THE DEPARTMENT OF HEALTH CARE ACCESS AND INFORMATION

HCAI Technical Note

For

AHRQ Pediatric Quality Indicators for California Hospitals, 2023

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Introduction

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

The results were produced using AHRQ PDIs software Version 2024 for SAS®. The data used for this report is the 2023 California inpatient discharge data from California state-licensed general acute care hospitals. HCAI made California-specific modifications to the software which were discussed with and supported by AHRQ. Additional AHRQ Quality Indicators reports can be found on the HCAI Healthcare Quality website.

Measure Definitions

The report includes five PDIs, the definitions and technical specifications of which can be found on the AHRQ PDIs website.

- **Neonatal Blood Stream Infection** – Hospital discharges with healthcare-associated blood stream infection per 100 discharges for newborns and outborns with birth weight of 500 grams or more but less than 1,500 grams; with gestational age between 24 and 30 weeks; or with birth weight of 1,500 grams or more associated with an operating room procedure, mechanical ventilation, transfer from another hospital within two days of birth, or death. Excludes discharges with a length of stay less than three days and discharges with a principal diagnosis (or secondary diagnosis present on admission) of sepsis, bacteremia, staphylococcal infection, or gram-negative bacterial infection.
- **Accidental Puncture or Laceration** – Accidental punctures or lacerations (secondary diagnosis) during a procedure per 100 discharges for patients ages 17 years and younger. Excludes discharges with accidental puncture or laceration as principal diagnosis, with accidental puncture or laceration as a secondary diagnosis that is present on admission, or with spinal surgery; discharges for normal newborns; discharges for neonates with birth weight less than 500 grams; and obstetric discharges.
- **Postoperative Respiratory Failure** – Hospital discharges with postoperative respiratory failure (secondary diagnosis), prolonged mechanical ventilation, or intubation cases per 100 elective surgical discharges for patients ages 17 years and younger. Excludes discharges with principal diagnosis of acute respiratory failure, a secondary diagnosis of acute respiratory failure present on admission, or any diagnosis of tracheostomy present on admission; discharges in which tracheostomy is the only operating room procedure, or in which tracheostomy occurs before the first operating room procedure; discharges with malignant hyperthermia, a neuromuscular disorder present on admission, a degenerative neurological disorder present on admission, or craniofacial anomalies; discharges with laryngeal, pharyngeal, nose, mouth, or facial surgery involving

significant risk of airway compromise; discharges with esophageal surgery, a lung cancer procedure, or a lung or heart transplant; discharges for treatment of respiratory diseases; discharges of neonates with birth weight less than 500 grams; and all obstetric discharges.

- **Postoperative Sepsis** – Hospital discharges with postoperative sepsis (secondary diagnosis) per 100 surgical discharges for patients ages 17 years and younger. 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; discharges in which the procedure belongs to surgical class 4; neonates; and obstetric discharges.

- **Central Venous Catheter-Related Blood Stream Infection** – Hospital discharges with central venous catheter-related bloodstream infections (secondary diagnosis) per 100 discharges for patients ages 17 years and younger. Excludes discharges with a principal diagnosis of a central venous catheter-related bloodstream infection, or a secondary diagnosis of a central venous catheter-related bloodstream infection present on admission; discharges of normal newborns; discharges of neonates with a birth weight of less than 500 grams, discharges with length of stay less than two (2) days; and obstetric discharges.

What Changes did HCAI Make to the AHRQ Pediatric Quality Indicators Software?

- California uses the statewide observed rates instead of the national reference rates as the benchmark when rating hospitals as “Above Average” or “Below Average” for the five PDIs.

- After discussions with AHRQ, HCAI 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 complications or 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 cases.[1] AHRQ indicated that incorporating exact confidence intervals is under consideration as potential future refinement, pending available resources during the August 2021 software release webinar.[2]

How were the AHRQ Pediatric Quality Indicators Results calculated?

HCAI used a modified version of the AHRQ PDIs software Version 2024 for SAS®, released in July 2024. AHRQ’s free software and associated documentation are

[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/webinars.

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 focuses on risk-adjusted rates and performance 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 2019-2021 National Inpatient Sample (NIS), collected from most states and maintained by the federal government.

Calculation of Observed Rates

Denominator – For each PDI, expert clinicians used ICD-10-CM/PCS codes to select patient discharge records with diagnoses indicating a particular medical condition. For example, postoperative sepsis is a medical complication that can be defined by numerous diagnoses, thus clinicians select only the specific codes that represent the intended concept of the indicator. From the initial cohorts of patients, some records were excluded. For example, obstetric discharges were excluded when constructing most of the indicators (see AHRQ documentation for additional exclusion criteria). In sum, the denominators represent the total number of patients at risk of developing specific conditions during their hospital stay.

Numerator – Discharges with the reported conditions in a specific denominator population meeting the inclusion and exclusion rules for the denominator.

Observed Rates – An observed rate is calculated by dividing the number of discharges with a specific medical condition or health care complication (numerator) by the number of discharges for patients at risk of such condition or complication (denominator).

Calculation of Expected Rates

The purpose of statistical risk adjustment is to provide an equitable comparison between hospitals by accounting for variations in risk factors of patients 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 patients'

preexisting medical conditions, clinical risk factors and procedure types. See a more detailed discussion of the risk adjustment processes in the AHRQ Quality Indicator Empirical Methods.

To create risk-adjusted rates, the first step is to estimate how many people would be expected to develop a certain medical complication or adverse event 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). The process of generating expected rates is outlined below:

Step 1: Select Risk Factors to Predict a Medical Complication

Consulting with medical experts and statisticians, AHRQ chose risk factors that predicted the rate of an in-hospital complication. The risk factors include, but are not limited to, patient age, gender, birth weight, diagnoses, comorbidities, and procedures. See risk factors in detail at the AHRQ PDIs website.

Step 2: Create Multivariate Model to Predict the Complication

AHRQ constructed logistic regression models to predict a patient's probability of developing a complication. When possible, hospital-level models are estimated using General Estimating Equations (GEE) (hierarchical modelling) 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. Each of the PDIs has a set of covariates identified in a logistic regression model where the risk adjustment parameters are estimated based on the reference population data. More details can be found at the AHRQ Quality Indicator Empirical Methods document.

Step 3: Apply Model Coefficients to California Data to Calculate Predicted Probability of the Complication

The AHRQ software calculates the coefficients and the population rates used in the risk-adjustment process, based on the 2019-2021 NIS complied 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 developing a specific medical complication 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 Cases with the PDI Condition at Each Hospital

Steps 1 – 3 above assign a probability of developing a medical complication for each patient. To obtain the expected number of patients with the condition 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 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) complication or adverse event rate at a hospital equals the state observed rate, multiplied by the ratio of the number of observed cases with a certain medical complication to the number of expected cases at that hospital (Observed Cases/Expected Cases 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 cases with a certain medical complication than expected (a good result) while a ratio greater than one indicates that there were more such 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 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 cases with certain medical complications reported. 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 3 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% 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 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 PDI may be identified as significantly different even when its risk-adjusted 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 257 hospitals were reported in the 2023 Pediatric Quality Indicators results. A list of excluded hospitals along with the exclusion criteria is 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 with fewer than three patients reported for each of the five PDIs were excluded from this report. The AHRQ software does not report results for a specific PDI if there were two or fewer cases in the denominator for a given hospital. Therefore, hospitals with fewer than three cases in the denominator for all PDIs 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 Pediatric Quality Indicators results due to provision of long-term acute care (CMS determination) 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
Fewer Than Three Patients	Adventist Health St. Helena
	Alameda Hospital
	Alhambra Hospital Medical Center
	Anaheim Global Medical Center
	California Pacific Medical Center – Davies Campus Hospital
	California Pacific Medical Center – Mission Bernal Campus
	Casa Colina Hospital
	Chapman Global Medical Center
	Emanate Health Inter – Community Hospital
	Healdsburg Hospital
	Huntington Beach Hospital
	Kentfield Hospital
	L.A. Downtown Medical Center
	Los Angeles County/Rancho Los Amigos National Rehab Center
	Mark Twain Medical Center
	Mayers Memorial Hospital
	Pacifica Hospital of the Valley
	Providence Redwood Memorial Hospital
	Sharp Coronado Hospital and Healthcare Center
	Sonoma Valley Hospital
	Sutter Solano Medical Center
	UC San Francisco Health – St. Mary's Hospital
	USC Kenneth Norris Jr. Cancer Hospital

Table 2. Hospitals with Name Changes between 2022 and 2023

Hospital Name in 2022	Hospital Name in 2023
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 – Walnut Creek Campus	John Muir Medical Center – Walnut Creek Medical Center
Kaiser Foundation Hospital – Oakland/Richmond	Kaiser Foundation Hospital – Oakland Medical Center
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
Southwest Healthcare System – Murrieta	Southwest Healthcare Rancho Springs Hospital
St. Mary Medical Center – Apple Valley	Providence St. Mary Medical Center
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

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