ACUMEN
500 Airport Blvd., Ste 365
Burlingame, CA 94010
Main (650) 558-8882
Fax (650) 558-3981
http://www.acumenllc.com

Method for Categorizing Home Health Agencies Based on Quality Measure Performance

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This technical brief describes a method for categorizing home health agencies (HHAs) as "better than expected", "same as expected", and "worse than expected" for the purposes of publicly reporting the newly developed measures of *Rehospitalization During the First 30 Days of Home Health* and *Emergency Department Use without Hospital Readmission During the First 30 Days of Home Health* measures (henceforth called the "Rehospitalization and "ED Use without Hospital Readmission" measures, respectively).

The goal of this method is to assign an HHA to the "better than expected" category if the agency's rate of Rehospitalization (resp. ED Use without Hospital Readmission) is lower than expected based on patient case mix by a statistically significant amount and to assign an HHA to the "worse than expected" category if the HHA's rate of Rehospitalization (resp. ED Use without Hospital Readmission) is higher than expected based on patient case mix by a statistically significant amount. The size of the difference between an HHA's observed rate and expected rate that is statistically significant at a specified level (e.g., 5%) depends on the number of home health stays eligible for the measure and the case-mix characteristics of the HHA's specific patients.

This brief is structured as follows: The first section describes the underlying data model and defines each HHA's observed rehospitalization (resp. ED Use without Hospital Readmission) rate as a random variable with a distribution that depends on the number of home health (HH) stays and the patient level predicted probability of rehospitalization (resp. ED Use without Hospital Readmission) for each HH stay. The second section precisely states the null and alternative hypotheses that correspond to classifying an HHA as "better than expected" and the null and alternative hypotheses that correspond to classifying an HHA as "worse than expected". The third section identifies an appropriate test-statistic and describes how to compute the appropriate p-values for rejecting each null hypothesis. The final section describes how the method was implemented and presents results.

Underlying Data Model

The underlying assumption of this method is that rehospitalization or ED use without hospital readmission by home health patients during the first 30 days of home health care is a random process that HHAs can influence but cannot entirely control. The extent to which agency j influences rehospitalization (resp. ED use without hospital readmission) is called the "care effect" and denoted ξ_j^{Rehosp} (ξ_j^{ED}). ξ_j is greater than 0 and scaled such that the average HHA has $\xi_j = 1$. Each HH stay also has stay-specific probabilities of rehospitalization and ED use without hospital readmission, denoted p_i^{Rehosp} and p_i^{ED}. These probabilities are computed using a multinomial logistic risk-adjustment model that relates 404 patient level risk factors to the outcomes "Rehospitalization", "ED Use without Hospital Readmission", and "No Acute Event".[1] If patient i is treated by HHA j, the probability of rehospitalization and ED use without hospital readmission are $\xi_j^{Rehosp} p_i^{Rehosp}$ and $\xi_j^{ED} p_i^{ED}$, respectively.

Realization of stay level outcome

The outcome for each HH stay (X_{ij}) follows a multinomial distribution over the set {"No Event", "ED Use without Hospital Readmission", "Rehospitalization"}. Specifically,

- $Pr(X_{ij} = Rehospitalization) = \xi_j^{Rehosp} p_i^{Rehosp}$
- $Pr(X_{ij} = EDUse) = \xi_j^{ED} p_i^{ED}$
- $Pr(X_{ij} = NoEvent) = 1 - \xi_j^{ED} p_i^{ED} - \xi_j^{Rehosp} p_i^{Rehosp}$

HHA observed rate as a random variable

Suppose agency j provides care for n_j HH stays and has care effects ξ_j^{Rehosp} and ξ_j^{ED}. Define agency j's rates of rehospitalization and ED use without hospital readmission as:

$$Y_j^{Rehosp} = \frac{1}{n_j} \sum_{i=1}^{n_j} \mathbf{1}\{X_{ij} = Rehospitalization\}$$

$$Y_j^{ED} = \frac{1}{n_j} \sum_{i=1}^{n_j} \mathbf{1}\{X_{ij} = EDUse\}$$

[1] See "Home Health Claims-Based Rehospitalization Measures: Risk Adjustment Methodology", November 2013, Acumen, LLC. http://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/HomeHealthQualityInits/HHQIQualityMeasures.html

For ease of notation, we will omit the superscript on Y_j and focus the remainder of our discussion on rehospitalization. Y_j is a random variable with a scaled Poisson binomial distribution with mean $\frac{1}{n_j}\sum_{i=1}^{n_j}\xi_j p_i$ and variance $\frac{1}{n_j^2}\sum_{i=1}^{n_j}\xi_j p_i(1-\xi_j p_i)$. We observe one realization of Y_j for each agency.

Hypothesis Testing

If agency care effects ξ_j were directly observed, then agencies with $\xi_j < 1$ would be categorized as "better than expected" and those with $\xi_j > 1$ would be categorized as "worse than expected". However, ξ_j is not observed. Rather, we must infer whether it is less than (greater than) 1 based on the realized rate of rehospitalization (resp. ED use without hospital readmission). The relevant test statistic is the agencies observed rate of rehospitalization (resp. ED use without hospital readmission), $ObsRate_j$, computed as per the measure specification.

Null and Alternate Hypotheses for "Better Than Expected" category

Determining if agency j is better than average requires rejecting the null hypothesis that care by agency j does not reduce the risk of rehospitalization by any more than average. Formally, we have the following pair of hypotheses:

(1.1) $H_0 : \xi_j \geq 1$

(1.2) $H_1 : \xi_j < 1$

Under the null hypothesis, the expected value of Y_j is at least $\frac{1}{n_j}\sum p_i$. Rejecting the null hypothesis at the 95% level requires that the p-value associated with $ObsRate_j$ to be less than 5%.

Null and Alternate Hypotheses for "Worse Than Expected" category

Determining if agency j is worse than average requires rejecting the null hypothesis that care by agency j does not increase the risk of rehospitalization by any more than average. Formally, we have the following pair of hypotheses:

(1.3) $H_0 : \xi_j \leq 1$

(1.4) $H_1 : \xi_j > 1$

Under the null hypothesis, the expected value of Y_j is at most $\frac{1}{n_j}\sum p_i$. Rejecting the null hypothesis at the 95% level requires that the p-value associated with $ObsRate_j$ to be less than 5%.

Computing P-values using a Simulated Distribution

Under each of the null hypotheses described above, $ObsRate_j$ is a realization Y_j which follows a scaled Poisson-binomial distribution with mean $\frac{1}{n_j}\sum_{i=1}^{n_j} p_i$ and variance $\frac{1}{n_j^2}\sum_{i=1}^{n_j} p_i(1-p_i)$. This is a discrete distribution over all attainable rates between 0 and 1. Only rates equal to $\frac{i}{n_j}$ for $i \in 0,\ldots,n_j$ have non-zero probability.

The p-value associated with the "Better Than Expected" hypothesis test for an agency with $ObsRate_j$ is $Pr(Y_j \le ObsRate_j \mid H_0)$. This p-value can be determined by simulating the distribution of Y_j. For all n_j home health stays at agency j, conduct N multinomial trials assuming $\xi_j = 1$ to realize stay-level outcomes X_{ij}. For each simulation $k \in 1,\ldots,N$, calculate the agency's rate of rehospitalization $Y_j^k = \frac{1}{n_j}\sum_{i=1}^{n_j} \mathbf{1}\{X_{ij} = Rehospitalization\}$. The simulated rates Y_j^k form the distribution of $Y_j \mid H_0$. The p-value associated with rejecting the null hypothesis (eq 1.1) is $Pr(Y_j \le ObsRate_j \mid H_0) = \frac{\sum_{k=1}^{N} \mathbf{1}\{Y_j^k \le ObsRate_j\}}{N}$. That is, the p-value equals the fraction of simulations that result in a simulated rate of rehospitalization less than or equal to the observed rate.

The p-value associated with the "Worse Than" hypothesis test for an agency with $ObsRate_j$ is $Pr(Y_j \ge ObsRate_j \mid H_0) = \frac{\sum_{k=1}^{N} \mathbf{1}\{Y_j^k \ge ObsRate_j\}}{N}$. In other words, the p-value for rejecting the null hypothesis that HHA j is no worse than average equals the fraction of simulations that result in a simulated rate of rehospitalization greater than or equal to the observed rate.

Implementation

Based on patient-level predicted rates from the multinomial logistic model, 20,000 simulated distributions of rehospitalization and ED use without hospital readmission rates were generated using SAS, and were used to categorize HHAs into “Better than Expected”, “Same as Expected” and “Worse than Expected” categories. As defined above, each agency received p-values associated with the “Better Than Expected” category and the “Worse Than Expected” category. If the p-value for a category was less than or equal to .05, the HHA was classified as within that category. If neither p-value was less than or equal to .05, the HHA was categorized as “Same as Expected.” Using a value of .05 means that the risk of categorizing a truly average or worse than average agency as better than average is less than 5%.

Table 1: Categorization of Rehospitalization Rates, by Number of Stays (July 2010 – June 2013)

Number of Stays	Better than Expected		Same as Expected		Worse than Expected		Total
	Count	% of Total	Count	% of Total	Count	% of Total	
<20	6	0.1%	4,035	98.2%	67	1.6%	4,108
20-49	51	3.1%	1,566	94.6%	38	2.3%	1,655
50-99	66	4.4%	1,352	91.0%	68	4.6%	1,486
100-199	85	6.1%	1,226	88.5%	74	5.3%	1,385
200-399	89	7.2%	1,057	85.0%	98	7.9%	1,244
400-999	124	11.1%	848	76.1%	143	12.8%	1,115
1000+	93	13.7%	439	64.6%	148	21.8%	680
Total	**514**	**4.4%**	**10,523**	**90.1%**	**636**	**5.4%**	**11,673**

Table 2: Categorization of Emergency Department Use without Hospital Readmission Rates, by Number of Stays (July 2010 – June 2013)

Number of Stays	Better than Expected		Same as Expected		Worse than Expected		Total
	Count	% of Total	Count	% of Total	Count	% of Total	
<20	0	0.0%	4,030	98.1%	78	1.9%	4,108
20-49	32	1.9%	1,568	94.7%	55	3.3%	1,655
50-99	60	4.0%	1,343	90.4%	83	5.6%	1,486
100-199	87	6.3%	1,189	85.8%	109	7.9%	1,385
200-399	96	7.7%	1,008	81.0%	140	11.3%	1,244
400-999	113	10.1%	779	69.9%	223	20.0%	1,115
1000+	155	22.8%	387	56.9%	138	20.3%	680
Total	**543**	**4.7%**	**10,304**	**88.3%**	**826**	**7.1%**	**11,673**