OSHPD Implementation of AHRQ Inpatient Mortality Indicators, 2006 and 2007 Data

Technical Note

Office of Statewide Health Planning and Development,
Healthcare Outcomes Center

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Background

This technical note details California hospital results when applying the Agency for Healthcare Research and Quality's (AHRQ) Inpatient Mortality Indicators (IMIs), a subset of the AHRQ Inpatient Quality Indicators (IQIs), to California's patient discharge data. The analyses include 8 of the 15 IMIs for which AHRQ calculates risk-adjusted mortality rates and quality ratings. The Office of Statewide Health Planning and Development provides hospital-level results on its Web site for other IQIs, including the AHRQ Volume and Utilization Indicators.

The data tables were produced by the Healthcare Outcomes Center at OSHPD and include inpatient data for calendar years 2006 and 2007 for 381 state-licensed general acute care hospitals. OSHPD used version 3.2a of the AHRQ Quality Indicators and Statistical Analysis Software (SAS®) software to produce the indicators.

How can the Inpatient Mortality Indicators be used?

The AHRQ IQIs are an inexpensive tool that takes advantage of readily available hospital discharge data to highlight possible differences in the quality of care provided by hospitals. These results may provide the foundation for further, more in-depth analyses of healthcare quality and contribute to quality improvement efforts at these institutions. The information may be useful for hospital administrators, clinicians, quality assurance personnel and others engaged in hospital quality improvement initiatives. In addition, when the information is carefully considered alongside its limitations, and in conjunction with other reliable healthcare provider information, it may inform patient or healthcare purchaser decision-making.

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

It should be emphasized that these are indicators of healthcare provider quality and not definitive determinations of quality. These indicators are meant to serve as a starting point for further investigation that employs more in-depth analyses. More definitive determinations of quality require extensive data scrutiny, more in-depth validation of the outcomes and associated processes of care, and related data validation and reliability analyses. OSHPD has produced reports on heart attack, community-acquired pneumonia, and heart bypass surgery that are well-validated measures of quality and are also available on this Web site. However, the small number of these "gold-standard" reports produced to date, and the increasing demand from healthcare stakeholders for quality metrics in additional clinical areas, has led OSHPD to produce and publicly report the AHRQ Inpatient Mortality Indicators. The hospital results come with several caveats, listed below, since the indicators have not been rigorously validated.

1. California hospital medical records for these conditions/procedures have not been validated through medical record reabstraction (with a few exceptions) to demonstrate that patient severity of illness and complications are accurately coded.
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 ICD-9 code-based risk models for these conditions/procedures perform well compared to gold standard clinical models that include information such as laboratory values and vital signs.

How does OSHPD's implementation of the indicators differ from the approach used by most states?

AHRQ modified their Inpatient Mortality Indicator software recently 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 field.

In most states, hospital information systems use the ICD-9-CM protocol to convert medical chart information to numeric codes. This system 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, which is built on the ICD-9-CM coding system, therefore cannot directly 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.

OSHPD's patient discharge data contain the data element Present on Admission (POA), which was recently adopted as a national standard for providing critical information on the timing of acute conditions and complications. The APR-DRG risk method used here was modified by AHRQ to take this POA information into account. While this modification appears to be a major improvement, the effects that this adjustment has on the APR-DRG method have not been well researched. Unpublished OSHPD analyses, however, indicate that the adjustment appears to result in more valid estimates of hospital risk-adjusted mortality rates.

How comparable are these indicators with other quality metrics produced by OSHPD or other organizations?

Hospital results in these tables may not be comparable with quality ratings obtained using other methods, even when the clinical area of examination is the same. For example, OSHPD's coronary artery bypass graft (CABG) surgery reports issued under the California

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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.

CABG Outcomes Reporting Program (CCORP) are different from the AHRQ CABG mortality indicator in a number of fundamentally 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); AHRQ's outcome is inpatient mortality
- uses clinical registry data; AHRQ's measure uses coded ICD-9-CM patient discharge data
- only includes clinically similar "isolated CABG" cases; the AHRQ measure includes all CABG cases
- uses a risk model based on clinical logic; the AHRQ risk model is empirically based
- computes risk-adjusted mortality rates using only California data; the AHRQ algorithm incorporates comparison data from California and New York
- uses audited data; the AHRQ measure does not

The IMIs also differ from OSHPD's traditional outcome reports based on administrative data (community-acquired pneumonia and heart attack) in several ways. The OSHPD reports:

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

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 very different results when comparing a given hospital using more than one metric.

What indicators and which hospitals are included in the tables?

AHRQ provides software to calculate 15 Inpatient Mortality Indicators, including 7 surgical indicators and 8 medical condition indicators.

The results for 7 indicators are not included in the accompanying tables for the following reasons. For CABG, OSHPD already reports hospital and surgeon-level risk-adjusted mortality rates and quality ratings. These reports use data from a clinical registry expressly created for quality monitoring and reporting, and along with many other features of the data collection program, results in quality assessments that are clearly superior to those obtained from the

AHRQ measure. With regard to acute myocardial infarction (AMI)[1] and community-acquired pneumonia (CAP), OSHPD has produced similar reports using validated data and risk models and feels its reports provide a more accurate portrayal of hospital performance for those conditions. A congestive heart failure (CHF) outcomes report, supported by medical chart validation, is currently being prepared by OSHPD so this condition is not reported. Additionally, abdominal aortic aneurysm repair is excluded because OSHPD is preparing an outcomes report. Finally, hip replacement was not included because this procedure was considered but not endorsed by the National Quality Forum. The following indicators are included in this report (definitions appear in Appendix):

Surgical Procedures:

- **Esophageal Resection** – the number of deaths per 100 patients with ICD-9 procedure code for esophageal resection.
- **Pancreatic Resection** – the number of deaths per 100 patients with ICD-9 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 procedure code for carotid endarterectomy.
- **Percutaneous Transluminal Coronary Angioplasty (PTCA)** – the number of deaths per 100 patients with ICD-9 principal procedure code for PTCA.

Medical Conditions:

- **Acute Stroke** – the number of deaths per 100 discharges with ICD-9 principal diagnosis code for stroke.
- **Gastrointestinal (GI) Hemorrhage** – the number of deaths per 100 discharges with ICD-9 principal diagnosis code for gastrointestinal (GI) hemorrhage.
- **Hip Fracture** – the number of deaths per 100 discharges with ICD-9 principal diagnosis code for hip fracture.

Hospital Selection:

All acute care hospitals reporting patient discharge information to OSHPD were included. In cases of hospital consolidation, name change, and change of address, the discharges were attributed to the name of the hospital being used at the time the services were provided.

1. The AHRQ IQIs provide two indicators of acute myocardial infarction (AMI); one that includes all patients and one that excludes patients that were transferred to another acute care hospital.

Exactly how were the indicators calculated?

OSHPD used AHRQ's free statistical software (SAS®-based) to calculate the mortality indicators. The first step in calculating rates was to transform the data elements and values of the 2006 and 2007 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, since OSHPD has the POA field, an option was turned on so that the software implemented the indicator algorithms using POA. This option removes all complications from the original dataset so that the APR-DRG values are based only on pre-existing conditions, and not hospital-related complications. In addition, the POA option removes complications from the numerators and denominators that are used to calculate the observed rates. Finally, the coefficients used in the risk-adjustment process (described below), as well as population rates, were constructed based on 2002-2004 State Inpatient Database from California and New York. At the time of development, these were the only two states with discharge data that incorporated POA fields. Once the data were transformed and the options set, the software was run to automatically calculate the rates described below.

Calculation of Observed Rates

The IQI mortality software produces numerators, denominators, observed rates, expected rates, risk-adjusted rates, and additional information to evaluate confidence intervals and reliability of the indicators. In this report, we focus on risk-adjusted rates and confidence intervals for California acute care hospitals. Other rates are described to help readers understand the process of generating risk-adjusted rates.

Denominator:
For each indicator, 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 criterion). 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.

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).

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 Risk-Adjusted Rates

The purpose of statistical risk adjustment is to create a level field of comparison between hospitals that treat sicker or healthier patients. To make comparisons fair, it is necessary to hold the patient "case mix" of hospitals constant by measuring and adjusting for the health of patients.

Expected Rates:
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 (California and New York for this report). Although the particular methods require some statistical expertise to understand, the process of generating expected rates is straightforward.

Consulting with medical experts and statisticians, AHRQ chose risk-factors that predicted inpatient death. To assess risk for the IQI mortality indicators they selected the "All Patient Refined Diagnosis Related Groups" (APR-DRGs), a proprietary tool of the 3M Health Information Systems Corporation. The APR-DRG system works with administrative claims data and provides a way 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 diagnoses, 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. Second, AHRQ researchers obtained the number of expected deaths at a hospital. To do this, they used logistic regression to obtain coefficients so that the software could later be used to assign the probability of death for each patient record. The sum of these probabilities across all the patients for a given hospital makes up the expected number of deaths for the hospital. Consider the following example for congestive heart failure:

For CHF, a simplified logistic regression equation is $E = I + C1 + C2 + C3 + C4$ where:

- E = patient's contribution to the expected rate
- I = model intercept
- C1 = age coefficient
- C2 = sex coefficient
- C3 = age by sex interaction coefficient
- C4 = APR-DRG risk of mortality coefficient

For example, an 87 year old female patient with a moderate level of mortality risk contributes more to the expected rate:

$$-3.62 = -5.304 + 0.663 + (-0.066) + (-0.023) + 1.109$$

Once each patient has been scored to account for their contribution to a hospital's expected rate, these scores are summed up for each hospital using the following equation:

$$\text{Expected rate} = \frac{\text{Sum (patient predicted mortality from logistic risk model)}}{\text{number of patients in hospital (i) for indicator (i)}}$$

Risk-Adjusted Rates:
With observed and expected mortality rates available for each hospital, it is then possible to construct risk-adjusted rates. Of course, it is sufficient to compare the difference between observed and expected rates to assess higher and lower quality, but adding a reference population makes it easier to compare rates. The risk-adjusted (or indirectly standardized) death rate at a hospital equals the state risk-adjusted rate, multiplied by the ratio of the number of observed deaths to the number of expected deaths at that hospital (O/E ratio). The O/E ratio provides a quick 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 indicator, hospitals were rated as "better than expected" if their risk-adjusted death rates were significantly lower than the statewide risk-adjusted rate. They were rated as "worse than expected" if their rates were significantly higher than the statewide risk-adjusted rate of the particular indicator. To calculate such outlier ratings, OSHPD used the 95% upper and lower confidence intervals provided in the AHRQ software. The confidence intervals were calculated as follows:

Lower CI = "Hospital A" observed rate – (1.96 * Standard Error)
Upper CI = "Hospital A" observed rate + (1.96 * Standard Error)

The standard error for the actual observed rates (for each hospital) is based on the following formula:

The root mean squared error (RMSE) for each hospital is:

RMSE = square root (observed rate, hospital A * (1 – observed 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]

To identify statistical outliers, OSHPD compared hospital risk-adjusted rates to the upper and lower confidence intervals. If a hospital's upper CI is less than the state rate, it is likely that the hospital is performing better than the average hospital. If a hospital's lower CI is more than the state rate, it is likely that the hospital is performing worse than the average state hospital. 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 significantly different from the statewide rate. Thus, their risk-adjusted death rates would have to be much higher or lower than the statewide rate for them to be "significantly" different. Conversely, a large hospital with more patients for a particular indicator is more likely to be found significantly different, even with death rates that are only moderately higher or lower.

Appendix

These procedures and conditions described below are defined by AHRQ.

Esophageal Resection Mortality Rate (IQI 8)

Esophageal cancer surgery is a rare procedure that requires technical proficiency; and errors in surgical technique or management may lead to clinically significant complications, such as sepsis, pneumonia, anastomotic breakdown, and death.

Relationship to Quality	Better processes of care may reduce mortality for esophageal resection, which represents better quality care.
Benchmark	State, regional, or peer group average.
Definition	Number of deaths per 100 patients with discharge procedure code of esophageal resection.
Numerator	Number of deaths (DISP=20) among cases meeting the inclusion and exclusion rules for the denominator
Denominator	Discharges, age 18 years and older, with ICD-9-CM codes of 424x, 425x or 426x in any procedure field and a diagnosis code of esophageal cancer in any field. Exclude cases: • missing discharge disposition (DISP=missing) • transferring to another short-term hospital (DISP=2) • MDC 14 (pregnancy, childbirth, and puerperium) • MDC 15 (newborns and other neonates)
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Procedures

Pancreatic Resection Mortality Rate (IQI 9)

Pancreatic resection is a rare procedure that requires technical proficiency; and errors in surgical technique or management may lead to clinically significant complications, such as sepsis, anastomotic breakdown, and death.

Relationship to Quality	Better processes of care may reduce mortality for pancreatic resection, which represents better quality care.
Benchmark	State, regional, or peer group average.
Definition	Number of deaths per 100 patients with discharge procedure code of pancreatic resection.
Numerator	Number of deaths (DISP=20) among cases meeting the inclusion and exclusion rules for the denominator
Denominator	Discharges, age 18 years and older, with ICD-9-CM codes of 526 or 527 in any procedure field and a diagnosis code of pancreatic cancer in any field. Exclude cases: • missing discharge disposition (DISP=missing) • transferring to another short-term hospital (DISP=2) • MDC 14 (pregnancy, childbirth, and puerperium) • MDC 15 (newborns and other neonates)
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Procedures

Craniotomy Mortality Rate (IQI 13)

Craniotomy for the treatment of subarachnoid hemorrhage or cerebral aneurysm entails substantially high post-operative mortality rates.

Relationship to Quality	Better processes of care may reduce mortality for craniotomy, which represents better quality care.
Benchmark	State, regional, or peer group average.
Definition	Number of deaths per 100 discharges with DRG code for craniotomy (DRG 001, 002, 528, 529, 530, and 543), with and without comorbidities and complications.
Numerator	Number of deaths (DISP=20) among cases meeting the inclusion and exclusion rules for the denominator
Denominator	All discharges, age 18 years and older, with DRG code for craniotomy (DRG 001, 002, 528, 529, 530, and 543), with and without comorbidities and complications. Exclude cases: • with a principle diagnosis of head trauma • missing discharge disposition (DISP=missing) • transferring to another short-term hospital (DISP=2)
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Procedures

Acute Stroke Mortality Rate (IQI 17)

Quality treatment for acute stroke must be timely and efficient to prevent potentially fatal brain tissue death, and patients may not present until after the fragile window of time has passed.

Relationship to Quality	Better processes of care may reduce short-term mortality, which represents better quality.
Benchmark	State, regional, or peer group average.
Definition	Number of deaths per 100 discharges with principal diagnosis code of stroke.
Numerator	Number of deaths (DISP=20) among cases meeting the inclusion and exclusion rules for the denominator
Denominator	All discharges, age 18 years and older, with a principal diagnosis code of stroke. Exclude cases: • missing discharge disposition (DISP=missing) • transferring to another short-term hospital (DISP=2) • MDC 14 (pregnancy, childbirth, and puerperium) • MDC 15 (newborns and other neonates)
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Conditions

Gastrointestinal Hemorrhage Mortality Rate (IQI 18)

Gastrointestinal (GI) hemorrhage may lead to death when uncontrolled, and the ability to manage severely ill patients with comorbidities may influence the mortality rate.

Relationship to Quality	Better processes of care may reduce mortality for GI hemorrhage, which represents better quality.
Benchmark	State, regional, or peer group average.
Definition	Number of deaths per 100 discharges with principal diagnosis code of GI hemorrhage.
Numerator	Number of deaths (DISP=20) among cases meeting the inclusion and exclusion rules for the denominator
Denominator	All discharges, age 18 years and older, with principal diagnosis code for gastrointestinal hemorrhage. Exclude cases: • missing discharge disposition (DISP=missing) • transferring to another short-term hospital (DISP=2) • MDC 14 (pregnancy, childbirth, and puerperium) • MDC 15 (newborns and other neonates)
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Conditions

Hip Fracture Mortality Rate (IQI 19)

Hip fractures, which are a common cause of morbidity and functional decline among elderly persons, are associated with a significant increase in the subsequent risk of mortality.

Relationship to Quality	Better processes of care may reduce mortality for hip fracture, which represents better quality.
Benchmark	State, regional, or peer group average.
Definition	Number of deaths per 100 discharges with principal diagnosis code of hip fracture.
Numerator	Number of deaths (DISP=20) among cases meeting the inclusion and exclusion rules for the denominator.
Denominator	All discharges, age 18 years and older, with a principal diagnosis code for hip fracture. Exclude cases: • missing discharge disposition (DISP=missing) • transferring to another short-term hospital (DISP=2) • MDC 14 (pregnancy, childbirth, and puerperium) • MDC 15 (newborns and other neonates)
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Conditions

Carotid Endarterectomy Mortality Rate (IQI 31)

Carotid endarterectomy (CEA) is a fairly common procedure that requires proficiency with the use of complex equipment; and technical errors may lead to clinically significant complications, such as abrupt carotid occlusion with or without stroke, myocardial infarction, and death.

Relationship to Quality	Better processes of care may reduce short-term mortality, which represents better quality.
Definition	Number of deaths per 100 CEAs.
Numerator	Number of deaths among cases meeting the inclusion and exclusion rules for the denominator
Denominator	Discharges, age 18 years and older, with ICD-9-CM codes of 3812 in any procedure field. Exclude cases: • missing discharge disposition (DISP=missing) • transferring to another short-term hospital (DISP=2) • MDC 14 (pregnancy, childbirth, and puerperium) • MDC 15 (newborns and other neonates)
Type of Indicator	Provider Level, Mortality Indicator – Recommended for use only with the corresponding volume indicator above.

Percutaneous Transluminal Coronary Angioplasty Mortality Rate (IQI 30)

Percutaneous transluminal coronary angioplasty (PTCA) is a relatively common procedure that requires proficiency with the use of complex equipment, and technical errors may lead to clinically significant complications.

Relationship to Quality	Better processes of care may reduce short-term mortality, which represents better quality.
Definition	Number of deaths per 100 PTCAs.
Numerator	Number of deaths among cases meeting the inclusion and exclusion rules for the denominator.
Denominator	Discharges, age 40 years and older, with ICD-9-CM codes 0066, 3601, 3602, 3605 in any procedure field. Exclude cases: • missing discharge disposition (DISP=missing) • transferring to another short-term hospital (DISP=2) • MDC 14 (pregnancy, childbirth, and puerperium) • MDC 15 (newborns and other neonates)
Type of Indicator	Provider Level, Mortality Indicator – Recommended for use only with the corresponding volume indicator above.