Risk Adjustment for Hospitalization Measures
Nursing Home Value Based Purchasing (NHVBP) demonstration

Introduction

Under the NHVBP demonstration, CMS will assess the performance of participating nursing homes based on quality measures in four domains: nurse staffing, avoidable hospitalizations, resident outcomes based on the minimum data set, and survey deficiencies from State health inspection surveys. This report addresses the approach that CMS will use to risk adjust the hospitalizations rate measures.

The intent of performance measures based on hospitalization rates is to give demonstration participants a direct incentive to reduce the rate of potentially avoidable hospitalizations. The domain includes two hospitalization rate measures: a "short stay" measure and a "long stay" measure. Short stay residents typically enter a nursing home following a hospital stay and need short term skilled nursing care or rehabilitation before being able to return to the community. Long stay residents require chronic care for extended periods and typically do not return to the community. The hospitalization measure is defined differently for these two kinds of residents because the hospitalization patterns of short and long stayers are significantly different.

For the purposes of the demonstration, the definition of short and long stay residents is based on whether the individual is a "permanent" resident of a nursing facility as determined by the length of the nursing home episode. For the demonstration, an episode begins with an admission to a nursing home and ends when the individual resides in the community for at least 30 days. If the individual spends at least 90 days of the episode as a nursing home resident, then that person will be considered a long stay resident for the entire episode. If the person spends less than 90 days of the episode in the nursing home, than that person will be a short stay resident for that episode.

The short stay hospitalization measure is the rate of hospitalizations for short stay residents per *stay.* The long stay hospitalization measure is the number of potentially avoidable hospitalizations for long stay residents per 100 long stay *days*. Further details on this domain are included in the NHVBP Design Refinements report (March 2009).

Risk Models

For both hospitalization measures, risk adjustment models will be used to adjust for differences in the medical acuity, functional impairment, and frailty of nursing home residents. Risk adjustment is intended to "level the playing field" among participating nursing homes, adjusting for differences in the medical acuity, functional impairment, and frailty of nursing home residents. Under risk adjustment, a nursing home will receive greater "credit" for avoiding a hospitalization of a high-risk resident (e.g., someone with a high predicted hospitalization rate based on the risk adjustment model) than for avoiding a hospitalization for a low-risk resident.

Data for risk adjustment models were derived from a combination of MDS and Medicare claims data, including SNF and hospital claims. Variables for the risk adjustment models were identified based on

the criteria of statistical significance, contribution to the explanatory power of the model, and clinical/policy relevance. Using a data set that included a 10 percent national sample of nursing homes, we examined the effectiveness of risk adjustment models, in terms of resident-level fit statistics describing the predictive performance of the models.

The risk models include these covariates:

- ***Demographic items:*** Both the short and long stay models include demographic items (covariates based on age and gender). Age is calculated relative to the episode starting date, using the date of birth and gender information that is collected on MDS assessments. For each facility, we calculate the proportion of residents who are female, age 65-74, age 75-85, and age 85+.

- ***Comorbidity index***: Both the short and long stay models use a covariate based on a comorbidity index originally developed by Charlson[1] and modified by Deyo[2]. The index is constructed from hospital claims (both inpatient and outpatient) ICD-9 primary/secondary diagnosis codes and fourteen matched disease conditions constructed from MDS Section I (Table 1). (Indicators from both claims and the MDS are used because a significant number of residents do not have a hospitalization, but all have at least one MDS assessment.) Binary indicators from these two sources are constructed if there is *any* indication of the presence of these disease conditions (using claims that started within 3 days of the end date of the episode and the 12 months prior to the beginning of the stay, as well as all MDS assessments during the episode).

Table 1:
Diagnoses and MDS Items Used in Comorbidty Index

#	Diagnosis Group	ICD9-CM codes	Section I items
1	Myocardial Infarction	410-412	
2	Congestive heart failure	398,402,428	I1f
3	Peripheral Vascular Disease	440-447	I1j
4	Cerebrovascular Disease	430-438	I1t
5	Dementia	290,291, 2494.1	I1u, I1q
6	Chronic Pulmonary Disease	490-496, 500-505, 506.4	I1ii
7	Rheumatologic Disease	710,714,725	
8	Peptic Ulcer Disease	531-534	
9	Mild Liver Disease	571,573	
10	Diabetes without complications	250.0-250.3, 250.7	I1a, I1kk
11	Diabetes with complications	250.4, 250.5, 250.6	
12	Paraplegia and Hemiplegia	342, 344.1	I1v, I1x, I1z
13	Renal Disease	403, 404, 580-586	I1qq
14	Cancer/Leukemia	140-165, 170-172, 174-176, 179-195, 200-208, 238.6	I1pp

[1] Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis. 1987;40(5):373-83.
[2] Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. J Clin Epidemiol. 1992 Jun;45(6):613-9.

15	Moderate or severe liver disease	070, 570, 572	
16	Metastatic Carcinoma	196-199	
17	AIDS/HIV	042-044	I2d
* First three digits of ICD9-CM code except where otherwise noted.			

For each of these diagnosis groups, we created a binary indicator based on whether or not the resident had a ICD-9 code or Section I item (from any MDS assessment) that indicated the presence of the item. The Charlson score is equal to the weighted sum of items present.

- Diagnosis groups 1-10 have a weight of one,
- Diagnosis groups 11-13 have a weight of two,
- Diagnosis group 14 has a weight of three,
- Diagnosis groups 15-17 have a weight of six.

- ***Prior hospitalizations:*** The long stay model also includes an indicator for whether there was an inpatient hospitalization in the 90 days prior to the start of the episode. Since most short-stay residents are admitted to the nursing home following a hospital stay, this measure is not used in the short stay model.

- ***Other MDS items:*** Individual MDS items that significantly affect the risk of hospitalization are included in the models. The short stay model includes pneumonia, urinary tract infection, pressure ulcer, and oral feeding tubes. In addition to these conditions, the long stay model includes septicemia, parenteral/IV nutrition, indwelling catheter, and antibiotic resistant infection. The long stay model includes an indicator of whether there is an advanced directive do not resuscitate (DNR) for the resident. This is defined based on MDS item A10b.

  Short stay episodes are assigned a value of one for these items if they are present on any of the five-day assessments associated with the episode, and zero otherwise. Note that there is usually only one five-day assessment associated with each short stay episode. But for residents who have multiple five-day assessments in an episode, we considered all five-day assessments, setting binary variables equal to one if there was an indication from any of the assessments during the episode that the item was present. Long stay episodes are assigned a value of one or zero for each of these items based on whether there is any indication (across all annual and quarterly assessments for the episode) that the item is present. We calculate the facility's mean value for each of these MDS covariates using all MDS assessments associated with long stay episodes for which the items are available.

- ***Functional status:*** The short stay model includes resident functional status. This is defined using the Barthel functional index. The Barthel index is created using nine ADL and functional status related items: feeding, transfer, grooming, toileting, bathing, walking, dressing, bowel incontinence, and bladder incontinence (see table 2 for the Barthel Index specifications). The Barthel index score is determined by adding up the scores for the individual items in the index.

Table 2: **Specifications for Barthel Index**	
Activity	**Scoring Rules**
Feeding (G1ha)	0= Extensive assistance or total dependence 5= Limited assistance or supervision required 10=Independent
Transfer (G1ba)	0= Total dependence 5=Extensive assistance 10= Limited assistance 15= Independent or only supervision required
Grooming (G1ja)	0= Limited or extensive assistance or totally dependent 5= Independent or only supervision required
Toileting (G1ga)	0= Extensive assistance or total dependence 5= Limited assistance 10=Independent or only supervision required
Bathing (G2a)	0= Limited or extensive assistance or totally dependent 5= Independent or only supervision required
Walking (G1da, G5b)	0= Total dependence (with no use of wheelchair) 5=Extensive assistance or total dependence with use of wheelchair 10= Limited assistance or supervision required 15= Independent
Dressing (G1ga)	0= Extensive assistance or total dependence 5= Limited assistance 10=Independent or only supervision required
Bowel incontinence (H1a)	0= Extensive assistance or total dependence 5= Limited assistance or supervision required 10=Independent
Bladder incontinence (H1b)	0= Extensive assistance or total dependence 5= Limited assistance or supervision required 10=Independent

For episodes with multiple five-day assessments, we use the average of the Barthel index score across all assessments in the episode.

Regression Coefficients

The regression coefficients for the long stay model are presented in Table 3. The dependent variable in the model is number of long stay hospitalizations per 100 long stay resident days.

Table 3: Regression Coefficients: Long Stay Model		
Variable	**Coefficient**	**Standard Error**
Intercept	-0.15998	0.00375
Comorbidity index	0.17656	0.00147
Indwelling catheter	0.08926	0.00252
Infections-Pneumonia	0.15124	0.0027
Oral-Feeding tube	0.11895	0.00309
Infections-Septicemia	0.15701	0.00571
Oral-Parenteral/IV	0.11671	0.00321
Infections-Antibiotic resistant	0.06369	0.00414
Pressure ulcer	0.04475	0.00207
Urinary tract infection	0.04974	0.00197
Hospital in prior 90 days	0.04277	0.00213
Age 65-74	-0.00161	0.00374
Age 75-84	0.00943	0.00334
Age 85+	0.01907	0.00338
Female	-0.00691	0.00195

The regression coefficients for the short stay model are presented in Table 4. These coefficients are from a logistic regression model in which the dependent variable was a binary indicator for whether there was an avoidable hospitalization during the episode.

Table 4: Regression Coefficients: Short Stay Model		
Variable	**Coefficient**	**Standard Error**
Intercept	-1.8057	0.0321
Comorbidity index	0.154	0.00211
Barthel index	-0.0177	0.000329
Infections-Pneumonia	0.4413	0.0149
Pressure ulcer	0.3779	0.0136
Urinary tract infection	0.3088	0.0136
Oral-Feeding tube	0.4611	0.022
Age 65-74	0.0193	0.0283
Age 75-84	0.0455	0.0263
Age 85+	0.0497	0.0272
Female	-0.0628	0.0133

Calculating Predicted Hospitalization Rate

Long Stay Residents:

The predicted long stay hospitalization rate for a facility is calculated using the regression coefficients from Table 3 and the facility's mean score for the covariates. The formula for calculating predicted hospitalization rate is:

-0.15998 + (0.17656 * charlson_score) + (0.08926 * catheter) + (0.11895 * feeding_tube) + (0.06369 * infection) + (0.15701 * septicemia) + (0.11671 * parenteral) + (0.15124 * pneumonia) + (0.04475 * ulcer) + (0.04974 * uti) + (-0.02686 * DNR) + (0.04277 * prior) +
(-0.00161* age6574) + (0.00943 * age7584) + (0.01907 * age85) + (-0.00691 * female).

An example illustrating the calculation of predicted hospitalization rate for two facilities is shown in Table 5.

Table 5:
Calculating Predicted Hospitalization Rate: Long Stay

		Facility A		Facility B	
Variable	**Coefficient**	**Facility Mean**	**Coefficient x Mean**	**Facility Mean**	**Coefficient x Mean**
Intercept	-0.15998	1.00	-0.1600	1.00	-0.1600
Charlson	0.17656	2.15	0.3796	1.75	0.3090
Catheter	0.08926	0.13	0.0116	0.05	0.0044
Feeding Tube	0.11895	0.04	0.0046	0.09	0.0107
Septicemia	0.15701	0.01	0.0016	0.02	0.0032
Parenteral	0.11671	0.05	0.0058	0.06	0.0069
Pneumonia	0.15124	0.08	0.0121	0.05	0.0077
Infection	0.06369	0.03	0.0021	0.00	0.0002
DNR	-0.02686	0.47	-0.0126	0.25	-0.0067
Ulcer	0.04475	0.12	0.0054	0.24	0.0106
UTI	0.04974	0.05	0.0025	0.16	0.0081
Prior Hosp	0.04277	0.39	0.0166	0.42	0.0181
Age 65-74	-0.00161	0.31	-0.0005	0.14	-0.0002
Age 75-84	0.00943	0.20	0.0019	0.32	0.0030
Age 85+	0.01907	0.13	0.0025	0.50	0.0095
Female	-0.00691	0.68	-0.0047	0.63	-0.0044
Predicted hospitalization rate			0.2685		0.2201
Note: Predicted hospitalization rate is calculated as the (sum of coefficients x mean column)					

Short Stay Residents:

The predicted short stay hospitalization rate for a facility is calculated using the regression coefficients from Table 4 and facility mean scores for the covariates.

Log (Predicted hospitalization rate)=-1.8057 + (0.154*charlson score) + (-0.0177*barthel index)+ (0.4413*pneumonia) +(0.3779 * ulcer)+ (0.3088*uti)+(0.4611* feeding_tube + (0.0193 * age6574) + (0.0455 * age7584) + (0.0497*age85)+ (-0.0628*female)

Because the short stay model is a logistic regression model, this predicted value is expressed as the log of the facility's predicted hospitalization rate. In order to use this value in the calculation of the adjusted rate, it must be transformed (as shown in the last row of Table 6). That is, predicted hospitalization rate= exp(Log (Predicted hospitalization rate)).

Table 6 shows the calculation of predicted hospitalization rates for two facilities.

Table 6:
Calculating Predicted Hospitalization Rate: Short Stay

		Facility A		Facility B	
Variable	**Coefficient**	**Facility Mean**	**Coefficient x Mean**	**Facility Mean**	**Coefficient x Mean**
Intercept	-1.8057	1.0000	-1.8057	1.0000	-1.8057
Comorbidity index	0.1540	1.2264	0.1889	1.5214	0.2343
Barthel index	-0.0177	48.6412	-0.8609	32.6923	-0.5787
Infections-Pneumonia	0.4413	0.0272	0.0120	0.0210	0.0093
Pressure ulcer	0.3779	0.0425	0.0161	0.0874	0.0330
Urinary tract infection	0.3088	0.1837	0.0567	0.1364	0.0421
Oral-Feeding tube	0.4611	0.0351	0.0162	0.1923	0.0887
Age 65-74	0.0193	0.2230	0.0043	0.2335	0.0045
Age 75-84	0.0455	0.3243	0.0148	0.3868	0.0176
Age 85+	0.0497	0.4324	0.0215	0.3275	0.0163
Female	-0.0628	0.8135	-0.0511	0.6516	-0.0409
Predicted hospitalization rate			-2.3873		-1.9795
Exponential of log of predicted hospitalization rate			0.0919		0.1381

Note: Predicted hospitalization rate is calculated as the (sum of coefficients x mean column). The coefficients are from a logistic regression so the predicted hospitalization rate is expressed as a log.

Calculating Adjusted Hospitalization Rates

For both long and short stay episodes, the risk adjusted hospitalization rates are calculated for each facility using this formula:

$$\text{Hosp Rate}_{\text{Adjusted}} = (\text{Hosp Rate}_{\text{Actual}}/\text{Hosp Rate}_{\text{Predicted}}) * \text{State adjustment factor}$$

Note that the above formula includes an adjustment factor. This factor is set separately for each State, and normalizes the facility adjusted rate to the State average hospitalization rate. All facilities in a

particular State will have the same adjustment factor applied to their hospitalization rate (i.e., the State average factor).

Long Stay Episodes:

Table 7 shows the calculation of the adjusted hospitalization rate for long stay episodes for the two sample facilities shown in Table 5.

Table 7: Calculation of Adjusted Hospitalization Rate: Long Stay		
Variable	**Facility A**	**Facility B**
	Value	**Value**
Actual hospitalization rate	0.1203	0.1502
Predicted hospitalization rate (from Table 5)	0.2685	0.2201
Adjustment factor for state	1.4561	1.4561
Adjusted hospitalization rate (calculated as actual * (actual/predicted)* adjustment factor)	0.0785	0.1286

Short Stay Episodes:

Table 8 shows the calculation of the adjusted hospitalization rate for short stay episodes for the two sample facilities shown in table 6. Note that the expected short stay hospitalization rate is calculated as exp(predicted rate)/(1+ exp(predicted rate)).

Table 8: Calculation of Adjusted Hospitalization Rate: Short Stay		
Variable	**Facility A**	**Facility B**
	Value	**Value**
Observed hospitalization rate	0.0551	0.1283
Expected rate	0.0919	0.1381
Adjustment factor for state	0.9452	0.9452
Adjusted hospitalization rate	0.0312	0.1127
Expected rate is calculated as exp(predicted rate)/(1+ exp(predicted rate))		

Conclusion

The NHVBP demonstration includes a performance measure related to the rate of potentially avoidable hospitalizations. The measure is calculated separately for short and long stay residents. This document describes the risk adjustment approach used for the avoidable hospitalization performance measure. This approach was used to calculate the pre-demonstration baseline hospitalization rate statistics that were sent to demonstration participants in April 2011, and it will be used to calculate risk adjusted hospitalization rates for the three performance years of the demonstration. While we anticipate using the same risk adjustment approach throughout the demonstration, implementation of MDS 3.0 may result in some small changes to the MDS items used in the risk adjustment models.