severity of patients, and allowances for potentially avoidable complications (PACs) and other provider-specific variations in payer costs. We outline the methods and findings of the hip and knee arthroplasty ECRs with an emphasis on PACs. Of the 2076 commercially insured patients undergoing hip arthroplasty in our study, PAC costs totaled \$7.8 million (14% of total costs; n = 699 index PAC stays). Similarly, PAC costs were \$12.7 million (14% of total costs; n = 897 index PAC stays) for 3403 patients undergoing knee arthroplasty. By holding

the providers clinically and financially responsible for PACs, and by segmenting and quantifying the type of PACs generated during and after the procedure, the Prometheus model creates an opportunity for providers to focus on the reduction of PACs, including readmissions, making the data actionable and turn the waste related to PAC costs into potential savings.

Introduction

Over the past 30 years, US healthcare expenditures have grown 2.8% per annum faster than the rest of the economy [15]. Meanwhile, disheartening numbers of patients are financially hurt by a reimbursement system that is indifferent to quality [19, 28] and outcomes, leading to substantial overuse, underuse, and misuse of healthcare resources [21]. Unnecessary medical errors abound within a badly fragmented delivery system; and providers, patients, and purchasers have little solid information on the quality and outcomes of care they deliver, receive, and pay for [25]. Although pay-for-performance programs have emerged as one approach to tackle these problems [6], they function as “add-ons” to a system that otherwise operates as it always has, whether capitation or fee-for-service, calling out for a new payment model that addresses the fundamental problems that plague our healthcare system today in terms of better accountability, coordination of care, and reducing medical waste [20, 27].

In August 2008, Peter Orszag, Director of the Congressional Budget Office, stated that as much as \$700 billion a year is spent in the United States on healthcare services that do not improve health outcomes [1]. A recent Agency for Healthcare Research and Quality (AHRQ) study estimated that employers spent nearly

Bridges to Excellence is funded by the Robert Wood Johnson Foundation.

A. Rastogi (✉)
Prometheus Payment®, Bridges to Excellence,
10326 Sandy Lane, Munster, IN 46321, USA
e-mail: amita.rastogi@bridgestoexcellence.org

B. A. Mohr
Brandeis University, Waltham, MA, USA

J. O. Williams
Masspro, Waltham, MA, USA

M.-J. Soobader
Statworks, Canton, MA, USA

F. de Brantes
Bridges to Excellence, Newtown, CT, USA

\$1.5 billion annually for potentially preventable medical errors occurring during or 90 days after surgery [12].

To address the problems of the existing reimbursement system, Prometheus Payment, Inc, a nonprofit organization, proposed a new payment model based on evidence-informed case rates (ECRs) [7]. ECRs are severity-adjusted, global reimbursements to providers for treatment of a specific condition across inpatient and outpatient settings [8]. Payments cover the cost of “typical” care, recommended by well-accepted clinical guidelines or expert opinion, and are adjusted for the type and intensity of services resulting from disease or injury severity and comorbid factors. A key element of Prometheus is that within an episode of medical care, risks inherent to the patient and risks imputed by the providers in management of the patient’s care can be identified and segregated. Distinguishing between typical care and potentially avoidable complications (PAC) creates an opportunity to hold the delivery system accountable for the latter while holding it harmless for the former, something that neither fee-for-service nor current forms of capitation can accomplish. As a result, contrary to cruder forms of episode payments such as the recently launched Medicare Acute Care Episode demonstration, the Prometheus model creates a global price for a procedure based on the severity of the patient’s injury or illness—thus reducing the potential for cherry picking—and includes an allowance for potentially avoidable complications (also severity-adjusted) within the global price.

We describe the methodology used to develop the Evidence-informed Case Rates for the Prometheus Payment model as it applies to hip and knee replacement. Specifically, we: (1) delineate the construction of the ECR costs for these surgeries and the bifurcation of costs between typical care and PACs; (2) identify the biggest cost drivers for PACs associated with joint replacements and their relationship to the CMS defined hospital acquired conditions (HACs); (3) define the costs of hip replacement under the current fee-for-service system as compared to that under the Prometheus payment model; and (4) show how the application of the Prometheus Payment model would serve as a catalyst for reducing PAC costs and improving quality.

Materials and Methods

We analyzed 2005 to 2006 claims data from a US commercially insured population of over 4.5 million members. The database contained claims from inpatient and outpatient facility and inpatient and outpatient professional, laboratory, radiology, ancillary, and pharmacy services. Diagnoses and procedures were coded using the

International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes and the American Medical Association’s Current Procedural Terminology (CPT®) codes. Medications from pharmacy claims were coded using National Drug Codes (NDC) and then classified into Prometheus drug groups using Lexicon drug categories. Results of laboratory or radiology tests were not available. We used AHRQ Clinical Classification Software (CCS) [2] as a means of grouping ICD-9-CM diagnosis and procedure codes and the CCS for CPT classification [3] to group CPT codes into meaningful, clinically homogenous Prometheus categories for further analysis. Cost was defined as the allowed amount, which is equal to the sum of the paid amounts, as well as the patient portion of the payment in the form of deductibles, copay, and coinsurance amounts.

Using the commercial database, we constructed ECRs, which are condition-specific formulae for a severity-adjusted global price used for paying providers. The formulae estimate the price for an entire episode of care for a given condition treated for a defined period of time. This defined period of time is called the “ECR time window” or the “ECR period”. Payments are for services relevant to the care of the condition during the period and include: (1) reimbursement for care recommended by well-accepted clinical guidelines or expert opinion and adjusted for type and intensity of services resulting from disease or injury severity and comorbid factors (“typical” care); (2) an allowance for PACs; and (3) a provider margin equal to 10% of typical care reimbursement. We chose two surgical procedures for ECR construction as a result of their high costs: hip and knee arthroplasties. These two ECRs were constructed using similar methods and included both inpatient and outpatient care.

For both hip and knee arthroplasties, the episode had two components: (1) stay, which included inpatient facility claims; and (2) professional and all others (PFO), which comprised professional, outpatient facility, pharmacy, and all other types of claims. All claims for a member, including pharmacy claims, were identified using a unique member identifier and aggregated together to create the complete set of services within the episode. “Relevant” stay and PFO claims during the episode time window that related directly to care and services for the index condition were retained and were further classified as either typical or PAC depending on whether the claim carried a potentially avoidable complication code (explained subsequently).

Condition-specific trigger codes determined the start of an episode, and a predefined time window (30-day look-back period and a 180-day look-forward period) established the ECR period (Table 1). All inpatient, professional, and pharmacy claims within the time window were potentially included in the construction of the ECR.

Table 1. Condition-specific definitions for ECR (evidence-informed case rate) episode construction for hip and knee arthroplasties

Definition	Hip or knee arthroplasties
Trigger codes*	The patient has a stay claim with: <ol style="list-style-type: none"> The following ICD-9-CM procedure code in any position: Hip arthroplasty: 81.51, knee arthroplasty: 81.54 and Any of these ICD-9-CM diagnosis codes as the principal diagnosis: Hip arthroplasty: 820.yx, y = 0,2,8; 733.14; 714.0x; 715.xy, y = 5,9; 719.95; 711.05; 716.xy, y = 5,9; 730.y5, y = 0,1,2; 733.4y, y = 2,3; 733.8x; 736.3x; 736.89; 170.7; 171.3; 198.5 Knee arthroplasty: 714.0x; 715.xy, y = 6,9; 716.xy, y = 6,9; 719.96; 730.y6, y = 0,1,2; 736.89; 736.yx, y = 4,5,6; 711.06; 170.7; 171.3; 198.5
ECR period	30 days before the admission date for the index replacement (look-back period) 180 days after discharge date for the index replacement (look-forward period)
Enrollment requirement	Patient should have continuous enrollment for the entire duration of the episode (typically 7–8 months: 1 month before + length of index stay + 6 months after index stay)
Patient exclusions	<ol style="list-style-type: none"> Continuous enrollment requirement not met Age younger than 18 or age 65 years or older Discharge status is left against medical advice In-hospital death The index stay had an additional ICD-9-CM procedure code of 80.05 for hip arthroplasty episode and 80.06 for knee arthroplasty episode Had a stay with more than one condition trigger codes Episode had more than one stay with a condition trigger code (whether index or revision) Does not have both the inpatient and PFO components (orphan episode)
Claim/episode cost exclusions	<ol style="list-style-type: none"> Remove episode if total cost for index stay are missing or less than \$50 or greater than \$1,000,000 Remove episode if total PFO costs are missing, or less than \$20, or greater than \$1,000,000 Remove PFO claims if claim costs less than \$10 Remove episodes that have no associated PFO claims (orphan episode)
Medical exclusions	HIV, suicide, pregnancy and newborn conditions
Procedural exclusions	Any major and irrelevant surgical procedure
Case breaker services [†]	Peripheral vascular bypass; other vascular bypass and shunt; transurethral excision, drainage, or removal urinary obstruction; transurethral resection of prostate (TURP)
PAC	Adverse effects of drugs, overdose, poisoning, complications of implanted device, complications of surgical procedure or medical care, revision procedures, vascular catheter associated infection, septicemia, meningitis, hepatitis, fluid and electrolyte disturbances, blood incompatibility, perioperative hematoma, hemorrhage, stroke, coma, syncope, delirium, AMI, shock, cardiac arrest, air embolism, pneumonia, respiratory failure, lung complications, iatrogenic pneumothorax, tracheostomy, mechanical ventilation, acute renal failure, urinary tract infections, gastritis, ulcer, deep vein thrombosis, pulmonary embolism, decubitus ulcers
ECR “typical” components	<ol style="list-style-type: none"> Stay; for typical care, use trimmed mean to estimate typical inpatient costs Professional, outpatient facility, pharmacy, and all other claims in episode (PFO); for typical care, use regression model to estimate costs

* x = any digit from 0–9 inclusive or blank, y is as indicated; [†]case-breaker services refer to services that indicate the patient’s condition has advanced to such a degree that the services are now for a different condition; ICD-9-CM = International Classification of Diseases, 9th Revision, Clinical Modification; PFO = professional and all others; PAC = potentially avoidable complication; AMI = acute myocardial infarction; ECR = evidence-informed case rate; PFO = professional, outpatient facility, pharmacy, and all other types of claims.

We excluded patients who did not meet the eligibility criteria, were not continuously enrolled for the entire duration of the ECR, had out of range or missing costs, or had medical exclusionary conditions or major unrelated surgical procedures. Additionally, claims with medical diagnosis or procedural codes for services not directly related to care for the index condition were excluded as were claims for “case-breaker” services, ie, major

procedures that could extensively distort the costs of the ECR (eg, vascular bypass procedure). Pharmacy claims with NDC codes not relevant to the ECR were also removed. Finally, we removed orphan procedures, ie, procedures with no professional claims associated with the “index” trigger stay or where the index stays or the associated PFO claims did not meet the cost criteria. The remaining claims were considered “relevant”; this

included claims related to (1) typical care or (2) PACs. All relevant claims that were not PACs were considered typical.

Inpatient and professional claims were considered PAC claims if they had a PAC code in any of the four diagnosis fields or a procedure code that was related to services provided for a potentially avoidable complication (Table 1). Pharmacy claims that were associated with treatment of potentially avoidable complications were classified as PACs.

Hospital-acquired conditions (HACs) were defined using The Centers for Medicare and Medicaid (CMS) definitions for the previously defined “never events” as well as those under the proposed rules for 2008 and 2009 [10, 11]. We used other potentially avoidable complications as suggested by AHRQ’s patient safety indicators [4] as well as by clinicians on the Prometheus Design Teams to create the Prometheus-defined PACs. Therefore, the PACs included both the HACs and other potentially avoidable complications as defined by the Prometheus Payment Design Team. All readmissions during the time window were also considered PACs unless they were for a major surgical procedure in which case they were excluded from the ECR.

The unit of analysis was the procedure. For each patient, we selected the first stay that met the eligibility criteria, as the index stay, and constructed the ECR around it. Therefore, each ECR is unique to a person. Because stays came as bundled payments in the current claims database, a patient could not have both a typical index stay and a PAC index stay. To estimate the portion of stay costs that were the result of PACs, we calculated the added burden of PAC stays as the difference in cost of an index PAC stay from an average typical stay. Additionally, although most readmission stays were considered PAC stays, we analyzed costs for the index PAC stays separately from the costs of readmission PAC stays and the entire readmissions stay costs were added to PAC costs. Costs associated with typical services were used to create severity-adjustment models to pay for typical care, and costs associated with PAC services were used to generate the PAC allowance.

Separate linear regression models were created for inpatient stay services and for PFO (professional and other) services to determine severity-adjusted costs for each component of the ECR separately. However, for both the hip and knee arthroplasty ECRs, the regression model for typical stays had a low adjusted R^2 suggesting that the variance in the model for “typical care” was difficult to explain by factors captured by claims data. We therefore decided to discard the stay model and use the average cost for the “typical” stay episodes toward development of the in-patient portion of the ECR. To prevent outlier costs from

skewing average cost calculations, typical stays with costs above the 97.5th percentile value and those below the 2.5th percentile value were removed, and a trimmed mean was computed.

For typical PFO claims, we used multiple linear regression analysis to identify predictors of cost, the dependent variable. Because the distribution of cost was right-skewed, we transformed it using natural logarithms to satisfy regression model assumptions. The independent variables considered consisted of demographics (age, gender), severity of index condition, comorbidities, pharmacy, and procedure variables. To avoid overfitting (ie, developing a model that predicts costs well using the analysis data but does not have good predictive ability on new data), we validated the models using split sampling methods [17, 24]. The episodes were randomly assigned to one of three data sets: model building (MB; 50% of episodes), validation (approximately 25%), and test (approximately 25%). For the hip models, the adjusted R-squares based on the MB, validation, and test data sets were close (22.8%, 24.8%, and 24.7%, respectively). For the knee models, the adjusted R-square for the MB and validation datasets were also close (36.7% and 33.2%, respectively). The test data set adjusted R-square was somewhat lower (28.2%). The final models were based on the MB sample and retained variables and coefficients that were stable across all three datasets. To create illustrative examples, the final model was used to estimate the total severity-adjusted ECR “typical” base price for three hypothetical patients (patient 1 low, patient 2 moderate, patient 3 high severity) (Table 2).

The total dollars in the health plan’s data that were associated with the treatment of PACs was called the PAC pool. This included the added burden for index PAC stays (derived as a difference in cost of an index PAC stay and an average typical stay), costs of potentially avoidable readmissions, professional and pharmacy costs associated with care for PACs, and provider-specific variation (calculated as the cost of treating outliers, eg, the stays trimmed from the typical sample). By convention, the Prometheus Payment model redistributes 50% of the PAC pool as a PAC allowance given to providers toward payment for PACs irrespective of their occurrence. The PAC allowance is, in part, proportional to the severity of illness and comorbid conditions in the patient. A portion of the PAC allowance (25%) is given as a fixed amount to each episode, and the balance (75%) is allocated as a proportion of the severity-adjusted base price for each patient [8].

We computed the total ECR price by summing the severity-adjusted cost of typical care plus the PAC allowance (fixed allowance plus proportional allowance), and a margin, set at 10% of the cost of typical care. Using the same three hypothetical patients as above we created

Table 2. Hip arthroplasty total typical portion of ECR price: severity-adjusted typical professional and pharmacy model and average typical stay costs for three hypothetical patients

Typical professional and pharmacy model						
Variable	Percent of patients (N = 925)	Ln coefficient [‡]	Standard error [§]	Patient 1	Patient 2	Patient 3
Intercept		8.0588	0.0537	1	1	1
Respiratory diagnostic and minor therapeutic procedures	11.8%	0.1738	0.0391	0	0	1
Other diagnostic procedures (interview, evaluation, consultation)	70.0%	0.0928	0.0275	0	1	1
Other services, immunizations, anesthesia, pathology	93.2%	0.2336	0.0505	0	1	1
Physical therapy and rehabilitation	25.5%	0.1772	0.0290	0	1	1
Antiplatelet agents, thrombin inhibitors	5.4%	0.1432	0.0559	0	1	1
Steroids	10.0%	0.1217	0.0435	0	0	1
Iron and other nutritional supplements	14.6%	0.1338	0.0365	0	0	1
Sedatives and hypnotics	29.6%	0.0881	0.0281	0	0	1
Antacids and antispasmodics	21.6%	0.2446	0.0316	0	1	1
Oncology drugs	3.4%	0.3272	0.0726	0	0	1
Antirheumatic and antigout agents	8.1%	0.1264	0.0483	0	1	1
Severity-adjusted typical professional and pharmacy portion of ECR				\$3161	\$8747	\$20,359
Total typical portion of ECR price				Patient 1	Patient 2	Patient 3
Severity-adjusted typical professional and pharmacy portion of ECR				\$3161	\$8747	\$20,359
Typical stay portion of ECR price*				\$17,452	\$17,452	\$17,452
Total Typical Portion of ECR price [†]				\$20,613	\$26,199	\$37,811

* Trimmed mean of typical stay costs (trimmed at 2.5th and 97.5th percentiles); [†]the total typical portion of ECR price is the sum of the severity-adjusted typical professional and pharmacy portion and the typical stay portion of the ECR price; [‡]for each predictor, Ln coefficient is the multiple linear regression coefficient on the natural log scale; the natural log of cost was regressed on all of the predictors shown; all coefficients were significantly different from 0 at the 0.05 level; the adjusted R² for the model was 22.9%; the severity-adjusted typical professional and pharmacy portion of ECR was computed by summing the Ln coefficients for the intercept and desired predictors (sum) and then calculating e^(sum); [§]standard error refers to the standard error of the Ln coefficient; ECR = evidence-informed case rate.

illustrative calculations for the complete price of a hip arthroplasty ECR (Table 3). The case rate includes the stay, professional and pharmacy costs and varies in accordance with the severity-adjusted base cost of typical care. When needed, the case rate could be split into its components such as when operating in a delivery system where the three components are not integrated. Additionally, within the Prometheus Payment model, 10% of the cost of typical care is held in a fund that is given back to the providers as a bonus when they meet certain quality standards as defined by the scorecard (under development). The money not paid back to providers either from the unpaid PAC pool after accounting for the 10% provider margin and the bonus pool becomes the payer savings. The ECR forms the basis of a price negotiation that each health plan can engage in with providers after normalizing their own data based on the benchmark coefficients. The methodology, results of the analysis, and coefficients of the typical severity adjustment models are available as open source and can be adopted by plans and

providers to create their own case rates based on their own data [26].

Results

Of the 2076 commercially insured patients undergoing hip arthroplasty, costs for relevant care were \$54.9 million, of which \$7.8 million (14%) were for care of potentially avoidable complications (n = 699 index PAC stays and 351 readmissions) (Fig. 1A–B). Added burden for PAC index stays (52.6% of PAC costs) and potentially avoidable readmissions (39.7% of PAC costs) contributed to the majority of the PAC costs. Similarly, for the 3403 patients who had knee arthroplasties, costs for relevant care were \$93.3 million, \$12.7 million (14%) of which were in PAC care (n = 897 index PAC stays and 644 readmissions), again mostly as a result of added burden of PAC index stays (55.0% of PAC costs) and potentially avoidable readmissions (42.4% of PAC costs).

Table 3. Hip arthroplasty total ECR price calculations: PAC allowance calculations added to the typical portion of the ECR price plus a margin

Calculation of the PAC allowance	Factors	Average costs [‡]	Number of episodes	Total costs
Total relevant costs (excluding readmissions)		\$24,960	2076	\$51,817,541
Typical costs (stay*, professional and pharmacy)		\$19,007	1913	\$36,360,547
Added burden [†] of PAC costs (stay, professional, and pharmacy)		\$7865	995	\$7,826,039
PAC allowance within Prometheus (50% of PAC costs)	50%			\$3,913,020
Flat fee portion (25% PAC allowance spread over all cases)	25%	\$471	2076	\$978,255
Proportional rate (75% of PAC allowance as a rate over base costs)	75%			7%
<hr/>				
Total ECR price calculations	Factors	Patient 1	Patient 2	Patient 3
Severity-adjusted cost of care of typical patient undergoing hip arthroplasty (stay, professional, pharmacy)		\$20,613	\$26,199	\$37,811
PAC allowance				
Flat fee allowance	\$471	\$471	\$471	\$471
Proportional allowance (7% of severity-adjusted costs)	7%	\$1443	\$1834	\$2647
Total allowance for PACs		\$1914	\$2305	\$3118
Margin	10%	\$2061	\$2620	\$3781
Total ECR price per patient (severity-adjusted base price + PAC allowance + margin)		\$24,589	\$31,124	\$44,710
Margin + allowance for PACs		\$3976	\$4925	\$6899
Net percent allowance for margin and PACs		19%	19%	18%

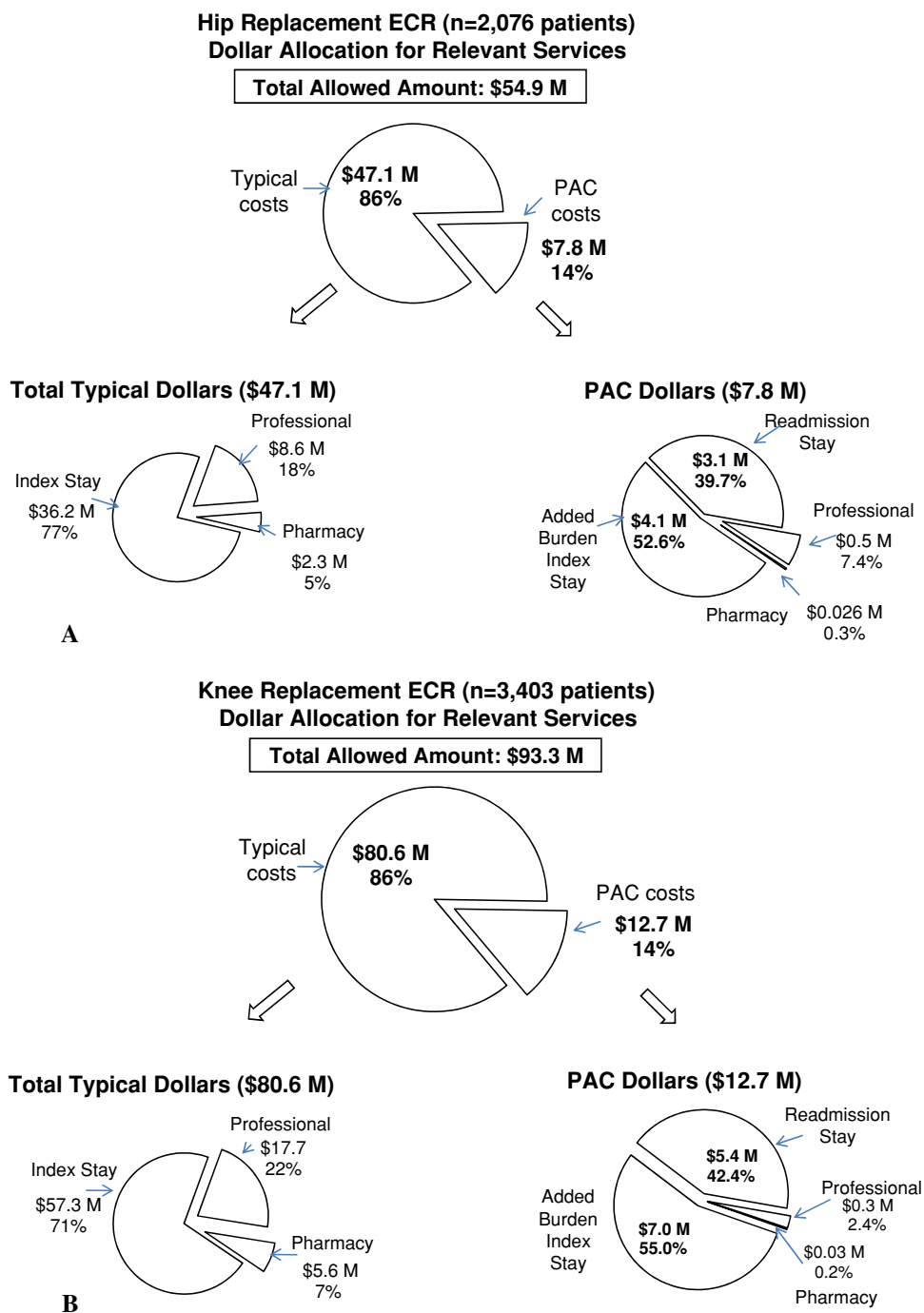
* Stay refers to inpatient facility; [†]added burden refers to excess costs related to PACs; for stays, it is calculated as the excess costs of an average PAC stay over an average typical stay; because stays come as bundled payments, a patient cannot have both a typical index stay and a PAC index stay; however, the other categories are not mutually exclusive; for example, a patient could have both typical professional and PAC professional claims and their associated costs; [‡]costs are defined as allowed amount, which is equal to the sum of the paid, deductible, copay, coinsurance, and coordination of benefit amounts; ECR = evidence-informed case rate; PAC = potentially avoidable complication.

Readmissions were the single biggest drivers of PAC costs for both hip and knee arthroplasties, constituting \$3.1 million of costs for hip replacement episodes and \$5.4 million for knee replacement episodes (Fig. 2A–B). Other potentially avoidable complications included Prometheus-defined conditions (\$2.3 million for hip and \$2.8 million for knee) and the excess costs associated with CMS-defined hospital-acquired conditions (\$0.36 million for hip and \$0.62 million for knee). For both hip and knee arthroplasties, besides the readmissions, the top three contributors toward excess costs for PACs were hemorrhage, fluid and electrolyte disturbances, and complications of medical care. Catheter-associated urinary tract infections, ventilator-assisted pneumonia, and deep vein thrombosis/pulmonary embolism were the common HACs. The average cost of a HAC stay was \$5,957 higher for hip and \$5,839 higher for knee; and for other PAC stays, it was \$3,645 higher for hip and \$3,529 higher for knee than the average cost of a typical stay, respectively. Overall, 14.4% of all hip replacements and 16.5% of all knee replacements had one or more readmissions; the average time between index discharge and readmission after a hip arthroplasty was 15.3 days (range, less than 1–175 days) and 18.1 days (range, less than 1–178 days) after a knee arthroplasty. The average length of stay for an index stay was 3.6 days for

both hip and knee arthroplasties; and for readmission, it was 7.2 days and 6.4 days, respectively. The most common reasons for PAC readmissions after hip arthroplasty were blood transfusion, excisional débridement of wound infection, and revision of hip arthroplasty (Fig. 3A). For knee arthroplasty, the most common causes of PAC readmissions were manual rupture of joint adhesions, excisional débridement of wound infection, and revision of knee arthroplasty (Fig. 3B).

Under the current fee-for-service system, the average cost of hip replacement is estimated at \$24,960 irrespective of severity of the patient's injury (Table 3). However, if patients incur potentially avoidable complications more money would be paid to care for those complications. Under the Prometheus Payment model, the price of the ECR is based on disease or injury severity. The estimated price for typical care depending on the severity is: \$20,613 for patient 1 with low severity, \$26,199 for patient 2 with moderate severity, and \$37,811 for patient 3 with high severity (Table 2). In addition, a PAC allowance and margin provides an additional \$3,976 (patient 1), \$4,925 (patient 2), and \$6,899 (patient 3) making the complete ECR price for patient 1 \$24,589, \$31,124 for patient 2, and \$44,710 for patient 3 (Table 3) irrespective of the actual occurrence of PACs.

Fig. 1 A summary of hip and knee arthroplasty costs is shown. The figure demonstrates total relevant costs for Hip and Knee Replacement ECRs and their segregation into typical and PAC costs. It further gives a breakdown of each of the typical and PAC costs into costs for stays, professional and pharmacy services. ECR = evidence-informed case rate; PAC = potentially avoidable complication.

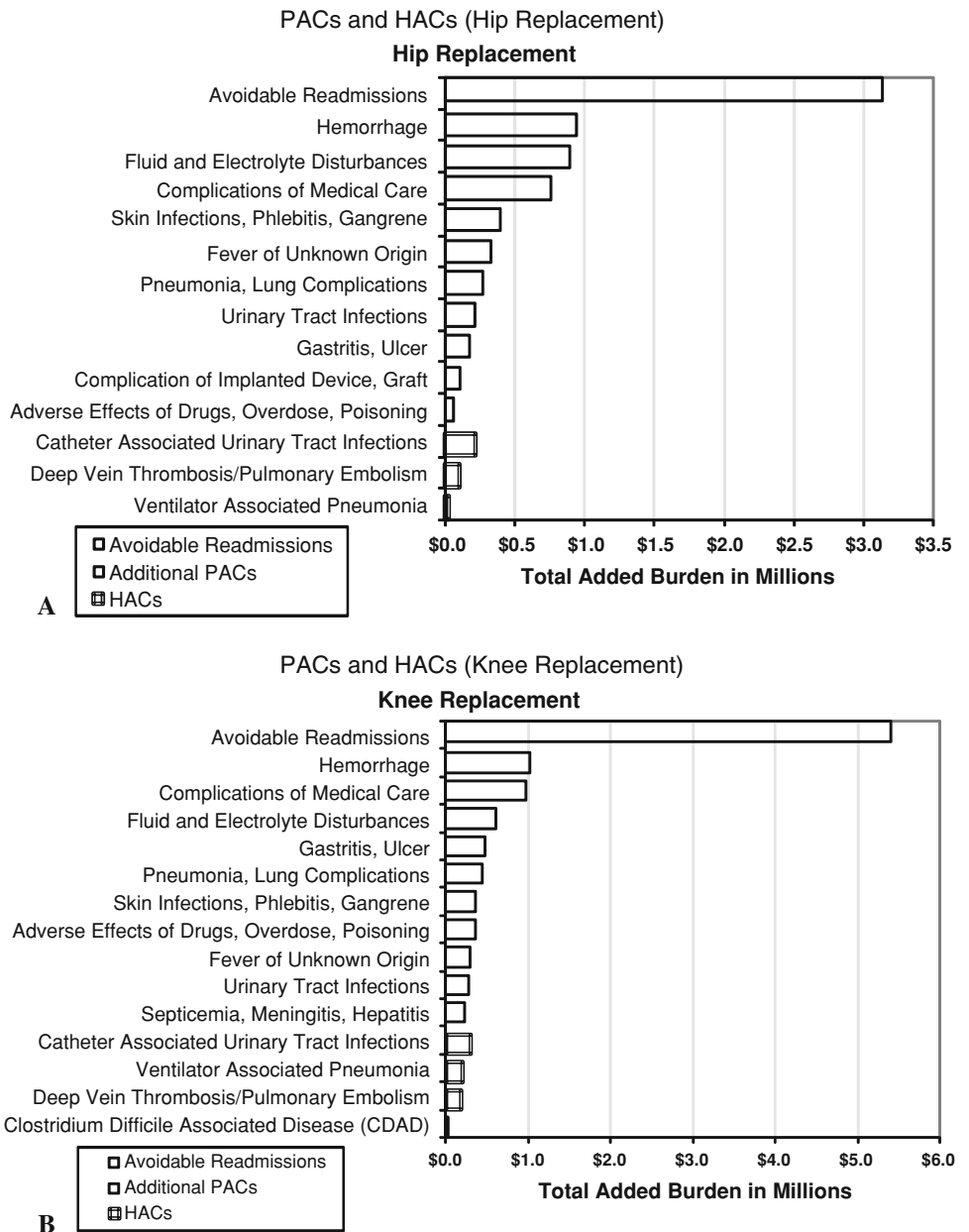


The total PAC dollars calculated across the 2076 patients who had a hip replacement were \$7.8 million. By design, 50% of the PAC dollars (\$3.9 million in the case of the hip replacement ECR) would be redistributed as a PAC allowance within the hip replacement ECRs, and these allowances can become an added margin for providers to the extent they can reduce PACs. The other half are designed to be payer and consumer savings, but could be used for other purposes, in particular as an added incentive for high quality scores.

Discussion

The ECR methodology and the results of applying that methodology to a large commercial payer data set demonstrate the ability to build a more rational payment model. It is possible to separate patient factors from treatment factors in understanding and attributing the various portions of the total cost of medical care within an ECR. At the same time, high-quality clinical practice is rewarded with sufficient payment to support its delivery, and a shared

Fig. 2 In hip and knee arthroplasty episodes, the costs for potentially avoidable complications (PACs) include costs for readmissions, the added burden of Prometheus-defined PACs and CMS-defined hospital-acquired complications (HACs). PACs and HACs with the highest added burden of total costs are shown here.

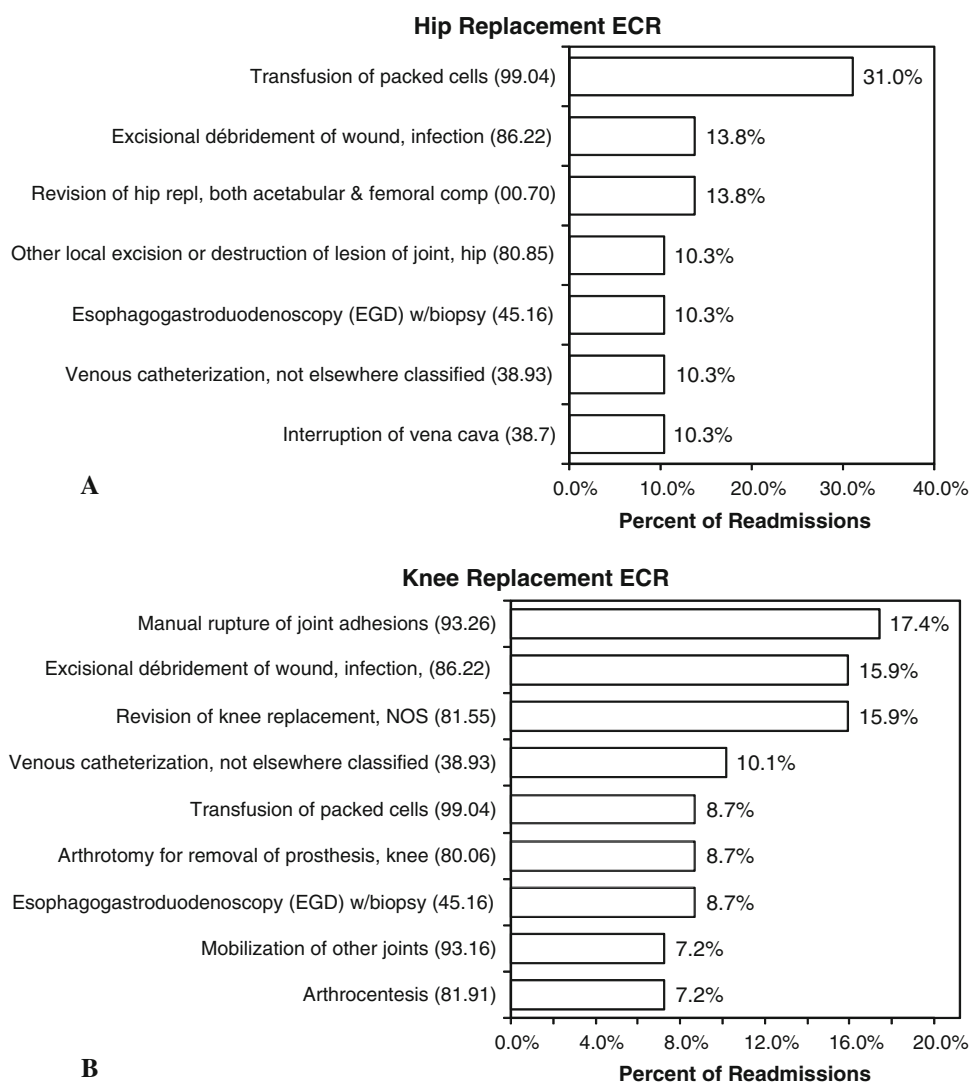


savings model creates provisions for providers to benefit from the gains realized by preventing complications. Ultimately, the models will be tested in the upcoming Prometheus Payment pilot sites to address the operational, financial and behavioral impacts of paying providers with ECRs.

The ECR price described here is based on a single national database of a commercially insured population and is thus not generalizable to other administrative data sets, in particular one that would primarily contain Medicare and Medicaid beneficiaries. Since a vast majority of hip and knee replacements are performed in the Medicare population, who are older and have considerably more comorbid conditions, the results described in this paper should not be

extrapolated to that group. Additionally, the actual price we arrived at needs to be geographically adjusted and normalized to other data sets for market implementation so that each payer-defined ECR reflects the actual fee schedules negotiated with providers. The ECR analyses were derived from pre-adjudicated claims and will require adjustments for various components of payment, including patient copayments, deductibles, and coinsurance, as well as payment from other parties. The Prometheus Payment model described in this article serves as a basis for contract negotiations between payers and providers in which additional provisions may be made based on specific arrangements in a given community. The analysis of hip and knee arthroplasty ECRs illustrates how a global fee for a

Fig. 3 Most common causes for readmissions after hip and knee arthroplasty are shown. The International Classification of Diseases, 9th Revision procedure codes are shown in parentheses. ECR = evidence-informed case rate.



procedure and associated services can create appropriate accountability for the variation in costs that providers impute into the total cost of care. However, the boundaries of each ECR are subjective and need to be vetted by experts, and consensus-based standards need to be established at the national policy level. Additionally, as seen in the creation of the severity-adjusted models for the stays, once the PAC stays (that result from “defects” within the system) were separated from the typical stays, the remaining variability could not be accounted for by patient-specific factors in the commercial population. Physician-preference items (choice of implant) [30], hospital characteristics, and geographic differences may be some of the reasons that account for the variation in stay costs that could not be identified from claims data. Moreover, when working with data from the Medicare population, better risk-adjustment models for stays may emerge with better allowances for PACs that are severity adjusted based on the several comorbidities in the older population.

Our study reported the average cost of a hip replacement episode to be \$24,960, which included inpatient costs, costs for preoperative workup as well as postoperative care for 6 months after surgery and included pharmacy costs. An extensive literature search did not reveal an analogous type of analysis, nor did it reveal the cost of potentially avoidable complications with respect to joint replacement surgeries. However, hospital costs for hip replacement have been reported at about \$14,500 per admission [30] and postoperative costs for one-year followup after hip arthroplasty in women (following femoral neck fracture in the Medicare population) as \$10,437 in 1996 [16]. These reported costs, which are, in total, close to the amounts reported in this study, would have included care for readmissions as well as other PAC costs.

On the other hand, the concept of preventable complications is well-founded in the medical literature. In our study we found that approximately 14% of the joint replacement costs were related to the treatment of PACs.

A recent study found that the underlying errors contributing to in-hospital surgical complications over a 12-month period were primarily related to human error such as error of technique (63.5%), errors in judgment (29.6%), inattention to detail (29.3%), and incomplete understanding of the problem (22.7%) [13]. The June 2007 MedPAC report to Congress on “Promoting Greater Efficiency in Medicare” highlighted the fact that in 2005, \$12 billion was spent on potentially preventable readmissions within 30 days of discharge from the hospital [22]. In her recent address at the Healthcare Incentives Institute, October 2008, Anne Mutti from MedPAC emphasized the need for bundled payments to cover hospitalizations plus some time after discharge (eg, 30 days) in order to motivate providers to collaborate with partners and improve collective performance as a way to reduce the unnecessary costs of avoidable readmissions [23].

Given the potential to reduce avoidable complications is sufficiently well researched and proven, the CMS and many payers in the country have begun to stop paying for the added costs associated with some of these complications [10, 22]. In doing so, these private and public sector payers have taken a view that some complications should almost never occur. While the definitions of PACs are broader than HACs and never-events, the Prometheus payment model aims for a reduction of 50% of the current rate of all PACs (including HACs). That policy is applied by redistributing half the total cost of all PACs into any triggered ECR as an allowance. The ECR’s PAC allowance not only insulates the provider for the cost of a PAC that might occur, but also creates a powerful incentive to continuously reduce the occurrence of any PAC. As a result, the ECR generates the potential for gain by both insurers and providers. The insurers can capitalize on the savings from unpaid complications and the providers can capitalize on savings from avoiding complications. By making the providers clinically as well as financially responsible for the comprehensive care of a procedure—before, during and after surgery—they should have a strong incentive to form coordinated care teams [5, 18, 29], whether integrated or virtual, centering care on the patient, and should collaborate actively to prevent unnecessary hospitalizations and reduce PACs [14]. In fact, the margins of physicians and hospitals would increase as PACs go down and quality of care increases [9].

Acknowledgments We thank the Robert Wood Johnson Foundation for their grant and their support in making this study possible.

References

1. Aaron HJ. Waste, we know you are out there. *N Engl J Med*. 2008;359:1865–1867.
2. AHRQ. *Clinical Classification Software (CCS) for ICD-9 CM*. 2008. Available at: <http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp>. Accessed Feb 21, 2009.
3. AHRQ. *Clinical Classification Software for Services and Procedures*. 2008. Available at: http://www.hcup-us.ahrq.gov/toolssoftware/ccs_svcsproc/ccssvcsproc.jsp. Accessed Feb 21, 2009.
4. AHRQ. *Quality Indicators: Guide to Patient Safety Indicators*. 2007. Available at: http://www.qualityindicators.ahrq.gov/downloads/psi/psi_guide_v31.pdf. Accessed October 30, 2008.
5. Coleman EA, Parry C, Chalmers S and Min SJ. The care transitions intervention. *Arch Intern Med*. 2006;166:1822–1828.
6. De Brantes F. *Pay for Performance and Beyond: A Recipe for Improving Healthcare. The Quality Conundrum: Practical Approaches for Enhancing Patient Care*. 2008:110–114. Available at: <http://www.pwc.com/extweb/pwcpublications.nsf/docid/c0204123b329c1d38525726700760e29>. Accessed October 30, 2008.
7. De Brantes F, Camillus JA. *Evidence-informed case rates: a new health care payment model*. The Commonwealth Fund Web site. Available at: <http://www.cmwf.org/Content/Publications/Fund-Reports/2007/Apr/Evidence-Informed-Case-Rates-A-New-Health-Care-Payment-Model.aspx>. Accessed March 30, 2009.
8. De Brantes F, Rastogi A. Evidence-informed case rates: paying for safer, more reliable care. *Issue Brief (Commonwealth Fund)*. 2008;40:1–13.
9. De Brantes F, D’Andrea G, Rosenthal M. Should health care come with a warranty? *Health Affairs*. 2009;28:w678–w687.
10. Department of Health and Human Services Center for Medicare and Medicaid Services. *Proposed Rules*. 73:23547–23562. Available at: <http://edocket.access.gpo.gov/2008/pdf/08-1135.pdf>. Accessed October 29, 2008.
11. ECRI Institute. *Special Advisory: List of CMS Hospital-Acquired Conditions Expanded Under New Final Rule*. 2008. Available at: https://www.ecri.org/PatientSafety/HrcReports/Pages/CMS_Final_Rule_on_Hospital_Acquired_Conditions.aspx. Accessed October 30, 2008.
12. Encinosa WE, Hellinger FJ. The impact of medical errors on ninety-day costs and outcomes: an examination of surgical patients. *Health Serv Res*. 2008;43:2067–2085.
13. Fabri PJ, Zayas-Castro JL. Human error, not communication and systems, underlies surgical complications. *Surgery*. 2008;144:557–563;discussion 563–565.
14. Fisher ES, Staiger DO, Bynum JPW, Gottlieb DJ. Creating accountable care organizations: the extended hospital medical staff. *Health Affairs*. 2007;26:w44–w57.
15. Fuchs VR. Three ‘inconvenient truths’ about health care. *N Engl J Med*. 2008;359:1749–1751.
16. Haentjens P, Autier P, Barette M, Boonen S. Costs of care after hospital discharge among women with a femoral neck fracture. *Clin Orthop Relat Res*. 2003;414:250–258.
17. Iezzoni LI. *Risk Adjustment for Measuring Health Care Outcomes*. 3rd Ed. Chicago, IL: Health Administration Press;2003.
18. Jack BW, Chetty VK, Anthony D, Greenwald JL, Sanchez GM, Johnson AE, Forsythe SR, O’Donnell JK, Paasche-Orlow MK, Manasseh C, Martin S, Culpepper L. A reengineered hospital discharge program to decrease rehospitalization: a randomized trial. *Ann Intern Med*. 2009;150:178–187.
19. O’Kane M, Corrigan J, Foote SM, Tunis SR, Isham GJ, Nichols LM, Fisher ES, Ebeler JC, Block JA, Bradley BE, Cassel CK, Ness DL, Tooker J. Crossroads in quality. *Health Aff (Millwood)*. 2008;27:749–758.
20. Mechanic RE, Altman SH. Payment reform options: episode payment is a good place to start. *Health Aff (Millwood)*. 2009;28:w262–w271.
21. McGlynn EA, Asch SM, Adams J, Keesey J, Hicks J, DeCristofaro A, Kerr EA. The quality of health care delivered to adults in the United States. *N Engl J Med*. 2003;348:2635–2645.

22. MedPAC. *Report to the Congress: Promoting Greater Efficiency in Medicare*. 2007. Available at: http://www.medpac.gov/documents/jun07_EntireReport.pdf. Accessed October 29, 2008.
23. Mutti A. Policies to encourage collective accountability: readmissions and bundled payment. Available at: http://www.ehcca.com/presentations/hcii1/mutti_1.pdf. Accessed October 29, 2008.
24. Neter J, Wasserman W, Kutner MH. *Applied Linear Statistical Models*. 3rd Ed. Homewood, IL: Irwin;1990.
25. PricewaterhouseCoopers' Health Research Institute. *The Price of Excess: Identifying Waste in Healthcare Spending*. 2008. Available at: <http://pwchealth.com/cgi-local/hregister.cgi?link=reg/waste.pdf>. Accessed October 30, 2008.
26. Prometheus Payment Inc. Available at: <http://www.prometheuspayment.org/>. 2008. Accessed Feb 20, 2009.
27. Rosenthal MB. Beyond pay for performance—emerging models of provider-payment reform. *N Engl J Med*. 2008;359:1197–1200.
28. Wharam JF, Sulmasy D. Improving the quality of health care: who is responsible for what? *JAMA*. 2009;301:215–217.
29. Wennberg JE, Bronner K, Skinner JS, Fisher ES, Goodman DC. Inpatient care intensity and patients' ratings of their hospital experiences. *Health Aff (Millwood)*. 2009;28:103–112.
30. Wilson NA, Schneller ES, Montgomery K, Bozic KJ. Hip and knee implants: current trends and policy considerations. *Health Aff (Millwood)*. 2008;27:1587–1598.