TO: **NQF Patient Safety Steering Committee Members**
NQF Staff
FROM: **Pam Owens, AHRQ Quality Indicators Program**
DATE: **June 30, 2014**
RE: **PSI 90 for Maintenance Endorsement**

As a follow-up to the Steering Committee Meetings held on April 17 and April 18, 2014, AHRQ is submitting additional materials related to PSI 90 –Patient Safety for Selected Indicators. Specifically, reviewers asked to see additional measure information related to the re-weighting of PSI 90 with three additional components, including PSI 09 – Perioperative Hemorrhage or Hematoma Rate, PSI 10 – Postoperative Physiologic and Metabolic Derangement Rate and PSI 11 – Postoperative Respiratory Failure Rate. This memo reviews the methodology of the composite PSI 90 – Patient Safety for Selected Indicators and provides the requested results of re-weighting PSI 90 to include a total of 11 component Patient Safety Indicators. We agree with the Steering Committee that this re-weighting approach achieves better balance across various hospital-associated, safety-related events, provides a more reliable and valid signal to users, and is more consistent with the original conception and design of the PSI composite. Thank you very much for giving AHRQ the opportunity to submit additional information regarding PSI 90

Summary

The analyses shown in this document suggest that the re-weighting of PSI 09, PSI 10 and PSI 11 improves the overall assessment of patient safety of a hospital. While maintaining the integrity of the methodology originally endorsed by the Steering Committee in 2009, the analyses and results of the revised PSI 90 can be summarized as follows:

1. The revised weighting is more consistent with the original conception and design of the PSI composite, as described in the Technical Report on the AHRQ QI website.
2. The revised weighting continues to account for the reliability of the indicator and the prevalence of the patient safety event.
3. The revised weighting balances the total weight more equitably and fairly across 11 different hospital-associated, safety-related events; no single indicator comprises more than 32% of the total weight.
4. Therefore, the reweighted composite sends a clearer and more consistent signal to users about safety-related events and performance across all hospitals.
5. The re-weighted composite retains or improves on all of the desirable properties of the previous version, including its consistency (repeatability) and ability to discriminate among hospitals.

In the next few months, AHRQ will conduct further analytic work to complete the testing of the weighting strategy and incorporate the concept of harm; in other words, the concept that some safety-related events are more important, from the clinical or public health perspective, than others of equal frequency.

Overview

The revised composite PSI 90 – Patient Safety for Selected Indicators is the weighted average of reliability-adjusted observed to expected ratios, where the component weights are the relative frequencies of the numerator events in the reference population. This approach is fully consistent with

the original design and analytic plan for PSI 90, as described in technical reports at the AHRQ QI website (see http://qualityindicators.ahrq.gov/Downloads/Modules/PSI/PSI_Composite_Development.pdf).

The following component indicators are included in PSI 90:

- PSI 03 Pressure Ulcer Rate
- PSI 06 Iatrogenic Pneumothorax Rate (NQF 0346)
- PSI 07 Central Venous Catheter-Related Blood Stream Infection Rate
- PSI 08 Postoperative Hip Fracture Rate
- PSI 09 Perioperative Hemorrhage or Hematoma Rate*
- PSI 10 Postoperative Physiologic and Metabolic Derangement Rate*
- PSI 11 Postoperative Respiratory Failure Rate (NQF 0533)*
- PSI 12 Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate (NQF 0450)
- PSI 13 Postoperative Sepsis Rate
- PSI 14 Postoperative Wound Dehiscence Rate
- PSI 15 Accidental Puncture or Laceration Rate (NQF 0345)

*NOTE: The information provided in this memo incorporates PSI 09, PSI 10 and PSI 11. These indicators are given non-zero weights based on the same methodology applied in the original submission.

The composite is intended to reflect the likelihood of harm associated with a potentially preventable adverse event where that likelihood is expressed as the probability of a potentially preventable adverse event x harm association with the event (in the current specification all events are assigned equal harm). The rationale is that numerator weights reflect the probability that an individual patient would experience a particular adverse event.

NOTE: As noted in the original documentation and as the Steering Committee reviewers pointed out, numerator weights that reflect the amount of harm associated with each of the indicators, such as excess mortality, [excess costs] or complications associated with the adverse event or that reflect the amount of confidence one has in identifying events (i.e., the positive predictive value) may also be derived. However, further testing is necessary for the implementation of composite weights based on harm. The operationalization of such weights including development, refinement, testing and vetting with stakeholders and clinical experts was not able to be accomplished in the time-frame allotted for submission of public comments. AHRQ will continue to examine the feasibility, utility and implications of including such weights in the patient safety composite.

Data Source for Measure Development and Testing:

The analyses presented in this memo are based on two data sources. All-payer discharge data from all community, non-rehabilitation hospitals in 46 states participating in the State Inpatient Databases (SIDs) of the Healthcare Cost and Utilization Project (HCUP) was used for initial development, refinement, and testing of PSI 90, Medicare Fee-for-Service (FFS) data from all Inpatient Prospective Payment System (IPPS) hospitals was used for further testing of PSI 90. The decision was made to use two data sources to assess the scientific properties of the reweighted PSI composite for two primary reasons: 1) HCUP data is the foundation for development, refinement, and testing of the reweighted composite; and 2) since the hospital composite ratios are derived with Medicare FFS data, it is important to determine whether the composite and its component indicators are reliable and valid using Medicare FFS data.

Healthcare Cost and Utilization Project (HCUP), State Inpatient Databases (SID). Analyses were completed using data from the Healthcare Cost and Utilization Project (HCUP) State Inpatient Databases

(SID), 2011. HCUP is a family of health care databases and related software tools and products developed through a Federal-State-Industry partnership and sponsored by the Agency for Healthcare Research and Quality (AHRQ). HCUP databases bring together the data collection efforts of State data organizations, hospital associations, private data organizations, and the Federal government to create a national information resource of encounter-level health care data. The HCUP SID contain the universe of the inpatient discharge abstracts in participating States, translated into a uniform format to facilitate multi-State comparisons and analyses. Together, the SID encompass about 97 percent of all U.S. community hospital discharges (in 2011, 46 states participated for a total of more than 38.5 million hospital discharges). As defined by the American Hospital Association, community hospitals are all non-Federal, short-term, general or other specialty hospitals, excluding hospital units of institutions. Veterans hospitals and other Federal facilities are excluded. These analyses are based only on data from community, non-rehabilitation hospitals in the 46 participating states. Taken from the Uniform Bill-04 (UB-04) and discharge abstracts, the SID data elements include ICD-9-CM coded principal and secondary diagnoses and procedures, additional detailed clinical and service information based on revenue codes, admission and discharge status, patient demographics, expected payment source (Medicare, Medicaid, private insurance as well as the uninsured), total charges and length of stay (www.hcup-us.ahrq.gov). HCUP State Inpatient Databases (SID). Healthcare Cost and Utilization Project (HCUP). 2011. Agency for Healthcare Research and Quality, Rockville, MD. www.ahrq.gov/sidoverview.jsp

The analysis for this submission was limited to community, non-rehabilitation, acute care hospitals and their respective discharges that were included in the 2011 HCUP SID (N=4,572 hospitals).

Medicare Fee-for-Service (FFS) data at Inpatient Prospective Payment System (IPPS) Hospitals. The Medicare claims data used in this analysis include claims submitted for Medicare fee-for-service (FFS) discharges from April 1, 2011 through March 31, 2013 for Inpatient Prospective Payment System (IPPS) hospitals. The inpatient claims data were drawn from the 2011 and 2012 SAFs final releases from June 2012 and June 2013 respectively, in addition to the June 2013 release of the 2013 SAF. All years of the SAF were in the 5010 format and include up to 25 diagnosis codes and 25 procedure codes. In addition to the SAF, Medicare enrollment and demographic information was derived from the 2011, 2012, and 2013 Denominator files. The 2011 and 2012 Denominator files were released in March 2012 and March 2013 respectively, and the 2013 denominator file was released in June 2013. The Denominator files are annual summary files containing enrollment and demographic information about Medicare beneficiaries enrolled during the calendar year.

Methodology

As stated in the original submission, the PSI 90 composite is derived using the following steps:

STEP 1. Compute the risk-adjusted rate and confidence interval of each of the patient safety components.

STEP 2. Scale the risk-adjusted component rates using the reference population. The levels of the rates vary from indicator to indicator. To combine the component indicators using a common scale, each indicator's risk-adjusted rate is divided by the reference population rate to yield a ratio (indirect standardization). The component indicators are scaled by the reference population rate so that each indicator reflects the degree of deviation from the overall average performance.

STEP 3. Compute the reliability-adjusted ratio. The reliability-adjusted ratio (also described as the smoothed indirectly standardized risk-adjusted ratio) is computed as the weighted average of the risk-adjusted ratio and the reference population ratio, where the weights vary from 0 to 1, depending on the degree of reliability for the indicator and provider (hospital). For small providers (hospitals), the weight is closer to 0. For larger providers, the weight is closer to 1. For a given provider, if the denominator is 0, then the weigh assigned is 0 (i.e., the reliability-adjusted ratio is the reference population ratio).

Reliability-Adjusted Ratio = (risk-adjusted ratio X weight) + reference population X (1-weight)

STEP 4. Select the component weights. The composite is the weighted average of the scaled reliability-adjusted ratios for the component indicators (indirect standardization of the smoothed rates). The AHRQ QI user has the ability to modify these weights, although the NQF-endorsed version is based on numerator weights. Numerator weights are based on the relative frequency of the numerator foe each component indicator in the reference population. Hence, the sum of the numerator weights is 1. In general, a numerator weight reflects the amount of harm in the outcome of interest, in this case a potentially preventable adverse event. Please note that only events reported by the hospital as "hospital-acquired" or "not present on admission" (i.e., POA=no or POA=documentation insufficient, as specified in regulations from CMS) are counted in this analysis.

For the purpose of this submission to NQF, composite numerator weights were based on prevalence only and harm is assumed to be of equal weight. To remain consistent with the previous submission, prevalence weights were based on the original prevalence estimates in version 4.5 of the AHRQ QI software and are as follows:

Table 1. Weights for Reweighted PSI 90 (including non-zero weights for PSI 09, PSI 10 and PSI 11)

Indicator	Weight*
PSI 03 Pressure Ulcer Rate	0.0146
PSI 06 Iatrogenic Pneumothorax Rate	0.0461
PSI 07 Central Venous Catheter-Related Blood Stream Infection Rate	0.0428
PSI 08 Postoperative Hip Fracture Rate	0.0007
PSI 09 Perioperative Hemorrhage or Hematoma Rate	0.2078
PSI 10 Postoperative Physiologic and Metabolic Derangement Rate	0.0100
PSI 11 Postoperative Respiratory Failure Rate	0.1431
PSI 12 Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate	0.1655
PSI 13 Postoperative Sepsis Rate	0.0476
PSI 14 Postoperative Wound Dehiscence Rate	0.0105
PSI 15 Accidental Puncture or Laceration Rate	0.3113
SUM	1.0000

*Please note that the software is refined and updated on an annual basis. Thus, each year, numerator weights may have slight shifts due to changes in the prevalence of the indicators.

STEP 5. Construct the composite measure. The composite measure is the weighted average of the component indicators using the numerator weights and the scaled reliability-adjusted ratios (RAR).

Composite = (PSI03 RAR X PSI03 weight) + (PSI06 RAR X PSI06 weight) + … + (PSI15 RAR X PSI15 weight)

Results

Population for Development of Reweighted PSI 90 (including non-zero weights for PSI 09, PSI 10, PSI 11)

Table 2. Summary Metrics of Components of the Reweighted PSI 90 Composite

Components	Outcome (Numerator)	Population at Risk (Denominator)	Observed Rate (per 1,000)	Weight In Composite[1,2]
PSI 03 Pressure Ulcer Rate	3,262	7,124,911	0.4578	0.0146
PSI 06 Iatrogenic Pneumothorax Rate	8,916	24,232,557	0.3679	0.0461
PSI 07 Central Venous Catheter-Related Blood Stream Infection Rate	7,915	19,622,508	0.4034	0.0428
PSI 08 Postoperative Hip Fracture Rate	153	4,454,660	0.0343	0.0007
PSI 09 Perioperative Hemorrhage or Hematoma Rate	40,299	7,006,284	5.7518	0.2078
PSI 10 Postoperative Physiologic and Metabolic Derangement Rate	1,985	3,952,276	0.5022	0.0100
PSI 11 Postoperative Respiratory Failure Rate	31,064	3,277,889	9.4768	0.1431
PSI 12 Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate	36,069	7,265,224	4.9646	0.1655
PSI 13 Postoperative Sepsis Rate	9,152	762,110	12.0088	0.0476
PSI 14 Postoperative Wound Dehiscence Rate	2,073	1,098,428	1.8872	0.0105
PSI 15 Accidental Puncture or Laceration Rate	57,545	25,166,109	2.2866	0.3113

[1]Including POA; [2]The weights include component weights and shrinkage weights. The component weights are numerator weights, defined as the relative frequency of the numerators for the component indicators in the reference population. The shrinkage weights are the signal-to-noise ratio, where the signal variance is estimated from the reference population, and the noise variance is estimated from the user's data.
Source: Agency for Healthcare Research and Quality, Healthcare Cost and Utilization Project (HCUP), State Inpatient Databases (SID), 2011. Calculated using AHRQ QI Software, Version 4.5

Note that the component weight assigned to PSI 15 is substantially lower with this re-weighting approach; no single indicator now contributes more than 32% of the total weight.

Table 3. Summary of the Reweighted PSI 90 Composite

Year/ Characteristic	Community, Non-Rehabilitation Hospitals	Outcome of Interest	Population at Risk	Overall Composite Performance Score
2011	4,572	-	13,112,888	1.000
Composite Performance Score Distribution 2011				
5th	**25th**	**Median**	**75th**	**95th**
0.201	0.889	0.971	1.023	2.492

Source: HCUP State Inpatient Databases (SID). Healthcare Cost and Utilization Project (HCUP). 2011. Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/sidoverview.jsp. (AHRQ QI Software Version 4.5)

Empirical Results to Support Composite Construction

The concept behind this quality construct is that use of the composite by consumers making selection decisions or providers allocating resources for change is likely to result in better allocation of effort to improve patient safety and thereby to prevent patient safety-related events. Our method is to conduct a correlation analysis to ensure that worse performance on the composite is associated with worse performance on the component measures.

Table 4. Correlation of PSI-90 Composite (Reweighted), PSI 90 Composite (Original), and PSI 90 Components

	PSI 90 (rewgt)	PSI90 (original)	PSI 03	PSI 06	PSI 07	PSI 08	PSI 09	PSI 10	PSI 11	PSI 12	PSI 13	PSI 14	PSI 15
PSI 90 – (rewgt)	1.0000												
PSI90 – (original)	0.9443	1.0000											
PSI 03	0.2122	0.2290	1.0000										
PSI 06	0.3504	0.3494	0.0300	1.0000									
PSI 07	0.3583	0.3982	0.1725	0.0942	1.0000								
PSI 08	0.0584	0.0532	0.0747	-0.0135	0.0702	1.0000							
PSI 09	0.4908	0.3035	0.0447	0.1467	0.0440	0.0084	1.0000						
PSI 10	0.1642	0.1101	0.0796	0.0650	0.0787	0.0380	0.1083	1.0000					
PSI 11	0.3810	0.1341	0.0267	0.0902	0.0218	0.0414	0.0595	0.1338	1.0000				
PSI 12	0.5168	0.5291	0.1297	0.1191	0.1284	0.0925	0.1375	0.1123	0.1468	1.0000			
PSI 13	0.2880	0.2441	0.0617	0.0448	0.0930	0.0610	0.1046	0.1307	0.2270	0.1286	1.0000		
PSI 14	0.0923	0.0733	0.0576	-0.0171	0.0105	0.0261	0.0564	0.0395	0.0740	0.0384	0.0110	1.0000	
PSI 15	0.7473	0.8037	0.0339	0.2778	0.0631	-0.0244	0.2813	0.0231	0.0494	0.0314	0.1015	0.0456	1.0000

Source: HCUP State Inpatient Databases (SID). Healthcare Cost and Utilization Project (HCUP). 2011. Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/sidoverview.jsp. (AHRQ QI Software Version 4.5)
NOTE: PSI 90 Reweighted includes PSI 09, PSI 10 and PSI 11. PSI 90 original excludes PSI 09, PSI 10 and PSI 11. All correlations are based on smoothed rates for component indicators at the hospital level.

Interpretation:
At the hospital level, all of the component measures are positively correlated with the reweighted PSI 90. The highest correlations ($r > 0.38$), as would be expected from the weighted algorithm, are between the reweighted PSI 90 and PSI 15, PSI 12, PSI 09, and PSI 11. Not surprisingly, weaker correlations are noted for rarer events, which cannot be estimated reliably as standalone indicators at the hospital level (e.g., PSI 08, PSI 14). In addition, the correlations among the components are low, suggesting that trade-offs are not required among component measures.

Reliability Testing

The composite is a weighted average of reliability-adjusted observed to expected ratios, where the component weights are the relative frequency of the numerator in the reference population.

Table 5. NQF Numerator Weights for the Reweighted PSI 90, Signal-to-Noise Ratio for Hospitals and Correlation with the Reweighted PSI 90 Composite.

Indicator	Weight[1]	Average Hospital Signal-to-Noise Ratio		Correlation With Reweighted PSI 90 Composite	
		HCUP SID, 2011	Medicare FFS, 2011	HCUP SID, 2011	Medicare FFS, 2011
PSI 03 Pressure Ulcer Rate	0.0146	0.6830	0.6191	0.2122	0.1800
PSI 06 Iatrogenic Pneumothorax Rate	0.0461	0.4206	0.2947	0.3504	0.2257
PSI 07 Central Venous Catheter-Related Blood Stream Infection Rate	0.0428	0.7878	0.7137	0.3583	0.3102
PSI 08 Postoperative Hip Fracture Rate	0.0007	0.0280	0.0104	0.0584	0.0186
PSI 09 Perioperative Hemorrhage or Hematoma Rate	0.2078	0.6399	0.5022	0.4908	0.4918
PSI 10 Postoperative Physiologic and Metabolic Derangement Rate	0.0100	0.4137	0.2981	0.1642	0.2048
PSI 11 Postoperative Respiratory Failure Rate	0.1431	0.6941	0.5870	0.3810	0.5188
PSI 12 Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate	0.1655	0.7402	0.6439	0.5168	0.5211
PSI 13 Postoperative Sepsis Rate	0.0476	0.5753	0.4644	0.2880	0.2507
PSI 14 Postoperative Wound Dehiscence Rate	0.0105	0.3255	0.1937	0.0923	0.0806
PSI 15 Accidental Puncture or Laceration Rate	0.3113	0.7762	0.6621	0.7473	0.6712
SUM	1.0000				

Sources: HCUP State Inpatient Databases (SID). Healthcare Cost and Utilization Project (HCUP). 2011. Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/sidoverview.jsp. (AHRQ QI Software Version 4.5). Medicare FFS discharges at IPPS hospitals from 4/1/2012 through 3/31/2013.

[1]Based on 2010 HCUP SID reference population

NOTE: Due to time constraints AHRQ was unable to calculate the average hospital signal-to-noise ratio for the overall reweighted composite. Technically, this step required detailed variance calculation estimates and complex statistical analysis that were not available prior to submission of this material. AHRQ will work in the coming months to provide an average hospital signal-to-noise ratio estimate for the overall composite.

Interpretation:

The overall composite retains the indicators in the original composite and adds three additional indicators with moderate average signal-to-noise ratios (0.414 to 0.694). We would expect that the signal-to-noise ratio for the overall reweighted composite would be at least the same if not better than the original composite. Many, but not all, of the indicators-specific average signal-to-noise ratios calculated using Medicare FFS data are similar to those calculated using HCUP all-payer data (4 indicators have an absolute difference in signal to noise ratios < 0.10; all have an absolute difference <

0.15). In addition, similar to the results using HCUP all-payer data, all of the component indicators are positively correlated with the reweighted composite indicators using Medicare FFS data. With the exception of PSI 06 and PSI 11, correlations between the component indicators and the reweighted composite indicator are similar using HCUP all-payer data and Medicare FFS data (absolute difference ranges from 0.01 to 0.08).

Validity Testing

We conduct construct validity testing to examine the association between the composite performance score and hospital structural characteristics potentially associated with quality of care, including prior performance, using regression analysis.

Measure	**How it is measured**	**Rationale**
Ln(Volume)	Natural log of the denominator	Practice makes perfect or referral
Reservation Quality	Inverse of average daily census (ADC)	Reflects the excess capacity in the inputs of production (e.g. nurse staffing)
Transfer Out	Overall percent transfer out	Routine transferring of particular categories of patients
Maximum DX	Maximum reported diagnosis codes	Higher prevalence and co-morbidities
Prior Performance	Prior year composite performance score	Share of performance likely to persist

The hypothesized relationship is as follows:

- Volume: Higher volume is associtaed with better outcomes, either because practice makes perfect (volume causes outcome) or selective referral (outcome causes volume)
- Reservation quality: Higher reservation quality is associated with better outcomes because reservation quality is associated with excess capacity
- Transfer out: Higher transfer out rate is associated with better outcomes because transferred cases may have higher risk of mortalityor adverse outcome
- Diagnosis codes: More reported diagnosis codes are associated with more reported comorbidities, therefore higher expected rates, there fore better outcomes

NOTE: Please note that estimation of prior performance estimates based on the reweighted PSI 90 using 2010 HCUP data were not able to be completed in time for this submission. AHRQ will be pursing such testing in the coming months.

In lieu of prior performance estimates using all-payer HCUP SID data 2010, we present construct validity testing using 2011-2013 Medicare Fee-for-Service data.

Table 6. Regression on Structure Measures: Medicare Fee-for-Service Discharges from IPPS Hospitals, 2011-2013

Variable	Label	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
lnvol	Ln(Volume)	-0.00143	0.00247	-0.58032	0.56174	-0.00626	0.00340
adcinv	Reservation Quality	0.00131	0.00113	1.15774	0.24705	-0.00091	0.00352
trnsout	Transfer Out	-0.15916	0.06814	-2.33582	0.01956	-0.29271	-0.02561
maxdx	Maximum DX	0.00070	0.00066	1.06070	0.28890	-0.00060	0.00200
_cons	Constant	0.97108	0.01983	48.97607	<0.0001	0.93222	1.00994
lnvol	Ln(Volume)	-0.00657	0.00203	-3.23650	0.00122	-0.01054	-0.00259
adcinv	Reservation Quality	-0.00002	0.00098	-0.02052	0.98363	-0.00194	0.00190
trnsout	Transfer Out	-0.02916	0.05567	-0.52381	0.60045	-0.13827	0.07995
maxdx	Maximum DX	0.00072	0.00054	1.33173	0.18304	-0.00034	0.00178
prior2	Prior Performance	0.55263	0.01306	42.32824	<0.0001	0.52704	0.57822
_cons	Constant	0.45768	0.02028	22.56429	<0.0001	0.41793	0.49744

Source: The dependent variable in the regression is the composite performance score that includes PSI 09, 10, and 11. The dependent variable and covariates are derived from Medicare FFS discharges at IPPS hospitals from 4/1/2012 through 3/31/2013. Prior performance is from Medicare FFS discharges at IPPS hospitals 4/1/2011 through 3/31/2012

Interpretation:
Using Medicare FFS data, hospitals with higher transfer out rate have better performance (lower ratio). However, once prior performance is accounted for, transfer out rate is not predictive of performance. Further, using Medicare FFS data, we found that conditional on prior performance, hospitals with higher volume have better performance (lower ratio). Overall performance is strongly persistent over time.

Although we were not able to present the results from HCUP data, we found similar results regarding prior performance and volume using the PSI 90 composite as originally specified. Given the results using Medicare FFS data, we expect to find similar results using the reweighted PSI 90 composite.