OSHPD Technical Note for Producing Agency for Healthcare Research and Quality Inpatient Mortality Indicators, 2008 and 2009 Data

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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 OSHPD to generate hospital results for 12 of the 15 available Inpatient Mortality Indicators (IMIs) for which AHRQ calculates risk-adjusted mortality rates and quality ratings.

The data tables were produced by OSHPD Healthcare Information Division, Healthcare Outcomes Center, using AHRQ Quality Indicators software version 4.1 for SAS released in December 2009 with 2008 and 2009 inpatient data. OSHPD made California-specific modifications to the software, discussed with and supported by AHRQ.

The 2008 report includes data from 337 state-licensed general acute care hospitals and the 2009 report includes data from 335 state-licensed general acute care hospitals.

Other AHRQ IQI reports can also be found on the OSHPD Web site, including hospital-level Volume and 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 healthcare quality, and are intended to contribute to quality improvement efforts made by hospital administrators, clinicians, quality assurance personnel and other stakeholders interested in healthcare quality. In addition, when the information is carefully considered along with its limitations, and in conjunction with other reliable healthcare provider information, it may inform policy maker, patient or healthcare purchaser decision making.

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

These measures are *indicators* of healthcare provider quality but are not *definitive* determinations of quality. Rather, they are meant to serve as a starting point for further investigation and in-depth analyses, to prompt more extensive data scrutiny and in-depth validation of the health outcomes and of the associated processes of care, and facilitate the conducting of additional data validation and reliability analyses.

In addition to Inpatient Mortality Indicators, OSHPD has produced hospital-specific risk-adjusted health outcome reports (available on its Web site) about heart attack, community-acquired pneumonia, and heart bypass surgery, using well-validated risk-adjusted measures of quality with California data. These "gold-standard" reports generally require many years of work to carefully construct risk models and validate the data. As a result, OSHPD has produced only a few such reports to date. Prompted by increasing demand for quality metrics and additional risk-adjusted hospital-specific outcome reports, beginning in 2008 OSHPD has produced and publicly reported additional measures, updated annually, using many of the AHRQ Inpatient Mortality Indicators.

It is important to note that the 2008 and 2009 hospital results come with several caveats:

1. California hospital medical record 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. OSHPD has not performed detailed clinical analyses to identify the processes of care that lead to improved risk-adjusted mortality rates.
3. OSHPD has not performed analyses to establish that the risk models for these medical conditions and procedures, using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) perform well compared to gold standard clinical models that include information such as laboratory values, vital signs, and imaging studies.

How does OSHPD's California implementation of the AHRQ Inpatient Mortality Indicators differ from the approach used by most states?

AHRQ modified its IMI software version 3.2 to address a deficiency in the All Patient Refined Diagnosis Related Groups (APR-DRG) risk-adjustment algorithm employed by the indicators.[1,2,3,4] The APR-DRG algorithm is a proprietary tool of the 3M Health Information Systems Corporation. In essence, the AHRQ modification improves the risk-adjustment method by including unique information contained in the California patient discharge data—the Present on Admission (POA) data fields.

In all states, hospital information systems use the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) protocol to convert medical chart information to numeric codes. This approach lacks a way of distinguishing between complications of care that arise post-hospitalization and acute medical conditions that exist prior to admission. The original APR-DRG risk adjustment, built on ICD-9-CM, therefore cannot generally distinguish between pre-existing risks and complications of care. This deficiency may result in hospitals with many treatment complications unfairly benefiting from the risk algorithm while hospitals with fewer complications are penalized.

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1. Glance LG, Osler TM, Mukamel DB, & Dick AW. (2008). Impact of the present-on-admission indicator on hospital quality measurement: experience with the Agency for Healthcare Research and Quality (AHRQ) Inpatient Quality Indicators. Medical Care, 46, (2), 112-119.

2. Hughes JS, Averill RF, Goldfield NI, Gay JC, Muldoon J, McCullough E, & Xiang J. (2006). Identifying potentially preventable complications using a present on admission indicator. Health Care Financing Review, 27, (3), 63-82.

3. Romano PS & Chan BK. (2000). Risk-adjusting acute myocardial infarction mortality: are APR-DRGs the right tool? Health Services Research, 34, 1469–1489.

4. Iezzoni LI, Ash AS, Shwartz M, Daley J, Hughes JS & Mackiernan YD. (1995). Predicting who dies depends on how severity is measured: Implications for evaluating patient outcomes. Annals of Internal Medicine, 123 (10), 763-770.

OSHPD patient discharge data contain the Present on Admission (POA) data fields, adopted in 2007 as a national standard for providing information on the timing of acute conditions and complications.[5] The APR-DRG risk method used previously was modified by AHRQ to take POA information into account. While this modification appears to be a major improvement, the effect this modification has on the existing APR-DRG method has not been well researched. Unpublished OSHPD analyses indicate, however, that the adjustment appears to result in improved estimates of hospital risk-adjusted mortality rates.

In past versions of the software, users could apply the indicators to data with or without POA. The current version of the software (4.1), however, no longer provides separate models with or without POA, and assumes that POA data are available for all or most patient records. For users without POA data, the model incorporates the likelihood that the co-morbidity was present on admission. For states with POA data, the model is based on the data element values provided. Unlike other states that have only recently started collecting POA data, California has mandated that hospitals report POA data since 2006. As a result, the software applied to California data does not depend on statistical estimates for missing data.

How comparable are these Inpatient Mortality Indicators with other quality metrics produced by OSHPD or other organizations?

Hospital results using 2008 and 2009 OSHPD data may not be comparable with quality ratings obtained using other methods, even when the clinical area of examination is the same. For example, coronary artery bypass graft (CABG) surgery issued by the OSHPD California CABG Outcomes Reporting Program (CCORP) are different from the AHRQ CABG mortality indicator in a number of important ways. Among other things, OSHPD's CABG report:

- Is based on a different outcome, "operative mortality" (including deaths occurring after discharge but within 30 days post-operation), while AHRQ's outcome is in-hospital mortality.
- Uses clinical registry data, while AHRQ's measure uses International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) coded patient discharge data.
- Only includes clinically similar "isolated CABG" cases, while the AHRQ measure includes most all CABG cases.
- Uses a risk model based on clinical logic, while the AHRQ risk model is empirically based.
- Computes risk-adjusted mortality rates using only California data, while the AHRQ algorithm incorporates comparison data from the 2007 National Inpatient Sample, developed by AHRQ Healthcare Cost and Utilization Project (HCUP).
- Uses audited data, while the AHRQ measure does not.

5. In previous years of OSHPD patient discharge data, a similar set of present-on-admission fields were available called condition present on admission. These fields had slightly different data element definitions, and were changed in 2007 to adhere to national standards.

The AHRQ IMIs also differ in several ways from OSHPD's gold-standard risk adjusted outcome reports that use administrative data (community-acquired pneumonia and heart attack). The OSHPD reports:

- Use a 98% confidence interval to identify hospitals whose performance differs significantly from the state average, while the AHRQ IMIs use a 95% confidence interval to identify hospital outliers.
- Use 30-day mortality post-admission or post-surgery as the outcome, while the AHRQ IMIs use in-hospital mortality.
- Use a risk model based on both clinical logic and empirical considerations, while the AHRQ IMI risk model is empirically based.
- Compute risk-adjusted mortality rates using only California data, while the AHRQ IMI algorithm incorporates data from other states.

Finally, it is important to note some of the differences between the previous OSHPD publication of the AHRQ IMIs (2006 and 2007 data) and this report. The AHRQ IMIs using 2008 and 2009 data:

- Use version 4.1 of the AHRQ software, while the previous reports used version 3.2a.
- Use an exact method to calculate confidence intervals (see below), while the previous reports used a normal approximation approach.

Even when data sources are similar, differences in the data years, inclusion and exclusion criteria, the risk model, the statistical methods employed, and decisions on how to categorize performance can lead to different results when comparing a given hospital using more than one metric.

What Inpatient Mortality Indicators and which hospitals are included in the 2008 and 2009 results for California hospitals?

The December 2009 release of AHRQ software version 4.1 allows calculation of 15 IMIs, including 7 measures related to surgical procedures and 8 measures related to medical conditions. The results for 3 of the 15 available IMIs were not reported using OSHPD 2008 and 2009 data for the following reasons:

- For coronary artery bypass graft (CABG) surgery, OSHPD California CABG Outcomes Reporting Program (CCORP) already reports hospital and surgeon-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 measure.
- For 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 experts on its Technical Advisory Committee (TAC), OSHPD decided

to report only the measure that includes transfer patients. Analyses showed 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.

- Finally, hip replacement was not included because it lacked National Quality Forum endorsement, had a very low mortality rate, and subsequently OSHPD's TAC questioned its value as a hospital-level reported measure.

As a result, the following indicators are included in this report (more detailed definitions, including technical specifications, may be found on the AHRQ Web site):

Surgical Procedures

- **Esophageal Resection** – the number of deaths per 100 patients with International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) procedure code for esophageal resection.
- **Pancreatic Resection** – the number of deaths per 100 patients with ICD-9-CM procedure code for pancreatic resection.
- **Craniotomy** – the number of deaths per 100 discharges with a Diagnosis-Related Group (DRG) code for craniotomy (DRG 001, 002, 528, 529, 530, and 543), with and without comorbidities and complications.
- **Carotid Endarterectomy** – the number of deaths per 100 patients with ICD-9-CM procedure code for carotid endarterectomy.
- **Percutaneous Transluminal Coronary Angioplasty (PTCA)** – the number of deaths per 100 patients with ICD-9-CM principal procedure code for PTCA.
- **Abdominal Aortic Artery (AAA) Repair** – the number of deaths per 100 patients with ICD-9-CM principal procedure codes for AAA repair and any secondary diagnosis of AAA.

AHRQ currently produces a single AAA repair indicator that includes inpatients with both ruptured and unruptured aneurysms. The OSHPD TAC recommended that OSHPD exclude rupture cases, as defined by ICD-9-CM code 4413, when calculating hospital risk-adjusted mortality rates. Patients with aneurysm rupture have an observed mortality rate of 42.4% and one of the key determinants of survival is the time elapsed since rupture, which is not available in these data as a risk adjuster. Excluding rupture cases removes approximately 9% of all AAA cases and reduces overall mortality from 5.9% to 2.4%.

Medical Conditions

- **Acute Stroke** – the number of deaths per 100 patient discharges with ICD-9-CM principal diagnosis code for stroke.
- **Gastrointestinal (GI) Hemorrhage** – the number of deaths per 100 patient discharges with ICD-9-CM principal diagnosis code for GI hemorrhage.

- **Hip Fracture** – the number of deaths per 100 patient discharges with ICD-9-CM principal diagnosis code for hip fracture.
- **Congestive Heart Failure (CHF)** – the number of deaths per 100 patient discharges with ICD-9-CM principal diagnosis code for CHF.
- **Acute Myocardial Infarction (AMI)** – the number of deaths per 100 patient discharges with ICD-9-CM principal diagnosis code for AMI.
- **Pneumonia** – the number of deaths per 100 patient discharges with ICD-9-CM principal diagnosis code for pneumonia.

Hospital Selection

To be included in this report, a California general acute care hospital (466 facilities in 2009) had to have at least one patient eligible for inclusion in the IMIs (374 facilities in 2009). In addition, 34 hospitals were excluded in 2009 for the following reasons:

- Twenty were excluded based on their categorization by the Center for Medicare and Medicaid Services (CMS) as long-term acute care hospitals, or having an average length of stay that exceeded CMS-designated long-term acute care hospitals – these facilities treat patients with long-term acute conditions (e.g., requiring respirator care) and have an average length of stay greater than 25 days.
- One facility was excluded because it provided only hospice care.
- Twelve facilities specializing in pediatric care were excluded.

The excluded hospitals are listed in Table 1.

Table 1. Hospitals excluded from AHRQ IMI reports using 2008 and 2009 OSHPD data due to provision of long-term acute care (CMS determination), hospice care or pediatric facility designation

Types of Exclusion	Hospital Name
CMS Long-Term Acute Care	1. Barlow Respiratory Hospital
	2. Kentfield Rehabilitation Hospital
	3. Kindred Hospital – La Mirada
	4. Kindred Hospital – Los Angeles
	5. Kindred Hospital – Sacramento
	6. Kindred Hospital – San Diego
	7. Kindred Hospital – Brea
	8. Kindred Hospital – Ontario
	9. Kindred Hospital – Westminster
	10. Kindred Hospital – San Francisco Bay Area

CMS Long-Term Acute Care (cont.)	11. Northern California Rehabilitation Hospital
	12. Promise Hospital of East Los Angeles – East Los Angeles Campus
	13. Promise Hospital of San Diego
	14. Vibra Hospital of San Diego (2009)/ Continental Rehab Hosp of San Diego (2008)
	15. Vista Hospital of Riverside
	16. Vista Hospital of San Gabriel Valley
	17. Vista Hospital of South Bay
	18. Newport Specialty Hospital (2009)/Tustin Hospital and Medical Center (2008)
	19. Rancho Specialty Hospital
	20. Los Angeles County/Rancho Los Amigos National Rehabilitation Center
Hospice Care	1. San Diego Hospice and Palliative Care – Acute Care Center
Pediatric Facility	1. Children's Hospital of Los Angeles
	2. Children's Hospital Central California
	3. Children's Hospital of Orange County
	4. Children's Hospital at Mission
	5. Lucile Salter Packard Children's Hospital at Stanford
	6. Children's Hospital and Research Center at Oakland
	7. Earl and Lorraine Miller Children's Hospital
	8. Rady Children's Hospital – San Diego
	9. Shriners Hospital for Children Northern California
	10. Shriners Hospital for Children – Los Angeles
	11. Sharp Mary Birch Hospital for Women and Newborns (2009)/Sharp Mary Birch Hospital for Women (2008)
	12. Sutter Maternity and Surgery Center of Santa Cruz

The final exclusion criterion relates to the volume of patients for each AHRQ IMI. The AHRQ software will not report results for a specific IMI if there were two or fewer cases in the denominator for a given hospital. Hence, hospitals with two or fewer cases in the denominator for all indicators do not appear in the report. Hospitals excluded based on this criterion are listed in Table 2. After exclusions, 336 hospitals remain and are included in the 2009 report.

Table 2. Hospitals excluded from AHRQ IMI reports using 2008 and 2009 OSHPD data due to reporting fewer than three patients for all AHRQ IMIs

2008	2009
1. Fresno Surgical Hospital	1. San Joaquin Valley Rehabilitation Hospital
2. Southern Inyo Hospital	2. Southern Inyo Hospital
3. College Hospital Costa Mesa	3. Monrovia Medical Center
4. Patients' Hospital of Redding	4. Seton Medical Center – Coastside
5. Sutter Surgical Hospital – North Valley	5. Thousand Oaks Surgical Hospital

In cases of hospital name changes, the discharges were attributed to the name of the hospital in use at the time the services were provided. Table 3 shows hospitals that changed names between 2008 and 2009.

Table 3. Hospitals with Name Changes in AHRQ IMI reports between 2008 and 2009

Hospital Name in 2008	Hospital Name in 2009
1. Redbud Community Hospital	1. Saint Helena Hospital – Clearlake
2. Community Medical Center – Clovis	2. Clovis Community Medical Center
3. Little Company of Mary Medical Center – Torrance	3. Providence Little Company of Mary Medical Center – Torrance
4. Little Company of Mary Medical Center – San Pedro	4. Providence Little Company of Mary Medical Center – San Pedro
5. Anaheim Memorial Medical Center	5. AHMC Anaheim Regional Medical Center
6. Community Hospital of Los Gatos	6. El Camino Hospital Los Gatos

Exactly how were the AHRQ Inpatient Mortality Indicators calculated?

OSHPD used a modified version of AHRQ Quality Indicators software version 4.1 for SAS, released in December 2009. AHRQ's free software and associated documentation are available online at www.qualityindicators.ahrq.gov/iqi_download.htm.

The first step in calculating rates was to transform the data elements and values of the 2008 and 2009 patient discharge data into a format that can be read by the AHRQ software. Second, OSHPD specified the number of diagnoses and procedures available in the dataset. Third, All Patient Refined Diagnosis Related Groups (APR-DRG) "groupers" and associated "risk of mortality" categories were added to each patient record by running the 3M Health Information Systems Corporation software licensed to AHRQ. Finally, the coefficients used in

the risk-adjustment process (described below), as well as population rates, were constructed based on the 2007 National Inpatient Sample (NIS) compiled by AHRQ Healthcare Cost and Utilization Project (HCUP). The coefficients from the 2007 NIS were used for both the 2008 and 2009 reports. Once the data were transformed and the options set, the software was run to automatically calculate the rates described below.

Standardizing the Patient Data

California hospitals electronically submit inpatient data, including patient age, length of stay, gender, race, and International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes and related information to OSHPD. The OSHPD, Healthcare Information 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 OSHPD 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, OSHPD 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 National Inpatient Sample, collected from many 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 2008 and 2009 reports produced by OSHPD focus 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 congestive heart failure (after excluding patient records based on the denominator definition).

Denominator – For each IMI, expert clinicians used ICD-9-CM codes to select patient discharge records with diagnoses or procedures that indicate a particular condition or procedure. For example, congestive 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 2008 and 2009 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. For most of the IMIs, the risk factors include patient age, gender, procedure/condition category, and a risk-of-mortality score associated with each procedure/condition category. To assign each patient into a procedure/condition category, AHRQ selected a proprietary tool from the 3M Health Information Systems Corporation—the All Patient Refined Diagnosis Related Groups (APR-DRGs). The APR-DRG system works with hospital administrative data and provides a way to categorize patients into procedure/condition groups, and, given membership to that group, to estimate the severity of patients' diseases and the likelihood that they will die in the hospital. These estimates are calculated by looking at patient age, principal diagnosis, and secondary diagnoses to assign each patient into one of four categories (low, moderate, high, and very high) for disease severity and risk of mortality.

OSHPD staff used the AHRQ-licensed software from 3M to apply the APR-DRG fields to the standardized California hospital inpatient data described above. This creates the base APR-DRG category and the associated "risk of mortality" fields in the dataset. The software automatically removes all of the ICD-9-CM codes flagged as "POA" = "No". In other words, all complication codes are removed from the dataset and, thus, hospitals are not rewarded for complications in the risk adjustment process.

Step 2: Create Multivariate Model to Predict Inpatient Death

In past versions of the software, AHRQ used simple logistic regression to assign probabilities to each patient. Version 4.1 of the AHRQ software, released December 2009, uses "general estimating equations" to improve the accuracy and precision of the regression estimates. This relatively new statistical approach allows for better estimation of patient case mix at hospitals with very ill patients. In addition, "Markov Chain Monte Carlo" techniques are used to differentiate the "true" impact of patient factors (e.g., avoid giving too much credit to patients with rare co-morbidities). AHRQ has stated plans to publish a more detailed summary of how these models work on its Web site.

Step 3: Apply Model Coefficients to California Data

The software provided by AHRQ includes the coefficients or weights for each IMI that were created by producing the multivariate model on the 2007 National Inpatient Sample. 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 so that a predicted probability of death is assigned to each patient.

Step 4: Recalibrate the Expected Probability of Death

Most traditional regression models such as logistic regression result in estimates in which the predicted number of deaths for the entire sample is very close to or exactly the same as the observed number of deaths in the sample. The newer Bayesian modeling approach selected by AHRQ, however, creates estimates in which the expected number of deaths is fewer than the observed deaths. AHRQ considered both "proportional" and "additive" alternatives to improve the model calibration, and its analyses suggested that model fit would be improved by some combination of a proportional and additive model where the relative weight would vary by the discharge predicted rate. In the 4.1 release of the AHRQ software, an additive calibration method was provided. However, AHRQ has indicated that the proportional method may be more appropriate, until the newer more complex method is developed, and plans to include this improvement in a future software release. After communication with AHRQ, OSHPD staff received the software changes from AHRQ to implement the proportional method in the software version used to produce the 2008 and 2009 reports.

Conceptually, the "additive" calculation in the earlier AHRQ software version was:

$$Y = C + E$$

Where:

C is a constant
E is the patient's expected probability of death

The "proportional" calculation in the later release (version 4.1b) of the AHRQ software is:

$$Y = (P / (P - C)) * E$$

Where:

C is a constant
P is the reference population rate
E is the patient's expected probability of death

Step 5: Estimate Expected Deaths at Each Hospital

The first four steps 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 Cases / Expected Case 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. To calculate outlier ratings, OSHPD used the 95% upper and lower confidence intervals. The 4.1 version of the AHRQ software calculates 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 rates (for each hospital) is based on the following formula:

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

RMSE = square root (risk-adjusted rate, hospital A * (1 – risk-adjusted rate, hospital A))

The Standard Error is:

SE = RMSE / square root (Denominator hospital A)

For example:

If hospital A had a rate of 0.20 and the 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]

After discussions with AHRQ and University of California researchers, OSHPD staff modified the 4.1 version of the AHRQ software and implemented confidence intervals (CI) based on the exact method. All OSHPD 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 that is described above in that it relies on fewer distributional assumptions and provides more conservative estimates for hospitals with relatively few expected deaths.[6] AHRQ agreed that the exact method is more appropriate for public reporting and may implement this improvement in future software releases.

To identify statistical outliers, OSHPD 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 state 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.

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