

TECHNICAL APPENDIX B

Chronic Care ECRs

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METHODS:

For each ECR, three basic process steps were followed:

Step 1 involved creating the claims code definitions and triggers for each episode, time window for the episode, eligibility and exclusion criteria. Decisions were made about which codes to include as part of typical care and services, which services to consider as related to potentially avoidable complications instead of a normal progression of the condition, and what to consider as an irrelevant service to be excluded from the episode.

Step 2 involved using statistical modeling to identify factors that directly impact the quantity of services within a given ECR from those that can be attributed to patient variables (e.g., comorbidities) and the relative strength of each variable. The result is a severity-adjusted formula for the base price for typical care.

Step 3 involved the quantification of the allowance for potentially avoidable complications and the full construction of the ECR (excluding the regional adjustment) into a global price for an episode of medical care.

The methodology is available as open source and can be adopted by plans and providers to create their own case rates based on their own data and fee schedules.^{xlviii}

Data Sources

We analyzed 2005-2006 claims data from a commercially insured population (CIP) of over 4.6 million members. The database contained inpatient and outpatient facility, inpatient and outpatient professional; laboratory; radiology; ancillary; and pharmacy claims. 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. National Drug Codes (NDC) were used for pharmacy claims. Results of laboratory or radiology tests were not available. We used the Agency for Healthcare Research and Quality (AHRQ)'s Clinical Classification Software (CCS) as a means of grouping ICD-9-CM diagnosis and procedure codes, and the CCS for CPTs classification to group CPT codes into meaningful, clinically homogenous categories for further analysis. To estimate ECR price, we created a cost field called "allowed amount" that represented the reimbursable amount and was a sum of the paid amount plus the patient portion of the payment in the form of co-pay, deductibles and coinsurance amounts, as reported in the CIP database. Throughout this paper, cost refers to the "allowed amount" field.

Evidence-Informed Case Rates

Using the commercial database, we constructed Evidence-informed Case Rates (ECRs), which are condition-specific formulas for calculating a risk-adjusted global price to be used as a basis for paying providers.^{xlix} Payments cover the cost of care recommended by well-accepted clinical guidelines or expert opinion, adjusted for type and intensity of services due to patient severity and comorbid factors (“typical” care). The formulas estimate the cost for an entire episode of care for a given condition treated for a defined period of time. In addition, an allowance is created for each episode, for 1) underuse adjustment/care coordination to account for minimum essential services required for each condition based on clinical guidelines, and 2) an additional allowance is created for payment for potentially avoidable complications, and is made available as part of the ECR price, irrespective of the fact that complications occur, but based on the severity of the episode. We created complete ECRs for six chronic medical conditions: congestive heart failure (CHF), coronary artery disease (CAD), diabetes, hypertension, chronic obstructive pulmonary disease (COPD), and asthma.

Episode Construction

The first step in ECR development was to construct an episode of care. Condition-specific trigger codes start an episode, and a predefined period determines the duration of the episode. For chronic medical conditions, this time period was one year from the trigger claim. Using CHF as an example, Table 1 displays condition-specific definitions (e.g., triggers, time period, exclusions). Similar criteria were defined for all the six chronic medical conditions. 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. The total costs for the entire episode were then calculated for each member.

Patients who did not meet the eligibility criteria, were not continuously enrolled for the entire episode duration, were missing gender, or had out of range or missing episode costs were excluded. 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, that is, major procedures which suggest that the index condition has advanced to a degree that services are now being provided for a different condition (e.g., coronary artery bypass graft in an episode of CHF or CAD). Pharmacy claims with NDC codes not relevant to the episode were also removed. The remaining claims were considered “relevant services”—this included claims related to (a) typical care or (b) potentially avoidable complications (PAC) for the index condition.

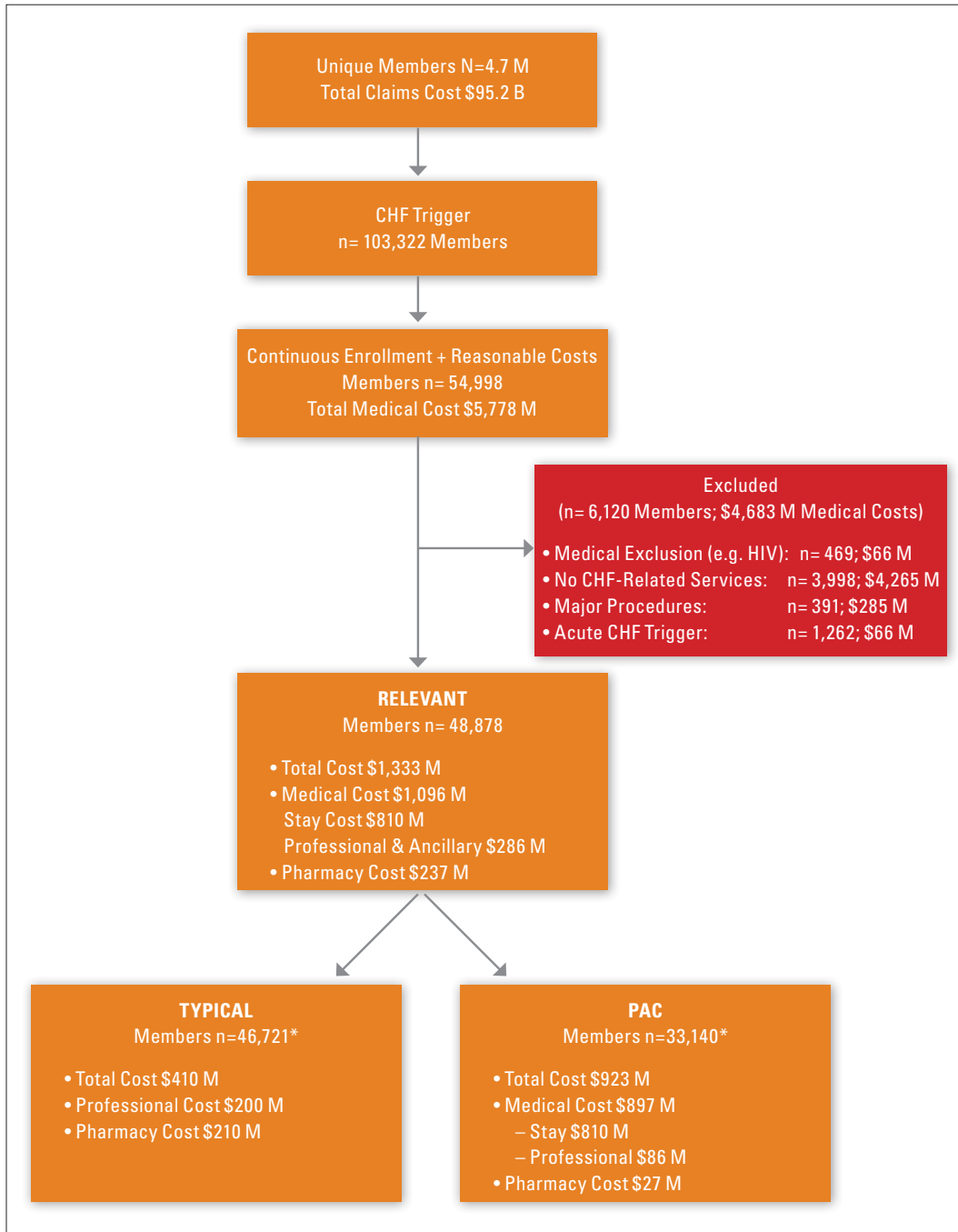
Table 1. **Condition-Specific Definitions for Episode Construction (Congestive Heart Failure)**

	Definition
Type of model(s) developed	Outpatient professional risk-adjustment model
Condition Trigger Codes*	The patient has a professional claim with one of these ICD-9-CM diagnosis codes in any position: 428 428.y, y=0,1,9 428.yz, y=2,3,4, z=0,2 or blank 402.y1, y=0,1,9 404.yz, y=0,1,9 z=1,3 398.91
Episode Period	One year starting from the date of service of the first trigger claim
Continuous enrollment requirement	9 months
Patient Exclusions	1. Remove episode if allowed amount (CHF and all other costs combined) are missing, < \$20, or > \$1,000,000. 2. Remove stay claim if stay claim costs are missing or < \$50.
Medical exclusions	Exclude patients with HIV, suicide, pregnancy and newborn conditions
Procedural exclusions	Exclude claims with any major or irrelevant surgical procedure
Case Breaker Services*	Exclude claims with any major but relevant surgical procedure
Potentially Avoidable Complications (PACs)	Syncope, coma, hypotension, dizziness, stroke, CVA, septicemia, meningitis, adverse effect of drugs, overdose, complications of medical care, acute myocardial infarction, acute renal failure, urinary tract infections, pneumonia, lung complications, lung abscess, empyema, bronchiectasis, respiratory failure, tracheostomy, mechanical ventilation, decubitus ulcer, gangrene, phlebitis, deep vein thrombosis, pulmonary embolism, skin and wound care, gastritis, stomach ulcers, gastrointestinal hemorrhage. Additionally, all hospitalizations and all emergency room visits are considered as PACs as well as professional services related to these hospitalizations.

* 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 (i.e. other than CHF).

For each of the chronic medical conditions, claims were considered PAC claims if they were classified as, or associated with, an inpatient stay or an emergency room visit (except for CAD); carried a PAC code in any of the four diagnosis fields for all other claims (Table 1); or had a procedure code that was related to services provided for a complication. The remaining claims were considered typical claims. For CAD, some of the hospital stays and emergency room visits were considered as typical services since services for chest pain are part of management of CAD and could be in the emergency room or hospital setting. Using typical professional, outpatient facility, inpatient facility (in case of CAD) and pharmacy claims, we created risk-adjustment models for each of the six chronic medical conditions. Episodes with <\$10 for remaining total typical costs were excluded from further modeling for the typical ECR. For each patient, we selected the first episode that met the eligibility criteria; therefore, each episode represented a unique person. Figure 1 details the data flow using CHF as an example.

Figure 1. **Flow Diagram**



Creating Severity-Adjustment Models

We used multiple linear regression modeling to identify factors that influence total costs—the dependent variable – for each chronic medical ECR. Since the distribution of total costs was right-skewed, we transformed it using natural logarithms to satisfy regression model assumptions. For the diabetes ECR, the log transformation was not strong enough to meet the constant error variance assumption, so the Box-Cox transformation was applied (formula: $(y^{0.25} - 1)/0.25$).¹ The independent variables considered consisted of demographics (age, gender), severity of index condition, comorbidities, pharmacy and procedure variables. To avoid overfitting (i.e., 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. For diabetes and CHF, split-sampling methods were used.^{3, li} The episodes in the analysis sample were randomly assigned to one of three datasets: model building (MB; 50 percent of episodes), validation (approximately 25 percent), and test (approximately 25 percent). The final models were based on the MB sample. Subsequent ECR model validation was performed using bootstrap techniques (see section below).

The methodology used to create the diabetes and CHF typical models is as follows. To select predictors for initial models, we conducted t-tests (or analysis of variance for age group) to measure the association between each independent variable and costs (univariate analysis). To improve the power to detect associations, we chose variables with at least 30 episodes per category and a univariate test p-value less than 0.25 to be candidate predictors for models. This p-value was chosen instead of 0.05 to increase our chances of detecting important variables.^{lii} Variables with high clinical relevance were initially forced into the model (e.g., for diabetes: type I or II, controlled or uncontrolled diabetes). Multiple linear regression with the stepwise variable selection procedure was used to select predictors of costs among the candidate variables. The p-value to enter and exit the model was set at 0.20 to improve our ability to identify important predictors.^{liiii}

The stepwise model was reviewed and modified by the clinical expert, and subsequent models were fit without the stepwise procedure. The final predictors retained in the model were those with at least 30 episodes per category, a positive coefficient (since during the PROMETHEUS implementation, variables with negative coefficients would require a negative payment), a low variance inflation factor ($VIF < 3$) to avoid collinearity, a high partial R-square to make the model parsimonious, performed consistently across the MB, validation and test samples, and those that were clinically plausible.

In October, 2008, we changed our statistical methodology so that the methodology would be easy for a wide variety of organizations to apply. This methodology was used for the COPD, asthma, hypertension and CAD typical models. We created a predictive model satisfying ordinary least-square (OLS) assumptions, using a natural log transformation of the dependent variable “cost.” We performed all analyses on the full dataset, after trimming outliers (below the 1st percentile and above the 99th percentile). We used similar univariate techniques as described above for screening variables to be kept into the model. Age and age-squared were fed into the models if the relationship of age to costs was quadratic. Multiple linear regression with the stepwise variable selection procedure was used to select predictors of costs among the candidate variables. The p-value to enter and exit the model was set at 0.25. Variables occurring in less than 1 percent of the patients, those having a p-value greater than 0.25, those with high variance inflation factors (VIF > 3.0), and those with negative coefficients (except for age and gender) were eliminated.

The model was then validated using bootstrap techniques. The model was run using stepwise selection with SLE=.05 and SLS=.05 on 200 bootstrap samples, and a record was kept of how many times each variable was selected in the 200 model runs. A bootstrap sample was created by sampling with replacement, from the full dataset until a sample of the same size as the full dataset was drawn. Any variables that were forced into the model above were also forced in the 200 bootstrap models. Any variable that entered into less than 170 bootstrap models (85 percent of the models) was dropped. The initial model was modified based on the results of the validation techniques, and unstable variables were dropped. The final model was recalibrated on the full dataset.

Creating Illustrative Examples

To create illustrative examples, the final model was used to estimate the total “typical” severity-adjusted ECR price for hypothetical patients. The intercept from the model, plus an adjustment for age and gender (if included in the model), was used to calculate the base price, also called as the “actual” minimum (intercept) cost of care. For CHF, the base price was \$1,488 for a hypothetical patient between 50 and 64 years of age with no comorbid conditions, no procedural services and no pharmacy costs. Patients with additional predictor variables / risk factors had additional costs determined by the respective regression coefficient from the model. All calculations for costs were performed on the transformed scale (CHF, CAD, hypertension, COPD and asthma: natural log; Diabetes: Box-Cox) and then the results were back-transformed to the original scale (dollars). Table 2 shows the final CHF model with the natural logarithmic coefficients and examples of three hypothetical patients and their ECR price for typical CHF care. Similar models were constructed for each of the six chronic medical conditions.

Table 2. **Construction of Severity-Adjusted Evidence-informed Case Rate (ECR) for Typical Care for Congestive Heart Failure (CHF) for Three Hypothetical Patients**

Predictor ¹	Number of Episodes with Variable	Percent Episodes (N=45,787)	Coefficient on Ln Scale ²	Hypothetical Patient Scenarios		
				Patient 1	Patient 2	Patient 3
Intercept	45,787	100.0%	7.3049	1	1	1
Age: < 50 vs. 50-64	782	1.7%	-0.0687	0	0	0
Age: 65-79 vs. 50-64	15,813	34.5%	0.1330	0	0	0
Age: >= 80 vs. 50-64	23,411	51.1%	-0.0059	0	0	0
Heart valve disorders	4,506	9.8%	0.1463	0	1	1
Coronary atherosclerosis and other heart disease	19,652	42.9%	0.2072	0	1	1
Carditis, Cardiomyopathy	4,058	8.9%	0.1294	0	1	1
Conduction disorders	3,723	8.1%	0.2003	0	1	1
Eye, ENT, oral procedures	615	1.3%	0.4293	0	1	1
Diagnostic cardiac catheterization, coronary arteriography	882	1.9%	0.4524	0	1	1
DME, visual and hearing aids	9,104	19.9%	0.4552	0	0	0
Cardiac ablation, pacemaker or cardioverter/defibrillator	680	1.5%	0.6575	0	0	0
Statins and other anti-lipid agents	6,581	14.4%	0.2161	0	1	1
Bronchodilators and other antiasthmatics	15,574	34.0%	0.2345	0	0	1
Antiarrhythmic agents	6,100	13.3%	0.2274	0	0	1
Inhalers and respiratory agents	7,376	16.1%	0.2061	0	1	1
Antacids and drugs for other oral and GI problems	27,060	59.1%	0.2915	0	1	1
Diuretics	36,548	79.8%	0.2469	0	1	1
Other cardiovascular agents	13,975	30.5%	0.1697	0	0	1
Beta-Blockers	31,234	68.2%	0.2322	0	0	1
ACEI, ARB, anti-renin drugs	29,454	64.3%	0.1672	0	1	1
Calcium channel blocking agents	16,172	35.3%	0.1672	0	0	1
Antiplatelet agents, thrombin inhibitors	11,699	25.6%	0.2214	0	1	1
Antidepressants	16,569	36.2%	0.1940	0	0	1
Severity-adjusted Price of ECR ³				\$1,488	\$27,418	\$93,341

¹ Predictors of episode costs from a multiple linear regression model. Professional, outpatient facility and pharmacy costs were modeled on the natural log scale. The models included patient demographic, medical comorbid conditions, procedures performed, and pharmacy use.

² All coefficients were significantly different from 0 at the 0.05 level. The adjusted R-square was 41.9%

³ To calculate the severity-adjusted price of the ECR by model, sum the estimates for the intercept and desired predictors (sumP) and compute e(sumP).

Pricing the Evidence-Based Services

A foundational element of PROMETHEUS is that the base set of services should include all the services that are recommended by Clinical Practice Guidelines or expert opinion as laid out by the Clinical Working Groups^{liv} or published guidelines in the literature. Table 3 outlines the minimum evidence-based core services for each of the chronic medical conditions priced using our developmental database. For CHF, the evidence-informed core services priced at \$3,597.

Table 3. **Evidence-informed Core Services and Prices**

Evidence-Based Services	CIP Database	CHF		CAD		Diabetes		Hypertension		COPD		Asthma	
	Unit price	N	Price	N	Price	N	Price	N	Price	N	Price	N	Price
Physicians													
PCP-new	\$178	1	\$178	1	\$178	0	\$0	0	\$0	1	\$178	0	\$0
PCP-established	\$104	5	\$519	3	\$312	4	\$416	4	\$416	2	\$208	4	\$416
Cardiology/ Pulmonologist	\$242	3	\$726	1	\$234	0	\$0	1	\$121	1	\$242	0	\$0
Endocrinologist	\$242	0	\$0	0	\$0	0.1	\$24	0	\$0	0	\$0	0	\$0
Ophthalmologist	\$242	0	\$0	0	\$0	1	\$242	0	\$0	0	\$0	0	\$0
Ancillary													
Diabetes Educator	\$104	0	\$0	0	\$0	1	\$104	0	\$0	0	\$0	0	\$0
Cardiac Rehab	\$35	12	\$422	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0
Emergency Room	\$469	0	\$0	0	\$0	0.1	\$47	0	\$0	0	\$0	0	\$0
Diagnostics / Lab													
Echo transthoracic	\$458	2	\$917	1	\$458	0	\$0	0	\$0	0	\$0	0	\$0
Electrocardiogram	\$58	2	\$116	1	\$58	0	\$0	1	\$58	0	\$0	0	\$0
Chest x-ray	\$90	2	\$180	1	\$90	0	\$0	0	\$0	1	\$90	1	\$90
Lung function test	\$35	2	\$70	0	\$0	0	\$0	0	\$0	4	\$141	1	\$35
metabolic panel	\$30	6	\$177	1	\$30	0	\$0	1	\$30	0	\$0	1	\$30
Lipid panel	\$70	2	\$139	1	\$70	2	\$139	1	\$70	0	\$0	0	\$0
Liver Function Tests	\$60	2	\$121	1	\$60	1	\$60	0	\$0	0	\$0	0	\$0
Microalbumin, quantitative	\$16	2	\$32	1	\$16	0	\$0	1	\$16	0	\$0	0	\$0
HbA1c	\$51	0	\$0	0	\$0	3	\$154	0	\$0	0	\$0	0	\$0
Potassium	\$37	0	\$0	0	\$0	1	\$19	0	\$0	0	\$0	0	\$0
Creatinine	\$75	0	\$0	0	\$0	2	\$113	0	\$0	0	\$0	0	\$0
Est. Evidence-Based Costs			\$3,597		\$1,505		\$1,317		\$710		\$858		\$570

¹ All specialists are computed at the same rate: cardiologist, pulmonologist, endocrinology, ophthalmologist.

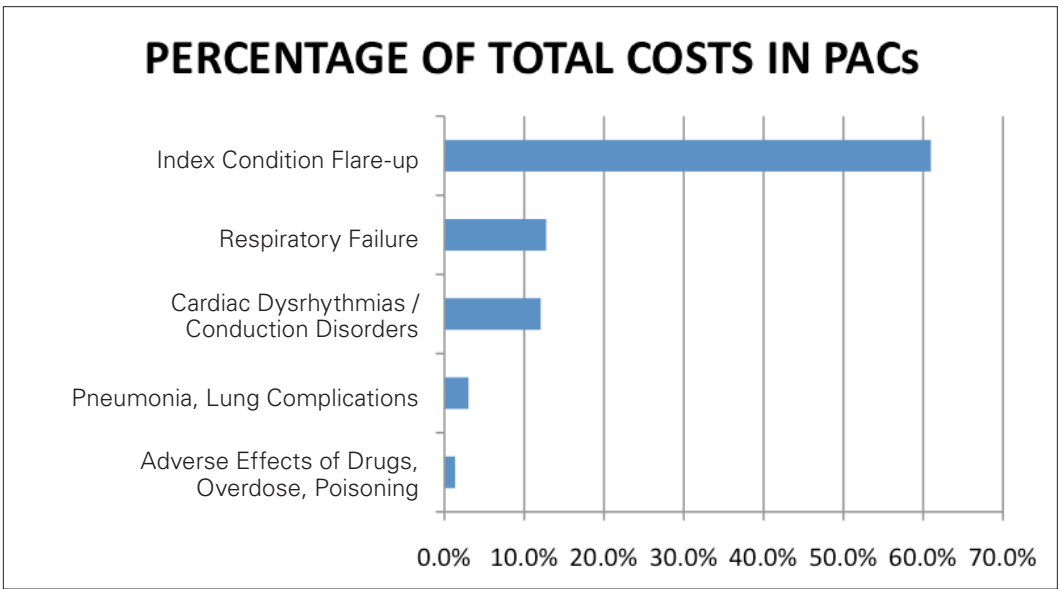
Determining the Underuse and Care-Coordination Allowance

If price of an individual episode fell below the minimum evidence-based costs, we classified it as underuse, and within PROMETHEUS, we provide an underuse and care-coordination allowance to these episodes. The allowance for care-coordination was calculated as the difference between the evidence-based recommended care and the actual minimum (intercept) costs of care from the regression models described above. The underuse amount represents the difference between what should have been the minimum costs based on care following evidence-informed guidelines, and what the patients in the database actually received for the core services provided. For CHF, the care coordination amount was calculated as \$2,112 as the difference between evidence-informed cost of minimum core services (\$3,597) and the actual minimum (intercept) costs (\$1,488).

Potentially Avoidable Complications and the PAC Pool

Claims and services that were aggregated as potentially avoidable complications (PACs) were used to create the PAC pool. The PAC pool helped quantify the waste within the system and identify specifically where the potential for savings lies. The total amount of dollars in the PAC pool formed the basis of determining the PAC allowance that in turn is paid to providers irrespective of the occurrence of PACs, and serves as a warranty for care defects. The details of the PAC analysis and the distribution of costs were used to identify which complications were major cost drivers, and to make the data actionable for providers to focus their energies on. Figure 2 shows the distribution of the most expensive PACs within an episode of CHF. Similar PAC analyses were conducted to identify the top cost drivers of PACs for each chronic medical condition studied.

Figure 2. **Distribution of Most Expensive Potentially Avoidable Complications (PACs) in Congestive Heart Failure as a Percentage of Total PAC Costs**



PAC Allowance

The total dollars associated with the treatment of PACs helped determine the PAC allowance that is given to providers towards payment for PACs irrespective of their occurrence, and is in part proportional to the severity and comorbidity factors present in the patients cared for within the ECR. By convention, PROMETHEUS reduces the total PAC allowance by the amount used to rebase the ECR for care coordination, and allocates 50 percent of the remaining PAC pool across each patient. A portion of this pool (25 percent) is given as a fixed amount to each episode, and the balance (75 percent) is allocated as a proportion of the risk-adjusted, rebased price for each patient. This is discussed in detail in another paper.^{lv} Similar PAC allowances were developed for all the six chronic medical conditions.

Construction of the Complete ECR

Table 4 illustrates development of the complete ECR using CHF as an example. A complete ECR is derived as the sum of the typical evidence informed case rate using the severity adjusted regression models plus the underuse/care-coordination allowance plus the PAC allowance for each patient. As the example shows, for patient 1, the severity adjusted price for typical care is \$1,488. This is adjusted for underuse/care coordination by \$2,112 and by the PAC allowance of \$3,165 to give a complete ECR price of \$6,765. Similarly, hypothetical patient 2 has a “typical” ECR price of \$27,418 based on the severity adjustment models for typical care and after the underuse/care coordination and PAC allowance adjustments, the complete ECR price is \$51,308.

Table 4. **Distribution of most Expensive Potentially Avoidable Complications (PACs) in Congestive Heart Failure as a Percentage of Total PAC Costs**

PAC Allowance Calculations	Factors	Average Cost	Number of Episodes	Total Cost
Total relevant CHF episodes		\$27,267	48,878	\$1,332,774,251
Typical CHF episodes		\$8,765	46,721	\$409,503,974
PAC CHF episodes		\$27,860	33,140	\$923,270,276
Added Burden for PACs		\$27,860		\$923,270,276
Evidence-informed Adjustment (Adjustment for Underuse)		\$2,112	48,878	\$103,248,387
Allowable Cost of PACs	50%			\$410,010,945
Flat Fee Portion (spread 25% of PAC costs over all episodes)	25%	\$2,097		\$102,502,736
Proportional Rate (75% of PAC costs as a rate over base costs)	75%			72%

ECR Construction	Hypothetical Patients			
	Factors	Patient 1	Patient 2	Patient 3
Severity-adjusted Base Price of ECR for typical CHF patients ^b		\$27,267	48,878	\$1,332,774,251
Allowance for Underuse and Care Coordination (\$3,597 - \$1,488)	\$2,112	\$8,765	46,721	\$409,503,974
Allowance for PACs		\$27,860	33,140	\$923,270,276
Flat Fee Allowance	\$2,097	\$27,860		\$923,270,276
Proportional Allowance	72%	\$2,112	48,878	\$103,248,387
Total ECR per Patient (severity-adjusted + Underuse/Care Coordination + PAC Allowance)	50%			\$410,010,945

^a The adjustment for underuse/care coordination (\$2,112) is the difference between (i) the evidence-informed core services price (table 3) and (ii) the intercept cost of the severity-adjusted base price for a patient with none of the comorbidities, procedures, etc. in the severity-adjusted regression model (Hypothetical patient 1 in table 2).

^{xlviii} For a complete description of the PROMETHEUS Payment methodology, the codesets for each episode, the results of the modeling effort to date, and access to the SAS programs that help develop Evidence-informed Case Rates, see www.PROMETHEUSpayment.org/playbook/index.htm, accessed January 2009.

^{xlix} F. de Brantes and A. Rastogi, "Evidence-Informed Case Rates: Paying for Safer, More Reliable Care," *The Commonwealth Fund* 40, publ. 1146 (2008): 1-14.

^l Neter J, Wasserman W, and Kutner MH. *Applied Linear Statistical Models*, 3rd ed. Homewood, IL: IRWIN, 1990.

^{li} Iezzoni LI, ed. *Risk Adjustment for Measuring Health Care Outcomes*, 3rd ed. Chicago, IL: Health Administration Press, 2003.

^{lii} Bendel RB and Afifi AA. "Comparison of stopping rules in forward regression", *JASA* no. 72 (1977): 46-53.

^{liii} Bendel RB, *ibid*

^{liiii} For Clinical Working Group Guidelines, see Guidelines for each chronic medical condition, www.PROMETHEUSpayment.org/playbook/index.htm, accessed January 2009.

^{liv} de Brantes et al, "Creating Warranties in an Episode of Care Payment System", under review.