Joint Replacement Outweighs Other Factors in Determining CMS Readmission Penalties

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Abstract

Many hospital leaders would like to pinpoint future readmission-related penalties and the return on investment associated with readmission reduction. However, the particularities of CMS penalty calculations do not allow for precise determination of either of these quantities. Using publicly available national data on 3,532 hospitals, we used multiple regression to isolate the effect on FY 2015 penalties of hospitals' readmission performance with respect to each of the five patient groups considered by CMS. We found that hip/knee replacement played a disproportionate role in the penalties assessed. This knowledge may assist hospitals in planning initiatives and therefore in targeting limited resources.

The Problem

Ask anyone in healthcare why they entered the field and you are most likely to hear responses such as "to make a difference," "to alleviate suffering," or "to solve the puzzle of a disease." What you most certainly will not hear is "to navigate the complex governmental guidelines that dictate reimbursement, and therefore my operating budget." One of the measures that is most pivotal to hospital operations is the 30-day unplanned readmission rate. It affects reimbursement directly, in the form of penalties, and indirectly, by influencing patients' choices of where to get their care. Great efforts are being made to influence both.

A question that remains unanswered is whether unplanned readmissions should be attacked globally or in a targeted manner. In an environment where we are unable to devote unlimited resources to a problem, we naturally prefer to prioritize where we focus our efforts. Many hospital administrators in the U.S. have asked how they can most effectively target their limited resources so as to reduce readmissions and the attendant penalties assessed by the Centers for Medicare and Medicaid Services (CMS). It is plain enough that CMS now takes into account hospital performance in five patient categories when it calculates the readmission penalty. But as we have discussed previously, these formulas are exceedingly complex. Leadership would like to know for which among these five categories will performance improvements be rewarded most.

We have delved into the calculations devised on behalf of CMS by their partners, QualityNet and the Yale New Haven Health Services Corporation/Center for Outcomes Research and Evaluation (YNHHSC/CORE). These calculations are not for the faint of heart. A paper describing their statistical methods features no fewer than eighteen authors. Each of the diagnosis- or procedure-specific readmission equations typically incorporates 50 variables. The authors quantify relationships based on multi-level, hierarchical logistic regression models, and they derive separate coefficients to characterize each of several thousand hospitals.

Sample Showing Complexity of CMS Penalty Equations

Step	Risk Factors Based on: Administrative Data
1	Compute Bivariate and Univariate summaries Z & Y
2	Generalized Linear Model $h(Y_{ij}) = \alpha^A + \beta^A Z_{ij}$ Obtain R^2, residuals, etc.
3	Hierarchical Generalized Linear Model $h(Y_{ij}) = \alpha_i^A + \beta^A Z_{ij}$ $\alpha_i^{(A)} \sim N(\mu_A, \tau_A^2)$
4	Hospital-Specific Predicted Outcomes $\hat{y}_i^A(\mathbf{Z}) = \frac{1}{n_i}\sum_{j=1}^{n_i} h^{-1}(\hat{\alpha}_i^A + \hat{\beta}^A \mathbf{Z}_{ij})$ Hospital-Specific Expected Outcomes $\hat{e}_i^A(\mathbf{Z}) = \frac{1}{n_i}\sum_{j=1}^{n_i} h^{-1}(\hat{\mu}_A + \hat{\beta}^A \mathbf{Z}_{ij})$ Hospital-Specific Standardized Outcomes $\hat{s}_i^A(\mathbf{Z}) = \frac{\hat{y}_i^A(\mathbf{Z})}{\hat{e}_i^A(\mathbf{Z})} \times \bar{y}$

As if that's not enough, in our detailed communications with them, these organizations have made it clear that **penalties for future years are not directly calculable**. This is not only because penalties may incorporate performance on additional conditions, but also because the system "grades on the curve": future penalties will depend in part on how the entire nation fares in its readmission reduction efforts.

In light of all this, **is there a workable way to identify the one or two patient categories that are the key determinants of the penalty?**

How We Isolated Each Condition's Role in the Penalty

Analyzing data provided to the public by CMS and Kaiser Health News on 3,532 US hospitals, we created a predictive model using the statistical technique of multiple linear regression.[1, 2] We arrived at a model that could successfully describe the ups and downs in the FY 2015 penalty as a function of eight variables. Five of these entailed readmission performance for patients admitted for acute myocardial infarction (AMI), heart failure (HF), and pneumonia (PN) – the three "core measures" considered by CMS for FY 2013 and 2014 – and two new indicators, for patients with chronic obstructive pulmonary disease (COPD) and those undergoing hip or knee replacement (Hip/Knee). The remaining three variables were quadratic (squared) terms that, as we will show, helped fully capture relationships that were nonlinear.

[1] Statistical analysis was conducted using the open-source statistical computing software *R* and IBM's SPSS package.

[2] We also explored other methods. We used the more specialized technique of censored regression, which had been effective in our FY 2013 analysis, but for FY 2015 data this technique performed no better than linear regression. We also looked into different ways of transforming the outcome variable, which was right-skewed, but none of them proved clearly superior to the regression methods described in the text.

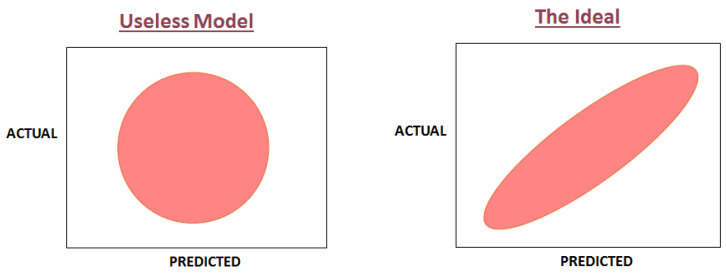
We obtained a regression equation that followed this form:

Predicted Penalty, FY 2015 = a
*+ b1*err.AMI*
+ b2 err.PN*
*+ b3*err.HF* *+ b4*err.HF*^{2}
*+ b5*err.HIP.KNEE* *+ b6*err.HIP.KNEE* ^{2}
*+ b7*err.COPD* *+ b8*err.COPD*^{2}, where

err = Excess Readmission Ratio (the ratio of actual to expected performance)[3],
a = the regression constant, and
b1 through *b8* are regression coefficients (weights).

We also made an adjustment so as to bring all predicted penalties into the range of 0% to 3%, inclusive, to match the range of those assigned by CMS. (We recoded the few predicted values that fell below 0% into "0%.")

Graphing the predicted vs. actual penalties in a scatterplot, how would we want the points to look? If predictive power were high, a low predicted penalty would usually mean a low actual one; high predicted, high actual. We'd see a band of points, one for each hospital, running from lower left to upper right. The points would form a cloud looking more like the idealized one at far right than the one to its left.



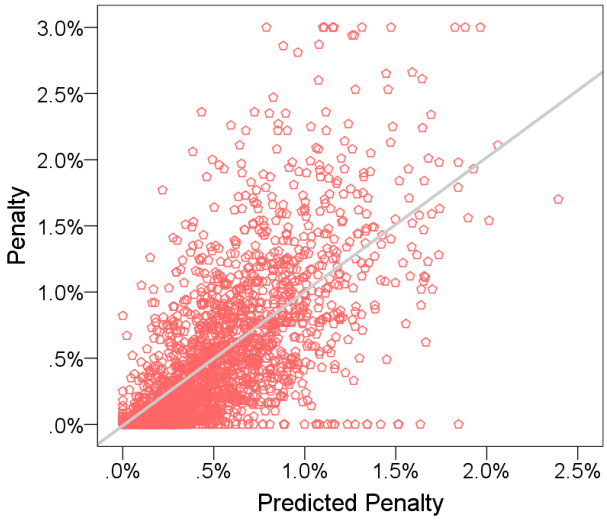
[3] This is the intended meaning behind the explanations given by CMS, QualityNet, and YNHHSC/CORE. We find this wording more helpful than the specific wording they have used over the years: the ratio of "predicted" to "expected."

How Accurate Are Our Regression Predictions?

The plot below shows the extent to which our predicted penalties lined up with the actual penalties, in this case for all 2,033 hospitals with publicly available and complete data.[4] There was indeed a strong lower-left-to-upper-right trend.

Specifically:

- 59% of the predictions fell within ¼ percentage point of the hospital's actual penalty.
- The in-sample *R*-squared, or percent of variance the model could explain, was 46%.



Such results constitute quite an improvement over all others currently known to us. Certainly they enable better prediction than the best guidelines we have encountered from CMS or its partners, guidelines which unfortunately boil down only to the truism that penalties will tend to go somewhat up or down in tandem with readmission performance.

The Key Predictor

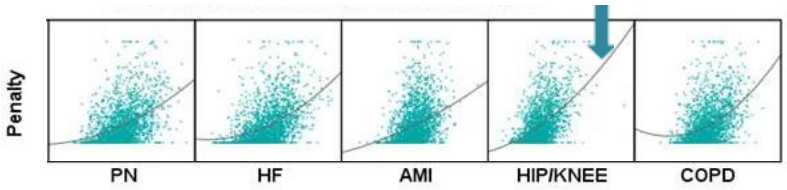
As a determinant of the FY 2015 readmission penalty, performance on the Hip/Knee measure trumps that of COPD, PN, HF, or AMI.

- All else being equal, for every additional tenth of a point in the Hip/Knee ERR, the penalty increases by about 0.2 percentage points.
- Beyond the linear relationship described just above, there is also a curved aspect; one might say the line "bends upward." That is, small differences in ERR mean greater penalty differences for hospitals whose Hip/Knee ERR is in the high range, compared to those in the lower ones.
    - This suggests that poorly performing hospitals stand to gain a great deal from even small improvements in Hip/Knee readmission performance.

[4] We also investigated the extent to which patterns in the data might have been distorted due to the fact that only these 2,033 cases (58%) were complete, i.e., that the remaining 42% were missing data in one or more relevant columns. We addressed this problem using multiple imputation through chained equations (MICE). We found essentially no evidence that observed relationships between variables had been distorted by missing data. This tells us that we can place trust in our estimates of the relative importance of the five predictors in explaining each hospital's penalty.

The chart below illustrates something of these connections.[5] Note the steeper curve for the fitline describing the Hip/Knee relationship.[6, 7]

US Hospitals' CMS Readmission Penalty, FY 2015,
As a Function of Performance on Five Readmission Measures



It may be discernable from the simplified graph above—it is abundantly clear from regression analysis, in which other variables are controlled – that the points follow the curve better for Hip/Knee than they do for the other four measures. Higher penalties are more strongly linked with an increase in the Hip/Knee ERR than with an increase on any of the other measures.

Can we say anything more definite about these predictors' relative importance? Here it's helpful to use a specialized type of correlation. You'll recall that an ordinary squared correlation, or *R*-squared, tells us to what degree we can account for one variable using another. A squared *part* correlation goes a little further and tells what portion of the variance in an outcome can be *uniquely* explained by performance in one area. The five performance indicators all matter, of course, and they overlap to some degree in explaining 46% of the "story" of the penalty. But using the part correlation we can see their distinct roles isolated.

[5] For all of these predictors, $p < .0001$.

[6] These plots are approximations; each shows a bivariate relationship rather than controlling for the other ERR variables.

[7] Besides the Hip/Knee, HF, and COPD plots, there is also some visible curve to the PN and AMI relationships, but not enough to materially affect predictions. That is why squared PN and AMI terms are not included in the regression equation.

Five Measures' Contribution to Explanation of FY 2015 Penalty in Regression Model		
	Predictor (ERR)	Variance Explained (R^2)[8]
Unique Contribution to Variance Explained (Linear Portion)	**Hip/Knee**	**17%**
	COPD	3%
	HF	3%
	PN	2%
	AMI	2%
Total of Unique Contributions (Linear Portions)		27%
Overlapping and Quadratic Portions		+ 19%
Total		= 46%

A natural question is "Why isn't *R*-squared 100%? After all, the penalty is determined by formula." The most important reason is that all ERR values less than 1.0 are treated the same in CMS's system. Doing a little bit better than expected is treated the same as doing vastly better. This has been a common criticism of the program. One might say that half the information in the ERRs is being discarded. A necessary consequence is that correlations will be imperfect and that the *R*-squared of any such model will be far less than 100%.

Seen through this lens, Hip/Knee is unquestioningly the most important of the five, and by a wide margin. Of the variance explained, over a third (17 of 46 percentage points) is due to the penalty's linear connection with the Hip/Knee indicator alone. PN and AMI performance, on the other hand, explain little that's unique about the penalty – little that cannot be established using the other indicators.

Conclusion

Our analysis uses publicly available data and draws on multiple regression and other methods to show that, of the five measures used by CMS to determine readmission penalties – readmission performance for patients with heart attack, heart failure, pneumonia, COPD and hip/knee replacement – the system clearly gives the most weight to hip/knee replacement. Data also suggest that hospitals that currently have higher-than-expected Hip/Knee readmission rates stand to gain from even small improvements on that measure. This knowledge is important for hospital leaders and other healthcare leaders affected by CMS regulations. As healthcare costs continue to spiral, leaders look for ways to focus resources that will improve outcomes – at both the patient and organizational levels. The findings of this paper may assist with both.

[8] Squared part correlation (Spearman method).

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About ReInforced Care

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