



Quality Indicator User Guide: Patient Safety Indicators (PSI) Composite Measures, v2022

Prepared for:

Agency for Healthcare Research and Quality
U.S. Department of Health and Human Services
5600 Fishers Lane
Rockville, MD 20857
<https://qualityindicators.ahrq.gov/>

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1.0 Overview

The goal in developing the Agency for Healthcare Research and Quality (AHRQ) Quality Indicators™ (QI) composite measures was to provide a measure that could be used to monitor performance over time or across regions and populations using a method that applied at the national, regional, state or hospital/area level. Potential benefits of composite measures are to: summarize quality across multiple indicators, improve the ability to detect differences, identify important domains and drivers of quality, prioritize action for quality improvement, make current decisions about future (unknown) health care needs and avoid cognitive “shortcuts”. Despite these potential advantages there are concerns with composite measures, such as: masking important differences and relations among components, not being actionable, not being representative of parts of the health care system that contribute most to quality or detracting from the impact and credibility of reports. In weighing the benefits and concerns of composite measures, there are also a number of potential uses to consider, such as: consumer use for selecting a hospital or health plan, hospital use for identifying domains and drivers of quality, purchaser use for selection of hospitals or health plans to improve employee health and policymaker use for setting policy priorities to improve the health of a population. This document provides a technical overview for AHRQ QI users.

2.0 What Are the Composites?

One could advocate for separate composites based on the type of adverse event (e.g., postoperative). However, in general, the component indicators apply to the same hospitals and show at least some positive correlation with one another. Therefore, the composite includes all of the hospital-level, non-obstetric indicators (see Table 1 below) with the exception of PSI 04 Death Rate Among Surgical Inpatients with Serious Treatable Complications (which itself is a composite) and PSI 05 Retained Surgical Item or Unretrieved Device Fragment Count (which is reported as a count). Future development might examine sub-composites for certain indicators.

Table 1. AHRQ PSI 90 Composite Measure, v2022

PSI 90 PATIENT SAFETY AND ADVERSE EVENTS COMPOSITE1
PSI 03 Pressure Ulcer Rate
PSI 06 Iatrogenic Pneumothorax Rate
PSI 08 In Hospital Fall with Hip Fracture Rate
PSI 09 Postoperative Hemorrhage or Hematoma Rate
PSI 10 Postoperative Acute Kidney Injury Requiring Dialysis Rate
PSI 11 Postoperative Respiratory Failure Rate
PSI 12 Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate
PSI 13 Postoperative Sepsis Rate
PSI 14 Postoperative Wound Dehiscence Rate
PSI 15 Abdominopelvic Accidental Puncture or Laceration Rate

3.0 How Are the Composites Created?

The AHRQ PSI 90 composite is a combination of the reliability-adjusted (smoothed), risk-standardized observed-to-expected ratio for each composite. The components are combined into one composite using weights. AHRQ PSI 90 weights reflect a potential harm-based approach and are based on two components: 1) numerator weights and 2) harm weights.

1. *Numerator weight.* A numerator weight is based on the relative frequency of the numerator for each component indicator in the reference population. In general, a numerator weight reflects the volume of harm in the outcome of interest, in this case a potentially preventable adverse event.
2. *Harm weight.* A harm weight is calculated by multiplying empirical estimates of excess harms associated with the patient safety event by utility weights linked to each of the harms (1-disutility). In general, harm weights measure the severity of the adverse events associated with each of the harms (i.e., outcome severity, or least preferred states from the patient perspective). To measure excess harm, potential harms, such as mortality, readmissions and additional treatments, were identified by a team of physicians and nurses for each PSI using literature review, environmental scan and clinical judgement. Excess harms are estimated using statistical models comparing patients with a safety event to those without a safety event in a Centers for Medicare and Medicaid (CMS) Medicare fee-for-service sample that allowed up to one year of follow-up from the discharge date for the hospital stay associated with the index event. To measure disutility of each harm, we used a two-pronged approach in which we elicited relative rankings of each harm from clinicians and then fitted these rankings to known literature-based disutilities. The final disutility estimates used a utility scale that assigned a relative value for decrements to the quality of life for each PSI event and its sequelae. Health utility refers to an individual's preference for a specific health state on a scale of 0 to 1, where 0 is equivalent to death and 1 denotes perfect health.

4.0 Steps for Creating the Composite

Step 1. Compute the risk-adjusted rate and confidence interval

The AHRQ QI risk-adjusted rate is computed based on a hierarchical logistic regression model for calculating a predicted value for each case. Then the predicted values among all the cases in the hospital are averaged to compute the expected rate. The risk-adjusted rate is computed using indirect standardization as the observed rate (OR) divided by the expected rate (ER), with the result multiplied by the reference population rate (PR): $(RR) = (OR/ER \times PR)$.

Step 2. Scale the risk-adjusted rate using the reference population

The relative magnitudes 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. The components of the composite are therefore defined in terms of a ratio to the reference population rate for each indicator. The component indicators are scaled by the reference population rate, so each indicator reflects the degree of deviation from the overall average performance.

Step 3. Compute the reliability-adjusted ratio

The reliability-adjusted ratio (RAR) 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 hospital (or other unit of analysis).

$$\text{RAR} = [\text{risk-adjusted ratio} \times \text{weight}] + [\text{reference population ratio} \times (1 - \text{weight})]$$

For small hospitals, the weight is closer to 0. For large hospitals, the weight is closer to 1. For a given hospital, if the denominator is 0, then the weight assigned is 0 (i.e., the RAR is the reference population ratio).

Step 4. Select the component weights

The composite measure is the weighted average of the scaled and RARs for the component indicators. The component weights provided in the PSI software for PSI 90 Patient Safety and Adverse Events Composite are based on numerator weights and harm weights.

Users may supply their own component weights. Some examples of possible weights follow, though others are possible:

Single indicator weight. In this case, the composite is simply the RAR for a single indicator. The reference population rate is the same among all hospitals.

Equal weight. In this case, each component indicator is assigned an identical weight based on the number of indicators. That is, the weight equals 1 divided by the number of indicators in the composite (e.g., $1/8 = 0.1250$).

Denominator weight. A denominator weight is based on the relative frequency of the denominator for each component indicator in the reference population. In general, a denominator weight reflects the amount of risk of experiencing the outcome of interest in a given population. For example, the denominator weight might be based on the demographic composition of a health plan, the employees of a purchaser, a State, an individual hospital, or a single patient.

Factor weight. A factor weight is based on some sort of analysis that assigns each component indicator a weight that reflects the contribution of that indicator to the common variation among the indicators. The component indicator that is most predictive of that common variation is assigned the highest weight.

Step 5. Construct the composite measure

The composite measure is the weighted average of the component indicators using the selected weights and the scaled and reliability-adjusted indicators.

$$\begin{aligned} \text{Composite} = & [\text{indicator1 RAR} \times \text{weight1}] + [\text{indicator2 RAR} \times \text{weight2}] + \dots + \\ & [\text{indicatorN RAR} \times \text{weightN}] \end{aligned}$$

The confidence interval of the composite is based on the standard error of the composite, which is the square root of the variance. The variance is computed based on the signal variance covariance matrix and the reliability weights.

5.0 How Have the Composites Changed?

With each new release of the AHRQ QI, the reference population is updated to the most current HCUP data available. The numerator weights are updated to reflect the indicator technical specifications as applied to the reference population. Harm weights are updated periodically using two years of Medicare Fee-for-Service (FSS) data.

Prior to PSI software v6.0, weighting of the individual component indicators was based on only numerator weights, calculated on the number of safety-related events for the component indicators in the all-payer reference population. Since version 2019, PSI 07 Central Venous Catheter-Related Blood Stream Infection Rate has not been included in the PSI 90 composite. For PSI 90 in PSI software v2022, weighting of the individual component indicators is based on two concepts: the volume of the adverse event and the harm associated with the adverse event.

Harms weights were developed specifically for the AHRQ QIs.¹ Based on literature review and expert opinion from 13 clinical specialists in surgery, internal medicine, nephrology, trauma and emergency care, critical care, nursing, and home healthcare, 37 downstream harms associated with 10 PSIs were defined. For some PSIs, harms were included for up to one year after the PSI event (such as mortality, skilled nursing facility days, and outpatient dialysis). An expert panel then ranked the harms. These rankings, along with information from relevant studies in the literature, were then used to assign disutilities, or a measure of the severity of the adverse effects, associated with each of the harms.

In PSI software v2022, harm weights were calculated by multiplying empirical estimates of the probability of excess harms associated with each patient safety event by the corresponding utility weights (1–disutility). Disutility is the measure of the severity of the adverse events associated with each of the harms (i.e., outcome severity, or least preferred states from the patient perspective). These excess harm probabilities were estimated by comparing patients with a safety-related event to very similar, otherwise eligible patients without that safety-related event over up to one year after the discharge during which the index event happened. Linked claims data for two years of Medicare FFS beneficiaries (2012–2013) were used for this analysis. To account for confounders in estimating the marginal impact of each PSI on the risk of excess harms, inverse probability propensity weighting with indicator- and harm-specific propensity models were calculated that included age, sex, racial/ethnic categories, Medicaid eligibility, point of origin, modified Medicare Severity–Diagnosis-Related Group (MS-DRG) categories,² Elixhauser comorbidities,³ and co-occurring PSIs.

6.0 What Composite Weights are included in the software?

To utilize the PSI 90 composite, users must use these “Component Weights” that include both numerator and harm weights, when using the AHRQ QI software to compute the composite measure using their own data. Table 2 provides the component weights for this composite measure. These component weights are included in the PSI_HOSP_Composite_Wt_v2022.sas macro. The sum of the component weights for the indicators included in the same composite always equals one.

¹ Learn more about the harm weight development here: <https://pubmed.ncbi.nlm.nih.gov/34859429/>

Zrelak PA, Utter GH, McDonald KM, Houchens RL, Davies SM, Skinner HG, Owens PL, Romano PS.

Incorporating harms into the weighting of the revised Agency for Healthcare Research and Quality Patient Safety for Selected Indicators Composite (Patient Safety Indicator 90). *Health Serv Res.* 2022 Jun;57(3):654–667. doi: 10.1111/1475-6773.13918.

² See the AHRQ Quality Indicator Empirical Methods document at

https://qualityindicators.ahrq.gov/Downloads/Resources/Publications/2021/Empirical_Methods_2021.pdf

³ Elixhauser Comorbidity Software Refined for ICD-10-CM Healthcare Cost and Utilization Project (HCUP). October 2021. Agency for Healthcare Research and Quality, Rockville, MD. [www.hcup-](http://www.hcup-us.ahrq.gov/toolsoftware/comorbidityicd10/comorbidity_icd10.jsp)

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Table 2. Composite Weights for PSI 90, v2022

INDICATOR	HARM WEIGHT	VOLUME WEIGHT	COMPONENT WEIGHT
PSI 03 Pressure Ulcer Rate	0.3080	0.1068	0.1669
PSI 06 Iatrogenic Pneumothorax Rate	0.1381	0.0435	0.0305
PSI 08 In Hospital Fall with Hip Fracture Rate	0.1440	0.0199	0.0145
PSI 09 Postoperative Hemorrhage or Hematoma Rate	0.0570	0.1499	0.0434
PSI 10 Postoperative Acute Kidney Injury Requiring Dialysis Rate	0.3584	0.0314	0.0572
PSI 11 Postoperative Respiratory Failure Rate	0.2219	0.2129	0.2397
PSI 12 Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate	0.1557	0.2288	0.1808
PSI 13 Postoperative Sepsis Rate	0.3102	0.1367	0.2151
PSI 14 Postoperative Wound Dehiscence Rate	0.1441	0.0238	0.0174
PSI 15 Abdominopelvic Accidental Puncture or Laceration Rate	0.1474	0.0461	0.0345

Source: Agency for Healthcare Research and Quality, Healthcare Cost and Utilization Project, State Inpatient Databases (SID), 2019. 2012-2013 Medicare FFS claims data.

7.0 Additional Resources

See the AHRQ QI website for additional PSI resources and downloads:

https://qualityindicators.ahrq.gov/modules/psi_resources.aspx.

Agency for Healthcare Research and Quality (2008). *Patient Safety Indicators (PSI) Composite Measure Workgroup Final Report*. The report is available at

https://qualityindicators.ahrq.gov/Downloads/Modules/PSI/PSI_Composite_Development.pdf



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1.0 Overview

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Step 2. Scale the risk-adjusted rate using the reference population

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The confidence interval of the composite is based on the standard error of the composite, which is the square root of the variance. The variance is computed based on the signal variance covariance matrix and the reliability weights.

5.0 How Have the Composites Changed?

With each new release of the AHRQ QI, the reference population is updated to the most current HCUP data available. The numerator weights are updated to reflect the indicator technical specifications as applied to the reference population. Harm weights are updated periodically using two years of Medicare Fee-for-Service (FSS) data.

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² See the AHRQ Quality Indicator Empirical Methods document at https://qualityindicators.ahrq.gov/Downloads/Resources/Publications/2023/Empirical_Methods_2023.pdf.

³ Elixhauser Comorbidity Software Refined for ICD-10-CM Healthcare Cost and Utilization Project (HCUP). December 2022. Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/toolssoftware/comorbidityicd10/comorbidity_icd10.jsp.

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PSI 09 Postoperative Hemorrhage or Hematoma Rate	0.0570	0.1347	0.0390
PSI 10 Postoperative Acute Kidney Injury Requiring Dialysis Rate	0.3584	0.0281	0.0512
PSI 11 Postoperative Respiratory Failure Rate	0.2219	0.2097	0.2366
PSI 12 Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate	0.1557	0.2195	0.1738
PSI 13 Postoperative Sepsis Rate	0.3102	0.1244	0.1963
PSI 14 Postoperative Wound Dehiscence Rate	0.1441	0.0227	0.0166
PSI 15 Abdominopelvic Accidental Puncture or Laceration Rate	0.1474	0.0322	0.0241

Source: 2019, 2020 and 2021 State Inpatient Databases (SID), Healthcare Cost and Utilization Program, Agency for Healthcare Research and Quality. 2012-2013 Medicare Fee-for-Service claims data.

7.0 Additional Resources

See the AHRQ QI website for additional PSI resources and downloads:

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