

THE DEPARTMENT OF HEALTH CARE ACCESS AND INFORMATION

HCAI Technical Note
For
AHRQ Postoperative Sepsis
Outcomes for Elective Surgeries in
California Hospitals, 2023

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Introduction

This Technical Note describes how the Agency for Healthcare Research and Quality (AHRQ) Patient Safety Indicators (PSIs) software was applied to California's patient discharge data collected by the Department of Health Care Access and Information (HCAI) to generate hospital risk-adjusted postoperative sepsis rates and quality ratings.

The data tables were produced using AHRQ PSIs software Version 2024 for SAS® with 2023 California inpatient data. HCAI made California-specific modifications to the software which is supported by AHRQ. Additional AHRQ Quality Indicators reports can be found on the HCAI [website](#).

Measure Definition

The Postoperative Sepsis Indicator is a measure of postoperative sepsis rates for all patients ages 18 years and older undergoing elective surgeries. This measure excludes discharges with a principal diagnosis of sepsis, or with a secondary diagnosis of sepsis present on admission; discharges with a principal diagnosis of infection, or with a secondary diagnosis of infection present on admission; and obstetric discharges. Details regarding the measure definition and inclusion/exclusion rules for case selection can be found on the [AHRQ website](#).

Measure Volume and Data Source

The 2023 results include a total of 217,922 elective surgery discharges from 292 hospitals. Of these discharges, 1,038 (0.48 percent) had postoperative sepsis. Of the 292 hospitals, 287 hospitals were assigned a risk-adjusted rate and performance rating on the postoperative sepsis measure. The remaining five hospitals did not receive risk-adjusted results due to the low case volume (less than 3 cases) at each of the five hospitals. The data used for this report is the 2023 California inpatient discharge data for California state-licensed general acute care hospitals.

What Changes did HCAI Make to the AHRQ Patient Safety Indicators Software?

- California uses the statewide observed rate instead of the national reference rate as the benchmark when rating hospitals as “Above Average” or “Below Average”.
- After discussions with AHRQ and University of California researchers, HCAI staff modified the AHRQ software and calculated confidence intervals (CIs) based on the exact method. All HCAI outcome reports to date have employed the exact method in calculating CIs. The exact method is based on the exact probability of the number of observed adverse events (or a more extreme number) occurring by chance, given the number of expected adverse events at a hospital. This approach differs from the normal approximation method used by AHRQ. It relies on fewer distributional assumptions and provides more conservative estimates

for hospitals with relatively few expected deaths.¹ AHRQ expressed their consideration of the exact method for software refinement in August 2021 at the software release webinar.²

How was the AHRQ Postoperative Sepsis Indicator calculated?

HCAI used a modified version of the AHRQ PSIs software Version 2024 for SAS®, released in July 2023. AHRQ's free software and associated documentation are available online at <https://qualityindicators.ahrq.gov/software>.

The AHRQ software produces numerators, denominators, observed rates, expected rates, risk-adjusted rates, CIs, and ratings of the indicators. The current report produced by HCAI focused on risk-adjusted rates and hospital ratings based on CIs for California state-licensed general acute care hospitals. Terminology and methodology used for determining these rates are described below to help explain the process of generating risk-adjusted rates.

Standardizing the Patient Data

California hospitals electronically submit inpatient data including patient age, length of stay, gender, race, ICD-10-CM/PCS codes, and related information to HCAI. The online application applies thousands of quality control automated “edits” that flags data values submitted by hospitals to HCAI as invalid or likely wrong. If certain thresholds are reached, hospitals are contacted and asked to review the data and make any necessary changes. Once the data have been finalized, the data elements are transformed to conform to the standards specified in the AHRQ documentation. These are the same standards that AHRQ applies to the State Inpatient Database and the NIS, collected from most states and maintained by the federal government.

Calculation of Observed Rates

Numerator – Discharges with any secondary diagnoses for sepsis among elective surgical discharges meeting the inclusion and exclusion rules for the denominator.

Denominator – The elective surgical discharges for all patients ages 18 years and older with any listed ICD-10-CM/PCS code for an operating room procedure. The denominator represents the total number of patients that are “at risk” of developing sepsis in hospital following surgeries. Note that discharges with a primary diagnosis of sepsis/infection, or a secondary diagnosis of sepsis/infection present on admission were excluded from the report.

Observed Rates – An observed postoperative sepsis rate is calculated by dividing the number of discharges with postoperative sepsis (numerator) by the number of discharges for patients at risk of postoperative sepsis (denominator).

¹ Luft HS, Brown BW Jr. (1993). Calculating the probability of rare events: Why settle for an approximation? *Health Services Research*, 28, 419-439.

² The AHRQ Quality Indicators Software v2021 release webinar at <https://qualityindicators.ahrq.gov/resources>.

Calculation of Expected Rates

The purpose of statistical risk adjustment is to provide an equitable comparison between hospitals by accounting for variations in case mix that affect outcome rates and that are unrelated to the quality of care. For a fair comparison of hospitals, it is necessary to hold the patient case mix constant by adjusting for clinical risk factors and procedure types. To create risk-adjusted rates, the first step is to estimate how many people would be expected to develop postoperative sepsis in a particular hospital if they had a mix of patients that was comparable to the average hospital from the reference population (California observed rates for this report). Although the particular methods require technical expertise, the process of generating expected rates is straightforward.

Step 1: Select Risk Factors to Predict Postoperative Sepsis Rate

Consulting with medical experts and statisticians, AHRQ chose risk factors that predicted the rate of in-hospital postoperative sepsis. The risk factors include patient age, gender, Modified Diagnosis Related Groups (MDRG), and comorbidities. See risk factors in detail at the [AHRQ PSI website](#).

Step 2: Create Multivariate Model to Predict Postoperative Sepsis

AHRQ constructed logistic regression models to predict a patient's probability of developing postoperative sepsis. When possible, hospital-level models are estimated using General Estimating Equations (GEE) to account for within-hospital correlation. If the GEE model does not converge or has other issues such as poor calibration, a logistic regression model is used. The postoperative sepsis indicator has a set of covariates identified in a logistic regression model where the risk adjustment parameters are estimated based on the reference population data. AHRQ has published a more detailed summary of these models on its [website](#).

Step 3: Apply Model Coefficients to California Data to Calculate Predicted Probability of Postoperative Sepsis

The AHRQ software calculates the coefficients and the population rates used in the risk-adjustment process, based on the 2019-2021 National Inpatient Sample (NIS) compiled by the AHRQ Healthcare Cost and Utilization Project.

To enable custom reports on new samples of data, the AHRQ software identifies which risk factors are present for each patient. The coefficients are appropriately applied to the California data so that a predicted probability of postoperative sepsis is assigned to each patient. The predicted probability calculated from this step is also referred to as the "direct predicted rate." In the AHRQ software, the direct predicted rates are adjusted with the O/E (observed rates to expected rates) ratios to ensure that the patient-level predicted rates are perfectly calibrated to the observed rates. AHRQ provides two options for rates calibration – to calibrate to the 2019-2021 NIS or to the user's input data. After consulting with AHRQ, HCAI elected to calibrate the outcome rates to the O/E ratios based on the California's discharge data.

Step 4: Estimate Expected Postoperative Sepsis Cases at Each Hospital

Steps 1 – 3 above assign a probability of postoperative sepsis for each patient record. To obtain the expected number of patients with postoperative sepsis for each hospital, the software simply adds up all of the patient-level probabilities for each facility.

Calculation of Risk-Adjusted Rates

With observed and expected postoperative sepsis rates available for each hospital, it is then possible to construct risk-adjusted rates. While it is sufficient to compare the difference between observed and expected rates to assess higher and lower quality, adding a reference population makes it easier to compare rates. The risk-adjusted (or indirectly standardized) adverse event rate at a hospital equals the state observed_rate, multiplied by the ratio of the number of observed postoperative sepsis cases to the number of expected postoperative sepsis cases at that hospital (Observed Deaths/Expected Deaths or O/E ratio). The O/E ratio provides a transparent and easy-to-understand assessment of that hospital's performance. A ratio that is less than one indicates there were fewer actual postoperative sepsis cases than expected (a good result) while a ratio greater than one indicates that there were more postoperative sepsis cases than would be expected given the level of risk in the patient mix.

Calculation of Statistical Outliers

Hospitals were rated as “Above Average” if their risk-adjusted postoperative sepsis rates were significantly lower than the statewide observed rate. They were rated as “Below Average” if their rates were significantly higher than the statewide rate. The AHRQ software calculates 95% CIs using the normal approximation as follows:

Lower CI = “Hospital A” risk-adjusted rate – (1.96 * Standard Error)

Upper CI = “Hospital A” risk-adjusted rate + (1.96 * Standard Error)

Formula for the standard error for the risk-adjusted rate (for each hospital)

The Root Mean Squared Error (RMSE) = square root (“Hospital A” risk-adjusted rate * (1 – “Hospital A” risk-adjusted rate))

The Standard Error (SE) = RMSE / square root (“Hospital A” denominator)

For example:

If “Hospital A” had a rate of 0.20 and a denominator of 500:

Lower CI = $0.20 - 1.96 * \sqrt{[(0.20 * (1 - 0.20)) / 500]}$

Upper CI = $0.20 + 1.96 * \sqrt{[(0.20 * (1 - 0.20)) / 500]}$

HCAI employed the exact method in calculating CIs to provide more conservative estimates for hospitals with relatively few expected postoperative sepsis cases. It is one

of the modifications HCAI made to the AHRQ software to adapt to California data. See the details about this modification on page 1 of the technical note.

To identify statistical outliers, hospital risk-adjusted rates are compared to the upper and lower CIs. If a hospital's upper CI is less than the statewide observed rate, it is designated as performing "Above" the average hospital. If a hospital's lower CI is greater than the state rate, it is designated as performing "Below" the average hospital. Using this approach, one can be 95 percent confident that a rating of "Above Average" or "Below Average" was not obtained by chance. Smaller hospitals, however, have less statistical power to be classified as performance outliers, especially significantly "Above" the statewide rate. Their risk-adjusted sepsis rates would have to be much higher or lower than a high-volume hospital's for them to be significantly different from the state average. Conversely, a large hospital with more patients for a particular indicator may be identified as significantly different even when its sepsis rate differs only moderately from the state average.

Hospitals Excluded from the Current Report

Data used for this report are from California state-licensed general acute care hospitals. Certain hospitals were excluded from reporting due to the exclusion criteria as follows. Based on the exclusion criteria, a total of 287 hospitals were reported in the 2023 postoperative sepsis results. A list of excluded hospitals along with the exclusion criteria are presented in Table 1.

- Hospitals identified by the Centers for Medicare and Medicaid Services (CMS) as long-term acute care hospitals, or hospitals having an average length of stay that exceeded CMS-designated long-term acute care hospitals were excluded from this analysis. These hospitals treat patients with long-term acute conditions (e.g., requiring respiratory care) and have an average length of stay greater than 25 days.
- Hospitals specializing in pediatric care were excluded from this report.
- Hospitals with fewer than three patients reported were excluded from this report. The AHRQ software does not report results for any quality indicators if there were two or fewer cases in the denominator for a given hospital. Therefore, hospitals with fewer than three cases in the denominator are not included in the report.

Note that if a hospital had a name change between years, the discharges were attributed to the name of the hospital in use at the time the services were provided. Tables 2 presents the hospitals that changed names between 2022 and 2023.

Table 1. Hospitals excluded from the 2023 HCAI Postoperative Sepsis results due to provision of long-term acute care (CMS determination), pediatric facility designation, or fewer than three patients reported

Type of Exclusion	Hospital Name
CMS Long-term Acute Care	Barlow Respiratory Hospital
	Central Valley Specialty Hospital
	Kentfield Hospital
	Kindred Hospital – Baldwin Park
	Kindred Hospital – Brea
	Kindred Hospital – La Mirada
	Kindred Hospital – Los Angeles
	Kindred Hospital – Ontario
	Kindred Hospital – Riverside
	Kindred Hospital – San Diego
	Kindred Hospital – San Francisco Bay Area
	Kindred Hospital – South Bay
	Kindred Hospital Paramount
	Kindred Hospital Rancho
	Kindred Hospital Westminster
	Monrovia Medical Center
	Vibra Hospital of Northern California
	Vibra Hospital of Sacramento
	Vibra Hospital of San Diego
Pediatric Facility	Children’s Hospital of Los Angeles
	Children’s Hospital of Orange County
	Loma Linda University Children’s Hospital
	Lucile Packard Children’s Hospital Stanford
	Martin Luther King Jr. – Harbor Hospital
	MemorialCare Miller Children’s & Women’s Hospital Long Beach
	Rady Children’s Hospital – San Diego
	Sharp Mary Birch Hospital for Women and Newborns
	Shriners Hospital for Children Northern California
	Sutter Maternity and Surgery Center of Santa Cruz
	UCSF Benioff Children’s Hospital Oakland
	University of Southern California Kenneth Norris, Jr. Cancer Hospital
	Valley Children’s Hospital
Fewer Than Three Patients	Adventist Health Mendocino Coast
	Bear Valley Community Hospital
	College Medical Center
	Greater El Monte Community Hospital
	Southern California Hospital at Hollywood

Table 2. Hospitals with Name Changes between 2022 and 2023

Hospital Name in 2022	Hospital Name in 2023
Alvarado Hospital Medical Center	UC San Diego Health – East Campus Medical Center
Antelope Valley Hospital	Antelope Valley Medical Center
Beverly Hospital	Adventist Health White Memorial Montebello
Cedars – Sinai Marina Del Rey Hospital	Cedars – Sinai Marina Hospital
Enloe Medical Center– Esplanade	Enloe Health
Fountain Valley Regional Hospital & Medical Center – Euclid	UC Irvine Health – Fountain Valley
John Muir Medical Center – Concord Campus	John Muir Medical Center – Concord Medical Center
John Muir Medical Center – Walnut Creek Campus	John Muir Medical Center – Walnut Creek Medical Center
Kaiser Foundation Hospital – Oakland/Richmond	Kaiser Foundation Hospital – Oakland Medical Center
Lakewood Regional Medical Center	UC Irvine Health – Lakewood
Los Alamitos Medical Center	UC Irvine Health – Los Alamitos
Los Angeles County+USC Medical Center	Los Angeles General Medical Center
PIH Health Hospital – Whittier	PIH Health Whittier Hospital
Placentia Linda Hospital	UC Irvine Health – Placentia Linda
Southwest Healthcare System – Murrieta	Southwest Healthcare Rancho Springs Hospital
St. Mary Medical Center – Apple Valley	Providence St. Mary Medical Center
St. Mary's Medical Center	UC San Francisco Health – St. Mary's Hospital
Tenet Health Central Coast Sierra Vista Regional Medical Center	Adventist Health Sierra Vista
Tenet Health Central Coast Twin Cities Community Hospital	Adventist Health Twin Cities
West Hills Hospital and Medical Center	UCLA West Valley Medical Center

Appendix: Acknowledgments

This report reflects the efforts and significant contributions of the following individuals:

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