THE DEPARTMENT OF HEALTH CARE ACCESS AND INFORMATION

HCAI Technical Note for Producing Agency for Healthcare Research and Quality Hospital Inpatient Mortality Indicators for California, 2023 Report

February 2025

Prepared by
Department of Health Care Access and Information

Suggested citation: State of California, Department of Health Care Access and Information. *Agency for Healthcare Research and Quality Hospital Inpatient Mortality Indicators for California, 2023 Repor*t, Sacramento, CA: Department of Health Care Access and Information, February 2025. Copies of this document may be found at https://data.chhs.ca.gov/dataset/california-hospital-inpatient-mortality-rates-and-quality-ratings

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Background

This Technical Note explains how the Agency for Healthcare Research and Quality (AHRQ) Inpatient Quality Indicator (IQI) software was applied to California's patient discharge data collected by the Department of Health Care Access and Information (HCAI) to generate hospital results for nine Inpatient Mortality Indicators (IMIs) for which AHRQ calculates hospital risk-adjusted mortality rates and quality ratings.

The data tables were produced by HCAI's Healthcare Analytics Branch in the Information Services Division using AHRQ Quality Indicators software Version 2024 for SAS® with the 2023 California inpatient data. HCAI made California-specific modifications to the software which were discussed with and supported by AHRQ.

The current IMI report includes data from 315 state-licensed general acute care hospitals in 2023. Other AHRQ IQI reports can also be found on the HCAI website including hospital-level utilization measures.

How are the Inpatient Mortality Indicators useful?

The AHRQ quality indicators and related software, provided at no cost to states, use readily available patient discharge data to highlight possible differences in the quality of care provided by hospitals. These results may provide the foundation for more in-depth analyses of health care quality, and are intended to contribute to quality improvement efforts made by hospital administrators, clinicians, quality assurance personnel, and other stakeholders interested in health care quality. In addition, when the information is carefully considered along with its limitations and in conjunction with other reliable health care provider information, it may inform decisions made by policy makers, patients, and health care purchasers.

Do the Inpatient Mortality Indicators measure actual quality of hospital care?

The IMIs are indicators of hospital quality of care but are not definitive determinations of quality. Rather, they are meant to provide a perspective on quality of care inside hospitals by focusing on inpatient mortality for certain procedures and medical conditions. In-hospital mortality rates vary substantially across hospitals, which may provide evidence suggesting that high in-hospital mortality may be associated with deficiencies in the quality of care. Health care providers can utilize the IMI findings for further investigation and validation of the health outcomes associated with their health care practices.

It is also important to note that the 2023 hospital IMI results come with several caveats:

1. California patient discharge data for the reported medical conditions and procedures have not been validated through medical record reabstraction (with a

few exceptions) to demonstrate that patient severity-of-illness and complications are accurately and reliably coded across all hospitals.

2. HCAI has not performed detailed clinical analyses to identify the processes of patient care that may lead to differential hospital mortality rates.

3. HCAI has not performed analyses to establish that the risk models for these medical conditions and procedures, using the International Classification of Diseases, Tenth Revision, Clinical Modification/Procedural Classification System (ICD-10-CM/PCS), perform well compared to gold-standard clinical models that include information such as laboratory values, vital signs, and imaging studies.

4. Comparisons of IMIs across years should be made with caution. First, the current results include discharge records with a COVID-19 diagnosis while previous years excluded COVID-19 records from the risk mortality calculations. Second, the current results were generated with the ICD-10-CM/PCS coding system while the results prior to 2016 were generated with the ICD-9-CM coding system. These two code sets are very different in the fundamental structure and concepts. Third, significant updates have been made to the risk model over the last few years. Finally, changes were made to the inclusion/exclusion rules for case selection. As a result, the current mortality rates may not be comparable to prior years.

5. Because these indicators use inpatient mortality as the outcome of interest, hospitals that are less likely to transfer patients post-treatment, such as academic medical centers or safety net hospitals, may appear to perform worse. Hospitals that regularly transfer patients to acute care or ventilator-assist facilities may appear to perform better because any deaths occurring post-transfer are not included in their outcome scores.

What changes did HCAI make to the AHRQ Inpatient Quality Indicators software?

- California uses the statewide observed rate instead of the national reference rate as the benchmark when rating hospitals as “Better” or “Worse”.

- After discussions with AHRQ and University of California researchers, HCAI staff modified the AHRQ software and implemented 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 deaths (or a more extreme number) occurring by chance, given the number of expected deaths 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

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

consideration of the exact method for software refinement in August 2021 at the software release webinar.[2]

How does the 2023 Inpatient Mortality Indicator report compare to the previous reports?

It is important to note that the current report may not be directly comparable to prior years due to the following reasons:

- This report used the AHRQ software Version 2024, which excluded the sub-measures of all IMI indicators due to a methodological change adopted by AHRQ. Specifically, for pancreatic resection and acute stroke, while previous reports included risk adjusted mortality rates for the sub-measures as well as the overall measures, the current report only include results at the overall indicator level.

- Previously, HCAI reported only stratified, unruptured cases as sub-measures of AAA repairs mortality rates. However, such results are not available in the current report due to the methodological change by AHRQ that no longer produce sub-measure level risk adjusted mortality rates.

- This report used 2019-2021 reference population data and the associated regression coefficients in computing the risk-adjusted mortality rates. Combining the three years of data to make the reference population allows for robust risk-adjustment models and accurate estimation of risk-scores in pre-pandemic (2019) and time-varying acute pandemic (2020-2021) periods. Reports prior to 2022, however, used the reference population data and associated regression coefficients from 2018 and before.

What Inpatient Mortality Indicators are included in the 2023 results for California hospitals?

A total of nine IMIs were calculated and discussed in this report, including five measures for surgical procedures, and six overall measures plus three sub-measures for medical conditions. As with the previous IMI reports, AAA ruptured cases are excluded from reporting. HCAI reports open repair of unruptured AAA cases and endovascular repair of unruptured AAA cases as two separate measures. IMI definitions and technical specifications can be found on the AHRQ website.

Surgical Procedures:

- **Carotid Endarterectomy** – In-hospital deaths per 100 discharges with a procedure for carotid endarterectomy for patients ages 18 years and older. Excludes obstetric discharges and transfers to another hospital.

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

- **Pancreatic Resection** – In-hospital deaths per 100 discharges with pancreatic resection with a presence or absence of a diagnosis of pancreatic cancer for patients ages 18 years and older. Excludes acute pancreatitis discharges, obstetric discharges, and transfers to another hospital.
- **Percutaneous Coronary Intervention** – In-hospital deaths per 100 discharges with a procedure for percutaneous coronary intervention for patients ages 40 years and older. Excludes obstetric discharges and transfers to another hospital.

Medical Conditions:

- **Acute Myocardial Infarction** – In-hospital deaths per 100 hospital discharges with acute myocardial infarction as a principal diagnosis for patients ages 18 years and older. Excludes cases in hospice care at admission, obstetric discharges, and transfers to another hospital.
- **Acute Stroke** – In-hospital deaths per 100 hospital discharges with a principal diagnosis of acute stroke for patients ages 18 years and older. Includes metrics for discharges grouped by type of stroke. Excludes obstetric discharges, cases in hospice care at admission, and transfers to another hospital.
- **Gastrointestinal Hemorrhage** – In-hospital deaths per 100 discharges with a principal diagnosis of gastrointestinal hemorrhage; or a secondary diagnosis of esophageal varices with bleeding along with a qualifying associated principal diagnosis for patients ages 18 years and older. Excludes obstetric discharges, cases in hospice care at admission, discharges with a procedure for liver transplant, and transfers to another hospital.
- **Heart Failure** – In-hospital deaths per 100 hospital discharges with a principal diagnosis of heart failure for patients ages 18 years and older. Excludes discharges with a procedure of heart transplant, cases in hospice care at admission, obstetric discharges, and transfers to another hospital.
- **Hip Fracture** – In-hospital deaths per 100 hospital discharges with a principal diagnosis of hip fracture for patients ages 65 years and older. Excludes periprosthetic fracture discharges, obstetric discharges, cases in hospice care at admission, and transfers to another hospital.
- **Pneumonia** – In-hospital deaths per 100 hospital discharges with a principal diagnosis of pneumonia or a principal diagnosis of sepsis with a secondary diagnosis of pneumonia that is present on admission for patients ages 18 years and older. Excludes cases with severe sepsis that is present on admission, obstetric discharges, cases admitted from a hospice facility, and transfers to another hospital.

Two measures, included in the Version 2024 of the AHRQ software, were excluded from HCAI reporting.

- Coronary artery bypass graft (CABG) surgery – the HCAI California Cardiovascular Outcomes Reporting Program (CCORP) reports hospital level risk-adjusted mortality rates and quality ratings using data from a clinical registry expressly created for quality monitoring and reporting. This, along with other features of the data collected by CCORP, results in superior quality assessments to those obtained from the AHRQ CABG IMI measure.

- Acute myocardial infarction (AMI) – AHRQ IMIs include two measures: one includes all AMI patients and one excludes patients transferred to another acute care hospital. Upon advice from a previous advisory panel, HCAI decided to report only the measure that includes all AMI patients. Analyses show that transfer patients were, on average, less severely ill and experienced lower mortality rates than non-transfer patients, so hospitals that received large numbers of transfer patients were not disadvantaged by this decision.

How were the AHRQ Inpatient Mortality Indicators calculated?

HCAI used a modified version of the AHRQ Quality Indicators software Version 2024 for SAS®, released in July 2024. AHRQ's free software and associated documentation are available online at http://www.qualityindicators.ahrq.gov/software/SAS.aspx.

The first step in calculating rates was to transform the data elements and values of the California patient discharge data into a format that can be read by the AHRQ software. Second, HCAI specified the number of diagnoses and procedures available in the data set. Third, the HCUP-developed CCSR tool was used to collapse individual ICD-10-CM/PCS codes into a smaller number of meaningful categories. The resulted CCSR categories for conditions and procedures were used to capture risk factors that relate to comorbidities, procedure subtype, and procedure complexity. Finally, the coefficients used in the risk-adjustment process (described below), as well as population rates, were constructed based on the 2019-2021 National Inpatient Sample (NIS) compiled by the AHRQ HCUP. Once the data were transformed and the options were set, the software was run to automatically calculate the rates described below.

<u>Standardizing the Patient Data</u>

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 HCAI Information Services Division Patient Data Section then applies thousands of quality control automated "edits" using a custom software program 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, HCAI researchers use SAS® software to transform the data elements 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

The AHRQ IMI software produces numerators, denominators, observed rates, expected rates, risk-adjusted rates, and additional information to evaluate confidence intervals and reliability of the indicators. The current report produced by HCAI focused on risk-adjusted rates and confidence intervals for California acute care hospitals. Terminology and methodology used for determining these rates are described below to help explain the process of generating risk-adjusted rates.

Numerator – The number of inpatient deaths that occurred in a specific denominator population. For example, the number of patients who died within the hospital after being admitted for heart failure (after excluding patient records based on the denominator definition).

Denominator – For each IMI, expert clinicians used ICD-10-CM/PCS codes to select patient discharge records with diagnoses or procedures that indicate a particular condition or procedure. For example, heart failure is a complex condition 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, patients that were transferred to another short-term hospital were excluded for some cohorts (see AHRQ documentation for additional exclusion criteria). In addition, maternal patients were excluded when constructing most of the indicators. In sum, the denominators represent the total number of patients for specific conditions or procedures that are "at risk" of dying during their hospital stay.

Observed Rates – An observed mortality rate is defined as the number of patient deaths that occur within a specified group of patients admitted to the hospital for a medical condition or surgical procedure.

Calculation of Expected Deaths at Each Hospital

The purpose of statistical risk adjustment is to provide an equitable comparison between hospitals by accounting for hospitals that treat sicker patients versus those that treat healthier ones. To make comparisons fair, it is necessary to hold the patient "case mix" of hospitals constant by adjusting for the illness severity of patients. To create risk-adjusted rates, the first step is to estimate how many people would be expected to die in a particular hospital if they had a mix of patients that was comparable to the average hospital from the reference population (the 2023 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 Inpatient Death

Consulting with medical experts and statisticians, AHRQ chose risk factors that predicted hospital inpatient death. The risk factors include patient age, gender, Major

Diagnostic Categories (MDC), and CCSR associated with each procedure or condition category.

The CCSR tool was developed by HCUP to aggregate over 70,000 ICD-10-CM diagnosis codes and 80,000 ICD-10-PCS procedure codes into a manageable number of clinically meaningful categories. Embedded in the AHRQ V2024 IQI module, the CCSR generates codes (0 or 1) that are used as covariates in the calculation of risk adjusted mortality rates for all IMIs. Starting in Version 2021 of the AHRQ IQI module, the CCSR for conditions software replaced the APR-DRGs, based on Refined-DRGs and All-Payer DRGs systems, in the condition-based mortality measures; starting in Version 2022, the CCSR for procedures replaced the APR-DRGs for procedure-based measures.

Step 2: Create Multivariate Model to Predict Inpatient Death

Logistic regression models were built by AHRQ to predict patient's probability of death. 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 indicator has a set of covariates identified in a logistic regression model. Its risk adjustment parameters are estimated based on 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 Death

The software provided by AHRQ includes the coefficients for each IMI that were created by the multivariate model on the 2019-2021 NIS. To enable custom reports on new samples of data, the AHRQ software identifies which risk factor is present for each patient. Then the coefficients are appropriately applied to the California data so that a predicted probability of death is assigned to each patient. The predicted probability calculated from this step is also referred to as the "direct predicted rate." In Version 2024 of the 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 mortality rates to the O/E ratios based on the California's discharge data.

Step 4: Estimate Expected Deaths at Each Hospital

The first three steps above assign a probability of death for each patient record. To obtain the expected number of deaths 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 mortality 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) death rate at a hospital equals the State Observed Rate, multiplied by the ratio of the number of observed deaths to the number of expected deaths 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 deaths than expected (a good result) while a ratio greater than one indicates that there were more deaths than would be expected given the level of risk in the patient mix.

Calculation of Statistical Outliers

For each IMI, hospitals were rated as "better than expected" if their risk-adjusted death rates were significantly lower than the statewide observed rate. They were rated as "worse than expected" if their rates were significantly higher than the statewide risk-adjusted rate of the particular IMI. The Version 2024 of the AHRQ software calculates 95% confidence intervals (CI) 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)

The standard error for the risk-adjusted rate (for each hospital) is based on the following formula:

The Root Mean Squared Error (RMSE) for each hospital is:

> RMSE = square root ("Hospital A" risk-adjusted rate * (1 – "Hospital A" risk-adjusted rate))

The Standard Error is:

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 confidence intervals (CIs) to provide more conservative estimates for hospitals with relatively few expected deaths.

To identify statistical outliers, HCAI compared hospital risk-adjusted rates to the upper and lower CIs. If a hospital's upper CI is less than the statewide observed rate, it is designated as performing "better" than the average hospital. If a hospital's lower CI is greater than the state rate, it is designated as performing "worse" than the average hospital. Using this approach, one can be 95% confident that a rating of "better than expected" or "worse than expected" was not obtained by chance. Smaller hospitals, however, have less statistical power to be classified as performance outliers, especially significantly "better" than the statewide rate. Their risk-adjusted death 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 death rate differs only moderately from the state average.

What hospitals are included in the 2023 IMI results?

Data used for this analysis came 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 315 hospitals were reported in the HCAI 2023 IMI 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 for each of the nine conditions and procedures were excluded from this report. The AHRQ software does not report results for a specific IMI 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 indicators 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. Table 2 presents the hospitals that changed names between 2022 and 2023.

Table 1. Hospitals excluded from the 2023 HCAI IMI results due to provision of long-term acute care (CMS determination), pediatric facility designation, or fewer than three patients reported for each of the 11 AHRQ IMIs

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 – San Gabriel Valley
	Kindred Hospital – Santa Ana
	Kindred Hospital – South Bay
	Kindred Hospital Paramount
	Kindred Hospital Rancho
	Kindred Hospital Westminster
	Monrovia Medical Center
	San Diego Hospice and Palliative Care – Acute Care Center
	Vibra Hospital of Northern California
	Vibra Hospital of Sacramento
	Vibra Hospital of San Diego
Pediatric Facility	Children's Healthcare Organization of Northern CA – Pediatric Hospital
	Children's Hospital at Mission
	Children's Hospital of Los Angeles
	Children's Hospital of Orange County
	Healthbridge Children's Hospital – Orange
	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
	Totally Kids Rehabilitation Hospital
	UCSF Benioff Children's Hospital Oakland
	University of Southern California Kenneth Norris, Jr. Cancer Hospital
	Valley Children's Hospital
Fewer than three Patients	Fresno Surgical Hospital
	Surprise Valley Community Hospital

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
Ojai Valley Community Hospital	Community Memorial Hospital – Ojai
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
Vibra Rehab Hospital of Rancho Mirage	Rehab Hospital of Southern California
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:

HCAI

Michael Valle
Deputy Director/
Chief Information Officer
Information Services Division

Christopher Krawczyk, Ph.D.
Chief Analytics Officer/Manager,
Healthcare Analytics Branch

Holly Hoegh, Ph.D.
Principal Investigator
Manager, Quality and Performance
Healthcare Analytics Branch

Ying Yang, M.S.
Supervisor, Quality Indicators Group
Healthcare Analytics Branch

Pu Peng, Ph.D.
Research Scientist
Quality Indicators Group
Healthcare Analytics Branch

Niya Fong
Research Scientist
Quality Indicators Group
Healthcare Analytics Branch