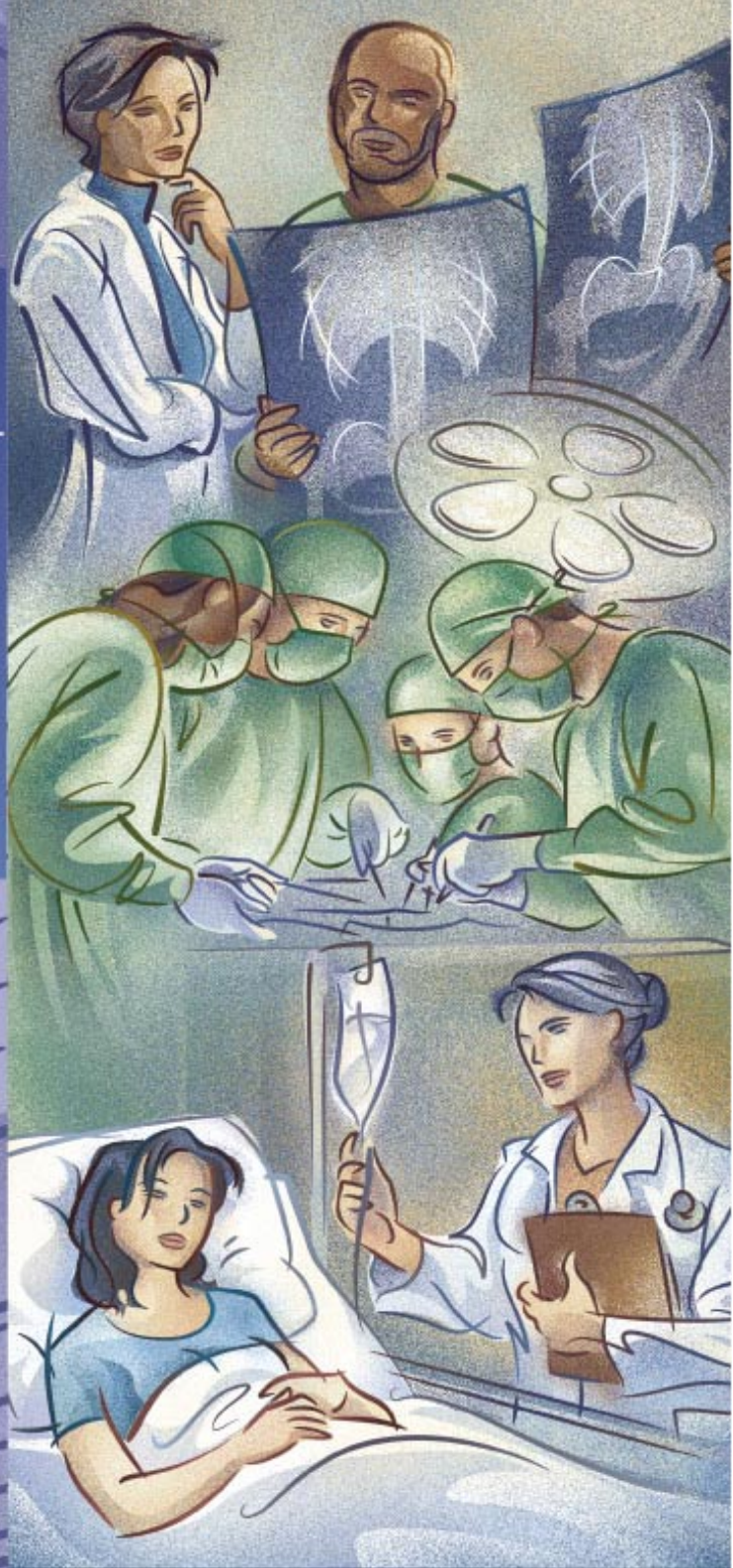




AHRQ QUALITY INDICATORS

Guide to Inpatient Quality Indicators



AHRQ Quality Indicators

Guide to Inpatient Quality Indicators:
Quality of Care in Hospitals – Volume, Mortality,
and Utilization

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Preface

In health care as in other arenas, that which cannot be measured is difficult to improve. Providers, consumers, policy makers, and others seeking to improve the quality of health care need accessible, reliable indicators of quality that they can use to flag potential problems or successes; follow trends over time; and identify disparities across regions, communities, and providers. As noted in a 2001 Institute of Medicine study, *Envisioning the National Health Care Quality Report*, it is important that such measures cover not just acute care but multiple dimensions of care: staying healthy, getting better, living with illness or disability, and coping with the end of life.

The Agency for Healthcare Research and Quality (AHRQ) Quality Indicators (QIs) are one Agency response to this need for multidimensional, accessible quality indicators. They include a family of measures that providers, policy makers, and researchers can use with inpatient data to identify apparent variations in the quality of inpatient or outpatient care. AHRQ's Evidence-Based Practice Center (EPC) at the University of California San Francisco (UCSF) and Stanford University adapted, expanded, and refined these indicators based on the original Healthcare Cost and Utilization Project (HCUP) Quality Indicators developed in the early 1990s.

The new AHRQ QIs are organized into three modules: **Prevention Quality Indicators**, **Inpatient Quality Indicators**, and **Patient Safety Indicators**. During 2001 and 2002, AHRQ will be publishing the three modules as a series. The first module—Prevention Quality Indicators—was released in 2001 and is available at AHRQ's Web site at <http://www.ahrq.gov/>.

This second module focuses on health care provided within the inpatient hospital setting. The Inpatient Quality Indicators include three distinct types of measures. **Volume** measures examine the volume of inpatient procedures for which a link has been demonstrated between the number of procedures performed and outcomes such as mortality. **In-hospital mortality** measures examine outcomes following procedures and for common medical conditions. **Utilization** examines procedures for which questions have been raised about overuse, underuse, and misuse.

Full technical information on the first two modules can be found in *Evidence Report for Refinement of the HCUP Quality Indicators*, prepared by the UCSF-Stanford EPC. It can be accessed at AHRQ's Web site. The technical report for the third module—Patient Safety Indicators—is currently under development.

Improving the quality of inpatient hospital services is a critical part of efforts to provide high quality health care in the United States. This guide is intended to facilitate such efforts. As always, we would appreciate hearing from those who use our measures and tools so that we can identify how they are used, how they can be refined, and how we can measure and improve the quality of the tools themselves.

Irene Fraser, Ph.D., Director
Center for Organization and Delivery Studies

The programs for the Inpatient Quality Indicators (IQIs) can be downloaded from <http://www.ahrq.gov/>. Instructions on how to use the programs to calculate the IQI rates are contained in the companion text, *Inpatient Quality Indicators: Software Documentation*.

Acknowledgments

This product is based on the work of many individuals who contributed to its development and testing.

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Introduction to the AHRQ Inpatient Quality Indicators

Hospitals in the United States provide the setting for some of life's most pivotal events—the birth of a child, major surgery, treatment for otherwise fatal illnesses. These hospitals house the most sophisticated medical technology in the world and provide state-of-the-art diagnostic and therapeutic services. But access to these services comes with certain costs. About 36% of personal health care expenditures in the United States go towards hospital care,¹ and the rate of growth in spending for hospital services has begun to increase following a half a decade of declining growth.² Simultaneously, concerns about the quality of health care services have reached a crescendo with the Institute of Medicine's series of reports describing the problem of medical errors³ and the need for a complete restructuring of the health care system to improve the quality of care.⁴ Policymakers, employers, and consumers have made the quality of care in U.S. hospitals a top priority and have voiced the need to assess, monitor, track, and improve the quality of inpatient care.

Hospital administrative data offer a window into the medical care delivered in our nation's hospitals. These data, which are collected as a routine step in the delivery of hospital services, provide information on diagnoses, procedures, age, gender, admission source, and discharge status. From these data elements, it is possible to construct a picture of the quality of medical care. Although quality assessments based on administrative data cannot be definitive, they can be used to flag potential quality problems and success stories, which can then be further investigated and studied. Hospital associations, individual hospitals, purchasers, regulators, and policymakers at the local, State, and Federal levels can use readily available hospital administrative data to begin the assessment of quality of care.

The Agency for Healthcare Research and Quality (AHRQ) Inpatient Quality Indicators (IQIs) are a tool that takes advantage of hospital administrative data. The IQIs represent the current state-of-the-art in measuring the quality of hospital care through analysis of inpatient discharge data.

What Are the Inpatient Quality Indicators?

The IQIs are a set of measures that can be used with hospital inpatient discharge data to provide a perspective on quality and include the following:

- P **Volume** indicators are proxy, or indirect, measures of quality. They are based on evidence suggesting that hospitals performing more of certain intensive, high-technology, or highly complex procedures may have better outcomes for those procedures. Volume indicators simply represent counts of admissions in which these procedures were performed.

¹<http://www.hcfa.gov/stats/NHE-Proj/proj2000/tables/t2.htm>: Table 2: National Health Expenditure Amounts, and Average Annual Percent Change by Type of Expenditure: Selected Calendar Years 1980-2010.

²Strunk BC, Ginsburg PB, Gabel JR. Tracking Health Care Costs. Health Affairs, 26 September 2001 (Web exclusive).

³Institute of Medicine. To Err is Human: Building a Safer Health System. Kohn LT, Corrigan JM, Donaldson MS (eds.) Washington DC: National Academy Press, 2000.

⁴Institute of Medicine. Crossing the Quality Chasm: A New Health System for the 21st Century. Committee of Quality of Care in America. Washington DC: National Academy Press, 2001.

- P **Mortality indicators for inpatient procedures** include procedures for which mortality has been shown to vary across institutions and for which there is evidence that high mortality may be associated with poorer quality of care.
- P **Mortality indicators for inpatient conditions** include conditions for which mortality has been shown to vary substantially across institutions and for which evidence suggests that high mortality may be associated with deficiencies in the quality of care.
- P **Utilization** indicators examine procedures whose use varies significantly across hospitals and for which questions have been raised about overuse, underuse, or misuse. High or low rates for these indicators are likely to represent inappropriate or inefficient delivery of care.

The IQIs include the following indicators, which are measured at the provider, or hospital, level:

Volume Indicators	Mortality Indicators for Inpatient Procedures
Esophageal resection volume	Esophageal resection mortality rate
Pancreatic resection volume	Pancreatic resection mortality rate
Pediatric heart surgery volume	Pediatric heart surgery mortality rate
Abdominal aortic aneurysm (AAA) repair volume	AAA repair mortality rate
Coronary artery bypass graft (CABG) volume	CABG mortality rate
Percutaneous transluminal coronary angioplasty (PTCA) volume	<i>PTCA mortality rate</i> ⁵
	<i>CEA mortality rate</i> ⁵
Carotid endarterectomy (CEA) volume	Craniotomy mortality rate
	Hip replacement mortality rate
Mortality Indicators for Inpatient Conditions	Utilization Indicators
Acute myocardial infarction (AMI) mortality rate	Cesarean section delivery rate
Congestive heart failure (CHF) mortality rate	Vaginal birth after Cesarean (VBAC) rate
Acute stroke mortality rate	Laparoscopic cholecystectomy rate
Gastrointestinal hemorrhage mortality rate	Incidental appendectomy in the elderly rate
Hip fracture mortality rate	Bilateral cardiac catheterization rate
Pneumonia mortality rate	

The IQIs also include area-level utilization indicators that reflect the rate of hospitalization in the area for specific procedures. They are designed using an age- and sex-adjusted population-based denominator and discharge-based numerator. These indicators represent procedures whose use varies widely across relatively similar geographic areas with (in most cases) substantial inappropriate use. The area-level IQIs include the following:

Utilization Indicators	
CABG area rate	Hysterectomy area rate
PTCA area rate	Laminectomy or spinal fusion area rate

⁵PTCA and CEA mortality are not recommended as standalone indicators, but are suggested as companion measures to the corresponding volume measures.

How Can the IQIs be Used in Quality Assessment?

The Inpatient Quality Indicators can be used by a variety of players in the health care arena to improve quality of care at the level of individual hospitals, the community, the State, or the nation. The following scenario illustrates one potential application of the IQIs.

A hospital association recognizes its member hospitals' needs for information that can help them evaluate the quality of care they provide. After learning about the IQIs, the association decides to apply the indicators to the discharge abstract data submitted by individual hospitals. For each hospital, the association develops a report with a graphic presentation of the risk-adjusted data to show how that hospital performs on each indicator compared with its peer group, the State as a whole, and other comparable States. National and regional averages are also provided as external benchmarks. Trend data are included to allow the hospital to examine any changing patterns in its performance.

One member hospital, upon receiving the report, convenes an internal work group comprised of both quality improvement professionals and clinicians to review the information and address potential areas for improvements. Since the report is based on administrative data, the work group compares the data with information obtained from other internal sources. For example, to examine the mortality data, they perform chart review for a random sample of patients with a particular condition to verify that the coding is accurate and to ascertain if the death was preventable.

After in-depth analysis of the data and additional chart review, the work group meets with various clinical departments to discuss the results. During those meetings, individual cases are examined and the processes of care are reviewed to identify what patient factors and care processes might have had an impact on patient outcomes. Best practices identified from the literature are also discussed. The work group puts together an internal document that summarizes the findings and makes recommendations for various quality improvement initiatives. The document is shared with the hospital's executives and physician leaders, who strongly support the implementation of several quality improvement projects:

- P To improve patient outcomes, the quality improvement team develops and implements comprehensive risk assessment tools and treatment protocols for patients at risk of mortality.
- P Physicians refine patient selection criteria for several elective procedures to improve appropriate utilization.
- P The hospital reaches out to the local chapter of the American College of Obstetrics and Gynecology and other health care organizations to address the high Cesarean section rates among obstetric patients in their community.
- P Problems in ICD-9-CM coding are discovered during the chart review process, so health information personnel in the hospital embark on a project to improve communication with physicians to increase the accuracy of coding medical records.

What Does this Guide Contain?

This guide provides information that hospitals, State data organizations, hospital associations, and others can use to decide how to use the IQIs. First, it describes the origin of the entire family of AHRQ Quality Indicators. Second, it provides an overview of the methods used to identify, select, and evaluate the AHRQ Quality Indicators. Third, the guide summarizes the IQIs specifically, describes strengths and limitations of the indicators, documents the evidence that links the IQIs to the quality of health care services, and then provides in-depth two-page descriptions of each IQI. Finally, two appendices present additional technical background information. Appendix A outlines the specific definitions of each IQI, with complete ICD-9-CM coding specifications. Appendix B provides the details of the empirical methods used to explore the IQIs.

Origins and Background of the Quality Indicators

In the early 1990s, in response to requests for assistance from State-level data organizations and hospital associations with inpatient data collection systems, AHRQ developed a set of quality measures that required only the type of information found in routine hospital administrative data—diagnoses and procedures, along with information on patient’s age, gender, source of admission, and discharge status. These States were part of the Healthcare Cost and Utilization Project, an ongoing Federal-State-private sector collaboration to build uniform databases from administrative hospital-based data.

AHRQ developed these measures, called the HCUP Quality Indicators, to take advantage of a readily available data source—administrative data based on hospital claims—and quality measures that had been reported elsewhere.⁶ The 33 HCUP QIs included measures for avoidable adverse outcomes, such as in-hospital mortality and complications of procedures; use of specific inpatient procedures thought to be overused, underused, or misused; and ambulatory care sensitive conditions.

Although administrative data cannot provide definitive measures of health care quality, they can be used to provide *indicators* of health care quality that can serve as the starting point for further investigation. The HCUP QIs have been used to assess potential quality-of-care problems and to delineate approaches for dealing with those problems. Hospitals with high rates of poor outcomes on the HCUP QIs have reviewed medical records to verify the presence of those outcomes and to investigate potential quality-of-care problems.⁷ For example, one hospital that detected high utilization rates for certain procedures refined patient selection criteria for these procedures to improve appropriate utilization.

Development of the AHRQ Quality Indicators

Since the original development of the HCUP QIs, the knowledge base on quality indicators has increased significantly. Risk adjustment methods have become more readily available, new measures have been developed, and analytic capacity at the State level has expanded considerably. Based on input from current users and advances to the scientific base for specific indicators, AHRQ funded a project to refine and further develop the original QIs. The project was conducted by the UCSF-Stanford EPC.

The major constraint placed on the UCSF-Stanford EPC was that the measures could require only the type of information found in hospital discharge abstract data. Further, the data elements required by the measures had to be available from most inpatient administrative data systems. Some State data systems contain innovative data elements, often based on additional information from the medical record. Despite the value of these record-based data elements, the intent of this project was to create measures that were based on a *common denominator discharge data set*, without the need for additional data collection. This was critical for two reasons. First, this constraint would result in a tool that could be used with any inpatient administrative data, thus making it useful to most data systems. Second, this would enable

⁶ Ball JK, Elixhauser A, Johantgen M, et al. *HCUP Quality Indicators, Methods, Version 1.1: Outcome, Utilization, and Access Measures for Quality Improvement*. (AHCPR Publication No. 98-0035). Healthcare Cost and Utilization project (HCUP-3) Research notes: Rockville, MD: Agency for Health Care Policy and Research, 1998.

⁷ *Impact: Case Studies Notebook – Documented Impact and Use of AHRQ’s Research*. Compiled by Division of Public Affairs, Office of Health Care Information, Agency for Healthcare Research and Quality.

national and regional benchmark rates to be provided using HCUP data, since these benchmark rates would need to be calculated using the universe of data available from the States.

AHRQ Quality Indicator Modules

The work of the UCSF-Stanford EPC resulted in the *AHRQ Quality Indicators*, which are being distributed as three separate modules:

- P **Prevention Quality Indicators.** These indicators consist of “ambulatory care sensitive conditions,” hospital admissions that evidence suggests could have been avoided through high-quality outpatient care or that reflect conditions that could be less severe, if treated early and appropriately.

- P **Inpatient Quality Indicators.** These indicators reflect quality of care inside hospitals and include inpatient mortality; utilization of procedures for which there are questions of overuse, underuse, or misuse; and volume of procedures for which there is evidence that a higher volume of procedures is associated with lower mortality.

- P **Patient Safety Indicators.** These indicators focus on preventable instances of harm to patients, such as surgical complications and other iatrogenic events.

Methods of Identifying, Selecting, and Evaluating the Quality Indicators

In developing the new quality indicators, the UCSF-Stanford EPC applied the Institute of Medicine's widely cited definition of quality care: "the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge."⁸ They formulated six specific key questions to guide the development process:

- P Which indicators are currently in use or described in the literature that could be *defined using hospital discharge data*?
- P What are the *quality relationships* reported in the literature that could be used to define new indicators using hospital discharge data?
- P What evidence exists for *indicators not well represented* in the original indicators—pediatric conditions, chronic disease, new technologies, and ambulatory care sensitive conditions?
- P Which indicators have *literature-based evidence* to support face validity, precision of measurement, minimum bias, and construct validity of the indicator?
- P What *risk-adjustment method* should be suggested for use with the recommended indicators, given the limits of administrative data and other practical concerns?
- P Which indicators perform well on *empirical tests* of precision of measurement, minimum bias, and construct validity?

As part of this project, the UCSF-Stanford EPC identified quality indicators reported in the literature and used by health care organizations, evaluated the original quality indicators and potential indicators using literature review and empirical methods, incorporated risk adjustment for comparative analysis, and developed new programs that could be employed by users with their own hospital administrative data. This section outlines the steps used to arrive at a final set of quality measures.

Step 1: Obtain Background Information on QI Use

The project team at the UCSF-Stanford EPC interviewed 33 individuals affiliated with hospital associations, business coalitions, State data groups, Federal agencies, and academia about various topics related to quality measurement, including indicator use, suggested indicators, and other potential contacts. Interviews were tailored to the specific expertise of interviewees. The sample was not intended to be representative of any population; rather, individuals were selected to include QI users and potential users from a broad spectrum of organizations in both the public and private sectors.

Three broad audiences were considered for the quality measures: health care providers and managers, who could use the quality measures to assist in initiatives to improve quality; public health policy makers, who could use the information from indicators to target public health

⁸ Institute of Medicine Division of Health Care Services. Medicare: a strategy for quality assurance. Washington, DC: National Academy Press; 1990.

interventions; and health care purchasers, who could use the measures to guide decisions about health policies.

Step 2: Search the Literature to Identify Potential QIs

The project team performed a structured review of the literature to identify potential indicators. They used Medline to identify the search strategy that returned a test set of known applicable articles in the most concise manner. Using the Medical Subject Heading (MeSH) terms “Hospital/statistics and numerical data” and “Quality Indicators, Health Care” resulted in approximately 2,600 articles published in 1994 or later. After screening titles and abstracts for relevancy, the search yielded 181 articles that provided information on potential quality indicators based on administrative data.

Clinicians, health services researchers, and other team members abstracted information from these articles in two stages. In the first stage, preliminary abstraction, they evaluated each of the 181 identified articles for the presence of a defined quality indicator, clinical rationale, and strengths and weaknesses. To qualify for full abstraction, the articles must have explicitly defined a novel quality indicator. Only 27 articles met this criterion. The team collected information on the definition of the quality indicator, validation, and rationale during full abstraction.

In addition, they identified additional potential indicators using the CONQUEST database; the National Library of Healthcare Indicators developed by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO); a list of ORYX-approved indicators provided by JCAHO; and telephone interviews.

Step 3: Review the Literature to Evaluate the QIs According to Predetermined Criteria

The project team evaluated each potential quality indicator against the following six criteria, which were considered essential for determining the reliability and validity of a quality indicator:

- P **Face validity.** An adequate quality indicator must have sound clinical or empirical rationale for its use. It should measure an important aspect of quality that is subject to provider or health care system control.
- P **Precision.** An adequate quality indicator should have relatively large variation among providers or areas that is not due to random variation or patient characteristics. This criterion measures the impact of chance on apparent provider or community health system performance.
- P **Minimum bias.** The indicator should not be affected by systematic differences in patient case-mix, including disease severity and comorbidity. In cases where such systematic differences exist, an adequate risk adjustment system should be possible using available data.
- P **Construct validity.** The indicator should be related to other indicators or measures intended to measure the same or related aspects of quality. For example, improved performance on measures of inpatient care (such as adherence to specific evidence-based treatment guidelines) ought to be associated with reduced patient complication rates.

- P **Fosters real quality improvement.** The indicator should be robust to possible provider manipulation of the system. In other words, the indicator should be insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care.
- P **Application.** The indicator should have been used in the past or have high potential for working well with other indicators. Sometimes looking at groups of indicators together is likely to provide a more complete picture of quality.

Based on the initial review, the team identified and evaluated over 200 potential indicators using these criteria. Of this initial set, 45 indicators passed this initial screen and received comprehensive literature and empirical evaluation. In some cases, whether an indicator complemented other promising indicators was a consideration in retaining it, allowing the indicators to provide more depth in specific areas.

For this final set of 45 indicators, the team reviewed an additional 2,000 articles to provide evidence on indicators during the evaluation phase. They searched Medline for articles relating to each of the six areas of evaluation described above. Clinicians and health services researchers reviewed the literature for evidence and prepared a referenced summary description on each indicator.

As part of the review process, the team assessed the link between each indicator and health care quality along the following dimensions:

- P **Proxy.** Some indicators do not specifically measure a patient outcome or a process measure of quality. Rather, they measure an aspect of care that is correlated with process measures of quality or patient outcomes. These indicators are best used in conjunction with other indicators measuring similar aspects of clinical care, or when followed with more direct and in-depth investigations of quality.
- P **Selection bias.** Selection bias results when a substantial percentage of care for a condition is provided in the outpatient setting, so the subset of inpatient cases may be unrepresentative. In these cases, examination of outpatient care or emergency room data may help reduce selection bias.
- P **Information bias.** Quality indicators are based on information available in hospital discharge data sets, but some missing information may actually be important to evaluating the outcomes of hospital care. In these cases, examination of missing information may help to improve indicator performance.
- P **Confounding bias.** Patient characteristics may substantially affect performance on a measure and may vary systematically across areas. In these cases, adequate risk adjustment may help to improve indicator performance.
- P **Unclear construct validity.** Problems with construct validity include uncertain or poor correlations with widely accepted process measures or with risk-adjusted outcome measures. These indicators would benefit from further research to establish their relationship with quality care.
- P **Easily manipulated.** Quality indicators may create perverse incentives to improve performance without actually improving quality. Although very few of these perverse responses have been proven, they are theoretically important and should be monitored to ensure true quality improvement.

- P **Unclear benchmark.** For some indicators, the “right rate” has not been established, so comparison with national, regional, or peer group means may be the best benchmark available. Very low IQI rates may flag an underuse problem, that is, providers may fail to hospitalize patients who would benefit from inpatient care. On the other hand, overuse of acute care resources may potentially occur when patients who do not clinically require inpatient care are hospitalized.

Step 4: Perform a Comprehensive Evaluation of Risk Adjustment

The project team identified potential risk-adjustment systems by reviewing the applicable literature and asking the interviewees in step 1 to identify their preferences. Generally, users preferred that the system be (1) open, with published logic; (2) cost-effective, with data collection costs minimized and additional data collection being well justified; (3) designed using a multiple-use coding system, such as those used for reimbursement; and (4) officially recognized by government, hospital groups, or other organizations.

Although no severity adjustment system based solely on administrative data is superior for all purposes, risk adjustment systems based on diagnosis-related groups (DRGs) seemed to meet the criteria for this evaluation better than other alternatives. Specifically, it was presumed that because a DRG-based system relies on the same diagnostic groups used for reimbursement, there may be more accurate coding as a result of the financial and audit incentives associated with use of DRGs.

One DRG-based system in particular—all-patient refined (APR)-DRGs—appeared to be promising for several reasons. First, APR-DRGs are based on a refinement of two previously developed systems (R-DRGs and AP-DRGs) and take advantage of the strengths of both of these systems. Second, APR-DRGs were enhanced to provide improved risk adjustment for pediatric cases; to take advantage of information on comorbidities and non-operating room procedures; and to allow the interaction of secondary diagnoses, principal diagnosis, and age to influence the assignment of severity classes. Third, APR-DRGs have been reported to perform well in predicting resource use and death when compared to other DRG-based systems. Fourth, APR-DRGs have been used with “smoothing” techniques, the statistical methods incorporated into the QI software, thus compatibility with the QI software was ensured. Finally, a majority of the users interviewed already used APR-DRGs; even though the system is proprietary, the burden on the group of potential QI users would be smaller than with another system that was less widely employed.

APR-DRGs were used to conduct indicator evaluations to determine the impact of measured differences in patient severity on the relative performance of providers and to provide the basis for implementing APR-DRGs as an optional risk-adjustment system for hospital-level QI measures. The implementation of APR-DRGs is based on an ordinary least squares regression model. Area indicators were risk-adjusted only for age and sex differences. Detailed information on the risk-adjustment methods can be found in Appendix B.

Step 5: Evaluate the Indicators Using Empirical Analyses

The project team conducted extensive empirical testing of all potential indicators using the 1995-97 HCUP State Inpatient Databases (SID) and Nationwide Inpatient Sample (NIS) to determine precision, bias, and construct validity. The 1997 SID contains uniform data on inpatient stays in community hospitals for 22 States covering approximately 60% of all U.S. hospital discharges. The NIS is designed to approximate a 20% sample of U.S. community hospitals and includes all stays in the sampled hospitals. Each year of the NIS contains between

6 million and 7 million records from about 1,000 hospitals. The NIS combines a subset of the SID data, hospital-level variables, and hospital and discharge weights for producing national estimates. The project team conducted tests to examine three things: precision, bias, and construct validity.

Precision. The first step in the analysis involved precision tests to determine the reliability of the indicator for distinguishing real differences in provider performance. For indicators that may be used for quality improvement, it is important to know with what precision, or surety, a measure can be attributed to an actual construct rather than random variation.

For each indicator, the variance can be broken down into three components: variation within a provider (actual differences in performance due to differing patient characteristics), variation among providers (actual differences in performance among providers), and random variation. An ideal indicator would have a substantial amount of the variance explained by between-provider variance, possibly resulting from differences in quality of care, and a minimum amount of random variation. The project team performed four tests of precision to estimate the magnitude of between-provider variance on each indicator:

- P Signal standard deviation was used to measure the extent to which performance of the QI varies systematically across hospitals or areas.
- P Provider/area variation share was used to calculate the percentage of signal (or true) variance relative to the total variance of the QI.
- P Signal-to-noise ratio was used to measure the percentage of the apparent variation in QIs across providers that is truly related to systematic differences across providers and not random variations (noise) from year to year.
- P In-sample R-squared was used to identify the incremental benefit of applying multivariate signal extraction methods for identifying additional signal on top of the signal-to-noise ratio.

In general, random variation is most problematic when there are relatively few observations per provider, when adverse outcome rates are relatively low, and when providers have little control over patient outcomes or variation in important processes of care is minimal. If a large number of patient factors that are difficult to observe influence whether or not a patient has an adverse outcome, it may be difficult to separate the “quality signal” from the surrounding noise. Two signal extraction techniques were applied to improve the precision of an indicator:

- P Univariate methods were used to estimate the “true” quality signal of an indicator based on information from the specific indicator and 1 year of data.
- P Multivariate signal extraction (MSX) methods were used to estimate the “true” quality signal based on information from a set of indicators and multiple years of data. In most cases, MSX methods extracted additional signal, which provided much more precise estimates of true hospital or area quality.

Bias. To determine the sensitivity of potential QIs to bias from differences in patient severity, unadjusted performance measures for specific hospitals were compared with performance measures that had been adjusted for age and gender. All of the Prevention QIs and some of the IQIs could only be risk-adjusted for age and sex. The 3M APR-DRG System Version 12 with Severity of Illness and Risk of Mortality subclasses was used for risk adjustment of the utilization indicators and the in-hospital mortality indicators, respectively. Five empirical tests were performed to investigate the degree of bias in an indicator:

- P Rank correlation coefficient of the area or hospital with (and without) risk adjustment—gives the overall impact of risk adjustment on relative provider or area performance.
- P Average absolute value of change relative to mean—highlights the amount of absolute change in performance, without reference to other providers' performance.
- P Percentage of highly ranked hospitals that remain in high decile—reports the percentage of hospitals or areas that are in the highest deciles without risk adjustment that remain there after risk adjustment is performed.
- P Percentage of lowly ranked hospitals that remain in low decile—reports the percentage of hospitals or areas that are in the lowest deciles without risk adjustment that remain there after risk adjustment is performed.
- P Percentage that change more than two deciles—identifies the percentage of hospitals whose relative rank changes by a substantial percentage (more than 20%) with and without risk adjustment.

Construct validity. Construct validity analyses provided information regarding the relatedness or independence of the indicators. If quality indicators do indeed measure quality, then two measures of the same construct would be expected to yield similar results. The team used factor analysis to reveal underlying patterns among large numbers of variables—in this case, to measure the degree of relatedness between indicators. In addition, they analyzed correlation matrices for indicators.

Summary Evidence on the Inpatient Quality Indicators

The rigorous evaluations performed by the UCSF-Stanford EPC, based on literature review and empirical testing of indicators, resulted in 29 indicators that reflect inpatient volume, mortality, and utilization. (Two additional mortality indicators are provided that should only be used with the corresponding volume measures.) Five of the provider-level IQIs and three area-level IQIs were included in the original HCUP QIs—Cesarean section delivery rate, incidental appendectomy in the elderly rate, VBAC rate, laparoscopic cholecystectomy rate, hip replacement mortality rate, CABG area rate, hysterectomy area rate, and laminectomy or spinal fusion area rate.

Table 1 summarizes the results of the literature review and empirical evaluations on the IQIs. The table lists each indicator, provides its definition, rates its empirical performance, recommends a risk adjustment strategy, and summarizes important caveats identified from the literature review.

Rating of performance on empirical evaluations, as described in step 5 in the previous section, ranged from 0 to 26. (The average score for the mortality IQIs is 6.2; the average score for the utilization IQIs is 19.3.) The scores were intended as a guide for summarizing the performance of each indicator on four empirical tests of precision (signal variance, area-level share, signal ratio, and R-squared) and five tests of minimum bias (rank correlation, top and bottom decile movement, absolute change, and change over two deciles), as described in the previous section and in Appendix B.

The magnitude of the scores, shown in the Empirical Rating column, provides an indication of the relative rankings of the indicators. These scores were based on indicator performance after risk-adjustment and smoothing, that is, they represent the “best estimate” of the indicator’s true value after accounting for case-mix and reliability. The score for each individual test is an ordinal ranking (e.g., very high, high, moderate, and low). The final summary score was derived by assigning a weight to each ranking (e.g., 3, 2, 1, 0) and summing across these nine individual tests. Higher scores indicate better performance on the empirical tests.

The Literature Review Caveats column summarizes evidence specific to each potential concern on the link between the IQIs and quality of care, as described in step 3 above. A question mark (?) indicates that the concern is theoretical or suggested, but no specific evidence was found in the literature. A check mark (T) indicates that the concern has been demonstrated in the literature. For additional details on the results of the literature review, see “Detailed Evidence for the Inpatient Quality Indicators.”

A complete description of each IQI is included later in the guide under “Detailed Evidence for Inpatient Quality Indicators” and in Appendix A. Details on the empirical methods can be found in Appendix B.

Table 1. AHRQ Inpatient Quality Indicators

Indicator Name	Description	Risk Adjustment Used by QI Software	Empirical Rating ^a	Literature Review Caveats ^b
Volume Indicators				
Esophageal resection volume	Raw volume compared to annual thresholds (6 and 7 procedures).	Not applicable.	Not applicable	T Proxy ? Easily manipulated
Pancreatic resection volume	Raw volume compared to annual thresholds (10 and 11 procedures).	Not applicable.	Not applicable	T Proxy ? Easily manipulated
Pediatric heart surgery volume	Raw volume compared to annual threshold (100 procedures).	Not applicable.	Not applicable	T Proxy ? Easily manipulated
Abdominal aortic aneurysm repair (AAA) volume	Raw volume compared to annual thresholds (20 and 32 procedures).	Not applicable.	Not applicable	T Proxy ? Easily manipulated
Coronary artery bypass graft (CABG) volume	Raw volume compared to annual thresholds (100 and 200 procedures).	Not applicable.	Not applicable	T Proxy ? Easily manipulated
Percutaneous transluminal coronary angioplasty (PTCA) volume	Raw volume compared to annual thresholds (200 and 400 procedures).	Not applicable.	Not applicable	T Proxy ? Selection bias T Easily manipulated
Carotid endarterectomy (CEA) volume	Raw volume compared to annual thresholds (50 and 101 procedures).	Not applicable.	Not applicable	T Proxy T Easily manipulated
Mortality Indicators for Inpatient Procedures				
Esophageal resection mortality rate	Number of deaths per 100 esophageal resections for cancer.	APR-DRG, though impact may be impaired by skewed distribution.	8	? Confounding bias ? Unclear construct validity
Pancreatic resection mortality rate	Number of deaths per 100 pancreatic resections for cancer.	APR-DRG, though impact may be impaired by skewed distribution.	5	? Confounding bias ? Unclear construct validity
Pediatric heart surgery mortality rate	Number of deaths per 100 heart surgeries in patients under age 18 years.	APR-DRG.	3	T Confounding bias ? Unclear construct validity ? Unclear benchmark

Indicator Name	Description	Risk Adjustment Used by QI Software	Empirical Rating ^a	Literature Review Caveats ^b
AAA repair mortality rate	Number of deaths per 100 AAA repairs.	APR-DRG, though impact may be impaired by skewed distribution.	8	T Confounding bias ? Unclear construct validity
CABG mortality rate	Number of deaths per 100 CABG procedures.	APR-DRG.	5	? Selection bias T Confounding bias ? Unclear construct validity ? Easily manipulated
<i>PTCA mortality rate^c</i>	<i>Number of deaths per 100 PTCA's</i>	<i>APR-DRG.</i>	—	—
<i>CEA mortality rate^c</i>	<i>Number of deaths per 100 CEAs.</i>	<i>APR-DRG.</i>	—	—
Craniotomy mortality rate	Number of deaths per 100 craniotomies.	APR-DRG.	6	T Confounding bias ? Unclear construct validity
Hip replacement mortality rate	Number of deaths per 100 hip replacements.	APR-DRG.	3	? Selection bias ? Confounding bias ? Unclear construct validity
Mortality Indicators for Inpatient Conditions				
Acute myocardial infarction (AMI) mortality rate	Number of deaths per 100 discharges for AMI.	APR-DRG.	5	T Information bias T Confounding bias
Congestive heart failure (CHF) mortality rate	Number of deaths per 100 discharges for CHF.	APR-DRG.	6	T Selection bias T Information bias T Confounding bias
Acute stroke mortality rate	Number of deaths per 100 discharges for stroke.	APR-DRG	10	T Selection bias ? Information bias T Confounding bias
Gastrointestinal (GI) hemorrhage mortality rate	Number of deaths per 100 discharges for GI hemorrhage.	APR-DRG.	5	T Confounding bias ? Unclear construct validity
Hip fracture mortality rate	Number of deaths per 100 discharges for hip fracture.	APR-DRG.	10	? Information bias T Confounding bias ? Unclear construct validity
Pneumonia mortality rate	Number of deaths per 100 discharges for pneumonia.	APR-DRG.	7	T Selection bias ? Information bias T Confounding bias
Utilization Indicators - Provider (Hospital) Level				
Cesarean section delivery rate	Number of Cesarean sections per 100 deliveries.	Age and potentially supplemental (clinical data, linked to infant record or linked to birth record).	17	? Confounding bias ? Unclear construct validity ? Unclear benchmark

Indicator Name	Description	Risk Adjustment Used by QI Software	Empirical Rating ^a	Literature Review Caveats ^b
Vaginal birth after Cesarean (VBAC) rate	Number of vaginal births per 100 deliveries in women with previous Cesarean section.	Age and potentially supplemental (clinical data, linked to infant record or linked to birth record).	19	T Selection bias ? Confounding bias ? Unclear construct validity ? Unclear benchmark
Laparoscopic cholecystectomy rate	Number of laparoscopic cholecystectomies per 100 cholecystectomies.	Age and sex and potentially supplemental clinical.	20	T Selection bias T Confounding bias ? Unclear construct validity T Easily manipulated T Unclear benchmark
Incidental appendectomy among the elderly rate	Number of incidental appendectomies per 100 abdominal surgeries.	APR-DRG.	13	? Unclear construct validity ? Easily manipulated
Bilateral cardiac catheterization rate	Number of bilateral catheterizations per 100 cardiac catheterizations.	APR-DRG.	25	? Selection bias ? Unclear construct validity
Utilization Indicators - Area Level				
CABG rate ^d	Number of CABGs per 100,000 population.	Age and sex.	19	T Proxy T Unclear construct validity T Unclear benchmark
PTCA rate ^d	Number of PTCAs per 100,000 population.	Age and sex.	19	T Proxy ? Selection bias T Unclear construct validity T Unclear benchmark
Hysterectomy rate	Number of hysterectomies per 100,000 population.	Age and additional factors such as parity.	22	T Proxy ? Confounding bias T Unclear construct validity T Unclear benchmark
Laminectomy rate	Number of laminectomies per 100,000 population.	Age and sex.	20	T Proxy T Unclear construct validity T Unclear benchmark

^a Higher scores in the **Empirical Rating** column indicate better performance on the nine empirical tests.

^b Notes under **Literature Review Caveats**:

Proxy – Indicator does not directly measure patient outcomes but an aspect of care that is associated with the outcome; thus, it is best used with other indicators that measure similar aspects of care.

Confounding bias – Patient characteristics may substantially affect the performance of the indicator; risk adjustment is recommended.

Unclear construct – There is uncertainty or poor correlation with widely accepted process measures.

Easily manipulated – Use of the indicator may create perverse incentives to improve performance on the indicator without truly improving quality of care.

Unclear benchmark – The “correct rate” has not been established for the indicator; national, regional, or peer group averages may be the best benchmark available.

? – The concern is theoretical or suggested, but no specific evidence was found in the literature.

- T – Indicates that the concern has been demonstrated in the literature.
- c PTCA and CEA mortality are not recommended as standalone indicators, but are suggested as companion measures to the corresponding volume measures.
- d CABG and PTCA area utilization are not recommended as stand-alone indicators. They are designed only for use with the corresponding volume and/or mortality measures.

Strengths and Limitations in Using the IQIs

This collection of AHRQ Quality Indicators represents the current state-of-the-art in assessing quality of care using hospital administrative data. However, these indicators must be used cautiously, because the administrative data on which the indicators are based are not collected for research purposes or for measuring quality of care, but for billing purposes. While these data are relatively inexpensive and convenient to use—and represent a rich data source that can provide valuable information—they should not be used as a definitive source of information on quality of health care. At least three limitations of administrative data warrant caution:

- P Coding differences across hospitals. Some hospitals code more thoroughly than others, making “fair” comparisons across hospitals difficult.
- P Ambiguity about when a condition occurs. Most administrative data cannot distinguish unambiguously whether a specific condition was present at admission or whether it occurred during the stay (i.e., a possible complication).
- P Limitations in ICD-9-CM coding. The codes themselves are often not specific enough to adequately characterize a patient’s condition, which makes it impossible to perfectly risk-adjust any administrative data set, thus fair comparisons across hospitals become difficult.

As a result, these quality indicators based on administrative data are appropriate for internal quality improvement efforts, but were not intended to be used for purchasing decisions or for sanctioning individual institutions. Public reporting with disclosure of individual hospital identities should be done cautiously and with appropriate caveats.

Ideally, the results on AHRQ IQIs for individual hospitals should be made available to those hospitals, with information on averages for a peer group, for the State, and for the nation. This information can be used by individual hospitals to launch investigations into reasons for potential quality problems. Further study may:

- P Reveal real quality problems for which quality improvement programs can be initiated.
- P Uncover problems in data collection that can be remedied through stepped-up efforts to code more diligently.
- P Determine that additional clinical information is required to understand the quality issues, beyond what can be obtained through billing data alone.

In short, the AHRQ IQIs are a valuable tool that takes advantage of readily available data to flag potential quality-of-care problems. However, they are not the final word in quality measurement that can unambiguously measure the quality of one hospital compared to another.

Questions for Future Work

The limitations discussed above suggest some directions for future work on development and use of the IQIs. Additional data and linkages could provide insights into whether the findings represent true quality problems, and could facilitate the exploration of potential interventions to prevent such events.

- P Hospitals with higher than average mortality rates for specific procedures or conditions should probe the underlying reasons: Are patients more severely ill? Is there a problem in the selection of patients for this particular procedure? Is there a quality-of-care problem? Although the mortality indicators use APR-DRG risk adjustment, limitations in the clinical sensitivity of administrative data mean that it is not possible to unambiguously measure and control for patient severity of illness. These indicators provide a starting point for further investigations that might explore severity of illness differences.
- P For hospitals with low volumes of particular procedures, how do patients fare? What is the mortality rate for patients who receive this procedure at this hospital compared with other hospitals? What is the resource use associated with receiving this procedure at this hospital compared with other hospitals? Is there evidence of higher complication rates that suggest a problem in quality of care?
- P What are potential explanations for hospitals with higher-than-average utilization rates? Is this hospital a referral center for this procedure? Do patients come from outside the area to receive their procedures at this hospital? Or is there evidence that patients from this area are receiving a greater number of procedures than expected? The AHRQ area-level IQIs presume no area-level identifiers for patients but, instead, use the hospital ZIP code to define areas. This reflects the fact that the IQIs are based on the common denominator discharge data set (data elements routinely available across most discharge data systems); therefore, information such as patient ZIP code is not always available. Future indicators that define the area using patient area identifiers such as patient ZIP code or patient county will provide more accurate analyses.
- P For two indicators (bilateral cardiac catheterization and incidental appendectomy), we would expect to see few, if any, procedures being performed. Records for these patients could be examined to discern a possible justification for performing these procedures.

Detailed Evidence for Inpatient Quality Indicators

This section provides an abbreviated presentation of the details of the literature review and the empirical evaluation for each IQI, including:

- P The relationship between the indicator and quality of health care services
- P A suggested benchmark or comparison
- P The definition of each indicator
- P The numerator (or outcome of interest)
- P The denominator (or population at risk)
- P The results of the empirical testing

The two-page descriptions for each indicator include a discussion of the summary of evidence, the limitations on using each indicator, and details on the following:

- P Face validity – *Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?*
- P Precision – *Is there a substantial amount of provider or community level variation that is not attributable to random variation?*
- P Minimum bias – *Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?*
- P Construct validity – *Does the indicator perform well in identifying true (or actual) quality of care problems?*
- P Fosters true quality improvement – *Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?*
- P Prior use – *Has the measure been used effectively in practice? Does it have potential for working well with other indicators?*

A full report on the literature review and empirical evaluation can be found in *Refinement of the HCUP Quality Indicators* by the UCSF-Stanford EPC, available at <http://www.ahrq.gov/>. Detailed coding information for each IQI is provided in Appendix A.

Esophageal Resection Volume

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	Higher volumes have been associated with better outcomes, which represent better quality.
Benchmark	Threshold 1: 6 or more procedures per year ⁹ Threshold 2: 7 or more procedures per year ^{9 10}
Definition	Raw volume of provider-level esophageal resection.
Numerator	Discharges with ICD-9-CM codes of 4240 through 4242 in any procedure field and a diagnosis code of esophageal cancer in any field. Exclude MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and neonates).
Denominator	Not applicable.
Type of Indicator	Provider Level, Procedure Volume Indicator
Empirical Rating	Not applicable.

Summary of Evidence

The relative rarity of esophageal resection results in an indicator that is less precise than most volume indicators, although still highly adequate for use as a quality indicator. Hospitals should examine more than one year of data if possible and average volumes for a more precise estimate. Hospitals may also consider use with the pancreatic resection indicator, another complex cancer surgery. The volume-outcome relationship on which this indicator is based may not hold over time, as providers become more experienced or as technology changes.

Most hospitals perform fewer than 10 procedures in a 5-year period; however, relatively strong relationships between volume and outcome—specifically post-operative mortality—have been noted in the literature.

Empirical evidence shows that a low percentage of procedures were performed at high-volume hospitals. At threshold 1, 39.5% of esophageal resection procedures were performed at high-volume providers (and 8.6% of providers are high

volume).⁹ At threshold 2, 34.3% were performed at high-volume providers (and 6.4% of providers are high volume).^{10 11}

Limitations on Use

As a volume indicator, esophageal resection is a proxy measure for quality and should be used with other indicators.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

⁹Patti MG, Corvera CU, Glasgow RE, et al. A hospital's annual rate of esophagectomy influences the operative mortality rate. *J Gastrointest Surg* 1998;2(2):186-92.

¹⁰Dudley RA, Johansen KL, Brand R, et al. Selective referral to high-volume hospitals: estimating potentially avoidable deaths. *JAMA* 2000;283(9):1159-66.

¹¹Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup>

The face validity of esophageal resection depends on whether a strong association with outcomes of care is both plausible and widely accepted in the professional community. No consensus recommendations regarding minimum procedure volume currently exist.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Esophageal resection is measured accurately with discharge data. Most facilities perform 10 or fewer esophagectomies for cancer during a 5-year period; therefore, this indicator is expected to have poor precision.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Risk adjustment is not appropriate, because volume measures are not subject to bias due to disease severity and comorbidities.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

Higher volumes have been repeatedly associated with better outcomes after esophageal surgery, although these findings may be limited by inadequate risk adjustment of the outcome measure.

Only one study used clinical data to estimate the association between hospital volume and mortality following esophageal cancer surgery. Begg et al. analyzed retrospective data from the Surveillance, Epidemiology, and End Results (SEER)-Medicare linked database from 1984 through 1993.¹² The crude 30-day mortality rate was 17.3% at hospitals that performed 1-5 esophagectomies on Medicare patients during the study period, versus 3.9% and 3.4% at hospitals that performed 6-10 and 11 or more esophagectomies, respectively. The association between volume and mortality remained highly significant ($p < .001$) in a multivariate model, adjusting for the number of comorbidities, cancer stage and volume, and age.

¹²Begg CB, Cramer LD, Hoskins WJ, et al. Impact of hospital volume on operative mortality for major cancer surgery. JAMA 1998;280(20):1747-51.

Studies based on California and Maryland data found that the risk-adjusted mortality rates at low-volume hospitals were around 3.0 times those at high-volume hospitals.^{13 14}

Empirical evidence shows that esophageal resection volume—after adjusting for age, sex, and APR-DRG—is moderately and negatively correlated with mortality for esophageal resection ($r = -.29$, $p < .05$), as well as mortality after other cancer resection procedures.¹⁵

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Low-volume providers may attempt to increase their volume without improving quality of care by performing the procedure on patients who may not qualify or benefit from the procedure. Additionally, shifting procedures to high-volume providers may impair access to care for certain types of patients.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

Esophageal cancer surgical volume has not been widely used as an indicator of quality.

¹³Patti MG, Corvera CU, Glasgow RE, et al. A hospital's annual rate of esophagectomy influences the operative mortality rate. J Gastrointest Surg 1998;2(2):186-92.

¹⁴Gordan TA, Bowman HM, Bass EB, et al. Complex gastrointestinal surgery: impact of provider experience on clinical and economic outcomes. J Am Coll Surg 1999;189(1):46-56.

¹⁵Nationwide Inpatient Sample.

Pancreatic Resection Volume

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	Higher volumes have been associated with better outcomes, which represent better quality.
Benchmark	Threshold 1: 10 or more procedures per year ¹⁶ Threshold 2: 11 or more procedures per year ^{16 17}
Definition	Raw volume of provider-level pancreatic resection.
Numerator	Discharges with ICD-9-CM codes of 526 or 527 in any procedure field and a diagnosis code of pancreatic cancer in any field. Exclude MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and neonates).
Denominator	Not applicable.
Type of Indicator	Provider Level, Procedure Volume Indicator
Empirical Rating	Not applicable.

Summary of Evidence

The relative rarity of pancreatic resection results in an indicator that is less precise than most volume indicators, although still highly adequate for use as a quality indicator. Hospitals should examine more than one year of data if possible and average volumes for a more precise estimate. Hospitals may also consider use with the esophageal resection indicator, another complex cancer surgery. Most hospitals perform fewer than 10 procedures in a 5-year period; however, relatively strong relationships between volume and outcome—specifically post-operative mortality—have been noted in the literature.

Empirical evidence shows that a low percentage of procedures were performed at high-volume hospitals. At threshold 1, 30.3% of pancreatic resection procedures were performed at high-volume providers (and 5.1% of providers are high volume).¹⁶ At threshold 2, 27.0% were performed

at high-volume providers (and 4.2% of providers are high volume).^{17 18}

Limitations on Use

As a volume indicator, pancreatic resection is a proxy measure for quality and should be used with other indicators.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

The face validity of pancreatic resection depends on whether a strong association with outcomes of care is both plausible and widely accepted in the professional community. No recommendations regarding minimum procedure volume exist.

¹⁶Glasgow RE, Mulvihill SJ. Hospital volume influences outcome in patients undergoing pancreatic resection for cancer. *West J Med* 1996;165(5):294-300.

¹⁷Glasgow, Mulvihill, 1996.

¹⁸Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup>

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Pancreatic resection is measured accurately with discharge data. Most facilities perform 10 or fewer pancreatectomies for cancer during a 5-year period; therefore, this indicator is expected to have poor precision.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Risk adjustment is not appropriate, because volume measures are not subject to bias due to disease severity and comorbidities.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

Higher volumes have been repeatedly associated with better outcomes after pancreatic surgery, although these findings may be limited by inadequate risk adjustment of the outcome measure.

One study used clinical data to estimate the association between hospital volume and mortality following pancreatic cancer surgery. Begg et al. analyzed retrospective data from the Surveillance, Epidemiology, and End Results (SEER)-Medicare linked database from 1984 through 1993.¹⁹ The crude 30-day mortality rate was 12.9% at hospitals performing 1-5 pancreatic resections during the study period, versus 7.7% and 5.8% at hospitals performing 6-10 and 11 or more procedures, respectively. The association between volume and mortality remained highly significant ($p < .001$) in a multivariate model, adjusting for comorbidities, cancer stage and volume, and age.

Lieberman et al. used 1984-91 hospital discharge data from New York State to analyze the association between mortality after pancreatic cancer resection and hospital volumes.²⁰ Adjusting

¹⁹Begg CB, Cramer LD, Hoskins WJ, et al. Impact of hospital volume on operative mortality for major cancer surgery. *JAMA* 1998;280(20):1747-51.

²⁰Lieberman MD, Kilburn H, Lindsey M, et al. Relation of perioperative deaths to hospital volume among patients undergoing pancreatic resection for

for the year of surgery, age, sex, race, payer source, transfer status, and the total number of secondary diagnoses, the standardized mortality rate was 19% at minimal-volume hospitals (fewer than 10 patients during the study period); 12% at low-volume hospitals (10-50 patients); 13% at medium-volume hospitals (51-80 patients); and 6% at high-volume hospitals (more than 80 patients). Studies using data from Ontario and Medicare data have generated similar results.^{21 22}

Empirical evidence shows that pancreatic resection volume—after adjusting for age, sex, and APR-DRG—is independently and negatively correlated with mortality for pancreatic resection ($r = -.41$, $p < .001$).²³

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Low-volume providers may attempt to increase their volume without improving quality of care by performing the procedure on patients who may not qualify or benefit from the procedure. Additionally, shifting procedures to high-volume providers may impair access to care for certain types of patients.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

Pancreatic cancer surgical volume has not been widely used as an indicator of quality.

malignancy. *Ann Surg* 1995;222(5):638-45.

²¹Simunovic M, To T, Theriault M, et al. Relation between hospital surgical volume and outcome for pancreatic resection for neoplasm in a publicly funded health care system [see comments]. *Cmaj* 1999;160(5):643-8.

²²Birkmeyer JD, Finlayson SR, Tosteson AN, et al. Effect of hospital volume on in-hospital mortality with pancreaticoduodenectomy. *Surgery* 1999;125(3):250-6.

²³Nationwide Inpatient Sample.

Pediatric Heart Surgery Volume

Pediatric heart surgery requires proficiency with the use of complex equipment, and technical errors may lead to clinically significant complications, such as arrhythmias, congestive heart failure, and death.

Relationship to Quality	Higher volumes have been associated with better outcomes, which represent better quality.
Benchmark	Threshold: 100 or more procedures per year ^{24 25}
Definition	Raw volume of pediatric heart surgery.
Numerator	Discharges with ICD-9-CM procedure codes for (1) specified heart surgery in any field or (2) any heart surgery and diagnosis of hypoplastic left heart syndrome in any field. Age less than 18 years old. Exclude MDC 14 (pregnancy, childbirth, and puerperium). See Appendix A for additional exclusions.
Denominator	Not applicable.
Type of Indicator	Provider Level, Procedure Volume Indicator
Empirical Rating	Not applicable.

Summary of Evidence

Pediatric heart surgery includes a number of procedures that vary in difficulty. Higher volumes of pediatric heart surgery have been associated with fewer in-hospital deaths.

This indicator is measured with great precision, although volume indicators overall are not direct measures of quality and are relatively insensitive. For this reason, pediatric heart surgery should be used in conjunction with other measures of mortality to ensure that increasing volumes truly improve patient outcomes. The volume-outcome relationship on which this indicator is based may not hold over time, as providers become more experienced or as technology changes.

Empirical analyses show that approximately 75% of pediatric heart surgeries are already performed at high-volume hospitals, suggesting regionalization. This leaves little room for improvement. Empirical evidence shows that a moderate percentage of procedures were performed at high-volume hospitals. At threshold 1, 75.5% of pediatric heart

surgeries were performed at high-volume providers (and 21% of providers are high volume).^{24 25}

Limitations on Use

As a volume indicator, pediatric surgery is a proxy measure for quality and should be used with other indicators.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

The face validity of pediatric surgery depends on whether a strong association with outcomes of care is both plausible and widely accepted in the

²⁴Hannan EL, Racz M, Kavey RE, et al. Pediatric cardiac surgery: the effect of hospital and surgeon volume on in-hospital mortality. *Pediatrics* 1998;101(6):963-9.

²⁵Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup>

professional community. No recommendations regarding minimum procedure volume currently exist.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Pediatric heart surgery is measured accurately with discharge data. Studies suggest that pediatric heart surgery is already highly concentrated at a relatively small number of facilities. This highly skewed volume distribution may have an adverse effect on the precision of this measure.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Risk adjustment is not appropriate, because volume measures are not subject to bias due to disease severity and comorbidities.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

Although higher volumes have been repeatedly associated with better outcomes after pediatric cardiac surgery, these findings may be limited by inadequate risk adjustment of the outcome measure.

A study using hospital discharge data showed that risk-adjusted mortality differed between low- and high-volume hospitals. Jenkins et al. estimated risk-adjusted mortality rates of 8.35% for low-volume hospitals (100 or fewer cases) and 5.95% for high-volume hospitals (more than 100 cases).²⁶ They also demonstrated especially high risk-adjusted mortality (18.5%) at very low-volume hospitals (fewer than 10 cases per year) and especially low risk-adjusted mortality (3.0%) at very high-volume hospitals (more than 300 cases per year).

Sollano et al. reported a modest but statistically significant volume effect for higher-risk procedures (OR=0.944 for each additional 100 annual cases),

²⁶Jenkins KJ, Newburger JW, Lock JE, et al. In-hospital mortality for surgical repair of congenital heart defects: preliminary observations of variation by hospital caseload. *Pediatrics* 1995;95(3):323-30.

which was limited to neonates and post-neonatal infants in stratified analyses.²⁷

Empirical evidence shows that pediatric heart surgery volume is independently and negatively correlated with mortality ($r=-.27$, $p<.05$).²⁸ However, this analysis does not include the intensive risk adjustment included in the volume studies described in the literature.

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Low-volume providers may attempt to increase their volume without improving quality of care by performing the procedure on patients who may not qualify or benefit from the procedure. Additionally, shifting procedures to high-volume providers may impair access to care for certain types of patients.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

Pediatric heart surgery volume has not been widely used as an indicator of quality.

²⁷Sollano JA, Gelijns AC, Moskowitz AJ et al. Volume-outcome relationships on cardiovascular operations: New York State, 1990-1995. *J Thorac Cardiovasc Surg* 1999;117(3):419-28.

²⁸Nationwide Inpatient Sample.

Abdominal Aortic Aneurysm Repair Volume

Abdominal aortic aneurysm (AAA) repair is a relatively rare procedure that requires proficiency with the use of complex equipment, and technical errors may lead to clinically significant complications, such as arrhythmias, acute myocardial infarction, colonic ischemia, and death.

Relationship to Quality	Higher volumes have been associated with better outcomes, which represent better quality.
Benchmark	Threshold 1: 10 or more procedures per year ²⁹ Threshold 2: 32 or more procedures per year ^{30 31 32}
Definition	Raw volume of provider-level AAA repair.
Numerator	Discharges with ICD-9-CM codes of 3834, 3844, and 3864 in any procedure field and a diagnosis code of AAA in any field. Exclude MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and neonates).
Denominator	Not applicable.
Type of Indicator	Provider Level, Procedure Volume Indicator
Empirical Rating	Not applicable.

Summary of Evidence

AAA repair volume is measured with great precision, although volume indicators overall are not direct measures of quality and are relatively insensitive. For this reason, this indicator should be used in conjunction with other measures of mortality to ensure that increasing volumes truly improve patient outcomes. The volume-outcome relationship on which this indicator is based may not hold over time, as providers become more experienced or as technology changes.

As noted in the literature, higher volume hospitals have lower mortality than lower volume hospitals, and the differences in patient case-mix do not account fully for these relationships.

Empirical evidence shows that a moderate to low percentage of procedures were performed at high-volume hospitals, depending on which threshold is used. At threshold 1, 83.9% of AAA repair procedures were performed at high-volume providers (and 44.3% of providers are high volume). At threshold 2, 43.0% were performed at

high-volume providers (and 12.2% of providers are high volume).^{29 30 31 32}

Limitations on Use

As a volume indicator, AAA repair is a proxy measure for quality and should be used with other indicators.

²⁹Hannan EL, Kilburn H, Jr., O'Donnell JF, et al. A longitudinal analysis of the relationship between in-hospital mortality in New York state and the volume of abdominal aortic aneurysm surgeries performed. *Health Serv Res* 1992;27(4):517-42.

³⁰Kazmers A, Jacobs L, Perkins A, et al. Abdominal aortic aneurysm repair in Veterans Affairs medical centers. *J Vasc Surg* 1996;23(2):191-200.

³¹Pronovost PJ, Jenckes MW, Dorman T, et al. Organizational characteristics of intensive care units related to outcomes of abdominal aortic surgery. *JAMA* 1999;281(14):1310-7.

³²Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/>

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

The face validity of AAA repair depends on whether a strong association with outcomes of care is widely accepted in the professional community. No consensus recommendations about minimum procedure volume currently exist.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

AAA repair is an uncommon cardiovascular procedure—only 48,600 were performed in the United States in 1997.³³ Although AAA repair is measured accurately with discharge data, the relatively small number of procedures performed annually at most hospitals suggests that volume may be subject to much random variation.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Risk adjustment is not appropriate, because volume measures are not subject to bias due to disease severity and comorbidities.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

Most studies published since 1985 showed a significant association between either hospital or surgeon volume and inpatient mortality after AAA repair, although these findings may be limited by inadequate risk adjustment of the outcome measure and differ by type of aneurysms (intact vs. ruptured) being considered.

Several studies have explored whether experience on related, but not identical, cases may lead to improved outcomes. One study found that hospital volume of surgery for ruptured aneurysms was not associated with postoperative inpatient mortality, but it was associated with fewer inpatient deaths for

ruptured aneurysms, suggesting that high-volume hospitals may manage ruptured aneurysms more aggressively.³⁴ One study that evaluated the impact of total vascular surgery volume found a significant effect for both ruptured and intact aneurysms.³⁵

Empirical evidence shows that AAA repair volume and mortality—after adjusting for age, sex, and APR-DRG—are independently and negatively correlated with each other ($r=-.35$, $p<.001$).³⁶

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Low-volume providers may attempt to increase their volume without improving quality of care by performing the procedure on patients who may not qualify or benefit. Additionally, shifting procedures to high-volume providers may impair access to care for certain types of patients.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

The Center for Medical Consumers posts volumes of “resection of aorta with replacement” for New York hospitals.³⁷ The Pacific Business Group on Health states that “one marker of how well a hospital is likely to perform is...the number of (AAA) surgeries a hospital performs.”³⁸

³⁴Kantonen I, Lepantalo M, Brommels M, et al. Mortality in ruptured abdominal aortic aneurysms. The Finnvasc Study Group. *Eur J Vasc Endovasc Surg* 1999;17(3):208-12.

³⁵Amundsen S, Skjaerven R, Trippestad A, et al. Abdominal aortic aneurysms. Is there an association between surgical volume, surgical experience, hospital type and operative mortality? Members of the Norwegian Abdominal Aortic Aneurysm Trial. *Acta Chir Scand* 1990;156(4):323-7; discussion 327-8.

³⁶Nationwide Inpatient Sample.

³⁷The Center for Medical Consumers. (<http://www.medicalconsumers.org/>)

³⁸<http://www.pbgh.org/>

³³HCUPnet. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/hcupnet.htm>.

Coronary Artery Bypass Graft Volume

Coronary artery bypass graft (CABG) requires proficiency with the use of complex equipment, and technical errors may lead to clinically significant complications, such as myocardial infarction, stroke, and death.

Relationship to Quality	Higher volumes have been associated with better outcomes, which represent better quality.
Benchmark	Threshold 1: 100 or more procedures per year ³⁹ Threshold 2: 200 or more procedures per year ^{40 41}
Definition	Raw volume of provider-level CABG.
Numerator	Discharges with ICD-9-CM codes of 3610 through 3619 in any procedure field. Age 40 years and older. Exclude MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and neonates).
Denominator	Not applicable.
Type of Indicator	Provider Level, Procedure Volume Indicator
Empirical Rating	Not applicable.

Summary of Evidence

CABG is measured with great precision, although volume indicators overall are not direct measures of quality and are relatively insensitive. For this reason, CABG should be used in conjunction with other measures of mortality to ensure that increasing volumes truly improve patient outcomes.

As noted in the literature, higher volumes of CABG have been associated with fewer deaths. However, the American Heart Association (AHA) and the American College of Cardiology (ACC) recommend that since some low-volume hospitals have very good outcomes, other measures besides volume should be used to evaluate individual surgeon's performance.

Empirical evidence shows that a high percentage of procedures were performed at high-volume hospitals. At threshold 1, 98.3% of CABG procedures were performed at high-volume providers (and 88% of providers are high volume).³⁹

³⁹Eagle KA, Guyton RA, Davidoff R, et al. ACC/AHA Guidelines for Coronary Artery Bypass Graft Surgery: A Report of the American College of

At threshold 2, 90.7% were performed at high-volume providers (and 68% of providers are high volume).^{40 41}

Limitations on Use

As a volume indicator, CABG is a proxy measure for quality and should be used with other indicators.

Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Revise the 1991 Guidelines for Coronary Artery Bypass Graft Surgery). American College of Cardiology/American Heart Association. J Am Coll Cardiol 1999;34(4):1262-347.

⁴⁰Hannan EL, Kilburn H, Jr., Bernard H, et al. Coronary artery bypass surgery: the relationship between in-hospital mortality rate and surgical volume after controlling for clinical risk factors. Med Care 1991;29(11):1094-107.

⁴¹Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup>

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

The face validity of CABG depends on whether a strong association with outcomes of care is both plausible and widely accepted in the professional community. The AHA and ACC have argued for “careful outcome tracking” and supported “monitoring institutions and individuals who annually perform fewer than 100 cases,” although the panel noted that “some institutions and practitioners maintain excellent outcomes despite relatively low volumes.”⁴²

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

CABG is measured accurately with discharge data. The large number of procedures performed annually at most hospitals suggests that annual volume is not subject to considerable random variation. Hannan et al. reported year-to-year hospital volume correlations of 0.96-0.97 in New York.⁴³

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Risk adjustment is not appropriate, because volume measures are not subject to bias due to disease severity and comorbidities.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

Higher volumes have been repeatedly associated with better outcomes of care, although these findings may be limited by inadequate risk adjustment of the outcome measure.

Hannan found that the adjusted relative risk of inpatient death at high-volume hospitals (more than 200 cases per year) in 1989-92 was 0.84,

⁴²Eagle et al. 1999.

⁴³Hannan EL, Kilburn H Jr., Racz M, et al. Improving the outcomes of coronary artery bypass surgery in New York state. JAMA 1994;271(10):761-6.

compared with low-volume hospitals.⁴⁴ However, only 3.3% of patients in that study underwent CABG at a low-volume hospital. Analyses using instrumental variables suggested that much of the volume effect may be due to “selective referral” of patients to high-quality centers.^{45 46}

Empirical evidence shows that CABG volume and mortality—after adjusting for age, sex, and APR-DRG—is independently and negatively correlated with mortality for CABG ($r=-.29$, $p<.001$).⁴⁷

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Low-volume providers may attempt to increase their volume without improving quality of care by performing the procedure on patients who may not qualify or benefit from the procedure. Additionally, shifting procedures to high-volume providers may impair access to care for certain types of patients.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

Specific CABG volume thresholds have been suggested as “standards” for the profession. The Pacific Business Group on Health states that “one marker of how well a hospital is likely to perform is...the number of (CABG) surgeries a hospital performs.”⁴⁸

⁴⁴Hannan et al. 1994.

⁴⁵Farley, DE, Ozminkowski RJ. Volume-outcome relationships and in-hospital mortality: the effect of changes in volume over time. Med Care 1992;30(1):77-94.

⁴⁶Luft HS, Hunt SS, Maerki SC. The volume-outcome relationship: practice-makes-perfect or selective-referral patterns? Health Serv Res 1987;22(2):157-82.

⁴⁷Nationwide Inpatient Sample.

⁴⁸<http://www.pbgh.org/>

Percutaneous Transluminal Coronary Angioplasty Volume

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	Higher volumes have been associated with better outcomes, which represent better quality.
Benchmark	Threshold 1: 200 or more procedures per year ⁴⁹ Threshold 2: 400 or more procedures per year ^{50 51}
Definition	Raw volume of PTCA.
Numerator	Discharges with ICD-9-CM codes 3601, 3602, 3605, or 3606 in any procedure field. Age 40 years and older. Exclude MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and neonates).
Denominator	Not applicable.
Type of Indicator	Provider Level, Procedure Volume Indicator
Empirical Rating	Not applicable.

Summary of Evidence

PTCA is measured with great precision, although volume indicators overall are not direct measures of quality and are relatively insensitive. For this reason, PTCA should be used in conjunction with measures of mortality and quality of care within cardiac care to ensure that increasing volumes truly improve patient outcomes. As noted in the literature, higher volumes of PTCA have been associated with fewer deaths and post-procedural coronary artery bypass grafts (CABG).

Empirical evidence shows that a moderate to high percentage of procedures were performed at high-volume hospitals. At threshold 1, 95.7% of PTCA procedures were performed at high-volume providers (and 69% of the providers are high

volume).⁴⁹ At threshold 2, 77.0% were performed at high-volume providers (and 42% of providers are high volume).^{50 51}

Limitations on Use

As a volume indicator, PTCA is a proxy measure for quality and should be used with other indicators.

Details

⁴⁹Ryan TJ, Bauman WB, Kennedy JW, et al. Guidelines for percutaneous transluminal coronary angioplasty. A report of the American Heart Association/American College of Cardiology Task Force on Assessment of Diagnostic and Therapeutic Cardiovascular Procedures (Committee on Percutaneous Transluminal Coronary Angioplasty). *Circulation* 1993;88(6):2987-3007.

⁵⁰Hannan EL, Racz M, Ryan TJ, et al. Coronary angioplasty volume-outcome relationships for hospitals and cardiologists. *JAMA* 1997;277(11):892-8.

⁵¹Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup>

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

The face validity of PTCA depends on whether a strong association with outcomes of care is both plausible and widely accepted in the professional community. The American Heart Association (AHA) and the American College of Cardiology (ACC) have stated that “a significant number of cases per institution—at least 200 PTCA procedures annually—is essential for the maintenance of quality and safe care.”⁵² Providers may wish to examine rates by surgeon with this indicator.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

PTCA is an increasingly common procedure (16.7 per 10,000 persons in 1997⁵³) and is measured accurately with discharge data. The large number of procedures performed annually at most hospitals suggests that annual volume is not subject to considerable random variation.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Risk adjustment is not appropriate, because volume measures are not subject to bias due to disease severity and comorbidities.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

Higher volumes have been repeatedly associated with better outcomes of care, although these findings may be limited by inadequate risk adjustment of the outcome measure.

Using hospital discharge data to adjust for age, gender, multilevel angioplasty, unstable angina, and six comorbidities, one study found that high-volume hospitals had significantly lower rates of same-stay coronary artery bypass surgery (CABG)

and inpatient mortality than low-volume hospitals.⁵⁴ Better studies based on clinical data systems (adjusting for left ventricular function) have confirmed higher risk-adjusted mortality and CABG rates at low-volume hospitals relative to high-volume hospitals.⁵⁵

Empirical evidence shows that PTCA volume is negatively related to several other post-procedural mortality rates: CABG ($r=-.21$, $p<.001$), craniotomy ($r=-.200$, $p<.0001$), and abdominal aortic aneurysm (AAA) repair ($r=-.45$, $p<.0001$).⁵⁶

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Low-volume providers may attempt to increase their volume without improving quality of care by performing the procedure on patients who may not qualify or benefit from the procedure. Additionally, shifting procedures to high-volume providers may impair access to care for certain types of patients.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

PTCA volume has not been widely used as an indicator of quality, although specific volume thresholds have been suggested as “standards” for the profession.⁵⁷

PTCA Mortality

The QI software calculates mortality for PTCA, so that the volumes for this procedure can be examined in conjunction with mortality. However, the mortality measure should not be examined

⁵²Ryan et al., 1993.

⁵³Kozak LJ, Lawrence L. National Hospital Discharge Survey: annual summary, 1997. Vital Health Stat 13 1999(144):i-iv, 1-46.

⁵⁴Ritchie JL, Maynard C, Chapko MK, et al. Association between percutaneous transluminal coronary angioplasty volumes and outcomes in the Healthcare Cost and Utilization Project 1993-1994. Am J Cardiol 1999;83(4):493-7.

⁵⁵Hannan et al. 1997.

⁵⁶Nationwide Inpatient Sample.

⁵⁷Hirshfeld JW, Jr., Ellis SG, Faxon DP. Recommendations for the assessment and maintenance of proficiency in coronary interventional procedures: Statement of the American College of Cardiology. J Am Coll Cardiol 1998;31(3):722-43.

independently, because it did not meet the literature review and empirical evaluation criteria to stand alone as its own measure.

Carotid Endarterectomy Volume

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	Higher volumes have been associated with better outcomes, which represent better quality.
Benchmark	Threshold 1: 50 or more procedures per year ⁵⁸ Threshold 2: 101 or more procedures per year ^{59 60}
Definition	Raw volume of provider-level CEA.
Numerator	Discharges with ICD-9-CM codes of 3812 in any procedure field. Exclude MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and neonates).
Denominator	Not applicable.
Type of Indicator	Provider Level, Procedure Volume Indicator
Empirical Rating	Not applicable.

Summary of Evidence

CEA is measured with great precision, although volume indicators overall are not direct measures of quality and are relatively insensitive. For this reason, CEA should be used with other measures of mortality to ensure that increasing volumes truly improve patient outcomes. As noted in the literature, higher volume hospitals have lower mortality and post-operative stroke rates than lower volume hospitals.

Empirical evidence shows that a moderate percentage of procedures were performed at high-volume hospitals.⁵⁸ At threshold 1, 77.8% of CEA procedures were performed at high-volume providers (and 37% of providers are high volume).⁵⁹

At threshold 2, 51.0% were performed at high-volume providers (and 17% of providers are high volume).^{60 61}

Limitations on Use

As a volume indicator, CEA is a proxy measure for quality and should be used with other indicators.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

The face validity of CEA depends on whether a strong association with outcomes of care is both

⁵⁸Nationwide Inpatient Sample and State Inpatient Databases, Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup>

⁵⁹Manheim LM, Sohn MW, Feinglass J, et al. Hospital vascular surgery volume and procedure mortality rates in California, 1982-1994. *J Vasc Surg* 1998;28(1):45-46.

⁶⁰Hannan EL, Popp AJ, Tranmer B, et al. Relationship between provider volume and mortality for carotid endarterectomies in New York state. *Stroke* 1998;29(11):2292-7.

⁶¹Dudley RA, Johansen KL, Brand R, et al. Selective referral to high-volume hospitals: estimating potentially avoidable deaths. *JAMA* 2000;283(9):1159-66.

plausible and widely accepted in the professional community. Recent guidelines focus on monitoring surgical outcomes rather than promoting volume standards.⁶²

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

CEA is measured accurately with discharge data. Approximately 144,000 CEAs were performed in the United States in 1997.⁶³ Many hospitals perform relatively few procedures, suggesting that the actual annual count of procedures may not be a reliable guide to the number of procedures performed on an ongoing basis. In one study of Medicare beneficiaries, approximately 50% of CEAs were performed in hospitals that performed 21 or fewer operations per year.⁶⁴

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Risk adjustment is not appropriate, because volume measures are not subject to bias due to disease severity and comorbidities.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

Although higher volumes have repeatedly been associated with better outcomes after CEA, these findings may be limited by inadequate risk adjustment of the outcome measure. Cebul et al. found that undergoing surgery in a high-volume hospital was associated with a 71% reduction in the risk of stroke or death at 30 days, after adjusting for age, gender, indication for surgery, renal insufficiency, and two cardiovascular

comorbidities.⁶⁵ In the study by Karp et al., the risk of severe stroke or death was 2.6 times higher at the lowest-volume hospitals than at the highest-volume hospitals.⁶⁶ Empirical evidence shows that CEA volume is negatively correlated with several other mortality indicators: coronary artery bypass graft (CABG) ($r=-.26$, $p<.0001$), abdominal aortic aneurysm (AAA) repair ($r=-.38$, $p<.0001$), and craniotomy ($r=-.18$, $p<.0001$).⁶⁷

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Low-volume providers may attempt to increase their volume without improving quality of care by performing the procedure on patients who may not qualify. Additionally, shifting procedures to high-volume providers may impair access to care for certain types of patients.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

The Center for Medical Consumers posts CEA volumes for New York hospitals.⁶⁸ The Pacific Business Group on Health states that “one marker of how well a hospital is likely to perform is...the number of (CEA) surgeries a hospital performs.”⁶⁹

CEA Mortality

The QI software calculates mortality for CEA, so that the volumes for this procedure can be examined in conjunction with mortality. However, the mortality measure should not be examined independently, because it did not meet the literature review and empirical evaluation criteria to stand alone as its own measure.

⁶²Biller J, Feinberg WM, Castaldo JE, et al. Guidelines for carotid endarterectomy: a statement of healthcare professionals from a Special Writing Group of the Stroke Council, American Heart Association. *Circulation* 1998;97(5):501-9.

⁶³Owings, MF, Lawrence L. Detailed diagnoses and procedures, National Hospital Discharge Survey, 1997. *Vital Health Stat* 13 199(145):1-157.

⁶⁴Cebul RD, Snow RJ, Pine R, et al. Indications, outcomes, and provider volumes for carotid endarterectomy. *JAMA* 1998;279(16):1282-7.

⁶⁵Cebul et al. 1998.

⁶⁶Karp, HR, Flanders WD, Shipp CC, et al. Carotid endarterectomy among Medicare beneficiaries: a statewide evaluation of appropriateness and outcome. *Stroke* 1998;29(1):46-52.

⁶⁷Nationwide Inpatient Sample.

⁶⁸The Center for Medical Consumers. (<http://www.medicalconsumers.org/>)

⁶⁹<http://www.pbgh.org/>

Esophageal Resection Mortality Rate

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 with a code of esophageal resection in any procedure field.
Denominator	Discharges with ICD-9-CM codes of 4240 through 4242 in any procedure field and a diagnosis code of esophageal cancer in any field. Exclude patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and neonates).
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Procedures
Empirical Rating	8

Summary of Evidence

Esophageal resection is a complex cancer surgery, and studies have noted that providers with higher volumes have lower mortality rates. This suggests that providers with higher volumes have some characteristics, either structurally or with regard to processes, that influence mortality.

This procedure is performed only by a select number of hospitals, which may compromise the precision of the indicator. Providers may wish to examine several consecutive years to potentially increase the precision of this indicator.

Limitations on Use

Risk adjustment for clinical factors is recommended because of the confounding bias for esophageal resection. In addition, little evidence exists supporting the construct validity of this indicator.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

The primary evidence for esophageal resection mortality as an indicator arises from the volume-outcome literature. The causal relationship between hospital volume and mortality is unclear, and the differing processes that may lead to better outcomes have not been identified.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Esophageal resection is a relatively uncommon procedure; Patti et al. noted that most hospitals perform 10 or fewer procedures during a 5-year period.⁷⁰ The precision of this indicator may be improved by using several years of data.

⁷⁰Patti MG, Corvera CU, Glasgow RE, et al. A hospital's annual rate of esophagectomy influences the operative mortality rate. *J Gastrointest Surg* 1998;2(2):186-92.

Empirical evidence shows that this indicator is precise, with a raw provider level mean of 20.2% and a substantial standard deviation of 36.6%.⁷¹

Relative to other indicators, a smaller percentage of the variation occurs at the provider level, rather than the discharge level. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is low, at 8.9%, indicating that most of the observed differences in provider performance very likely do not represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Although no studies specifically addressed the need for risk adjustment, most of the volume-outcome studies published have used some sort of risk adjustment. Most of these studies used administrative data for risk adjustment.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

There is no evidence for the construct validity of esophageal resection beyond the volume-outcome relationship. Two studies examined hospital volume as compared to in-hospital mortality rates. Patti et al. found decreasing mortality rates across five volume categories (17% for 1-5 procedures, 19% for 6-10 procedures, 10% for 11-20 procedures, 16% for 21-30 procedures, and 6% for more than 30 procedures).⁷² Gordan et al. combined all complex gastrointestinal procedures, finding that low-volume hospitals (11-20 procedures per year) had an adjusted odds of death of 4.0 as compared to the one high-volume hospital.⁷³

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

No evidence exists on whether or not this indicator would stimulate true improvement in quality; however, it is possible that high-risk patients may be denied surgery.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

Esophageal resection has not been widely used as a quality indicator.

⁷¹Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/>

⁷²Patti et al., 1998.

⁷³Gordan TA, Bowman HM, Bass EB, et al. Complex gastrointestinal surgery: impact of provider experience on clinical and economic outcomes. *J Am Coll Surg* 1999;189(1):46-56.

Pancreatic Resection Mortality Rate

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 with a code of pancreatic resection in any procedure field.
Denominator	Discharges with ICD-9-CM codes of 526 or 527 in any procedure field and a diagnosis code of pancreatic cancer in any field. Exclude patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and neonates).
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Procedures
Empirical Rating	5

Summary of Evidence

Pancreatic resection is a complex cancer surgery, and studies have noted that providers with higher volumes have lower mortality rates for the procedure than providers with lower volumes. This suggests that providers with higher volumes have some characteristics, either structurally or with regard to processes, that influence mortality.

This procedure is performed only by a select number of hospitals, which may compromise the precision of the indicator. Providers may wish to examine several consecutive years to potentially increase the precision of this indicator.

Limitations on Use

Risk adjustment for clinical factors is recommended because of the confounding bias for pancreatic resection. In addition, little evidence exists supporting the construct validity of this indicator.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

The primary evidence for pancreatic resection mortality as an indicator arises from the volume-outcome literature. The causal relationship between hospital volume and mortality is unclear, and the differing processes that may lead to better outcomes have not been identified.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Pancreatic resection is a relatively uncommon procedure; Glasgow et al. found that most hospitals in California perform 10 or fewer procedures during a 5-year period.⁷⁴ However, the mortality rate is high, ranging from 4% to 13%.⁷⁵ The precision of this indicator may be improved by using several years of data. Empirical evidence shows that this indicator is moderately precise, with a raw provider

⁷⁴Glasgow RE, Mulvihill SJ. Hospital volume influences outcome in patients undergoing pancreatic resection for cancer. *West J Med* 1996;165(5):294-300.

⁷⁵Begg CB, Cramer LD, Hoskins WJ et al. Impact of hospital volume on operative mortality for major cancer surgery. *JAMA* 1998;280(20):1747-51.

level mean of 15.4% and a standard deviation of 31.3%.⁷⁶

Relative to other indicators, a higher percentage of the variation occurs at the provider level, rather than the discharge level. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is low, at 16.5%, indicating that some of the observed differences in provider performance very likely do not represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Although no studies specifically addressed the need for risk adjustment, most of the volume-outcome studies published have used administrative data for risk adjustment.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

There is no evidence for the construct validity of pancreatic resection beyond the volume-outcome relationship. Ten studies examined hospital volume as compared to in-hospital mortality rates. Glasgow and Mulvihill estimated the following risk-adjusted mortality rates across hospital volume categories during the 5-year study period: 14% for 1-5 procedures, 10% for 6-10 procedures, 9% for 11-20 procedures, 7% for 21-30 procedures, 8% for 31-50 procedures, and 4% for over 50 procedures.⁷⁷ Lieberman et al. found that surgeon volume was less significantly associated with mortality (6-13% across three volume categories).⁷⁸

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

No evidence exists on whether or not this indicator would stimulate true improvement in quality; however, it is possible that high-risk patients may be denied surgery.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

Pancreatic resection has not been widely used as a quality indicator.

⁷⁶Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/>

⁷⁷Glasgow RE, Mulvihill SJ. Hospital volume influences outcome in patients undergoing pancreatic resection for cancer. *West J Med* 1996;165(5):294-300.

⁷⁸Lieberman MD, Kilburn H, Lindsey M, et al. Relation of perioperative deaths to hospital volume among patients undergoing pancreatic resection for malignancy. *Ann Surg* 1995;222(5):638-45.

Pediatric Heart Surgery Mortality Rate

Pediatric heart surgery requires proficiency with the use of complex equipment, and technical errors may lead to clinically significant complications, such as arrhythmias, congestive heart failure, and death.

Relationship to Quality	Better processes of care may reduce mortality for pediatric heart surgery, which represents better quality care.
Benchmark	State, regional, or peer group average.
Definition	Number of deaths per 100 patients with discharge procedure code of pediatric heart surgery.
Numerator	Number of deaths with a code of pediatric heart surgery in any procedure field.
Denominator	Discharges with ICD-9-CM procedure codes for (1) specified heart surgery in any field or (2) any heart surgery and diagnosis of hypoplastic left heart syndrome in any field. Age less than 18 years old. Exclude patients transferring to another short-term hospital and MDC 14 (pregnancy, childbirth, and puerperium). (See Appendix A for additional exclusions.)
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Procedures
Empirical Rating	3

Summary of Evidence

Pediatric heart surgeries range from fairly straightforward to rather complex procedures, and studies have noted that providers with higher volumes have lower mortality rates. This suggests that providers with higher volumes have some characteristics, either structurally or with regard to processes, that influence mortality.

This procedure is performed by relatively few hospitals, which may compromise the precision of the indicator. APR-DRG adjustment is not adequate and providers may want to consider breakdown in the types of surgeries performed. This indicator should also be considered with length of stay and transfer rates to account for differing discharge practices among hospitals.

Limitations on Use

Risk adjustment for clinical factors is recommended because of the substantial confounding bias for pediatric heart surgery. In addition, limited

evidence exists supporting the construct validity of this indicator.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

Pediatric cardiac surgery represents a composite of numerous procedures performed to repair or palliate congenital anomalies. The literature suggests that post-operative mortality rates vary considerably across hospitals in a manner that reflects quality of care. Studying provider volume and mortality together would offer a comprehensive perspective on provider performance for pediatric cardiac surgery.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Pediatric cardiac surgery appears to be highly concentrated at a relatively small number of

facilities, a significant number of which perform fewer than 10 surgeries per year. Empirical evidence shows that this indicator is adequately precise, with a raw provider level mean of 7.2% and a substantial standard deviation of 1.7%.⁷⁹

Relative to other indicators, a lower percentage of the variation occurs at the provider level, rather than the discharge level. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is low, at 22.2%, indicating that some of the observed differences in provider performance very likely do not represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

The extreme heterogeneity among pediatric heart surgeries, as well as the underlying anomalies, makes bias a serious concern. For example, among procedures with at least 100 cases in New York's Cardiac Surgery Reporting System in 1992-95, in-hospital mortality varied from 0.4% for repair of atrial septal defect to 34.2% for Norwood repair of hypoplastic left ventricle.⁸⁰ Technical factors that may be important are not available in administrative data, which could confound inter-provider performance comparisons.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

Several studies have reported an association between hospital volume and mortality following pediatric cardiac surgery. For example, Hannan et al. found 8.26% risk-adjusted mortality at hospitals with fewer than 100 cases per year, versus 5.95% at higher volume hospitals, using a multivariate model that included age, complexity category, and

four comorbidities.⁸¹ (The effect was limited to surgeons who performed at least 75 procedures per year.)

Experienced surgeons should be able to improve post-operative mortality by reducing cardiopulmonary bypass or aortic cross-clamp time, which has been repeatedly associated with post-operative mortality after adjusting for a variety of patient characteristics.^{82 83} This relationship has been demonstrated for the Fontan procedure and the Norwood procedure for hypoplastic left heart syndrome.⁸⁴

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Potential responses by physicians to public reporting of procedure mortality rates would be to avoid operating on high-risk patients and to discharge patients earlier. It is unclear whether efforts to reduce length of stay may have unintended negative consequences, such as increased complications and re-admissions.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

Pediatric cardiac surgery mortality has not been widely used as an indicator of quality.

⁸¹Hannan et al. 1998.

⁸²Knott-Craig CJ, Danielson GK, Schaff HV, et al. The modified Fontan operation. An analysis of risk factors for early postoperative death or takedown in 702 consecutive patients from one institution. J Thorac Cardiovasc Surg 1995;109(6):1237-43.

⁸³Gentles TL, Mayer JE, Jr., Gauvreau K, et al. Fontan operation in 500 consecutive patients: factors influencing early and late outcome. J Thorac Cardiovasc Surg 1997;114(3):376-91.

⁸⁴Kern JH, Hayes CJ, Michler RE, et al. Survival and risk factor analysis for the Norwood procedure for hypoplastic left heart syndrome. Am J Cardiol 1997;80(2):170-4.

⁷⁹Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/>

⁸⁰Hannan EL, Racz M, Kavey RE, et al. Pediatric cardiac surgery: the effect of hospital and surgeon volume on in-hospital mortality. Pediatrics 1998;101(6):963-9.

Abdominal Aortic Aneurysm Repair Mortality Rate

Abdominal aortic aneurysm (AAA) repair is a relatively rare procedure that requires proficiency with the use of complex equipment, and technical errors may lead to clinically significant complications, such as arrhythmias, acute myocardial infarction, colonic ischemia, and death.

Relationship to Quality	Better processes of care may reduce mortality for AAA repair, which represents better quality care.
Benchmark	State, regional, or peer group average.
Definition	Number of deaths per 100 discharges with procedure code of AAA repair.
Numerator	Number of deaths with a code of AAA repair in any procedure field.
Denominator	Discharges with ICD-9-CM codes of 3834, 3844, and 3864 in any procedure field and a diagnosis code of AAA in any field. Exclude patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and neonates).
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Procedures
Empirical Rating	8

Summary of Evidence

AAA repair is a technically difficult procedure with a relatively high mortality rate. Higher volume hospitals have been noted to have lower mortality rates, which suggests that some differences in the processes of care between lower and higher volume hospitals result in better outcomes.

Empirical analyses of demographic risk adjustment noted some potential bias for this indicator. Additional medical chart review or analyses of laboratory data may be helpful in determining whether more detailed risk adjustment is necessary. This indicator should also be considered with length of stay and transfer rates to account for differing discharge practices among hospitals.

Limitations on Use

Risk adjustment for clinical factors is recommended because of the confounding bias for AAA repair mortality rate. In addition, little evidence exists supporting the construct validity of this indicator.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

Studies have reported 40-55% in-hospital mortality after emergent repair of ruptured aneurysms.^{85 86 87} These data suggest that improved quality of care could have a substantial impact on public health.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

⁸⁵Dardik A, Burleyson GP, Bowman H, et al. Surgical repair of ruptured abdominal aortic aneurysms in the state of Maryland: factors influencing outcome among 527 recent cases. *J Vasc Surg* 1998;28(3):413-20.

⁸⁶Kazmers A, Jacobs L, Perkins A, et al. Abdominal aortic aneurysm repair in Veterans Affairs medical centers. *J Vasc Surg* 1996;23(2):191-200.

⁸⁷Rutledge R, Oller DW, Meyer AA, et al. A statewide, population-based time-series analysis of the outcome of ruptured abdominal aortic aneurysm. *Ann Surg* 1996;223(5):492-502.

The relatively small number of AAA resections performed by each hospital suggests that mortality rates at the hospital level are likely to be unreliable. Empirical evidence shows that this indicator is precise, with a raw provider level mean of 21.5% and a substantial standard deviation of 26.8%.⁸⁸

Relative to other indicators, a higher percentage of the variation occurs at the provider level, rather than the discharge level. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is low, at 30.7%, indicating that some of the observed differences in provider performance likely do not represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

The known predictors of in-hospital mortality include whether the aneurysm is intact or ruptured, age, female gender, admission through an emergency room, various comorbidities such as renal failure and dysrhythmias, and Charlson's comorbidity index.^{89 90 91} In the absence of studies explicitly comparing models with and without additional clinical elements, it is difficult to assess whether administrative data contain sufficient information to remove bias.

⁸⁸Nationwide Inpatient Sample and State Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/>

⁸⁹Manheim LM, Sohn MW, Feinglass J, et al. Hospital vascular surgery volume and procedure mortality rates in California, 1982-1994. *J Vasc Surg* 1998;28(1):45-56.

⁹⁰Hannan EL, Kilburn H, Jr., O'Donnell JF, et al. A longitudinal analysis of the relationship between in-hospital mortality in New York state and the volume of abdominal aortic aneurysm surgeries performed. *Health Serv Res* 1992;27(4):517-42.

⁹¹Wen SW, Simunovic M, Williams JI, et al. Hospital volume, calendar age, and short term outcomes in patients undergoing repair of abdominal aortic aneurysm: the Ontario experience, 1988-92. *J Epidemiol Community Health* 1996;50(2):207-13.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

The correlation between hospital or physician characteristics and in-hospital mortality in most studies supports the validity of in-hospital mortality as a measure of quality.^{92 93} Finally, excessive blood loss, which is a potentially preventable complication of surgery, has been identified as the most important predictor of mortality after elective AAA repair.⁹⁴

Empirical evidence shows that AAA repair mortality is positively related to other post-procedural mortality measures, such as craniotomy ($r=.28$, $p<.0001$) and coronary artery bypass graft (CABG) ($r=.17$, $p<.01$).⁹⁵

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

All in-hospital mortality measures may encourage earlier post-operative discharge, and thereby shift deaths to skilled nursing facilities or outpatient settings. Another potential response would be to avoid operating on high-risk patients.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

The Pennsylvania Health Care Cost Containment Council includes AAA repair in the "Other major vessel operations except heart (DRG 100)" indicator. It is also used by HealthGrades.com.

⁹²Pearce WH, Parker MA, Feinglass J, et al. The importance of surgeon volume and training in outcomes for vascular surgical procedures. *J Vasc Surg* 1999;29(5):768-76.

⁹³Rutledge et al., 1996.

⁹⁴Pilcher DB, Davis JH, Ashikaga T, et al. Treatment of abdominal aortic aneurysm in an entire state over 7½ years. *Am J Surg* 1980;139(4):487-94.

⁹⁵Nationwide Inpatient Sample.

Coronary Artery Bypass Graft Mortality Rate

Coronary artery bypass graft (CABG) is a relatively common procedure that requires proficiency with the use of complex equipment, and technical errors may lead to clinically significant complications, such as myocardial infarction, stroke, and death.

Relationship to Quality	Better processes of care may reduce mortality for CABG, which represents better quality care.
Benchmark	State, regional, or peer group average.
Definition	Number of deaths per 100 discharges with procedure code of CABG.
Numerator	Number of deaths with a code of CABG in any procedure field.
Denominator	Discharges with ICD-9-CM codes of 3610 through 3619 in any procedure field. Age 40 years and older. Exclude patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and neonates).
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Procedures
Empirical Rating	5

Summary of Evidence

CABG mortality is one of the most widely used and publicized post-procedural mortality indicators. Demographics, comorbidities, and clinical characteristics of severity of disease are important predictors of outcome that may vary systematically by provider. Chart review may help distinguish comorbidities from complications.

This indicator should be considered with length of stay and transfer rates to account for differing discharge practices among hospitals. The use of smoothed estimates to help avoid the erroneous labeling of outlier hospitals is recommended.

Limitations on Use

Some selection of the patient population may lead to bias; providers may perform more CABG procedures on less clinically complex patients with questionable indications. Risk adjustment for clinical factors, or at a minimum APR-DRGs, is recommended because of the confounding bias of this indicator. Finally, the evidence for the construct validity of this indicator is limited.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

Post-CABG mortality rates have recently become the focus of State public reporting initiatives.⁹⁶ Studies suggest that these reports serve as the basis for discussions between physicians and patients about the risks of cardiac surgery.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Without applying hierarchical statistical models to remove random noise, it is likely that hospitals will be identified as outliers as a result of patient variation and other factors beyond the hospital's control. Empirical evidence shows that this

⁹⁶Localio AR, Hamory BH, Fisher AC, et al. The public release of hospital and physician mortality data in Pennsylvania. A case study. *Med Care* 1997;35(3):272-286.

indicator is precise, with a raw provider level mean of 5.1% and a standard deviation of 6.2%.⁹⁷

Relative to other indicators, a lower percentage of the variation occurs at the provider level, rather than the discharge level. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is moderate, at 54.5%, indicating that some of the observed differences in provider performance likely do not represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Based on studies using large databases, cardiac function, coronary disease severity, and the urgency of surgery appear to be powerful predictors of mortality.⁹⁸ Some of these risk factors are not available from administrative data.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

Numerous studies have reported an association between hospital volume and mortality after CABG surgery. However, experienced surgeons and surgical teams should be able to improve post-operative mortality by reducing aortic cross-clamp time, which has been repeatedly associated with post-operative mortality after adjusting for a variety of patient characteristics.⁹⁹ It is unknown how performance of these processes of care would affect hospital-level mortality rates.

Empirical evidence shows that CABG mortality is positively related to bilateral catheterization and negatively related to laparoscopic cholecystectomy.¹⁰⁰

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Public reporting of CABG mortality rates may cause providers to avoid high-risk patients. Sixty-three percent of cardiothoracic surgeons surveyed in Pennsylvania reported that they were “less willing” to operate on the most severely ill patients since mortality data were released.¹⁰¹ However, one study using Medicare data shows no evidence that cardiac surgeons in New York, which also reports CABG mortality rates, avoided high-risk patients.¹⁰² All in-hospital mortality measures may encourage earlier post-operative discharge, shifting deaths to skilled nursing facilities or outpatient settings and causing biased comparisons across hospitals with different mean lengths of stay.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

CABG mortality is publicly reported by California, New Jersey, New York, and Pennsylvania. Recent users of CABG mortality as a quality indicator include the University Hospital Consortium, the Joint Commission on Accreditation of Healthcare Organizations’ (JCAHO’s) IMSsystem, Greater New York Hospital Association, the Maryland Hospital Association (as part of the Maryland QI Project) and HealthGrades.com.

⁹⁷Nationwide Inpatient Sample and State Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/>

⁹⁸Higgins TL, Estafanous FG, Loop FD, et al. Stratification of morbidity and mortality outcome by preoperative risk factors in coronary artery bypass patients. A clinical severity score. JAMA 1992;267(17):2344-8.

⁹⁹Ottino G, Bergerone S, Di Leo M, et al. Aortocoronary bypass results: a discriminant multivariate analysis of risk factors of operative mortality. J Cardiovasc Surg (Torino) 1990;31(1):20-5.

¹⁰⁰Nationwide Inpatient Sample.

¹⁰¹Hannan EL, Siu AL, Kumar D, et al. Assessment of coronary artery bypass graft surgery performance in New York. Is there a bias against taking high-risk patients? Med Care 1997;35(1):49-56.

¹⁰²Peterson ED, DeLong ER, Jollis JG, et al. Public reporting of surgical mortality: a survey of new York State cardiothoracic surgeons. Ann Thorac Surg 1999;68(4):1195-200; discussion 12-1-2.

Craniotomy Mortality Rate

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 of craniotomy (DRG 001: craniotomy, except for trauma).
Numerator	Number of deaths with DRG 001: craniotomy, except for trauma.
Denominator	All discharges with DRG code of craniotomy (DRG 001: craniotomy except for trauma). Age 18 years or older. Exclude patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and neonates).
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Procedures
Empirical Rating	6

Summary of Evidence

Craniotomy is a complex procedure. Providers with high rates have better outcomes, although this may be an artifact of patient selection.

This indicator is measured with good precision and very high provider systematic variation. Empirical analyses showed substantial bias for this indicator, particularly for age, and providers should risk-adjust for age and comorbidities. Medical chart reviews or analyses of laboratory tests can also be used to examine other patient characteristics that increase case-mix complexity.

Limitations on Use

Risk adjustment for clinical factors, or at a minimum APR-DRGs, is recommended because of the confounding bias for craniotomy. In addition, little evidence exists supporting the construct validity of this indicator.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

Craniotomy requires technical skill and the ability to identify the most appropriate cases. Post-operative mortality rates for craniotomy—together with measures of volume and utilization—will give a comprehensive perspective on provider performance for this condition.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Most providers perform relatively high numbers of procedures; post-operative mortality rates are also relatively high, averaging nearly 14% for patients over age 65.¹⁰³

¹⁰³Taylor CL, Yuan A, Selman WR, et al. Mortality rates, hospital length of stay, and the cost of treating subarachnoid hemorrhage in older patients: institutional and geographical differences. *J Neurosurg* 1997;86(4):583-8.

Empirical evidence shows that this indicator is precise, with a raw provider level mean of 16.2% and a substantial standard deviation of 18.5%.¹⁰⁴

Relative to other indicators, a higher percentage of the variation occurs at the provider level, rather than the discharge level. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is low, at 28.9%, indicating that most of the observed differences in provider performance likely do not represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Studies have shown that patients undergoing treatment for subarachnoid hemorrhage had significantly higher post-craniotomy mortality rates by age group (from 3% for those 23-39 years old to 17% for those over 70 years old).^{105 106}

Older patients generally present with more severe illness on admission, including lower levels of consciousness, worse grade, thicker subarachnoid clot, intraventricular hemorrhage, and hydrocephalus. Older patients also present with higher comorbidity rates, including diabetes; hypertension; and pulmonary, myocardial, and cerebrovascular disease.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

Providers performing more than 30 procedures per year have lower mortality than providers performing fewer than 30, although the volume-outcome relationship may be a product of patient

selection.¹⁰⁷ In one study, patients who were referred to a large medical center for subarachnoid hemorrhage were less likely to have died early and had fewer severe indications, including lower clinical grade, rate of coma, diastolic blood pressure, and younger patient age.¹⁰⁸

Craniotomy appears to be positively related to mortality associated with abdominal aortic aneurysm (AAA) repair ($r=.28$, $p<.0001$), coronary artery bypass graft (CABG) ($r=.23$, $p<.0001$), and stroke ($r=.49$, $p<.0001$).¹⁰⁹

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

All in-hospital mortality measures may encourage earlier post-operative discharge, and thereby shift deaths to skilled nursing facilities or outpatient settings. This phenomenon may also lead to biased comparisons among hospitals with different mean lengths of stay.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

The University Hospital Consortium uses post-operative mortality for craniotomy, non-trauma related, as a quality measure.

¹⁰⁴Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/>

¹⁰⁵Stachniak JB, Layon AJ, Day AL, et al. Craniotomy for intracranial aneurysm and subarachnoid hemorrhage. Is course, cost, or outcome affected by age? *Stroke* 1996;27(2):276-81.

¹⁰⁶Lanzino G, Kassell NF, Germanson TP, et al. Age and outcome after aneurysmal subarachnoid hemorrhage: why do older patients fare worse? *J Neurosurg* 1996;85(3):410-8.

¹⁰⁷Soloman RA, Mayer SA, Tarmey JJ. Relationship between the volume of craniotomies for cerebral aneurysm performed at New York state hospitals and in-hospital mortality. *Stroke* 1996;27(1):13-7.

¹⁰⁸Whisnant JP, Sacco SE, O'Fallon WM, et al. Referral bias in aneurysmal subarachnoid hemorrhage. *J Neurosurg* 1993;78(5):726-32.

¹⁰⁹Nationwide Inpatient Sample.

Hip Replacement Mortality Rate

Total hip arthroplasty (without hip fracture) is an elective procedure performed to improve function and relieve pain among patients with chronic osteoarthritis, rheumatoid arthritis, or other degenerative processes involving the hip joint.

Relationship to Quality	Better processes of care may reduce mortality for hip replacement, which represents better quality care.
Benchmark	State, regional, or peer group average.
Definition	Number of deaths per 100 patients with discharge procedure code of partial or full hip replacement.
Numerator	Number of deaths with a procedure code for partial or full hip replacement in any field.
Denominator	All discharges with procedure code of partial or full hip replacement in any field. Include only discharges with uncomplicated cases: diagnosis codes of osteoarthritis of hip in any field. Exclude patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and neonates).
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Procedures
Empirical Rating	3

Summary of Evidence

Hip replacement is an elective surgery with relatively low mortality rates. However, the main recipients of hip replacement are elderly individuals with increased risk for complications and morbidity from surgery.

Although the low mortality rate is likely to affect the precision of this indicator, the precision is adequate for a quality indicator. Patient characteristics such as age and comorbidities may influence the mortality rate. Risk adjustment is highly recommended for this indicator, and providers may want to examine the case mix of their populations. This indicator should be considered with length of stay and transfer rates to account for differing discharge practices among hospitals.

Limitations on Use

Because hip replacement is an elective procedure, some selection of patient population may create bias. Risk adjustment for clinical factors, or at a minimum APR-DRGs, is recommended because of

the confounding bias for hip replacement. In addition, little evidence exists supporting the construct validity of this indicator.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

Mortality for hip replacement is very low, as it should be for a procedure that is designed to improve function rather than extend survival. However, elderly patients are at a significant risk of post-operative complications such as pneumonia, osteomyelitis, myocardial ischemia, and deep vein thrombosis. If not recognized and effectively treated, complications may lead to life-threatening problems.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Primary total hip arthroplasty is one of the most frequent types of major orthopedic surgery; about 160,000 were performed in the United States in 1998.¹¹⁰ The relatively small number of deaths following total hip arthroplasty suggests that mortality rates are likely to be unreliable at the hospital level. Empirical evidence shows that this indicator is adequately precise, with a raw provider level mean of 1.2% and a substantial standard deviation of 5.7%.¹¹¹

Relative to other indicators, a high percentage of the variation occurs at the provider level, rather than the discharge level. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is low, at 20.0%, indicating that some of the observed differences in provider performance very likely do not represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Hip replacement has the potential for selection bias caused by the decision to select surgery. The known predictors of in-hospital mortality include age, hip fracture, and the presence of any significant comorbidity.^{112 113}

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

Using administrative data without any risk adjustment, Lavernia and Guzman found no association between hospital volume and mortality

following total hip arthroplasty.¹¹⁴ However, surgeons with fewer than 10 cases per year showed a significant increase in the death rate, and hospitals with fewer than 10 cases per year showed a significant increase in complications.

One observational study attributed a decrease in post-operative mortality (from 0.36% in 1981-85 to 0.10% in 1987-91) to changes in perioperative care, such as reduced intraoperative blood loss, more aggressive arterial and oximetric monitoring, and increased use of epidural instead of general anesthesia.¹¹⁵

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

All in-hospital mortality measures may encourage earlier post-operative discharge, and thereby shift deaths to skilled nursing facilities or outpatient settings.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

Hip replacement was included in the original HCUP QIs; it is also used by HealthGrades.com and the Greater New York Hospital Association.

¹¹⁰Popovic JR, Kozak LJ. National hospital discharge survey: annual summary, 1998 [In Process Citation]. Vital Health Stat 13 2000(148):1-194.

¹¹¹Nationwide Inpatient Sample. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/hcupnet.htm>.

¹¹²Kreder HF, Williams JI, Jaglal S, et al. Are complication rates for elective primary total hip arthroplasty in Ontario related to surgeon and hospital volumes? A preliminary investigation. Can J Surg 1998;41(6):431-7.

¹¹³Whittle J, et al. 1993.

¹¹⁴Lavernia CJ, Guzman JF. Relationship of surgical volume to short-term mortality, morbidity, and hospital charges in arthroplasty. J Arthroplasty 1995;10(2):133-40.

¹¹⁵Sharrock et al. 1995.

Acute Myocardial Infarction Mortality Rate

Timely and effective treatments for acute myocardial infarction (AMI), which are essential for patient survival, include appropriate use of thrombolytic therapy and revascularization.

Relationship to Quality	Better processes of care may reduce mortality for AMI, which represents better quality.
Benchmark	State, regional, or peer group average.
Definition	Number of deaths per 100 discharges with a principal diagnosis code of AMI.
Numerator	Number of deaths with a principal diagnosis code of AMI.
Denominator	All discharges with a principal diagnosis code of AMI. Age 18 years and older. Exclude patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and neonates).
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Conditions
Empirical Rating	5

Summary of Evidence

Reductions in the mortality rate for AMI on both the patient level and the provider level have been related to better processes of care. AMI mortality rate is measured with adequate precision, although some of the observed variance may not actually reflect true differences in performance. Risk adjustment may be important—particularly for the extremes. Otherwise, some providers may be mislabeled as outliers.

Limitations on Use

Thirty-day mortality may be significantly different than in-hospital mortality, leading to information bias. This indicator should be considered in conjunction with length-of-stay and transfer rates. Risk adjustment for clinical factors (or at a minimum APR-DRGs) is recommended.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

AMI affects 1.5 million people each year, and approximately one-third die in the acute phase of

the heart attack.¹¹⁶ Studies that show processes of care linked to survival improvements have resulted in detailed practice guidelines covering all phases of AMI management.¹¹⁷

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

The precision of AMI mortality rate estimates may be problematic for medium and small hospitals. Empirical evidence shows that this indicator is

¹¹⁶American Heart Association. Heart Attack and Stroke Facts: 1996 Statistical Supplement. Dallas, TX: American Heart Association; 1996.

¹¹⁷Ryan TJ, Antman EM, Brooks NH, et al. 1999 update: ACC/AHA guidelines for the management of patients with acute myocardial infarction. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Management of Acute Myocardial Infarction). J Am Coll Cardiol 1999;34(3):890-911.

precise, with a raw provider level mean of 24.4% and a standard deviation of 16.1%.¹¹⁸

Relative to other indicators, a higher percentage of the variation occurs at the provider level rather than the discharge level. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is moderate, at 42.8%, indicating that some of the observed differences in provider performance likely do not represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Numerous studies have established the importance of risk adjustment for AMI patients. The most important predictors of short-term AMI mortality have been shown to include age, previous AMI, tachycardia, pulmonary edema and other signs of congestive heart failure, hypotension and cardiogenic shock, anterior wall and Q-wave infarction, cardiac arrest, and serum creatinine or urea nitrogen. Using different risk adjustment methods or data sources (administrative versus clinical data) affects which specific hospitals are identified as outliers.^{119 120}

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

When Meehan et al. evaluated coding accuracy, severity of illness, and process-based quality of care in Connecticut hospitals, they found that the hospitals with the highest risk-adjusted mortality had significantly lower utilization of beneficial

therapies.¹²¹ In the California Hospital Outcomes Project, hospitals with low risk-adjusted AMI mortality were more likely to give aspirin within 6 hours of arrival in the emergency room, perform cardiac catheterization and revascularization procedures within 24 hours, and give heparin to prevent thromboembolic complications.¹²²

Empirical evidence shows that AMI mortality is correlated with bilateral catheterization ($r=-.16$, $p<.0001$), mortality for congestive heart failure (CHF) ($r=.46$, $p<.0001$), pneumonia ($r=.46$, $p<.0001$), coronary artery bypass graft (CABG) ($r=.50$, $p<.0001$), stroke ($r=.40$, $p<.0001$), and gastrointestinal hemorrhage ($r=.38$, $p<.0001$).¹²³

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

The use of AMI mortality as an indicator is unlikely to impede access to needed care. However, a few patients who fail to respond to resuscitative efforts may not be admitted if there is pressure to reduce inpatient mortality.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

AMI mortality has been widely used as a hospital quality indicator by State health departments and the Joint Commission for the Accreditation of Healthcare Organizations (JCAHO).

¹¹⁸Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup>

¹¹⁹Landon B, Iezzoni LI, Ash AS, et al. Judging hospitals by severity-adjusted mortality rates: the case of CABG surgery. *Inquiry* 1996;33(2):155-66.

¹²⁰Second Report of the California Hospitals Outcomes Project, May 1996, Acute Myocardial Infarction. Sacramento, CA: Office of Statewide Health Planning and Development; 1996.

¹²¹Meehan TP, Hennen J, Radford MJ, et al. Process and outcome of care for acute myocardial infarction among Medicare beneficiaries in Connecticut: a quality improvement demonstration project. *Ann Intern Med* 1995;122(12):928-36.

¹²²Second Report of the California Hospitals Outcomes Project, May 1996. Acute Myocardial Infarction. Sacramento, CA: Office of Statewide Health Planning and Development; 1996.

¹²³Nationwide Inpatient Sample.

Congestive Heart Failure Mortality Rate

Congestive heart failure (CHF) is a progressive, chronic disease with substantial short-term mortality, which varies from provider to provider.

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 CHF.
Numerator	Number of deaths with a principal diagnosis code of CHF.
Denominator	All discharges with a principal diagnosis code of CHF. Age 18 years and older. Exclude discharges with cardiac procedure codes in any field, patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and neonates).
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Conditions
Empirical Rating	6

Summary of Evidence

CHF is a relatively common admission, with a relatively high short-term mortality rate. Certain procedures have been shown to decrease short-term CHF mortality on a patient level, but the impact of these practices on decreasing provider-level mortality is unknown.

CHF mortality has not been studied extensively as an indicator; however, some risk models have been developed that demonstrate the importance of comorbidities and some clinical factors in predicting death. Risk adjustment may be important—particularly for the extremes. Otherwise, some providers may be mislabeled as outliers.

Limitations on Use

CHF care occurs in an outpatient setting, and selection bias may be a problem for this indicator. In addition, 30-day mortality may be significantly different than in-hospital mortality, leading to information bias. Risk adjustment for clinical factors (or at a minimum APR-DRGs) is recommended.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

Approximately 2 million persons in the United States have heart failure each year.¹²⁴ These numbers will likely increase as the population ages. The literature suggests that hospitals have improved care for heart failure patients. In a study of 29,500 elderly patients in Oregon, the 3-day mortality decreased by 41% from 1991 to 1995.¹²⁵

The accuracy of ICD-9-CM coding for heart failure has been questioned. Although the specificity of a principal diagnosis of heart failure is high, the

¹²⁴Smith, WM. Epidemiology of congestive heart failure. *Am J Cardiol* 1985;55(2):3A-8A.

¹²⁵Ni H, Hershberger FE. Was the decreasing trend in hospital mortality from heart failure attributable to improved hospital care? The Oregon experience, 1991-1995. *Am J Manag Care* 1999;5(9):1105-15.

sensitivity is low.¹²⁶ Face validity will be maximized by limiting analyses to patients with a principal diagnosis of heart failure.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Empirical evidence shows that this indicator is precise, with a raw provider level mean of 7.5% and an standard deviation of 9.5%.¹²⁷

Relative to other indicators, a lower percentage of the variation occurs at the provider level rather than the discharge level. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is moderate, at 53.5%, indicating that some of the observed differences in provider performance likely do not represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Mortality is greatly influenced by age, transfer, cerebrovascular disease, chronic obstructive pulmonary disease, hyponatremia, other hydro-electrolytic disturbance, metastatic disease, renal disease, ventricular arrhythmia, liver disease, malignancy, hypotension, and shock.^{128 129 130}

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

No studies specifically examined the construct validity of in-hospital mortality from heart failure. Although processes of care have been shown to decrease mortality on a patient level, the effect of these processes of care on provider-level mortality rates is unknown.

Empirical evidence shows that CHF mortality is positively related to other mortality indicators, such as pneumonia, gastrointestinal hemorrhage, and stroke.

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Risk-adjusted measures of mortality may lead to an increase in coding of comorbidities. All in-hospital mortality measures may encourage earlier post-operative discharge, and thereby shift deaths to skilled nursing facilities or outpatient settings. However, Rosenthal et al. found no evidence that hospitals with lower in-hospital standardized mortality had higher (or lower) early post-discharge mortality.¹³¹

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

CHF mortality has been widely used as a quality indicator. HealthGrades.com, the University Hospital Consortium, and the Greater New York Hospital Association have used this measure. The Maryland Hospital Association includes this measure in its Maryland QI Project Indicator set. Likewise, the Michigan Hospital Association includes CHF in an aggregated mortality measure.

¹²⁶Goff, DC, Jr., Pandey DK, Chan FA, et al. Congestive heart failure in the United States: is there more than meets the I(CD code)? The Corpus Christi Heart Project. Arch Intern Med 2000;160(2):197-202.

¹²⁷Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup>

¹²⁸Yusuf, et al. 1989.

¹²⁹MacIntyre K, Capewell IS, Stewart S, et al. Evidence of improving prognosis in heart failure: trends in case fatality in 66,547 patients hospitalized between 1986 and 1995 [see comments]. Circulation 2000;102(10):1126-31.

¹³⁰Psaty BM, Boineau R, Kuller LH, et al. The potential costs of upcoding for heart failure in the United States. Am J Cardiol 1999;84(1):108-9, A9.

¹³¹Rosenthal GE, Baker DW, Norris DG, et al. Relationships between in-hospital and 30-day standardized hospital mortality: implications for profiling hospitals. Health Serv Res 2000;34(7):1449-68.

Acute Stroke Mortality Rate

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 with a principal diagnosis code of stroke.
Denominator	All discharges with a principal diagnosis code of stroke. Age 18 years and older. Exclude patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and neonates).
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Conditions
Empirical Rating	10

Summary of Evidence

Quality treatment for stroke must be timely and efficient to prevent brain tissue death. Clinical factors of severity at presentation, including use of mechanical ventilation on the first day, may vary by hospital and influence mortality. Providers with high rates may wish to examine the case mix for these potentially complicating factors.

Further, hospitals with rehabilitation programs may have higher mortality rates. Providers may want to use acute stroke mortality in conjunction with length of stay for their hospitals and for surrounding areas. Many deaths occur out of the hospital, suggesting that linkage to death records for patients post-discharge may be a good addition to this indicator.

Limitations on Use

Some stroke care occurs in an outpatient setting, and selection bias may be a problem for this indicator. In addition, 30-day mortality may be somewhat different than in-hospital mortality, leading to information bias. Risk adjustment for clinical factors (or at a minimum APR-DRGs) is recommended. Coding appears suboptimal for acute stroke and may lead to bias.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

Stroke remains the third leading cause of death in the United States.¹³² However, hospital care has a relatively modest impact on patient survival, and most stroke deaths occur after the initial acute hospitalization.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Because stroke severity has a large effect on acute mortality, hospital mortality rates may be subject to considerable random variation. According to the literature, only 10-15% of stroke patients die during

¹³²Centers for Disease Control and Prevention. Report of Final Mortality Statistics, 1996. Volume 47, Number 9. Available at http://www.cdc.gov/nchs/products/pubs/nvsr/47-pre/47-pre.htm#NVSr47_19.

hospitalization.¹³³ Empirical evidence shows that this indicator is precise, with a raw provider level mean of 21.3% and a standard deviation of 13.7%.¹³⁴

Relative to other indicators, a higher percentage of the variation occurs at the provider level, rather than the discharge level. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is moderate, at 51.9%, indicating that some of the observed differences in provider performance likely do not represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Williams et al. pooled the results of four studies that showed significant inaccuracies in ICD-9-CM codes for identifying stroke patients.¹³⁵ However, there are no studies documenting cross-hospital variations in these coding practices.

More patients with transient ischemic attacks (TIAs) are likely to be admitted to some hospitals because of the increased interest in the care of acute stroke patients.¹³⁶ Therefore, hospitals with more liberal admitting policies may appear to have lower mortality rates.

Coma at presentation and a history of previous stroke substantially increase the mortality of

patients admitted with stroke.¹³⁷ Patients with prior aspirin use tend to have better outcomes.¹³⁸

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

Thrombolytic therapy has been shown to be beneficial in acute stroke; however, the small percentage of patients who receive this treatment suggests that it is likely to have only a modest impact on hospital mortality.¹³⁹ Empirical evidence shows that stroke mortality is positively related to mortality indicators for pneumonia, gastrointestinal hemorrhage, and congestive heart failure.

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

All in-hospital mortality measures may encourage earlier post-operative discharge, thereby shifting deaths to skilled nursing facilities or outpatient settings. This may lead to biased comparisons among hospitals with different mean lengths of stay. "Overcoding" TIAs as strokes may also decrease stroke mortality rates.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

Stroke mortality indicators have been used by the HealthGrades.com, University Hospital Consortium, Maryland Hospital Association Quality Indicators Project, and the Greater New York Hospital Association.

¹³³Brown RD, Whisnant JP, Sicks JD, et al. Stroke incidence, prevalence, and survival: secular trends in Rochester, Minnesota, through 1989. *Stroke* 1996;27(3):373-80.

¹³⁴Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/>

¹³⁵Williams GR, Jiang JG, Matchar DB, et al. Incidence and occurrence of total (first-ever and recurrent) stroke. *Stroke* 1999;30(12):2523-8.

¹³⁶Feinberg WM. Guidelines for the management of transient ischemic attacks. Ad Hoc Committee on Guidelines for the Management of Transient Ischemic Attacks of the Stroke Council, American Heart Association, *Heart Dis Stroke* 1994;3(5):275-83.

¹³⁷Samsa GP, Bian J, Lipscomb J, et al. Epidemiology of recurrent cerebral infarction: a Medicare claims-based comparison of first and recurrent strokes on 2-year survival and cost. *Stroke* 1999;30(2):338-49.

¹³⁸Kalra L, Perez I, Smithard DG, et al. Does prior use of aspirin affect outcome in ischemic stroke? *Am J Med* 2000;108(3):205-9.

¹³⁹Tissue plasminogen activator for acute ischemic stroke. The National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group. *N Engl J Med* 1995;333(24):1581-7.

Gastrointestinal Hemorrhage Mortality Rate

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 with a principal diagnosis code of GI hemorrhage.
Denominator	All discharges with GI hemorrhage in a principal diagnosis field. Age 18 years and older. Exclude patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and neonates).
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Conditions
Empirical Rating	5

Summary of Evidence

GI hemorrhage itself is rarely the cause of death, and the extreme influence of comorbidities on the survival rate of patients with GI hemorrhage—as well as the influence of age and timing of onset (pre- or post-hospitalization)—raises questions about the potential bias of this indicator. Providers should risk-adjust for comorbidities. In addition, providers with high rates may want to examine their case-mix for higher complexity of cases (e.g., patients over 60, more comorbidities).

Hospital practices differ, with some hospitals discharging patients earlier than others. For this reason, this indicator should be considered in conjunction with length of stay and transfer rates.

Limitations on Use

Limited evidence supports the construct validity of this indicator. Risk adjustment for clinical factors, or at a minimum APR-DRGs, is recommended because of the substantial confounding bias for this indicator.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

Admission for GI hemorrhage is fairly common, and mortality rates vary greatly. Lower mortality has been associated with more use of treatments such as early endoscopy (within 24–48 hours of presentation). Mortality rates on large population-based databases have not changed since the 1940s, although the ages and comorbidities of patients have increased.¹⁴⁰

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Rates of mortality in GI hemorrhage vary from 0% to 29%, with most studies reporting rates of 3.5% to 11%. Empirical evidence shows that this indicator

¹⁴⁰Rockall TA, Logan RF, Devlin HB, et al. Variation in outcome after acute upper gastrointestinal haemorrhage. The National Audit of Acute Upper Gastrointestinal Haemorrhage. *Lancet* 1995;346(8971):346-50.

is precise, with a raw provider mean of 4.6% and a standard deviation of 5.7%.¹⁴¹

Relative to other indicators, a lower percentage of the variation occurs at the provider level, rather than the discharge level. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is low, at 20.2%, indicating that some of the observed differences in provider performance do not represent true differences in provider performance.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Mortality from GI hemorrhage is highly influenced by patient comorbidities, as well as the nature and severity of the bleed itself. One study noted that some endoscopic findings, hemodynamic characteristics, and comorbidities were highly predictive of life-threatening events.¹⁴² Another study tested the effect of risk adjustment on hospital ranking for gastrointestinal hemorrhage mortality. Risk adjusting for age, shock, and comorbidity changed 30 hospitals' rankings by more than 10. Adding diagnosis, endoscopy findings, and rebleed status changed 32 hospital rankings by more than 10.¹⁴³

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

No studies explicitly evaluated the construct validity of GI hemorrhage. Although processes of care have been shown to decrease mortality on a patient level, the effect of these processes of care on provider-level mortality rates is unknown.

Empirical evidence shows that GI hemorrhage is positively related to mortality indicators such as pneumonia, stroke, and congestive heart failure.¹⁴⁴

One meta-analysis showed a slight advantage for early endoscopy.¹⁴⁵ Another study found that endoscopy was not related to mortality in either the bivariate or multivariate analyses.¹⁴⁶

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Risk-adjusted measures of mortality may lead to an increase in coding of comorbidities. All in-hospital mortality measures may encourage earlier post-operative discharge, and thereby shift deaths to skilled nursing facilities or outpatient settings. This phenomenon may also lead to biased comparisons among hospitals with different mean lengths of stay.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

GI hemorrhage is currently used by the Cleveland Choice Health Quality Choice. The Maryland Hospital Association includes this measure in its Maryland QI Project Indicator set. Likewise, the Michigan Hospital Association includes GI hemorrhage in an aggregated mortality measure.

¹⁴¹Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup>

¹⁴²Hay JA, Lyubashevsky E, Elashoff J, et al. Upper gastrointestinal hemorrhage clinical guideline determining the optimal hospital length of stay. *Am J Med* 1996;100(3):313-22.

¹⁴³Rockall et al., 1995.

¹⁴⁴HCUPnet, Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/hcupnet.htm>

¹⁴⁵Cook DJ, Guyatt GH, Salena BJ, et al. Endoscopic therapy for acute nonvariceal upper gastrointestinal hemorrhage: a meta-analysis. *Gastroenterology* 1992;102(1):139-48.

¹⁴⁶Cooper GS, Chak A, Way LE, et al. Early endoscopy in upper gastrointestinal hemorrhage: associations with recurrent bleeding, surgery, and length of hospital stay. *Gastrointest Endosc* 1999;49(2):145-52.

Hip Fracture Mortality Rate

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 with a principal diagnosis code of hip fracture.
Denominator	All discharges with a principal diagnosis code of hip fracture. Age 18 years and older. Exclude patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and neonates).
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Conditions
Empirical Rating	10

Summary of Evidence

Complications of hip fracture and other comorbidities lead to a relatively high mortality rate, and evidence suggests that some of these complications are preventable. Hip fracture mortality rate is measured with good precision, although some of the observed variance does not reflect true differences in performance. About 89% of hip fracture patients are elderly.

Patient age, sex, comorbidities, fracture site, and functional status are all predictors of functional impairment and mortality. Administrative data may not contain sufficient information for these risk factors.

Limitations on Use

Thirty-day mortality may be somewhat different than in-hospital mortality, leading to information bias. Mortality rates should be considered in conjunction with length of stay and transfer rates. Risk adjustment for clinical factors (or at a minimum APR-DRGs) is recommended. Limited evidence exists for the construct validity of this indicator.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

Hip fractures are associated with a significant increase in the subsequent risk of mortality, which persists for a minimum of 3 months among the oldest and most impaired individuals.^{147 148} Elderly patients often have multiple comorbidities and pre-fracture functional impairments. As a result, they are at significant risk of postoperative complications, which—if not recognized and effectively treated—can lead to life-threatening problems.

¹⁴⁷Forsen L, Sogaard AJ, Meyer HE, et al. Survival after hip fracture: short- and long-term excess mortality according to age and gender. *Osteoporos Int* 1999;10(1):73-8.

¹⁴⁸Wolinsky FD, Fitzgerald JF, Stump TE. The effect of hip fracture on mortality, hospitalization, and functional status: a prospective study. *Am J Public Health* 1997;87(3):398-403.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

The largest published study of in-hospital mortality reported a rate of 4.9% in 1979-88, which suggests that mortality rates are likely to be relatively reliable at the hospital level.¹⁴⁹ Empirical evidence shows that this indicator is precise, with a raw provider level mean of 14.4% and a standard deviation of 16.0%.¹⁵⁰

Relative to other indicators, a higher percentage of the variation occurs at the provider level, rather than the discharge level. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is moderate, at 54.3%, indicating that some of the observed differences in provider performance likely do not represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Demographic predictors of in-hospital or 30-day mortality include age, male sex, and prior residence in a nursing home. Fracture site may be a significant predictor for long-term outcomes. Comorbidity predictors include malnutrition; venous, digestive, and cardiovascular diseases; neoplasms, disorientation or delirium, chronic obstructive pulmonary disease, the number of chronic medical conditions, prior hospitalization within 1 month, and the American Society of Anesthesiology physical status score.

Empirical analyses confirm that this indicator has some potential bias, and risk adjustment with age and sex and APR-DRGs is highly recommended. Chart review may identify differences in functional status or other clinical factors not accounted for in discharge data.

¹⁴⁹Myers AH, Robinson EG, Van Natta ML, et al. Hip fractures among the elderly: factors associated with in-hospital mortality. *Am J Epidemiol* 1991;134(10):1128-37.

¹⁵⁰Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/>

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

One study demonstrated that Medicare patients with poor “process of care” had similar risk-adjusted 30-day mortality rates as patients with good process of care.¹⁵¹ Nevertheless, there is substantial evidence that at least two major causes of death among hip fracture patients are partially preventable: pulmonary emboli and acute myocardial infarction.¹⁵² Very little evidence supports an association between hospital volume and mortality following hip fracture repair.

Empirical evidence shows that hip fracture repair mortality is positively related to pneumonia, stroke, gastrointestinal hemorrhage, and congestive heart failure mortality.¹⁵³

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

All in-hospital mortality measures may encourage earlier post-operative discharge. Thirty-day mortality for hip fracture is substantially higher than in-hospital mortality in the largest published studies, suggesting that a relatively modest decrease in mean length of stay could significantly decrease inpatient mortality. Another potential effect would be to avoid operating on high-risk patients, although this seems unlikely.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

In-hospital mortality following hip fracture repair has not been widely used as a quality indicator, although it is included within a University Hospital Consortium indicator (mortality for DRG 209).

¹⁵¹Kahn KL, Rogers WH, Rubenstein LV, et al. Measuring quality of care with explicit process criteria before and after implementation of the DRG-based prospective payment system. *JAMA* 1990;264(15):1969-73.

¹⁵²Perez JV, Warwick DJ, Case CP, et al. Death after proximal femoral fracture—an autopsy study. *Injury* 1995;26(4):237-40.

¹⁵³Nationwide Inpatient Sample.

Pneumonia Mortality Rate

Treatment with appropriate antibiotics may reduce mortality from pneumonia, which is a leading cause of death in the United States.

Relationship to Quality	Inappropriate treatment for pneumonia may increase mortality.
Benchmark	State, regional, or peer group average.
Definition	Mortality in discharges with principal diagnosis code of pneumonia.
Numerator	Number of deaths with a principal diagnosis code of pneumonia.
Denominator	All discharges with principal diagnosis code of pneumonia. Age 18 years and older. Exclude patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and neonates).
Type of Indicator	Provider Level, Mortality Indicator for Inpatient Conditions
Empirical Rating	7

Summary of Evidence

Pneumonia admissions are fairly common, and hospitals and physicians vary in admission practices. The high degree of patient heterogeneity suggests that providers may be mislabeled as poor quality without risk adjustment.

Providers with particularly high and low mortality rates should examine the case-mix of their patients for comorbidities, age, and clinical characteristics. Chart reviews may be helpful in determining whether differences truly arise from quality of care, or from patient-level differences in coding, comorbidities, or severity of disease. Providers may also wish to examine rates of outpatient care, because some patients are treated in outpatient settings.

Limitations on Use

Pneumonia care occurs in an outpatient setting, and selection bias may be a problem for this indicator. In addition, 30-day mortality may be somewhat different than in-hospital mortality, leading to information bias. Risk adjustment for clinical factors (or at a minimum APR-DRGs) is recommended.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

Pneumonia is the sixth leading cause of death in the United States.¹⁵⁴ Patient characteristics are relatively important predictors of in-hospital mortality, although the performance of specific processes of care may also lead to better patient outcomes.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

The high degree of heterogeneity among patients admitted for pneumonia suggests that the mortality indicator will be imprecise. However, empirical evidence shows that this indicator is precise, with a raw provider level mean of 13.8% and a standard deviation of 10.2%.¹⁵⁵

¹⁵⁴Hoyert DL, Kochanek KD, Murphy SL. Deaths: final data for 1997. Natl Vital Stat Rep 1999;47(19):1-104.

¹⁵⁵Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality,

Relative to other indicators, a higher percentage of the variation occurs at the provider level rather than the discharge level. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is moderate, at 62.9%, indicating that some of the observed differences in provider performance likely do not represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Comparison of hospital death rates with population death rates suggests that selection bias due to differing thresholds for admitting patients with pneumonia influences observed hospital mortality rates for pneumonia.¹⁵⁶ Population death rates from pneumonia (in particular, non-inpatient deaths) may be an important supplement to indicators based on hospital mortality. Some important predictors of pneumonia outcome are not reliably captured in administrative databases, including the microbial etiology, certain radiographic patterns, and pre-hospital functional status.^{157 158}

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

A recent study reported an association between choice of antibiotics and 3-day mortality for patients hospitalized with pneumonia.¹⁵⁹ More basic than

the choice of a particular antibiotic regimen is the timely administration of any antibiotic to the patient, which bears a plausible connection to improved outcomes.¹⁶⁰

Empirical evidence shows that pneumonia mortality is positively related to stroke, gastrointestinal hemorrhage, and congestive heart failure.¹⁶¹

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

All in-hospital mortality measures may encourage earlier post-operative discharge, and thereby shift deaths to skilled nursing facilities or outpatient settings. This phenomenon may also lead to biased comparisons among hospitals with different mean lengths of stay.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

Pneumonia mortality is used as an indicator by the University Hospital Consortium, Greater New York Hospital Association, HealthGrades.com, Maryland Hospital Association, the Pennsylvania Health Care Cost Containment Council, and the California Hospital Outcomes Project.

Rockville, MD. <http://www.ahrq.gov/data/hcup/>

¹⁵⁶Markowitz JS, Pashko S, Gutterman EM, et al. Death rates among patients hospitalized with community-acquired pneumonia: a reexamination with data from three states. *Am J Public Health* 1996;86(8 Pt 1):1152-4.

¹⁵⁷Fine MJ, Smith MA, Carson CA, et al. Prognosis and outcomes of patients with community-acquired pneumonia. A meta-analysis. *JAMA* 1996;275(2):134-41.

¹⁵⁸Davis RB, Iezzoni LI, Phillips RS, et al. Predicting in-hospital mortality. The importance of functional status information. *Med Care* 1995;33(9):906-21.

¹⁵⁹Gleason PP, Heehan TP, Fine JM, et al. Associations between initial antimicrobial therapy and medical outcomes for hospitalized elderly patients with

pneumonia. *Arch Intern Med* 1999;159(21):2562-72.

¹⁶⁰Meehan TP, Fine MJ, Krumholz HM, et al. Quality of care, process, and outcomes in elderly patients with pneumonia. *JAMA* 1997;278(23):2080-4.

¹⁶¹Nationwide Inpatient Sample.

Cesarean Section Delivery Rate

Cesarean delivery is the most common operative procedure performed in the United States and is associated with higher costs than vaginal delivery. Despite a recent decrease in the rate of Cesarean sections, many organizations have aimed to monitor and reduce the rate.

Relationship to Quality	Cesarean section has been identified as an overused procedure. As such, lower rates represent better quality.
Benchmark	State, regional, or peer-group average.
Definition	Provider-level number of Cesarean sections per 100 deliveries.
Numerator	Number of Cesarean sections.
Denominator	All deliveries.
Type of Indicator	Provider Level, Procedure Utilization Indicator
Empirical Rating	17

Summary of Evidence

The rate of Cesarean section in the United States increased from 5.5% in 1970 to a high of 24.7% in 1988 and decreased to 20.7% in 1996.¹⁶² A review of the literature indicates that risk adjustment affects the outlier status and rankings of as many as 25% of hospitals. Given these results, providers may want to examine the clinical characteristics of their populations when interpreting the results of this indicator.

Clinical characteristics such as prior Cesarean, parity, breech presentation, placental or cord complications, sexually transmitted diseases (STDs), infections, and birth weight have been shown to explain substantial variation in Cesarean section rates. Information regarding some of these factors may be available by linking maternal discharge records to birth records. Providers may also wish to break down this indicator into primary and repeat Cesarean section rates. Empirical analyses demonstrated that Cesarean section rate is measured with good precision.

Limitations on Use

Potential additional bias may result from clinical differences not identifiable in administrative data, so supplemental risk adjustment with linked birth

records or other clinical data may be desirable. As a utilization indicator, the construct validity relies on the actual inappropriate use of procedures in hospitals with high rates, which should be investigated further.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

While the appropriateness of Cesarean section depends largely on patients' clinical characteristics, studies have shown that individual physician practice patterns account for a significant portion of the variation in Cesarean delivery rates.^{163 164} Non-clinical factors such as patient insurance status,

¹⁶²Menard MK. Cesarean delivery rates in the United States. The 1990s. *Obstet Gynecol Clin North Am* 1999;26(2):275-86.

¹⁶³Goyert GL, Bottoms FS, Treadwell MC, et al. The physician factor in cesarean birth rates [see comments]. *N Engl J Med* 1989;320(11):706-9.

¹⁶⁴Berkowitz GS, Fiarman GS, Mojica MA, et al. Effect of physician characteristics on the cesarean birth rate [see comments]. *Am J Obstet Gynecol* 1989;161(1):146-9.

hospital characteristics, and geographic region have also been related to rates.^{165 166 167}

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Based on empirical evidence, this indicator is precise, with a raw provider level mean of 21.4% and a substantial standard deviation of 8.7%.¹⁶⁸

Relative to other indicators, a higher percentage of the variation occurs at the provider level rather than the discharge level. However, the signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is high, at 88.2%, indicating that the observed differences in provider performance represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

The overall Cesarean section rate cannot determine appropriate use, but the variation in rates across institutions and regions may, if the variations do not merely reflect variations in patient disease severity and comorbidities.

Aron et al. used data from standardized reviews of medical records to adjust for clinical risk factors in women without prior Cesarean section. They found that hospital rankings often changed after risk adjustment, and in 57% of hospitals, the relative difference in unadjusted and adjusted rates was

greater than 10%.¹⁶⁹ Additional studies found that risk-adjusting primary Cesarean delivery rates using a State birth certificate database substantially changes how hospital performance is judged.¹⁷⁰

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

The Cesarean rate for “optimal” quality of care is unknown, and many studies note that lower Cesarean rates do not necessarily reflect better quality care. Based on empirical evidence, Cesarean section rate is inversely related to vaginal delivery after Cesarean (VBAC).¹⁷¹

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

The Cesarean delivery rate can be decreased by decreasing the primary Cesarean delivery rate or increasing the VBAC rate. Sachs et al. note that when a trial of labor after Cesarean delivery fails, the rate of maternal morbidity, including infection and operative injuries, increases substantially.¹⁷²

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

Cesarean section was included in the original HCUP QIs, and the reduction of Cesarean section rate is a goal for Healthy People 2010.¹⁷³

¹⁶⁵Stafford RS. The impact of nonclinical factors on repeat cesarean section [see comments]. JAMA 1991;265(1):59-63.

¹⁶⁶Haas JS, Udvarhelyi S, Epstein AM. The effect of health coverage for uninsured pregnant women on maternal health and the use of cesarean section [see comments]. JAMA 1993;270(1):61-4.

¹⁶⁷Stafford RS, Sullivan SD, Gardner LB. Trends in cesarean section use in California, 1983 to 1990. Am J Obstet Gynecol 1993;168(4):1297-302.

¹⁶⁸Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup>

¹⁶⁹Aron DC, Harper DL, Shepardson LB, et al. Impact of risk-adjusting cesarean delivery rates when reporting hospital performance. JAMA 1998;279(24):1968-72.

¹⁷⁰Balit JL, Dooley SL, Peaceman AN. Risk adjustment for interhospital comparison of primary cesarean rates. Obstet Gynecol 1999;93(6):1025-30.

¹⁷¹Nationwide Inpatient Sample.

¹⁷²Sachs BP, Kobelin C, Castro MA, et al. The risks of lowering the cesarean-delivery rate. N Engl J Med 1999;340(1):54-7.

¹⁷³Healthy People 2010. Office of Disease Prevention and Health Promotion, U.S. Department of Health and Human Services.

Vaginal Birth After Cesarean Rate

The policy of recommending vaginal birth after Cesarean section (VBAC) represents to some degree a matter of opinion on the relative risks and benefits of a trial of labor in patients with previous Cesarean section.

Relationship to Quality	VBAC has been identified as a potentially underused procedure. As such, higher rates represent better quality.
Benchmark	State, regional, or peer-group average.
Definition	Provider-level vaginal births per 100 discharges with a diagnosis of previous Cesarean section.
Numerator	Number of vaginal births in women with a diagnosis of previous Cesarean section.
Denominator	All deliveries with a previous Cesarean section diagnosis in any diagnosis field.
Type of Indicator	Provider Level, Procedure Utilization Indicator
Empirical Rating	19

Summary of Evidence

Health People 2010 established a goal of indirectly increasing VBAC rates by decreasing Cesarean sections in women with previous Cesarean sections to 63%.¹⁷⁴

This indicator is measured with very good precision, and it is likely that the observed differences represent true differences in provider performance rather than random variation. According to the literature, some clinical factors—such as previous classic Cesarean section—may contraindicate VBAC, and this indicator should be risk-adjusted for these factors. Because these clinical factors may not be available in administrative data, linkage to birth records may provide for better risk adjustment.

The best rate for VBAC has not been established. This indicator should be used in conjunction with area rates, national rates, and complication rates (maternal uterine rupture and length of stay, neonatal length of stay) to assess whether a rate is truly too high or too low.

¹⁷⁴Healthy People 2010. Office of Disease Prevention and Health Promotion. U.S. Department of Health and Human Services.

Limitations on Use

Selection bias due to patient preferences and other factors may impact performance on this indicator. As noted earlier, supplemental adjustment with linked birth records or other clinical data may be desirable to address bias from clinical differences not identifiable in administrative data.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

Despite the widespread use of VBAC rates as a quality indicator, a randomized trial comparing a trial of labor with elective repeat Cesarean section has yet to appear. In addition, approximately one-third of patients prefer to pursue repeat Cesarean section.¹⁷⁵ Many physicians appear to consider Cesarean delivery preferable to vaginal delivery, given the potential complications of the former.¹⁷⁶

¹⁷⁵Roberts RG, Bell HS, Wall EM, et al. Trial of labor or repeated cesarean section. The woman's choice. Arch Fam Med 1997;6(2):120-5.

¹⁷⁶Al-Mufti R, McCarthy A, Fisk NM. Obstetricians' personal choice and mode of delivery [letter] [see comments]. Lancet 1996;347(9000):544.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Empirical evidence shows that this indicator is very precise, with a raw provider level mean of 33.6% and a substantial standard deviation of 14.8%.¹⁷⁷ Relative to other indicators, a higher percentage of the variation occurs at the provider level rather than the discharge level. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is high, at 83.1%. This indicates that the observed differences in provider performance likely represent true differences, although some of the observed difference is due to patient characteristics.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

A study using birth certificates suggests that administrative data accurately distinguish the current mode of delivery (vaginal vs. Cesarean section), but less accurately identify VBAC and primary Cesarean delivery.¹⁷⁸ In addition, administrative data sources do not include the clinical factors required to identify appropriate candidates for trial of labor.¹⁷⁹ As a result, the denominator for VBAC rates calculated using administrative data will include women with an accepted medical indication for repeat Cesarean delivery, as well as patients who make an informed decision not to pursue a trial of labor.¹⁸⁰

¹⁷⁷Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup>

¹⁷⁸Green DC, Moore JM, Adams MM, et al. Are we underestimating rates of vaginal birth after previous cesarean birth? The validity of delivery methods from birth certificates. *Am J Epidemiol* 1998;147(6):581-6.

¹⁷⁹Aron DC, Harper DL, Shepardson LB, et al. Impact of risk-adjusting cesarean delivery rates when reporting hospital performance. *JAMA* 1998;279(24):1968-72.

¹⁸⁰Roberts RG, Bell HS, Wall EM, et al. Trial of labor or repeated cesarean section. The woman's choice. *Arch Fam Med* 1997;6(2):120-5.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

The likelihood that a patient will undergo VBAC correlates with certain provider and institutional variables, suggesting that certain providers are more likely to adapt to changes in policy or technology. Based on empirical results, VBAC rates are inversely related to Cesarean section delivery.¹⁸¹

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Promotion of VBAC as a quality indicator has led to successful increases in the VBAC rate in some cases, but not in others.^{182 183}

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

VBAC was included in the original HCUP QI indicator set. In addition, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) has selected VBAC as one of its core measures.

¹⁸¹Nationwide Inpatient Sample.

¹⁸²Kazandjian VA, Lied TR. Cesarean section rates: effects of participation in a performance measurement project. *Jt Comm J Qual Improv* 1998;24(4):187-96.

¹⁸³Bickell NA, Zdeb MS, Applegate MS, et al. Effect of external peer review on cesarean delivery rates: a statewide program. *Obstet Gynecol* 1996;87(5 Pt 1):664-7.

Laparoscopic Cholecystectomy Rate

Surgical removal of the gall bladder (cholecystectomy) performed with a laparoscope has been identified as an underused procedure. Laparoscopic cholecystectomy is associated with less morbidity in less severe cases.

Relationship to Quality	Laparoscopic cholecystectomy is a new technology with lower risks than open cholecystectomy (removal of the gall bladder). Higher rates represent better quality.
Benchmark	State, regional, or peer-group average.
Definition	Number of laparoscopic cholecystectomies per 100 cholecystectomies.
Numerator	Number of laparoscopic cholecystectomies (any procedure field).
Denominator	All discharges with any procedure code of cholecystectomy in any field. Include only discharges with uncomplicated cases: cholecystitis or cholelithiasis in any diagnosis field. Exclude MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and other neonates).
Type of Indicator	Provider Level, Procedure Utilization Indicator
Empirical Rating	20

Summary of Evidence

Cholecystectomy—surgical removal of the gall bladder—is now performed with a laparoscope in about 75% of uncomplicated cases.¹⁸⁴

This indicator has a high percentage of variation attributable to providers. According to the literature, laparoscopic cholecystectomy may need to be adjusted for clinical severity, age, and other factors, because the procedure may be contraindicated for some patients, and others may not be clinically severe enough to qualify for cholecystectomy at all. Too many procedures in patients without appropriate clinical indications may artificially inflate the laparoscopic cholecystectomy rate without improving quality.

Limitations on Use

Up to one-half of all cholecystectomies are performed on an outpatient basis, and providers should incorporate outpatient data if possible when interpreting this indicator. Additional bias may result from clinical differences not identifiable in administrative data, so supplemental risk adjustment using other clinical data may be desirable. As a utilization indicator, the construct validity relies on the actual appropriate use of procedures in hospitals with high rates, which should be investigated further.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

Laparoscopic cholecystectomy is associated with less postoperative pain, lower patient-controlled morphine consumption, better postoperative

¹⁸⁴Southern Surgeons Club. A prospective analysis of 1518 laparoscopic cholecystectomies. *NEJM* 1991;324:1073-1078.

pulmonary function and oxygen saturation, and quicker return to limited activity.^{185 186}

Laparoscopic cholecystectomy requires more technical skill than the open approach. Therefore, a higher rate for this procedure (as a proportion of all cholecystectomies) suggests that a hospital can rapidly achieve proficiency in up-to-date treatment methods.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

According to the literature, cholecystectomies are relatively common, so moderately precise estimates of differences in laparoscopic use can be obtained. Based on empirical evidence, this indicator is very precise, with a raw provider level mean of 66.2% and a substantial standard deviation of 19.2%.¹⁸⁷

Relative to other indicators, a higher percentage of the variation occurs at the provider level, rather than the discharge level. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is high, at 89.1%, indicating that the observed differences in provider performance likely represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

As surgeons become more experienced in laparoscopic cholecystectomies, they are likely to perform the procedure on more difficult patients. In addition, higher risks of complications are

associated with older age and the presence of common bile duct stones.¹⁸⁸

Patient referral patterns and other selection factors may lead to substantial differences in laparoscopy rates (as a proportion of all cholecystectomies) across hospitals. Empirical results show that age and sex adjustment does seem to disproportionately impact hospitals in the low extreme relative to those in the high extreme.

Use of inpatient data could be substantially biasing, in that it eliminates those cholecystectomies performed on an outpatient basis, most of which are likely to be laparoscopic.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

According to the literature, there is no evidence that hospitals that use the laparoscopic approach more frequently provide better quality of care, based on other measures.

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

One concern with this indicator is that the advent of laparoscopic surgery has led to a substantial increase in the overall cholecystectomy rate, especially involving uncomplicated and elective patients.¹⁸⁹ Another concern is that the “optimal” rate for this procedure has not been defined, and incentives to increase use may have negative consequences if local physicians lack appropriate training and expertise.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

Laparoscopic cholecystectomy was included in the original HCUP QI indicator set.

¹⁸⁵McMahon AJ, Russell IT, Baxter JN, et al. Laparoscopic and minilaparotomy cholecystectomy: a randomised trial [see comment]. *Lancet* 1994;343(8890):135-8.

¹⁸⁶McMahon AF, Russell IT, Ramsay G, et al. Laparoscopic and minilaparotomy cholecystectomy: a randomized trial comparing postoperative pain and pulmonary function. *Surgery* 1994;115(5):533-9.

¹⁸⁷Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup>

¹⁸⁸Jatzko GR, Lisborg PH, Pertl AM, et al. Multivariate comparison of complications after laparoscopic cholecystectomy and open cholecystectomy. *Ann Surg* 1995;221(4):381-6.

¹⁸⁹Escarce JJ, Chen W, Schwartz JS. Falling cholecystectomy thresholds since the introduction of laparoscopic cholecystectomy. *JAMA* 1995;273(20):1581-5.

Incidental Appendectomy in the Elderly Rate

Removal of the appendix incidental to other abdominal surgery—such as urological, gynecological, or gastrointestinal surgeries—is intended to eliminate the risk of future appendicitis and to simplify any future differential diagnoses of abdominal pain.

Relationship to Quality	Incidental appendectomy among the elderly is contraindicated. As such, lower rates represent better quality.
Benchmark	State, regional, or peer-group average.
Definition	Number of incidental appendectomies per 100 elderly with intra-abdominal procedure.
Numerator	Number of incidental appendectomies (any procedure field).
Denominator	All discharges age 65 years or older with intra-abdominal procedure (based on DRGs). Exclude MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and neonates).
Type of Indicator	Provider Level, Procedure Utilization Indicator
Empirical Rating	13

Summary of Evidence

Incidental appendectomy is contraindicated in the elderly population, because this population has both a lower risk for developing appendicitis and a higher risk of postoperative complications. Given the low rate of incidental appendectomies, the precision for this indicator may be lower than other indicators.

Empirical analyses found that this indicator is moderately precisely measured, and the bias with respect to provider differences is not likely to be high.

Limitations on Use

As a utilization indicator, the construct validity relies on the actual inappropriate use of procedures in hospitals with high rates, which should be investigated further.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

For the population as a whole, evidence remains unclear whether the removal of the appendix

increases risk of morbidity and mortality significantly, or whether it is worth any amount of extra risk, given the low risk for future appendicitis and the ease of treatment.

Andrew and Roty showed that incidental appendectomy was associated with a higher risk of wound infection (5.9% versus 0.9%) among cholecystectomy patients who were at least 50 years of age, but not among younger patients.¹⁹⁰ Based on this finding and the findings of Warren and colleagues, the risk of incidental

¹⁹⁰Andrew MH, Roty AR, Jr. Incidental appendectomy with cholecystectomy: is the increased risk justified? *Am Surg* 1987;53(10):553-7.

appendectomy is believed to outweigh the benefits for elderly patients.^{191 192 193 194 195}

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Fewer than one-third of surgery departments routinely perform incidental appendectomies, and rates may be difficult to estimate with precision at the majority of hospitals where it is not a routine procedure.¹⁹⁶

Based on empirical evidence, this indicator is precise, with a raw provider level mean of 2.7% and a standard deviation of 3.5%.¹⁹⁷ Relative to other indicators, a higher percentage of the variation occurs at the discharge level than for some indicators. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is moderate, at 55.4%, indicating that some of the observed differences in provider performance do not represent true differences.

¹⁹¹Warren JL, Penberthy LT, Addiss DG, et al. Appendectomy incidental to cholecystectomy among elderly Medicare beneficiaries. *Surg Gynecol Obstet* 1993;177(3):288-94.

¹⁹²Fisher KS, Ross DS. Guidelines for therapeutic decision in incidental appendectomy. *Surg Gynecol Obstet* 1990;171(1):95-8.

¹⁹³Synder TE, Selanders JR. Incidental appendectomy—yes or no? A retrospective case study and review of the literature. *Infect Dis Obstet Gynecol* 1998;6(1)30-7.

¹⁹⁴Wolff BG. Current status of incidental surgery. *Dis Colon Rectum* 1995;38(4):435-41.

¹⁹⁵Nockerts SR, Detmer DE, Fryback, DG. Incidental appendectomy in the elderly? No. *Surgery* 1980;88(2):301-6.

¹⁹⁶Neulander EZ, Hawke CK, Soloway MS. Incidental appendectomy during radical cystectomy: an interdepartmental survey and review of the literature. *Urology* 2000;56(2):241-4.

¹⁹⁷Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup>

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Incidental appendectomy appears to be contraindicated in an elderly population; therefore, very few (if any) cases would be justified by patients' preoperative characteristics. Empirical evidence shows that this indicator performs well to very well on multiple measures of minimum bias, and risk adjustment does not appear to impact the extremes of the distribution substantially.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

Most of the available evidence appears to contraindicate incidental appendectomy in the elderly, and performance of the procedure is subject to patient and surgeon preference. Therefore, incidental appendectomy rates may correlate poorly with other measures of hospital performance.

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Incidental appendectomy does not generally affect hospital payment; therefore, widespread use of this indicator may lead to less frequent coding of the procedure when it is performed. A reduction in the rate of incidental appendectomy may lead to a subsequent increase in the incidence of acute appendicitis, although this risk is expected to be small for the elderly population.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

Incidental appendectomy in the elderly is a provider-level utilization indicator in the original HCUP QI set.

Bilateral Cardiac Catheterization Rate

Right-side coronary catheterization incidental to left-side catheterization has little additional benefit for patients without indications of right-side catheterization.

Relationship to Quality	Bilateral catheterization is contraindicated in most patients without proper indications. As such, lower rates represent better quality.
Benchmark	State, regional, or peer-group average.
Definition	Provider level bilateral cardiac catheterizations per 100 discharges with procedure code of heart catheterization.
Numerator	All simultaneous right and left heart catheterizations (in any procedure field). Exclude valid indications for right-sided catheterization in any diagnosis field.
Denominator	All heart catheterizations in any procedure field. Include only coronary artery disease. Exclude MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and other neonates).
Type of Indicator	Provider Level, Procedure Utilization Indicator
Empirical Rating	25

Summary of Evidence

Bilateral cardiac catheterization received one of the highest precision ratings. Provider level variation accounts for a relatively large portion of the total variation compared to other indicators, meaning that variation for this indicator is influenced less by discharge level variation (patient level) than total variation for other indicators. It is likely that the observed differences in provider performance represent true differences, rather than random variation.

Analyses of minimum bias identified very little bias in this indicator when adjusting for APR-DRGs.

Limitations on Use

Outpatient procedures may result in selection bias for this indicator and should be examined. In addition, as a utilization indicator, the construct validity relies on the actual inappropriate use of procedures in hospitals with high rates, which should be investigated further.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

Left-sided catheterization provides very useful information about coronary anatomy, as well as left ventricular function and valvular anatomy. However, the clinical yield for right-sided catheterization, which is often performed at the same time, is extremely low. The American College of Cardiology (ACC) and the American Heart Association (AHA) published guidelines for cardiac catheterization laboratories stating that “without specific indications, routine right heart catheterizations...are unnecessary.”¹⁹⁸

¹⁹⁸Pepine CJ, Allen HD, Bashore TM, et al. ACC/AHA guidelines for cardiac catheterization and cardiac catheterization laboratories. American College of Cardiology/American Heart Association Ad Hoc Task Force on Cardiac Catheterization. *Circulation* 1991;84(5):2213-47.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

This measure should be estimable with reasonable precision, given that more than 1.2 million inpatient cardiac catheterizations were performed in the United States in 1998.¹⁹⁹ Based on empirical evidence, this indicator is very precise, with a raw provider level mean of 19.3% and a substantial standard deviation of 20.0%.²⁰⁰

Relative to other indicators, a higher percentage of the variation occurs at the provider level, rather than the discharge level. The signal ratio (i.e., the proportion of the total variation across providers that is truly related to systematic differences in provider performance rather than random variation) is very high, at 96.2%, indicating that the observed differences in provider performance likely represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Bilateral cardiac catheterization is considered appropriate in the presence of certain clinical indications: suspected pulmonary hypertension or significant right-sided valvular abnormalities, congestive heart failure, cardiomyopathies, congenital heart disease, pericardial disease, and cardiac transplantation. The validity of this measure rests on the assumption that the prevalence of these clinical indications is low and relatively uniform across the country. However, Malone et al. found that substantial variation in the use of bilateral catheterization persisted among 37 cardiologists at two large community hospitals, even after adjusting for clinical indications.²⁰¹

¹⁹⁹Hall M, Popovic J. 1998 summary: National Hospital Discharge Survey. Advance Data from Vital and Health Statistics 2000;316.

²⁰⁰Nationwide Inpatient Sample and State Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup>

²⁰¹Malone ML, Bajwa TK, Battiola RJ, et al. Variation among cardiologists in the utilization of right heart catheterization at time of coronary angiography [see comments]. *Cathet Cardiovasc Diagn* 1996;37(2):125-30.

Another source of potential bias is the large number of catheterizations performed on an outpatient basis.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

No studies were found that explicitly address the construct validity of this indicator. Empirical testings show that bilateral catheterization is positively related to coronary artery bypass graft (CABG) and negatively related to laparoscopic cholecystectomy.²⁰²

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Bilateral cardiac catheterization does not generally affect hospital payment; therefore, widespread use of this indicator may lead to less frequent coding when the procedure is performed. A reduction in the rate of bilateral cardiac catheterization may lead to rare, but potentially serious, missed diagnoses (e.g., pulmonary hypertension).

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

Bilateral cardiac catheterization has been widely used as an indicator of quality in the Medicare program and is one of five quality indicators included in the Medicare Quality of Care Report of Surveillance Measures.²⁰³ The success of education and outreach projects suggests that right heart catheterization rates represent an actionable opportunity for quality improvement.

²⁰²Nationwide Inpatient Sample.

²⁰³Medicare Quality of Care Report of Surveillance Measures. Centers for Medicare and Medicaid Services (formerly Health Care Financing Administration), U.S. Department of Health and Human Services.

Coronary Artery Bypass Graft Rate

Coronary artery bypass graft (CABG) is performed on patients with coronary artery disease. No ideal rate for CABG has been established.

Relationship to Quality	CABG is an elective procedure that may be overused; therefore, more average rates would represent better quality.
Benchmark	State, regional, or peer group average.
Definition	Number of CABGs per 100,000 population.
Numerator	Number of CABGs in any procedure field. Age 40 years or older. Exclude MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and neonates).
Denominator	Population in MSA or county, age 40 years or older.
Type of Indicator	Area Level, Utilization Indicator
Empirical Rating	19

Summary of Evidence

CABG is a potentially overused procedure, although several studies have noted that CABG is not often performed for inappropriate indications (under 15%). The risk factors associated with CABG include smoking, hyperlipidemia, and older age, and risk adjustment with demographic data—at a minimum—is recommended. This indicator was designed for use with CABG volume and mortality indicators.

This indicator is measured with very high precision. Substantial and systematic small area variation that is not explained by sociodemographic characteristics has been noted in the literature. Examination of data containing patient residence may aid in identifying the extent to which patients are referred into an area.

Limitations on Use

As an area utilization indicator, CABG is a proxy for actual quality problems. This indicator in particular has unclear construct validity, because CABG does not appear to be performed inappropriately often. Caution should be maintained for CABG rates that are drastically below or above the average or recommended rates.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

Most previous studies of small area variation have found relatively high variation in CABG rates, as noted by the systematic component of variation (.758), which compares geographic variability between DRGs after removing random effects.²⁰⁴ This variation is not explained by population characteristics such as age and sex. No randomized controlled trials have demonstrated that CABG improves clinical outcomes in patients with symptoms less major than three-vessel disease, previous myocardial infarction, or less than strongly positive exercise ECG tests.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Precise estimates of utilization can be generated at the area level; however, random variation may become more problematic for relatively small areas

²⁰⁴Gittelsohn A, Powe NR, Small area variations in health care delivery in Maryland. *Health Serv Res* 1995;30(2):295-317.

(e.g., ZIP codes) or underpopulated areas (e.g., rural counties). Based on empirical evidence, the indicator is moderately precise, with a raw area level mean of 180.4 per 100,000 population and a standard deviation of 571.6.²⁰⁵

Relative to other indicators, a larger percentage of the variation occurs at the area level, rather than the discharge level. The signal ratio (i.e., the proportion of the total variation that is truly related to systematic differences in area performance rather than random variation) is very high, at 97.3%, indicating that observed differences in area performance very likely represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

The prevalence of coronary artery disease may be related to the age structure of the population and the prevalence of behavioral or physiologic risk factors such as smoking and hyperlipidemia. Although race and demographic factors have significant effects on the likelihood of CABG, previous studies have shown that sociodemographic differences account for very little of the observed variation in CABG rates.²⁰⁶

Some differences in CABG rates across areas may be attributable to the referral of rural and other patients from outside the area for surgery; however, such referrals are unlikely to explain a large part of the substantial differences in rates across small geographic areas.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

Although most studies have found relatively low rates of inappropriate CABG use, there is some evidence of variation in inappropriate rates across geographic areas. In addition, a larger proportion of bypass surgery procedures is performed for indications in which benefits are uncertain;

²⁰⁵Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/>

²⁰⁶Leape LL, Hilborne LH, Park RE, et al. The appropriateness of use of coronary artery bypass graft surgery in New York state. JAMA 1993;269(6):753-60.

procedure rates for uncertain indications may also vary substantially across hospitals and areas.

In a follow-up to a New York appropriateness study, a panel of cardiologists found a rate of inappropriate procedure of 6% and a rate of uncertain procedures of 12%.²⁰⁷ In another study of 12 hospitals, the rate of CABG for inappropriate indications ranged from 0% to 5% across hospitals, and the rate of CABG for uncertain indications ranged from 5% to 8%.²⁰⁸

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Little evidence exists on whether the use of CABG as a quality indicator might differentially reduce procedures that are inappropriate or of unclear benefit, rather than appropriate procedures.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

The hospital-based rate of CABG was included in the original HCUP QI indicator set. The area-based rate of CABG is a current indicator in the Dartmouth Atlas.²⁰⁹

²⁰⁷Leape LL, Park RE, Bashore TM, et al. Effect of variability in the interpretation of coronary angiograms on the appropriateness of use of coronary revascularization procedures. American Heart Journal 2000;139(1 Pt 1):106-13.

²⁰⁸Leape LL, Hilborne LH, Schwartz JS, et al. The appropriateness of coronary artery bypass graft surgery in academic medical centers. Working Group of the Appropriateness Project of the Academic Medical Center Consortium. Ann Intern Med 1996;125(1):8-18.

²⁰⁹Dartmouth Atlas of Health Care, Center for the Evaluative Clinical Sciences at Dartmouth Medical School.

Percutaneous Transluminal Coronary Angioplasty Rate

Percutaneous transluminal coronary angioplasty (PTCA) is performed on patients with coronary artery disease. No ideal rate for PTCA has been established.

Relationship to Quality	PTCA has been identified as a potentially overused procedure; therefore, more average rates represent better quality care.
Benchmark	State, regional, or peer group average.
Definition	Number of PTCA procedures per 100,000 population.
Numerator	Number of PTCA procedures in any procedure field. Age 40 years and older. Exclude MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and neonates).
Denominator	Population in MSA or county, age 40 years and older.
Type of Indicator	Area Level, Utilization Indicator
Empirical Rating	19

Summary of Evidence

PTCA is a potentially overused procedure, and rates vary widely and systematically between areas. Patient and physician preferences may play a role in this variation. Clinical factors that are appropriate indications for PTCA may be more prevalent in areas with an older age structure or higher rates of smoking or hyperlipidemia. It is unlikely that these factors would account for all the observed variance.

Empirical evidence shows that risk adjustment by age and sex affects the performance of this indicator; without adequate risk adjustment, areas may be mislabeled as outliers. In addition, examination of data containing patient residence may aid in identifying the extent to which patients are referred into an area.

Limitations on Use

As an area utilization indicator, PTCA is a proxy for actual quality problems. The indicator has unclear construct validity, as high utilization of PTCA has not been shown to necessarily be associated with higher rates of inappropriate utilization. A minor source of bias may be the small number of procedures performed on an outpatient basis. Caution should be maintained for PTCA rates that

are drastically below or above the average or recommended rates.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

No randomized controlled trials have demonstrated that PTCA improves clinical outcomes in many patients who commonly receive the procedure, and previous studies have documented large differences across hospitals in the likelihood of treatment with PTCA after myocardial infarction and in other clinical settings. Studies on small area variation also found substantial variation in PTCA rates.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Precise estimates of utilization can be generated at the area level; however, random variation may become more problematic for relatively small areas (e.g., ZIP codes) or underpopulated areas (e.g., rural counties). Based on empirical evidence, this indicator is precise, with a raw area level mean of

190.8 per 100,000 population and a standard deviation of 455.6.²¹⁰

Relative to other indicators, a higher percentage of the variation occurs at the area level, rather than the discharge level. The signal ratio (i.e., the proportion of the total variation that is truly related to systematic differences in area performance rather than random variation) is very high, at 97.3%, indicating that observed differences in area performance very likely represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Little evidence exists on the extent to which area differences in socioeconomic and clinical characteristics may explain area differences in PTCA rates, although large variations in rates across small geographic areas suggest that population characteristics are unlikely to explain most of the differences.²¹¹

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

For this indicator to perform well in identifying true quality of care problems, there must be evidence of significant inappropriate use in population-based studies, as well as substantial variation in the rate of inappropriate use across providers or small areas. In a study of seven Swedish heart centers, 38.3% of all PTCA procedures were performed for inappropriate indications and 30% for uncertain indications.²¹² In a follow-up study of a coronary

angiography study conducted in New York, a panel of cardiologists found the rate for inappropriate indications was 12% and the rate of procedures performed for uncertain indications was 27%.²¹³

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Providers might engage in practices such as miscoding cases or recruiting patient groups that are known to have increased risk of coronary artery disease to achieve more favorable quality assessment results. Instead of serving as quality assessments, patients and their providers might use the results of appropriateness studies to spark questions and discussion about coronary artery disease, the patient's specific indications, and the treatment that poses the least risk to the patient.²¹⁴

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

The area-based rate of PTCA is a current indicator in the Dartmouth Atlas.²¹⁵

²¹⁰Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/>

²¹¹Ziskind AA, Lauer MA, Bishop G, et al. Assessing the appropriateness of coronary revascularization: the University of Maryland Revascularization Appropriateness Score (RAS) and its comparison to RAND expert panel ratings and American College of Cardiology/American Heart Association guidelines with regard to assigned appropriateness rating and ability to predict outcome. *Clin Cardiol* 1999;22(2):67-76.

²¹²Bernstein SJ, Brorsson B, Aberg T, et al. Appropriateness of referral of coronary angiography patients in Sweden. SECOR/SBU Project Group. *Heart*

1999;81(5):470-7.

²¹³Leape LL, Park RE, Bashore TM, et al. Effect of variability in the interpretation of coronary angiograms on the appropriateness of use of coronary revascularization procedures. *American Heart Journal* 2000;139(1 Pt 1):106-13.

²¹⁴Hilborne LH, Leape LL, Bernstein SJ, et al. The appropriateness of use of percutaneous transluminal coronary angioplasty in New York state. *JAMA* 1993;269(6):761-5.

²¹⁵Dartmouth Atlas of Health Care, Center for the Evaluative Clinical Sciences at Dartmouth Medical School.

Hysterectomy Rate

Hysterectomy is performed on patients with a number of indications, such as recurrent uterine bleeding, chronic pelvic pain, or menopause, usually in some combination. No ideal rate for hysterectomy has been established.

Relationship to Quality	Hysterectomy has been identified as a potentially overused procedure; therefore, more average rates represent better quality care.
Benchmark	State, regional, or peer group average.
Definition	Number of hysterectomies per 100,000 population.
Numerator	Number of hysterectomies in any procedure field. Females age 18 years and older. Exclude discharges with diagnosis for genital cancer or pelvic or lower abdominal trauma in any diagnosis field. Exclude MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and neonates).
Denominator	Female population in MSA or county age 18 years or older.
Type of Indicator	Area Level, Utilization Indicator
Empirical Rating	22

Summary of Evidence

Hysterectomy is a potentially overused procedure. Population rates have been shown to vary systematically by small geographic area; however, patient and physician preference may play a role in the choice to have a hysterectomy, which in turn may affect area rates. Examination of data containing patient residence may aid in identifying the extent to which patients are referred into an area.

This indicator is not expected to be substantially biased, because it is unlikely that appropriate indications for hysterectomy would vary systematically by area. However, risk adjustment with age is recommended. Although the ideal rate for hysterectomy has not been established, several studies have noted relatively high rates of inappropriate indicators for surgery (16-70%).

Limitations on Use

As an area utilization indicator, hysterectomy is a proxy for actual quality problems. The indicator has unclear construct validity, as high utilization of hysterectomy has not been shown to necessarily be

associated with higher rates of inappropriate utilization. Additional clinical risk adjustment, such as for parity, may be desirable. Caution should be maintained for hysterectomy rates that are drastically below or above the average or recommended rates.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

No randomized controlled trials have demonstrated that hysterectomy improves outcomes in patients with uncertain clinical indications, including persistent or recurrent abnormal bleeding, pain, adnexal mass, limited hormonal therapy, and premenopausal age.

Small area variation has been noted in the literature on hysterectomy rates.²¹⁶

²¹⁶Gittlesohn A, Powe NR. Small area variations in health care delivery in Maryland. *Health Serv Res* 1995;30(2):295-317.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Precise estimates of utilization can be generated at the area level; however, random variation may become more problematic for relatively small areas (e.g., ZIP codes) or underpopulated areas (e.g., rural counties). Based on empirical evidence, this indicator is precise, with a raw area level rate of 419.4 per 100,000 population and a substantial standard deviation of 323.3.²¹⁷

Relative to other indicators, a higher percentage of the variation occurs at the area level, rather than the discharge level. The signal ratio (i.e., the proportion of the total variation that is truly related to systematic differences in area performance rather than random variation) is very high, at 93.6%, indicating that observed differences in area performance likely represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Utilization rates standardized at the area level (e.g., adult population of the county or standard metropolitan statistical area) may be biased by differences in the prevalence of those indications that warrant the procedure. The prevalence of these indications may, in turn, be related to the age structure of the population and the prevalence of behavioral or physiologic risk factors. In a study of seven managed care organizations, older women were more likely than younger women to have received a hysterectomy for appropriate reasons.²¹⁸

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

For this indicator to perform well in identifying true quality of care problems, there must be evidence of

significant inappropriate use in population-based studies, as well as substantial variation in the rate of inappropriate use across providers or small areas. In a random sample of 642 hysterectomies, 16% of procedures were inappropriate based on patient indications, and 25% were uncertain.²¹⁹ Another study found a 70% rate of overall inappropriate indications, varying from 45% to 100% across diagnoses indicative of hysterectomy.²²⁰

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Little evidence exists on whether hysterectomy as a quality indicator might reduce appropriate as well as inappropriate hysterectomies, or the extent to which overall hysterectomy rates are correlated with inappropriate hysterectomy rates.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

The hospital-based rate of hysterectomy was included in the original HCUP QI indicator set. The area-based rate of hysterectomy is a current indicator in the Dartmouth Atlas.²²¹

²¹⁷Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/>

²¹⁸Bernstein SJ, McGlynn EA, Siu AL, et al. The appropriateness of hysterectomy. A comparison of care in seven health plans. Health Maintenance Organization Quality of Care Consortium [see comments]. JAMA 1993;269(18):2398-402.

²¹⁹Bernstein et al., 1993.

²²⁰Broder MS, Kanouse DE, Mittman BS, et al. The appropriateness of recommendations for hysterectomy. Obstet Gynecol 2000;95(2):199-205.

²²¹Dartmouth Atlas of Health Care, Center for the Evaluative Clinical Sciences at Dartmouth Medical School.

Laminectomy or Spinal Fusion Rate

Laminectomy is performed on patients with a herniated disc or spinal stenosis. No ideal rate for laminectomy has been established.

Relationship to Quality	Laminectomy has been identified as a potentially overused procedure; therefore, more average rates represent better quality care.
Benchmark	State, regional, or peer group average.
Definition	Number of laminectomies or spinal fusions per 100,000 population.
Numerator	Number of laminectomies or spinal fusions in any procedure field. Age 18 years and older. Exclude MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and neonates).
Denominator	Population in MSA or county, age 18 years or older.
Type of Indicator	Area Level, Utilization Indicator
Empirical Rating	20

Summary of Evidence

Laminectomy, which is a potentially overused procedure, has been shown to vary widely and systematically between areas. Patient and physician preference may play a role in the decision to have a laminectomy, which may in turn affect area rates.

Empirical analysis suggests that performance is not highly influenced by the demographic breakdown of the population. Without adequate risk adjustment for age and sex, areas may be mislabeled as outliers. Although the ideal rate for laminectomy has not been established, several studies have noted relatively high rates of inappropriate procedures (23-38%).

High area rates may not take into account that some patients are referred into an area hospital from a different area. Examination of data with patient residence can help in determining the extent to which patients are referred into the area.

Limitations on Use

As an area utilization indicator, laminectomy is a proxy for actual quality problems. The indicator has unclear construct validity, as high utilization of laminectomy has not been shown to necessarily be

associated with higher rates of inappropriate utilization. Caution should be maintained for laminectomy rates that are drastically below or above the average or recommended rates.

Details

Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?

No randomized controlled trials have demonstrated that laminectomy improves outcomes in patients with uncertain clinical indications, including minor neurological findings, lengthy restricted activity, and equivocal imaging for discal hernia or spinal stenosis.

Prior research on small area variation has found relatively high variation in laminectomy rates.²²² Larequi-Lauber et al. report that the use of back surgery in the United States varies from one area to

²²²Gittlesohn A, Powe NR. Small area variations in health care delivery in Maryland. *Health Serv Res* 1995;30(2):295-317.

another by as much as 15-fold.²²³ This high variation was not explained by population characteristics such as age and sex.

Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?

Precise estimates of utilization can be generated at the area level; however, random variation may become more problematic for relatively small areas (e.g., ZIP codes) or underpopulated areas (e.g., rural counties). Based on empirical evidence, this indicator is moderately precise, with a raw area level mean of 139.0 per 100,000 population and a standard deviation of 347.5.²²⁴

Relative to other indicators, a higher percentage of the variation occurs at the area level, rather than the discharge level. The signal ratio (i.e., the proportion of the total variation that is truly related to systematic differences in area performance rather than random variation) is very high, at 96.7%, indicating that observed differences in area performance very likely represent true differences.

Minimal bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Utilization rates standardized at the area level (e.g., county or metropolitan statistical area) may be biased by differences in the prevalence of herniated disc or spinal stenosis, which may in turn be related to the age structure of the population and the prevalence of behavioral or physiologic risk factors. However, studies have shown that sociodemographic differences and other measurable population characteristics account for very little or none of the observed variation in laminectomy rates.²²⁵

²²³Larequi-Lauber T, Vader JP, Burnand B, et al. Appropriateness of indications for surgery of lumbar disc hernia and spinal stenosis. *Spine* 1997;22(2):203-9.

²²⁴Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/>

²²⁵Barron M, Kazandjian VA. Geographic variation in lumbar diskectomy: a protocol for evaluation. *QRB Qual Rev Bull* 1992;18(3):98-107.

Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?

For this indicator to perform well in identifying true quality of care problems, there must be evidence of significant inappropriate use in population-based studies, as well as substantial variation in the rate of inappropriate use across providers or small areas. In an assessment of cases at one Swiss hospital, 23% of patients received surgical treatment for herniated discs for inappropriate reasons and 29% received surgical treatment for uncertain indications.²²⁶ In another study of teaching hospital patients undergoing surgery for herniated disc or spinal stenosis, 38% of surgeries were performed for inappropriate indications.

Fosters true quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Little evidence exists on whether use of laminectomy as a quality indicator would lead to less performance of laminectomies for inappropriate or uncertain indications without reducing the use of laminectomy for appropriate indications.

Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

The hospital-based rate of laminectomy was included in the original HCUP QI indicator set. The area-based rate of laminectomy is a current indicator in the Dartmouth Atlas.²²⁷

²²⁶Porchet F, Vader JP, Larequi-Lauber T, et al. The assessment of appropriate indications for laminectomy. *J Bone Joint Surg Br* 1999;81(2):234-9.

²²⁷Dartmouth Atlas of Health Care, Center for the Evaluative Clinical Sciences at Dartmouth Medical School.

References

- Al-Mufti R, McCarthy A, Fisk NM. Obstetricians' personal choice and mode of delivery [letter] [see comments]. *Lancet* 1996;347(9000):544.
- American Heart Association. Heart Attack and Stroke Facts: 1996 Statistical Supplement. Dallas, TX: American Heart Association; 1996.
- Amundsen S, Skjaerven R, Trippestad A, et al. Abdominal aortic aneurysms. Is there an association between surgical volume, surgical experience, hospital type and operative mortality? Members of the Norwegian Abdominal Aortic Aneurysm Trial. *Acta Chir Scand* 1990;156(4):323-7; discussion 327-8.
- Andrew MH, Roty AR, Jr. Incidental appendectomy with cholecystectomy: is the increased risk justified? *Am Surg* 1987;53(10):553-7.
- Aron DC, Harper DL, Shepardson LB, et al. Impact of risk-adjusting cesarean delivery rates when reporting hospital performance. *JAMA* 1998;279(24):1968-72.
- Balit JL, Dooley SL, Peaceman AN. Risk adjustment for interhospital comparison of primary cesarean rates. *Obstet Gynecol* 1999;93(6):1025-30.
- Ball JK, Elixhauser A, Johantgen M, et al. *HCUP Quality Indicators, Methods, Version 1.1: Outcome, Utilization, and Access Measures for Quality Improvement*. (AHCPR Publication No. 98-0035). Healthcare Cost and Utilization project (HCUP-3) Research notes: Rockville, MD: Agency for Health Care Policy and Research, 1998.
- Barron M, Kazandjian VA. Geographic variation in lumbar discectomy: a protocol for evaluation. *QRB Qual Rev Bull* 1992;18(3):98-107.
- Begg CB, Cramer LD, Hoskins WJ, et al. Impact of hospital volume on operative mortality for major cancer surgery. *JAMA* 1998;280(20):1747-51.
- Berkowitz GS, Fiarman GS, Mojica MA, et al. Effect of physician characteristics on the cesarean birth rate [see comments]. *Am J Obstet Gynecol* 1989;161(1):146-9.
- Bernstein SJ, Brorsson B, Aberg T, et al. Appropriateness of referral of coronary angiography patients in Sweden. SECOR/SBU Project Group. *Heart* 1999;81(5):470-7.
- Bernstein SJ, McGlynn EA, Siu AL, et al. The appropriateness of hysterectomy. A comparison of care in seven health plans. Health Maintenance Organization Quality of Care Consortium [see comments]. *JAMA* 1993;269(18):2398-402.
- Bickell NA, Zdeb MS, Applegate MS, et al. Effect of external peer review on cesarean delivery rates: a statewide program. *Obstet Gynecol* 1996;87(5 Pt 1):664-7.
- Biller J, Feinberg WM, Castaldo JE, et al. Guidelines for carotid endarterectomy: a statement of healthcare professionals from a Special Writing Group of the Stroke Council, American Heart Association. *Circulation* 1998;97(5):501-9.
- Birkmeyer JD, Finlayson SR, Tosteson AN, et al. Effect of hospital volume on in-hospital mortality with pancreaticoduodenectomy. *Surgery* 1999;125(3):250-6.
- Broder MS, Kanouse DE, Mittman BS, et al. The appropriateness of recommendations for hysterectomy. *Obstet Gynecol* 2000;95(2):199-205.

- Brown RD, Whisnant JP, Sicks JD, et al. Stroke incidence, prevalence, and survival: secular trends in Rochester, Minnesota, through 1989. *Stroke* 1996;27(3):373-80.
- Cebul RD, Snow RJ, Pine R, et al. Indications, outcomes, and provider volumes for carotid endarterectomy. *JAMA* 1998;279(16):1282-7.
- Centers for Disease Control and Prevention. Report of Final Mortality Statistics, 1996. Volume 47, Number 9. Available at http://www.cdc.gov/nchs/products/pubs/nvsr/47-pre/47-pre.htm#NVSR47_19.
- Cook DJ, Guyatt GH, Salena BJ, et al. Endoscopic therapy for acute nonvariceal upper gastrointestinal hemorrhage: a meta-analysis. *Gastroenterology* 1992;102(1):139-48.
- Cooper GS, Chak A, Way LE, et al. Early endoscopy in upper gastrointestinal hemorrhage: associations with recurrent bleeding, surgery, and length of hospital stay. *Gastrointest Endosc* 1999;49(2):145-52.
- Dardik A, Burleyson GP, Bowman H, et al. Surgical repair of ruptured abdominal aortic aneurysms in the state of Maryland: factors influencing outcome among 527 recent cases. *J Vasc Surg* 1998;28(3):413-20.
- Dartmouth Atlas of Health Care, Center for the Evaluative Clinical Sciences at Dartmouth Medical School, 1999.
- Davis RB, Iezzoni LI, Phillips RS, et al. Predicting in-hospital mortality. The importance of functional status information. *Med Care* 1995;33(9):906-21.
- Dudley RA, Johansen KL, Brand R, et al. Selective referral to high-volume hospitals: estimating potentially avoidable deaths. *JAMA* 2000;283(9):1159-66.
- Eagle KA, Guyton RA, Davidoff R, et al. ACC/AHA Guidelines for Coronary Artery Bypass Graft Surgery: A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Revise the 1991 Guidelines for Coronary Artery Bypass Graft Surgery). American College of Cardiology/American Heart Association. *J Am Coll Cardiol* 1999;34(4):1262-347.
- Escarce JJ, Chen W, Schwartz JS. Falling cholecystectomy thresholds since the introduction of laparoscopic cholecystectomy. *JAMA* 1995;273(20):1581-5.
- Farley, DE, Ozminkowski RJ. Volume-outcome relationships and in-hospital mortality: the effect of changes in volume over time. *Med Care* 1992;30(1):77-94.
- Feinberg WM. Guidelines for the management of transient ischemic attacks. Ad Hoc Committee on Guidelines for the Management of Transient Ischemic Attacks of the Stroke Council, American Heart Association, *Heart Dis Stroke* 1994;3(5):275-83.
- Fine MJ, Smith MA, Carson CA, et al. Prognosis and outcomes of patients with community-acquired pneumonia. A meta-analysis. *JAMA* 1996;275(2):134-41.
- Fisher KS, Ross DS. Guidelines for therapeutic decision in incidental appendectomy. *Surg Gynecol Obstet* 1990;171(1):95-8.
- Forsen L, Sogaard AJ, Meyer HE, et al. Survival after hip fracture: short- and long-term excess mortality according to age and gender. *Osteoporos Int* 1999;10(1):73-8.
- Gentles TL, Mayer JE, Jr., Gauvreau K, et al. Fontan operation in 500 consecutive patients: factors influencing early and late outcome. *J Thorac Cardiovasc Surg* 1997;114(3):376-91.
- Ghali WA, Ash AS, Hall RE, et al. Statewide quality improvement initiatives and mortality after cardiac surgery. *JAMA* 1997;277(5):379-82.

- Gittelsohn A, Powe NR, Small area variations in health care delivery in Maryland. *Health Serv Res* 1995;30(2):295-317.
- Glasgow RE, Mulvihill SJ. Hospital volume influences outcome in patients undergoing pancreatic resection for cancer. *West J Med* 1996;165(5):294-300.
- Gleason PP, Heehan TP, Fine JM, et al. Associations between initial antimicrobial therapy and medical outcomes for hospitalized elderly patients with pneumonia. *Arch Intern Med* 1999;159(21):2562-72.
- Goff, DC, Jr., Pandey DK, Chan FA, et al. Congestive heart failure in the United States: is there more than meets the I(CD code)? The Corpus Christi Heart Project. *Arch Intern Med* 2000;160(2):197-202.
- Gordan TA, Bowman HM, Bass EB, et al. Complex gastrointestinal surgery: impact of provider experience on clinical and economic outcomes. *J Am Coll Surg* 1999;189(1):46-56.
- Goyert GL, Bottoms FS, Treadwell MC, et al. The physician factor in cesarean birth rates [see comments]. *N Engl J Med* 1989;320(11):706-9.
- Green DC, Moore JM, Adams MM, et al. Are we underestimating rates of vaginal birth after previous cesarean birth? The validity of delivery methods from birth certificates. *Am J Epidemiol* 1998;147(6):581-6.
- Haas JS, Udvarhelyi S, Epstein AM. The effect of health coverage for uninsured pregnant women on maternal health and the use of cesarean section [see comments]. *JAMA* 1993;270(1):61-4.
- Hall M, Popovic J. 1998 summary: National Hospital Discharge Survey. *Advance Data from Vital and Health Statistics* 2000;316.
- Hannan EL, Racz M, Kavey RE, et al. Pediatric cardiac surgery: the effect of hospital and surgeon volume on in-hospital mortality. *Pediatrics* 1998;101(6):963-9.
- Hannan EL, Popp AJ, Tranmer B, et al. Relationship between provider volume and mortality for carotid endarterectomies in New York state. *Stroke* 1998;29(11):2292-7.
- Hannan EL, Kilburn H, Jr., O'Donnell JF, et al. A longitudinal analysis of the relationship between in-hospital mortality in New York state and the volume of abdominal aortic aneurysm surgeries performed. *Health Serv Res* 1992;27(4):517-42.
- Hannan EL, Racz M, Ryan TJ, et al. Coronary angioplasty volume-outcome relationships for hospitals and cardiologists. *JAMA* 1997;277(11):892-8.
- Hannan EL, Kilburn H, Jr., Bernard H, et al. Coronary artery bypass surgery: the relationship between inhospital mortality rate and surgical volume after controlling for clinical risk factors. *Med Care* 1991;29(11):1094-107.
- Hannan EL, Racz M, Kavey RE, et al. Pediatric cardiac surgery: the effect of hospital and surgeon volume on in-hospital mortality. *Pediatrics* 1998;101(6):963-9.
- Hannan EL, Kilburn H Jr., Racz M, et al. Improving the outcomes of coronary artery bypass surgery in New York state. *JAMA* 1994;271(10):761-6.
- Hannan EL, Siu AL, Kumar D, et al. Assessment of coronary artery bypass graft surgery performance in New York. Is there a bias against taking high-risk patients? *Med Care* 1997;35(1):49-56.
- Hay JA, Lyubashevsky E, Elashoff J, et al. Upper gastrointestinal hemorrhage clinical guideline determining the optimal hospital length of stay. *Am J Med* 1996;100(3):313-22.

- HCUPnet. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup/hcupnet.htm>.
- Healthy People 2010. Office of Disease Prevention and Health Promotion, U.S. Department of Health and Human Services, Washington, DC: U.S. Government Printing Office.
- Higgins TL, Estafanous FG, Loop FD, et al. Stratification of morbidity and mortality outcome by preoperative risk factors in coronary artery bypass patients. A clinical severity score. *JAMA* 1992;267(17):2344-8.
- Hilborne LH, Leape LL, Bernstein SJ, et al. The appropriateness of use of percutaneous transluminal coronary angioplasty in New York state. *JAMA* 1993;269(6):761-5.
- Hirshfeld JW, Jr., Ellis SG, Faxon DP. Recommendations for the assessment and maintenance of proficiency in coronary interventional procedures: Statement of the American College of Cardiology. *J Am Coll Cardiol* 1998;31(3):722-43.
- Hoyert DL, Kochanek KD, Murphy SL. Deaths: final data for 1997. *Natl Vital Stat Rep* 1999;47(19):1-104.
- <http://www.hcfa.gov/stats/NHE-Proj/proj2000/tables/t2.htm>: Table 2: National Health Expenditure Amounts, and Average Annual Percent Change by Type of Expenditure: Selected Calendar Years 1980-2010.
- Impact: Case Studies Notebook – Documented Impact and Use of AHRQ's Research*. Compiled by Division of Public Affairs, Office of Health Care Information, Agency for Healthcare Research and Quality.
- Institute of Medicine Division of Health Care Services. Medicare: a strategy for quality assurance. Washington, DC: National Academy Press; 1990.
- Institute of Medicine. To Err is Human: Building a Safer Health System. Kohn LT, Corrigan JM, Donaldson MS (eds.) Washington DC: National Academy Press, 2000.
- Institute of Medicine. Crossing the Quality Chasm: A New Health System for the 21st Century. Committee of Quality of Care in America. Washington DC: National Academy Press, 2001.
- Jatzko GR, Lisborg PH, Pertl AM, et al. Multivariate comparison of complications after laparoscopic cholecystectomy and open cholecystectomy. *Ann Surg* 1995;221(4):381-6.
- Jenkins KJ, Newburger JW, Lock JE, et al. In-hospital mortality for surgical repair of congenital heart defects: preliminary observations of variation by hospital caseload. *Pediatrics* 1995;95(3):323-30.
- Kahn KL, Rogers WH, Rubenstein LV, et al. Measuring quality of care with explicit process criteria before and after implementation of the DRG-based prospective payment system. *JAMA* 1990;264(15):1969-73.
- Kalra L, Perez I, Smithard DG, et al. Does prior use of aspirin affect outcome in ischemic stroke? *Am J Med* 2000;108(3):205-9.
- Kantonen I, Lepantalo M, Brommels M, et al. Mortality in ruptured abdominal aortic aneurysms. The Finnvasc Study Group. *Eur J Vasc Endovasc Surg* 1999;17(3):208-12.
- Karp, HR, Flanders WD, Shipp CC, et al. Carotid endarterectomy among Medicare beneficiaries: a statewide evaluation of appropriateness and outcome. *Stroke* 1998;29(1):46-52.
- Kazandjian VA, Lied TR. Cesarean section rates: effects of participation in a performance measurement project. *Jt Comm J Qual Improv* 1998;24(4):187-96.
- Kazmers A, Jacobs L, Perkins A, et al. Abdominal aortic aneurysm repair in Veterans Affairs medical centers. *J Vasc Surg* 1996;23(2):191-200.

- Kern JH, Hayes CJ, Michler RE, et al. Survival and risk factor analysis for the Norwood procedure for hypoplastic left heart syndrome. *Am J Cardiol* 1997;80(2):170-4.
- Knott-Craig CJ, Danielson GK, Schaff HV, et al. The modified Fontan operation. An analysis of risk factors for early postoperative death or takedown in 702 consecutive patients from one institution. *J Thorac Cardiovasc Surg* 1995;109(6):1237-43.
- Kozak LJ, Lawrence L. National Hospital Discharge Survey: annual summary, 1997. *Vital Health Stat* 13 1999(144):i-iv, 1-46.
- Kreder HF, Williams JI, Jaglal S, et al. Are complication rates for elective primary total hip arthroplasty in Ontario related to surgeon and hospital volumes? A preliminary investigation. *Can J Surg* 1998;41(6):431-7.
- Landon B, Iezzoni LI, Ash AS, et al. Judging hospitals by severity-adjusted mortality rates: the case of CABG surgery. *Inquiry* 1996;33(2):155-66.
- Lanzino G, Kassell NF, Germanson TP, et al. Age and outcome after aneurysmal subarachnoid hemorrhage: why do older patients fare worse? *J Neurosurg* 1996;85(3):410-8.
- Larequi-Lauber T, Vader JP, Burnand B, et al. Appropriateness of indications for surgery of lumbar disc hernia and spinal stenosis. *Spine* 1997;22(2):203-9.
- Lavernia CJ, Guzman JF. Relationship of surgical volume to short-term mortality, morbidity, and hospital charges in arthroplasty. *J Arthroplasty* 1995;10(2):133-40.
- Leape LL, Hilborne LH, Schwartz JS, et al. The appropriateness of coronary artery bypass graft surgery in academic medical centers. Working Group of the Appropriateness Project of the Academic Medical Center Consortium. *Ann Intern Med* 1996;125(1):8-18.
- Leape LL, Park RE, Bashore TM, et al. Effect of variability in the interpretation of coronary angiograms on the appropriateness of use of coronary revascularization procedures. *American Heart Journal* 2000;139(1 Pt 1):106-13.
- Leape LL, Hilborne LH, Park RE, et al. The appropriateness of use of coronary artery bypass graft surgery in New York state. *JAMA* 1993;269(6):753-60.
- Lieberman MD, Kilburn H, Lindsey M, et al. Relation of perioperative deaths to hospital volume among patients undergoing pancreatic resection for malignancy. *Ann Surg* 1995;222(5):638-45.
- Localio AR, Hamory BH, Fisher AC, et al. The public release of hospital and physician mortality data in Pennsylvania. A case study. *Med Care* 1997;35(3):272-286.
- Luft HS, Hunt SS, Maerki SC. The volume-outcome relationship: practice-makes-perfect or selective-referral patterns? *Health Serv Res* 1987;22(2):157-82.
- MacIntyre K, Capewell IS, Stewart S, et al. Evidence of improving prognosis in heart failure: trends in case fatality in 66,547 patients hospitalized between 1986 and 1995 [see comments]. *Circulation* 2000;102(10):1126-31.
- Malone ML, Bajwa TK, Battiola RJ, et al. Variation among cardiologists in the utilization of right heart catheterization at time of coronary angiography [see comments]. *Cathet Cardiovasc Diagn* 1996;37(2):125-30.
- Manheim LM, Sohn MW, Feinglass J, et al. Hospital vascular surgery volume and procedure mortality rates in California, 1982-1994. *J Vasc Surg* 1998;28(1):45-46.

- Markowitz JS, Pashko S, Gutterman EM, et al. Death rates among patients hospitalized with community-acquired pneumonia: a reexamination with data from three states. *Am J Public Health* 1996;86(8 Pt 1):1152-4.
- McMahon AJ, Russell IT, Baxter JN, et al. Laparoscopic and minilaparotomy cholecystectomy: a randomised trial [see comment]. *Lancet* 1994;343(8890):135-8.
- McMahon AF, Russell IT, Ramsay G, et al. Laparoscopic and minilaparotomy cholecystectomy: a randomized trial comparing postoperative pain and pulmonary function. *Surgery* 1994;115(5):533-9.
- Medicare Quality of Care Report of Surveillance Measures. Centers for Medicare and Medicaid Services (formerly Health Care Financing Administration), U.S. Department of Health and Human Services.
- Meehan TP, Hennen J, Radford MJ, et al. Process and outcome of care for acute myocardial infarction among Medicare beneficiaries in Connecticut: a quality improvement demonstration project. *Ann Intern Med* 1995;122(12):928-36.
- Meehan TP, Fine MJ, Krumholz HM, et al. Quality of care, process, and outcomes in elderly patients with pneumonia. *JAMA* 1997;278(23):2080-4.
- Menard MK. Cesarean delivery rates in the United States. The 1990s. *Obstet Gynecol Clin North Am* 1999;26(2):275-86.
- Myers AH, Robinson EG, Van Natta ML, et al. Hip fractures among the elderly: factors associated with in-hospital mortality. *Am J Epidemiol* 1991;134(10):1128-37.
- Nationwide Inpatient Sample and State Inpatient Databases. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.ahrq.gov/data/hcup>
- Neulander EZ, Hawke CK, Soloway MS. Incidental appendectomy during radical cystectomy: an interdepartmental survey and review of the literature. *Urology* 2000;56(2):241-4.
- Ni H, Hershberger FE. Was the decreasing trend in hospital mortality from heart failure attributable to improved hospital care? The Oregon experience, 1991-1995. *Am J Manag Care* 1999;5(9):1105-15.
- Nockerts SR, Detmer DE, Fryback, DG. Incidental appendectomy in the elderly? No. *Surgery* 1980;88(2):301-6.
- Ottino G, Bergerone S, Di Leo M, et al. Aortocoronary bypass results: a discriminant multivariate analysis of risk factors of operative mortality. *J Cardiovasc Surg (Torino)* 1990;31(1):20-5.
- Owings, MF, Lawrence L. Detailed diagnoses and procedures, National Hospital Discharge Survey, 1997. *Vital Health Stat* 13 199(145):1-157.
- Pacific Business Group on Health. (<http://www.pbgh.org/>)
- Patti MG, Corvera CU, Glasgow RE, et al. A hospital's annual rate of esophagectomy influences the operative mortality rate. *J Gastrointest Surg* 1998;2(2):186-92.
- Pearce WH, Parker MA, Feinglass J, et al. The importance of surgeon volume and training in outcomes for vascular surgical procedures. *J Vasc Surg* 1999;29(5):768-76.
- Pepine CJ, Allen HD, Bashore TM, et al. ACC/AHA guidelines for cardiac catheterization and cardiac catheterization laboratories. American College of Cardiology/American Heart Association Ad Hoc Task Force on Cardiac Catheterization. *Circulation* 1991;84(5):2213-47.

- Perez JV, Warwick DJ, Case CP, et al. Death after proximal femoral fracture—an autopsy study. *Injury* 1995;26(4):237-40.
- Peterson ED, DeLong ER, Jollis JG, et al. Public reporting of surgical mortality: a survey of new York State cardiothoracic surgeons. *Ann Thorac surg* 1999;68(4):1195-200; discussion 12-1-2.
- Pilcher DB, Davis JH, Ashikaga T, et al. Treatment of abdominal aortic aneurysm in an entire state over 7½ years. *Am J Surg* 1980;139(4):487-94.
- Popovic JR, Kozak LJ. National hospital discharge survey: annual summary, 1998 [In Process Citation]. *Vital Health Stat* 13 2000(148):1-194.
- Porchet F, Vader JP, Larequi-Lauber T, et al. The assessment of appropriate indications for laminectomy. *J Bone Joint Surg Br* 1999;81(2):234-9.
- Pronovost PJ, Jenckes MW, Dorman T, et al. Organizational characteristics of intensive care units related to outcomes of abdominal aortic surgery. *JAMA* 1999;281(14):1310-7.
- Psaty BM, Boineau R, Kuller LH, et al. The potential costs of upcoding for heart failure in the United States. *Am J Cardiol* 1999;84(1):108-9, A9.
- Ritchie JL, Maynard C, Chapko MK, et al. Association between percutaneous transluminal coronary angioplasty volumes and outcomes in the Healthcare Cost and Utilization Project 1993-1994. *Am J Cardiol* 1999;83(4):493-7.
- Roberts RG, Bell HS, Wall EM, et al. Trial of labor or repeated cesarean section. The woman's choice. *Arch Fam Med* 1997;6(2):120-5.
- Rockall TA, Logan RF, Devlin HB, et al. Variation in outcome after acute upper gastrointestinal haemorrhage. The National Audit of Acute Upper Gastrointestinal Haemorrhage. *Lancet* 1995;346(8971):346-50.
- Rosenthal GE, Baker DW, Norris DG, et al. Relationships between in-hospital and 30-day standardized hospital mortality: implications for profiling hospitals. *Health Serv Res* 2000;34(7):1449-68.
- Rutledge R, Oller DW, Meyer AA, et al. A statewide, population-based time-series analysis of the outcome of ruptured abdominal aortic aneurysm. *Ann Surg* 1996;223(5):492-502.
- Ryan TJ, Bauman WB, Kennedy JW, et al. Guidelines for percutaneous transluminal coronary angioplasty. A report of the American Heart Association/American College of Cardiology Task Force on Assessment of Diagnostic and Therapeutic Cardiovascular Procedures (Committee on Percutaneous Transluminal Coronary Angioplasty). *Circulation* 1993;88(6):2987-3007.
- Ryan TJ, Antman EM, Brooks NH, et al. 1999 update: ACC/AHA guidelines for the management of patients with acute myocardial infarction. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Management of Acute Myocardial Infarction). *J Am Coll Cardiol* 1999;34(3):890-911.
- Sachs BP, Kobelin C, Castro MA, et al. The risks of lowering the cesarean-delivery rate. *N Engl J Med* 1999;340(1):54-7.
- Samsa GP, Bian J, Lipscomb J, et al. Epidemiology of recurrent cerebral infarction: a Medicare claims-based comparison of first and recurrent strokes on 2-year survival and cost. *Stroke* 1999;30(2):338-49.
- Second Report of the California Hospitals Outcomes Project, May 1996. Acute Myocardial Infarction. Sacramento, CA: Office of Statewide Health Planning and Development; 1996.

- Simunovic M, To T, Theriault M, et al. Relation between hospital surgical volume and outcome for pancreatic resection for neoplasm in a publicly funded health care system [see comments]. *Cmaj* 1999;160(5):643-8.
- Smith, WM. Epidemiology of congestive heart failure. *Am J Cardiol* 1985;55(2):3A-8A.
- Sollano JA, Gelijns AC, Moskowitz AJ et al. Volume-outcome relationships on cardiovascular operations: New York State, 1990-1995. *J Thorac Cardiovasc Surg* 1999;117(3):419-28.
- Soloman RA, Mayer SA, Tarmey JJ. Relationship between the volume of craniotomies for cerebral aneurysm performed at New York state hospitals and in-hospital mortality. *Stroke* 1996;27(1):13-7.
- Southern Surgeons Club. A prospective analysis of 1518 laparoscopic cholecystectomies. *NEJM* 1991;324:1073-1078.
- Stachniak JB, Layon AJ, Day AL, et al. Craniotomy for intracranial aneurysm and subarachnoid hemorrhage. Is course, cost, or outcome affected by age? *Stroke* 1996;27(2):276-81.
- Stafford RS. The impact of nonclinical factors on repeat cesarean section [see comments]. *JAMA* 1991;265(1):59-63.
- Stafford RS, Sullivan SD, Gardner LB. Trends in cesarean section use in California, 1983 to 1990. *Am J Obstet Gynecol* 1993;168(4):1297-302.
- Strunk BC, Ginsburg PB, Gabel JR. Tracking Health Care Costs. *Health Affairs*, 26 September 2001 (Web exclusive).
- Synder TE, Selanders JR. Incidental appendectomy—yes or no? A retrospective case study and review of the literature. *Infect Dis Obstet Gynecol* 1998;6(1)30-7.
- Taylor CL, Yuan A, Selman WR, et al. Mortality rates, hospital length of stay, and the cost of treating subarachnoid hemorrhage in older patients: institutional and geographical differences. *J Neurosurg* 1997;86(4):583-8.
- The Center for Medical Consumers. (<http://www.medicalconsumers.org/>)
- Tissue plasminogen activator for acute ischemic stroke. The National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group. *N Engl J Med* 1995;333(24):1581-7.
- Warren JL, Penberthy LT, Addiss DG, et al. Appendectomy incidental to cholecystectomy among elderly Medicare beneficiaries. *Surg Gynecol Obstet* 1993;177(3):288-94.
- Wen SW, Simunovic M, Williams JI, et al. Hospital volume, calendar age, and short term outcomes in patients undergoing repair of abdominal aortic aneurysm: the Ontario experience, 1988-92. *J Epidemiol Community Health* 1996;50(2):207-13.
- Whisnant JP, Sacco SE, O'Fallon WM, et al. Referral bias in aneurysmal subarachnoid hemorrhage. *J Neurosurg* 1993;78(5):726-32.
- Williams GR, Jiang JG, Matchar DB, et al. Incidence and occurrence of total (first-ever and recurrent) stroke. *Stroke* 1999;30(12):2523-8.
- Wolff BG. Current status of incidental surgery. *Dis Colon Rectum* 1995;38(4):435-41.
- Wolinsky FD, Fitzgerald JF, Stump TE. The effect of hip fracture on mortality, hospitalization, and functional status: a prospective study. *Am J Public Health* 1997;87(3):398-403.

Ziskind AA, Lauer MA, Bishop G, et al. Assessing the appropriateness of coronary revascularization: the University of Maryland Revascularization Appropriateness Score (RAS) and its comparison to RAND expert panel ratings and American College of Cardiology/American Heart Association guidelines with regard to assigned appropriateness rating and ability to predict outcome. *Clin Cardiol* 1999;22(2):67-76.

Appendix A: Inpatient Quality Indicator Definitions

For ICD-9-CM codes introduced after October 1995, the date of introduction is indicated after the code label. For example, "OCT96-" indicates the ICD-9-CM code was introduced in October 1996.

Provider-Level Indicators

Procedure Volume Indicators

Esophageal Resection Volume			
Numerator:			
Discharges with ICD-9-CM codes of 4240 through 4242 in any procedure field and a diagnosis code of esophageal cancer in any field.			
ICD-9-CM esophageal resection procedure codes:			
4240	ESOPHAGECTOMY NOS		
4241	PARTIAL ESOPHAGECTOMY		
4242	TOTAL ESOPHAGECTOMY		
ICD-9-CM esophageal cancer diagnosis codes:			
1500	MAL NEO CERVICAL ESOPHAG	1504	MAL NEO MIDDLE 3RD ESOPH
1501	MAL NEO THORACIC ESOPHAG	1505	MAL NEO LOWER 3RD ESOPH
1502	MAL NEO ABDOMIN ESOPHAG	1508	MAL NEO ESOPHAGUS NEC
1503	MAL NEO UPPER 3RD ESOPH	1509	MAL NEO ESOPHAGUS NOS
Exclude:			
MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and other neonates).			
Denominator:			
Not applicable.			

Pancreatic Resection Volume

Numerator:

Discharges with ICD-9-CM codes of 526 or 527 in any procedure field and a diagnosis code of pancreatic cancer in any field.

ICD-9-CM pancreatic resection procedure codes:

526 TOTAL PANCREATECTOMY
527 RAD PANCREATICODUODENECT

ICD-9-CM pancreatic cancer diagnosis codes:

1520	MALIGNANT NEOPL DUODENUM	1572	MAL NEO PANCREAS TAIL
1561	MAL NEO EXTRAHEPAT DUCTS	1573	MAL NEO PANCREATIC DUCT
1562	MAL NEO AMPULLA OF VATER	1574	MAL NEO ISLET LANGERHANS
1570	MAL NEO PANCREAS HEAD	1578	MALIG NEO PANCREAS NEC
1571	MAL NEO PANCREAS BODY	1579	MALIG NEO PANCREAS NOS

Exclude:

MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and other neonates).

Denominator:

Not applicable.

Pediatric Heart Surgery Volume

Numerator:

Discharges with ICD-9-CM codes for specified heart surgery (1P) in any field or for any heart surgery (2P) plus a diagnosis code of hypoplastic left heart syndrome (1D) in any field.

Age less than 18 years.

Specified heart surgery (1P)

ICD-9-CM procedure codes:

3500	CLOSED VALVOTOMY NOS		3552	PROS REPAIR ATRIA DEF-CL
3501	CLOSED AORTIC VALVOTOMY		3553	PROST REPAIR VENTRIC DEF
3502	CLOSED MITRAL VALVOTOMY		3554	PROS REP ENDOCAR CUSHION
3503	CLOSED PULMON VALVOTOMY	3560		GRFT REPAIR HRT SEPT NOS
3504	CLOSED TRICUSP VALVOTOMY		3561	GRAFT REPAIR ATRIAL DEF
3510	OPEN VALVULOPLASTY NOS		3562	GRAFT REPAIR VENTRIC DEF
3511	OPN AORTIC VALVULOPLASTY		3563	GRFT REP ENDOCAR CUSHION
3512	OPN MITRAL VALVULOPLASTY		3570	HEART SEPTA REPAIR NOS
3513	OPN PULMON VALVULOPLASTY		3571	ATRIA SEPTA DEF REP NEC
3514	OPN TRICUS VALVULOPLASTY		3572	VENTR SEPTA DEF REP NEC
3520	REPLACE HEART VALVE NOS		3573	ENDOCAR CUSHION REP NEC
3521	REPLACE AORT VALV-TISSUE		3581	TOT REPAIR TETRAL FALLOT
3522	REPLACE AORTIC VALVE NEC		3582	TOTAL REPAIR OF TAPVC
3523	REPLACE MITR VALV-TISSUE		3583	TOT REP TRUNCUS ARTERIOS
3524	REPLACE MITRAL VALVE NEC		3584	TOT COR TRANSPOS GRT VES OCT88-
3525	REPLACE PULM VALV-TISSUE		3591	INTERAT VEN RETRN TRANSP
3526	REPLACE PULMON VALVE NEC	3592		CONDUIT RT VENT-PUL ART
3527	REPLACE TRIC VALV-TISSUE		3593	CONDUIT LEFT VENTR-AORTA
3528	REPLACE TRICUSP VALV NEC		3594	CONDUIT ARTIUM-PULM ART
3531	PAPILLARY MUSCLE OPS		3595	HEART REPAIR REVISION
3532	CHORDAE TENDINEAE OPS		3598	OTHER HEART SEPTA OPS
3533	ANNULOPLASTY		3599	OTHER OP ON HRT VALVES
3534	INFUNDIBULECTOMY		3835	THOR VESSEL RESECT/ANAST
3535	TRABECUL CARNEAE CORD OP		3845	RESECT THORAC VES W REPL
3539	TISS ADJ TO VALV OPS NEC		3885	OCCLUDE THORACIC VES NEC
3541	ENLARGE EXISTING SEP DEF		390	SYSTEMIC-PULM ART SHUNT
3542	CREATE SEPTAL DEFECT		3921	CAVAL-PULMON ART ANASTOM
3550	PROSTH REP HRT SEPTA NOS		3959	REPAIR OF VESSEL NEC
3551	PROS REP ATRIAL DEF-OPN			

Or any heart surgery (2P)

ICD-9-CM procedure codes:

3601	PTCA-1 VES/ATH W/O AGENT		3734	CATH ABLATION LES HEART
3602	PTCA-1 VES/ATH W AGENT		3735	PARTIAL VENTRICULECTOMY OCT97-
3603	OPEN CORONRY ANGIOPLASTY		374	HEART & PERICARD REPAIR
3604	INTRCORONRY THROMB INFUS		375	HEART TRANSPLANTATION
3605	PTCA-MULTIPLE VESSEL/ATH		3761	PULSATION BALLOON IMPLAN
3606	INSERT OF COR ART STENT OCT95-		3762	IMPLANT HRT ASST SYS NEC
3609	REM OF COR ART OBSTR NEC		3763	REPLACE HRT ASSIST SYST
3610	AORTOCORONARY BYPASS NOS		3764	REMOVE HEART ASSIST SYS
3611	AORTOCOR BYPAS-1 COR ART		3765	IMP EXT PUL HRT ASST SYS OCT95-
3612	AORTOCOR BYPAS-2 COR ART		3766	IMP IMP PUL HRT ASST SYS OCT95-
3613	AORTOCOR BYPAS-3 COR ART		3767	IMP CARDIOMYOSTIMUL SYS OCT98-
3614	AORTCOR BYPAS-4+ COR ART		3770	INT INSERT PACEMAK LEAD
3615	INT MAM-COR ART BYPASS		3771	INT INSERT LEAD IN VENT

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3616	INT MAM-COR ART BYPASS	3772	INT INSERT LEAD ATRI-VENT
3617	ABD-CORON ARTERY BYPASS OCT96-	3773	INT INSERT LEAD IN ATRIUM
3619	HRT REVAS BYPS ANAS NEC	3774	INT OR REPL LEAD EPICAR
362	ARTERIAL IMPLANT REVASC	3775	REVISION OF LEAD
363	HEART REVASCULARIZAT NEC OCT98-	3776	REPL TV ATRI-VENT LEAD
3631	OPEN CHEST TRANS REVASC OCT98-	3777	REMOVAL OF LEAD W/O REPL
3632	OTH TRANSMYO REVASCULAR OCT98-	3778	INSERT TEMP PACEMAKER SYS
3639	OTH HEART REVASCULAR OCT98-	3779	REVIS OR RELOCATE POCKET
3691	CORON VESS ANEURYSM REP	3780	INT OR REPL PERM PACEMKR
3699	HEART VESSEL OP NEC	3781	INT INSERT 1-CHAM, NON
370	PERICARDIOCENTESIS	3782	INT INSERT 1-CHAM, RATE
3710	INCISION OF HEART NOS	3783	INT INSERT DUAL-CHAM DEV
3711	CARDIOTOMY	3785	REPL PACEM W 1-CHAM, NON
3712	PERICARDIOTOMY	3786	REPL PACEM 1-CHAM, RATE
3721	RT HEART CARDIAC CATH	3787	REPL PACEM W DUAL-CHAM
3722	LEFT HEART CARDIAC CATH	3789	REVISE OR REMOVE PACEMAK
3723	RT/LEFT HEART CARD CATH	3791	OPN CHEST CARDIAC MASSAG
3724	PERICARDIAL BIOPSY	3792	INJECTION INTO HEART
3725	CARDIAC BIOPSY	3793	INJECTION INTO PERICARD
3726	CARDIAC ELECTROPHY STIM	3794	IMPLT/REPL CARDDEFIB TOT
3727	CARDIAC MAPPING	3795	IMPLT CARDIODEFIB LEADS
3729	HRT/PERICAR DX PROC NEC	3796	IMPLT CARDIODEFIB GENATR
3731	PERICARDIECTOMY	3797	REPL CARDIODEFIB LEADS
3732	HEART ANEURYSM EXCISION	3798	REPL CARDIODEFIB GENRATR
3733	EXC/DEST OTH HRT LESION	3799	OTHER HEART/PERICARD OPS

with only hypoplastic left heart syndrome (1D)
ICD-9-CM diagnosis code:

7467 HYPOPLAS LEFT HEART SYND

Exclude:

P MDC 14 (pregnancy, childbirth, and puerperium).

P Patients who underwent PDA ligation as a single cardiac procedure (diagnosis code 7470 [2D] and procedure code 3885 [3P]):

ICD-9-CM procedure code (3P), if single procedure:

3885 OCCLUDE THORACIC VES NEC*

with ICD-9-CM diagnosis code (2D):

7470 PATENT DUCTUS ARTERIOSUS

P Patients with prosthetic closures of atrial septal defects (procedure codes 3551, 3552, 3571) or ventricular septal defects (codes 3553, 3572) or atrial septal enlargement (3541 [4P]) without concomitant use of cardiopulmonary bypass (code 3961 [5P]):

ICD-9-CM procedure codes (4P):

3541	ENLARGE EXISTING SEP DEF#	3553	PROST REPAIR VENTRIC DEF#
3551	PROS REP ATRIAL DEF-OPN#	3571	ATRIA SEPTA DEF REP NEC#
3552	PROS REPAIR ATRIA DEF-CL#	3572	VENTR SEPTA DEF REP NEC#

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without cardiopulmonary bypass (5P)
ICD-9-CM procedure code:

3961 EXTRACORPOREAL CIRCULAT

P Patients with PDA closure as a single cardiac procedure (procedure code 3885 [3P]) with concomitant cardiac catheterization (codes 3721, 3722, 3723, 8842, 8843 [6P]):

ICD-9-CM procedure code (3P), if single procedure:

3885 OCCLUDE THORACIC VES NEC*

with cardiac catheterization (6P)
ICD-9-CM procedure codes:

3721	RT HEART CARDIAC CATH	8842	CONTRAST AORTOGRAM
3722	LEFT HEART CARDIAC CATH	8843	CONTR PULMON ARTERIOGRAM
3723	RT/LEFT HEART CARD CATH		

P Patients with occlusion of thoracic vessel (procedure code 3885 [3P]) without congenital heart defect (diagnosis codes 7450 through 7479 [3D]):

ICD-9-CM procedure code (3P):

3885 OCCLUDE THORACIC VES NEC*

without congenital heart defect (3D)
ICD-9-CM diagnosis codes:

7450	COMMON TRUNCUS	74684	OBSTRUCT HEART ANOM NEC
74510	COMPL TRANSPOS GREAT VES	74685	CORONARY ARTERY ANOMALY
74511	DOUBLE OUTLET RT VENTRIC	74686	CONGENITAL HEART BLOCK
74512	CORRECT TRANSPOS GRT VES	74687	MALPOSITION OF HEART
74519	TRANSPOS GREAT VESS NEC	74689	CONG HEART ANOMALY NEC
7452	TETRALOGY OF FALLOT	7469	CONG HEART ANOMALY NOS
7453	COMMON VENTRICLE	7470	PATENT DUCTUS ARTERIOSUS
7454	VENTRICULAR SEPT DEFECT	74710	COARCTATION OF AORTA
7455	SECUNDUM ATRIAL SEPT DEF	74711	INTERRUPT OF AORTIC ARCH
74560	ENDOCARD CUSHION DEF NOS	74720	CONG ANOM OF AORTA NOS
74561	OSTIUM PRIMUM DEFECT	74721	ANOMALIES OF AORTIC ARCH
74569	ENDOCARD CUSHION DEF NEC	74722	AORTIC ATRESIA/STENOSIS
7457	COR BILOCULARE	74729	CONG ANOM OF AORTA NEC
7458	SEPTAL CLOSURE ANOM NEC	7473	PULMONARY ARTERY ANOM
7459	SEPTAL CLOSURE ANOM NOS	74740	GREAT VEIN ANOMALY NOS
74600	PULMONARY VALVE ANOM NOS	74741	TOT ANOM PULM VEN CONNEC
74601	CONG PULMON VALV ATRESIA	74742	PART ANOM PULM VEN CONN
74602	CONG PULMON VALVE STENOS	74749	GREAT VEIN ANOMALY NEC
74609	PULMONARY VALVE ANOM NEC	7475	UMBILICAL ARTERY ABSENCE
7461	CONG TRICUSP ATRES/STEN	74760	UNSP PRPHERL VASC ANOMAL
7462	EBSTEIN'S ANOMALY	74761	GSTRONTEST VESL ANOMALY
7463	CONG AORTA VALV STENOSIS	74762	RENAL VESSEL ANOMALY
7464	CONG AORTA VALV INSUFFIC	74763	UPR LIMB VESSEL ANOMALY
7465	CONGEN MITRAL STENOSIS	74764	LWR LIMB VESSEL ANOMALY
7466	CONG MITRAL INSUFFICIENC	74769	OTH SPCF PRPH VSCL ANOML
7467	HYPOPLAS LEFT HEART SYND	74781	CEREBROVASCULAR ANOMALY

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74681	CONG SUBAORTIC STENOSIS	74782	SPINAL VESSEL ANOMALY
74682	COR TRIATRIATUM	74789	CIRCULATORY ANOMALY NEC
74683	INFUNDIB PULMON STENOSIS	7479	CIRCULATORY ANOMALY NOS

Denominator:

Not applicable.

Abdominal Aortic Aneurysm (AAA) Repair Volume**Numerator:**

Discharges with ICD-9-CM codes of 3834, 3844, or 3864 in any procedure field and a diagnosis of AAA in any field.

ICD-9-CM AAA procedure codes:

3834	AORTA RESECTION & ANAST
3844	RESECT ABDM AORTA W REPL
3864	EXCISION OF AORTA

ICD-9-CM AAA diagnosis codes:

4413	RUPT ABD AORTIC ANEURYSM
4414	ABDOM AORTIC ANEURYSM

Exclude:

MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and other neonates).

Denominator:

Not applicable.

Coronary Artery Bypass Graft (CABG) Volume**Numerator:**

Discharges with ICD-9-CM codes of 3610 through 3619 in any procedure field.

Age 40 years and older.

ICD-9-CM CABG procedure codes:

3610	AORTOCORONARY BYPASS NOS	3615	INT MAM-COR ART BYPASS
3611	AORTOCOR BYPAS-1 COR ART	3616	INT MAM-COR ART BYPASS
3612	AORTOCOR BYPAS-2 COR ART	3617	ABD-CORON ART BYPASS OCT96-
3613	AORTOCOR BYPAS-3 COR ART	3619	HRT REVAS BYPS ANAS NEC
3614	AORTCOR BYPAS-4+ COR ART		

Exclude:

MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and other neonates).

Denominator:

Not applicable.

Percutaneous Transluminal Coronary Angioplasty (PTCA) Volume**Numerator:**

Discharges with ICD-9-CM codes of 3601, 3602, 3605, or 3606 in any procedure field.

Age 40 years and older.

ICD-9-CM PTCA procedure codes:

3601	PTCA-1 VESSEL W/O AGENT
3602	PTCA-1 VESSEL WITH AGNT
3605	PTCA-MULTIPLE VESSEL
3606	INSERT OF COR ART STENT OCT95-

Exclude:

MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and other neonates).

Denominator:

Not applicable.

Carotid Endarterectomy Volume
Numerator: Discharges with an ICD-9-CM code of 3812 in any procedure field. ICD-9-CM carotid endarterectomy procedure code: 3812 HEAD & NECK ENDARTER NEC Exclude: MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and other neonates).
Denominator: Not applicable.

Mortality Indicators for Inpatient Procedures

Esophageal Resection Mortality Rate			
Numerator:			
Number of deaths with a code of esophageal resection in any procedure field.			
Denominator:			
Discharges with ICD-9-CM codes of 4240 through 4242 in any procedure field and a diagnosis code of esophageal cancer in any field.			
ICD-9-CM esophageal resection procedure code:			
4240	ESOPHAGECTOMY NOS		
4241	PARTIAL ESOPHAGECTOMY		
4242	TOTAL ESOPHAGECTOMY		
ICD-9-CM esophageal cancer diagnosis codes:			
1500	MAL NEO CERVICAL ESOPHAG	1504	MAL NEO MIDDLE 3RD ESOPH
1501	MAL NEO THORACIC ESOPHAG	1505	MAL NEO LOWER 3RD ESOPH
1502	MAL NEO ABDOMIN ESOPHAG	1508	MAL NEO ESOPHAGUS NEC
1503	MAL NEO UPPER 3RD ESOPH	1509	MAL NEO ESOPHAGUS NOS
Exclude:			
Patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and other neonates).			

Pancreatic Resection Mortality Rate

Numerator:

Number of deaths with a code of pancreatic resection in any procedure field.

Denominator:

Discharges with ICD-9-CM codes of 526 or 527 in any procedure field and a diagnosis code of pancreatic cancer in any field.

ICD-9-CM pancreatic resection procedure codes:

526	TOTAL PANCREATECTOMY
527	RAD PANCREATICODUODENECT

ICD-9-CM pancreatic cancer diagnosis codes:

1520	MALIGNANT NEOPL DUODENUM	1572	MAL NEO PANCREAS TAIL
1561	MAL NEO EXTRAHEPAT DUCTS	1573	MAL NEO PANCREATIC DUCT
1562	MAL NEO AMPULLA OF VATER	1574	MAL NEO ISLET LANGERHANS
1570	MAL NEO PANCREAS HEAD	1578	MALIG NEO PANCREAS NEC
1571	MAL NEO PANCREAS BODY	1579	MALIG NEO PANCREAS NOS

Exclude:

Patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and other neonates).

Pediatric Heart Surgery Mortality Rate

Numerator:

Number of deaths with a code of pediatric heart surgery in any procedure field.

Denominator:

Discharges with ICD-9-CM codes for specified heart surgery (1P) in any field or for any heart surgery (2P) plus a diagnosis code of hypoplastic left heart syndrome (1D) in any field.

Age less than 18 years.

Specified heart surgery (1P)

ICD-9-CM procedure codes:

3500	CLOSED VALVOTOMY NOS	3552	PROS REPAIR ATRIA DEF-CL
3501	CLOSED AORTIC VALVOTOMY	3553	PROST REPAIR VENTRIC DEF
3502	CLOSED MITRAL VALVOTOMY	3554	PROS REP ENDOCAR CUSHION
3503	CLOSED PULMON VALVOTOMY	3560	GRFT REPAIR HRT SEPT NOS
3504	CLOSED TRICUSP VALVOTOMY	3561	GRAFT REPAIR ATRIAL DEF
3510	OPEN VALVULOPLASTY NOS	3562	GRAFT REPAIR VENTRIC DEF
3511	OPN AORTIC VALVULOPLASTY	3563	GRFT REP ENDOCAR CUSHION
3512	OPN MITRAL VALVULOPLASTY	3570	HEART SEPTA REPAIR NOS
3513	OPN PULMON VALVULOPLASTY	3571	ATRIA SEPTA DEF REP NEC
3514	OPN TRICUSP VALVULOPLASTY	3572	VENTR SEPTA DEF REP NEC
3520	REPLACE HEART VALVE NOS	3573	ENDOCAR CUSHION REP NEC
3521	REPLACE AORT VALV-TISSUE	3581	TOT REPAIR TETRAL FALLOT
3522	REPLACE AORTIC VALVE NEC	3582	TOTAL REPAIR OF TAPVC
3523	REPLACE MITR VALV-TISSUE	3583	TOT REP TRUNCUS ARTERIOS
3524	REPLACE MITRAL VALVE NEC	3584	TOT COR TRANSPOS GRT VES OCT88-
3525	REPLACE PULM VALV-TISSUE	3591	INTERAT VEN RETRN TRANSP
3526	REPLACE PULMON VALVE NEC	3592	CONDUIT RT VENT-PUL ART
3527	REPLACE TRIC VALV-TISSUE	3593	CONDUIT LEFT VENTR-AORTA
3528	REPLACE TRICUSP VALV NEC	3594	CONDUIT ARTIUM-PULM ART
3531	PAPILLARY MUSCLE OPS	3595	HEART REPAIR REVISION
3532	CHORDAE TENDINEAE OPS	3598	OTHER HEART SEPTA OPS
3533	ANNULOPLASTY	3599	OTHER OP ON HRT VALVES
3534	INFUNDIBULECTOMY	3835	THOR VESSEL RESECT/ANAST
3535	TRABECUL CARNEAE CORD OP	3845	RESECT THORAC VES W REPL
3539	TISS ADJ TO VALV OPS NEC	3885	OCCCLUDE THORACIC VES NEC
3541	ENLARGE EXISTING SEP DEF	390	SYSTEMIC-PULM ART SHUNT
3542	CREATE SEPTAL DEFECT	3921	CAVAL-PULMON ART ANASTOM
3550	PROSTH REP HRT SEPTA NOS	3959	REPAIR OF VESSEL NEC
3551	PROS REP ATRIAL DEF-OPN		

Or any heart surgery (2P)

ICD-9-CM procedure codes:

3601	PTCA-1 VES/ATH W/O AGENT	3734	CATH ABLATION LES HEART
3602	PTCA-1 VES/ATH W AGENT	3735	PARTIAL VENTRICULECTOMY OCT97-
3603	OPEN CORONRY ANGIOPLASTY	374	HEART & PERICARD REPAIR
3604	INTRCORONRY THROMB INFUS	375	HEART TRANSPLANTATION
3605	PTCA-MULTIPLE VESSEL/ATH	3761	PULSATION BALLOON IMPLAN
3606	INSERT OF COR ART STENT OCT95-	3762	IMPLANT HRT ASST SYS NEC
3609	REM OF COR ART OBSTR NEC	3763	REPLACE HRT ASSIST SYST
3610	AORTOCORONARY BYPASS NOS	3764	REMOVE HEART ASSIST SYS
3611	AORTOCOR BYPAS-1 COR ART	3765	IMP EXT PUL HRT ASST SYS OCT95-

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3612	AORTOCOR BYPAS-2 COR ART	3766	IMP IMP PUL HRT ASST SYS OCT95-
3613	AORTOCOR BYPAS-3 COR ART	3767	IMP CARDIOMYOSTIMUL SYS OCT98-
3614	AORTCOR BYPAS-4+ COR ART	3770	INT INSERT PACEMAK LEAD
3615	INT MAM-COR ART BYPASS	3771	INT INSERT LEAD IN VENT
3616	INT MAM-COR ART BYPASS	3772	INT INSER LEAD ATRI-VENT
3617	ABD-CORON ARTERY BYPASS OCT96-	3773	INT INSER LEAD IN ATRIUM
3619	HRT REVAS BYPS ANAS NEC	3774	INT OR REPL LEAD EPICAR
362	ARTERIAL IMPLANT REVASC	3775	REVISION OF LEAD
363	HEART REVASCULARIZAT NEC OCT98-	3776	REPL TV ATRI-VENT LEAD
3631	OPEN CHEST TRANS REVASC OCT98-	3777	REMOVAL OF LEAD W/O REPL
3632	OTH TRANSMYO REVASCULAR OCT98-	3778	INSER TEMP PACEMAKER SYS
3639	OTH HEART REVASCULAR OCT98-	3779	REVIS OR RELOCATE POCKET
3691	CORON VESS ANEURYSM REP	3780	INT OR REPL PERM PACEMKR
3699	HEART VESSEL OP NEC	3781	INT INSERT 1-CHAM, NON
370	PERICARDIOCENTESIS	3782	INT INSERT 1-CHAM, RATE
3710	INCISION OF HEART NOS	3783	INT INSERT DUAL-CHAM DEV
3711	CARDIOTOMY	3785	REPL PACEM W 1-CHAM, NON
3712	PERICARDIOTOMY	3786	REPL PACEM 1-CHAM, RATE
3721	RT HEART CARDIAC CATH	3787	REPL PACEM W DUAL-CHAM
3722	LEFT HEART CARDIAC CATH	3789	REVISE OR REMOVE PACEMAK
3723	RT/LEFT HEART CARD CATH	3791	OPN CHEST CARDIAC MASSAG
3724	PERICARDIAL BIOPSY	3792	INJECTION INTO HEART
3725	CARDIAC BIOPSY	3793	INJECTION INTO PERICARD
3726	CARDIAC ELECTROPHY STIM	3794	IMPLT/REPL CARDDEFIB TOT
3727	CARDIAC MAPPING	3795	IMPLT CARDIODEFIB LEADS
3729	HRT/PERICAR DX PROC NEC	3796	IMPLT CARDIODEFIB GENATR
3731	PERICARDIECTOMY	3797	REPL CARDIODEFIB LEADS
3732	HEART ANEURYSM EXCISION	3798	REPL CARDIODEFIB GENRATR
3733	EXC/DEST OTH HRT LESION	3799	OTHER HEART/PERICARD OPS

with only hypoplastic left heart syndrome (1D)
ICD-9-CM diagnosis code:

7467 HYPOPLAS LEFT HEART SYND

Exclude:

- P Patients transferring to another short-term hospital.
- P MDC 14 (pregnancy, childbirth, and puerperium).
- P Patients who underwent PDA ligation as a single cardiac procedure (diagnosis code 7470 [2D] and procedure code 3885 [3P]):

ICD-9-CM procedure code (3P), if single procedure:

3885 OCCLUDE THORACIC VES NEC*

with ICD-9-CM diagnosis code (2D):

7470 PATENT DUCTUS ARTERIOSUS

- P Patients with prosthetic closures of atrial septal defects (procedure codes 3551, 3552, 3571) or ventricular septal defects (codes 3553, 3572) or atrial septal enlargement (3541) [4P] without concomitant use of cardiopulmonary bypass (code 3961) [5P]:

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ICD-9-CM procedure codes (4P):

3541	ENLARGE EXISTING SEP DEF#	3553	PROST REPAIR VENTRIC DEF#
3551	PROS REP ATRIAL DEF-OPN#	3571	ATRIA SEPTA DEF REP NEC#
3552	PROS REPAIR ATRIA DEF-CL#	3572	VENTR SEPTA DEF REP NEC#

without cardiopulmonary bypass (5P)

ICD-9-CM procedure code:

3961 EXTRACORPOREAL CIRCULAT

P Patients with PDA closure as a single cardiac procedure (procedure code 3885) [3P] with concomitant cardiac catheterization (codes 3721, 3722, 3723, 8842, 8843) [6P]:

ICD-9-CM procedure code (3P), if single procedure

3885 OCCLUDE THORACIC VES NEC*

with cardiac catheterization (6P)

ICD-9-CM procedure codes:

3721	RT HEART CARDIAC CATH	8842	CONTRAST AORTOGRAM
3722	LEFT HEART CARDIAC CATH	8843	CONTR PULMON ARTERIOGRAM
3723	RT/LEFT HEART CARD CATH		

P Patients with occlusion of thoracic vessel (procedure code 3885) [3P] without congenital heart defect (diagnosis codes 7450 through 7479) [3D]:

ICD-9-CM procedure code (3P):

3885 OCCLUDE THORACIC VES NEC*

without congenital heart defect (3D)

ICD-9-CM diagnosis codes:

7450	COMMON TRUNCUS	74684	OBSTRUCT HEART ANOM NEC
74510	COMPL TRANSPOS GREAT VES	74685	CORONARY ARTERY ANOMALY
74511	DOUBLE OUTLET RT VENTRIC	74686	CONGENITAL HEART BLOCK
74512	CORRECT TRANSPOS GRT VES	74687	MALPOSITION OF HEART
74519	TRANSPOS GREAT VESS NEC	74689	CONG HEART ANOMALY NEC
7452	TETRALOGY OF FALLOT	7469	CONG HEART ANOMALY NOS
7453	COMMON VENTRICLE	7470	PATENT DUCTUS ARTERIOSUS
7454	VENTRICULAR SEPT DEFECT	74710	COARCTATION OF AORTA
7455	SECUNDUM ATRIAL SEPT DEF	74711	INTERRUPT OF AORTIC ARCH
74560	ENDOCARD CUSHION DEF NOS	74720	CONG ANOM OF AORTA NOS
74561	OSTIUM PRIMUM DEFECT	74721	ANOMALIES OF AORTIC ARCH
74569	ENDOCARD CUSHION DEF NEC	74722	AORTIC ATRESIA/STENOSIS
7457	COR BILOCULARE	74729	CONG ANOM OF AORTA NEC
7458	SEPTAL CLOSURE ANOM NEC	7473	PULMONARY ARTERY ANOM
7459	SEPTAL CLOSURE ANOM NOS	74740	GREAT VEIN ANOMALY NOS
74600	PULMONARY VALVE ANOM NOS	74741	TOT ANOM PULM VEN CONN
74601	CONG PULMON VALV ATRESIA	74742	PART ANOM PULM VEN CONN
74602	CONG PULMON VALVE STENOS	74749	GREAT VEIN ANOMALY NEC
74609	PULMONARY VALVE ANOM NEC	7475	UMBILICAL ARTERY ABSENCE
7461	CONG TRICUSP ATRES/STEN	74760	UNSP PRPHERL VASC ANOMAL

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7462	EBSTEIN'S ANOMALY	74761	GSTRONTEST VESL ANOMALY
7463	CONG AORTA VALV STENOSIS	74762	RENAL VESSEL ANOMALY
7464	CONG AORTA VALV INSUFFIC	74763	UPR LIMB VESSEL ANOMALY
7465	CONGEN MITRAL STENOSIS	74764	LWR LIMB VESSEL ANOMALY
7466	CONG MITRAL INSUFFICIENC	74769	OTH SPCF PRPH VSCL ANOML
7467	HYOPLAS LEFT HEART SYND	74781	CEREBROVASCULAR ANOMALY
74681	CONG SUBAORTIC STENOSIS	74782	SPINAL VESSEL ANOMALY
74682	COR TRIATRIATUM	74789	CIRCULATORY ANOMALY NEC
74683	INFUNDIB PULMON STENOSIS	7479	CIRCULATORY ANOMALY NOS

Abdominal Aortic Artery (AAA) Repair Mortality Rate**Numerator:**

Number of deaths with a code of AAA repair in any procedure field and a diagnosis of AAA in any field.

Denominator:

Discharges with ICD-9-CM codes of 3834, 3844, or 3864 in any procedure field and a diagnosis of AAA in any field.

ICD-9-CM AAA repair procedure codes:

3834	AORTA RESECTION & ANAST
3844	RESECT ABDM AORTA W REPL
3864	EXCISION OF AORTA

ICD-9-CM AAA diagnosis codes:

4413	RUPT ABD AORTIC ANEURYSM
4414	ABDOM AORTIC ANEURYSM

Exclude:

Patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and other neonates).

Coronary Artery Bypass Graft (CABG) Mortality Rate**Numerator:**

Number of deaths with a code of CABG in any procedure field.

Denominator:

Discharges with ICD-9-CM codes of 3610 through 3619 in any procedure field. Age 40 years and older.

ICD-9-CM CABG procedure codes:

3610	AORTOCORONARY BYPASS NOS	3615	INT MAM-COR ART BYPASS
3611	AORTOCOR BYPAS-1 COR ART	3616	INT MAM-COR ART BYPASS
3612	AORTOCOR BYPAS-2 COR ART	3617	ABD-CORON ART BYPASS OCT96-
3613	AORTOCOR BYPAS-3 COR ART	3619	HRT REVAS BYPS ANAS NEC
3614	AORTCOR BYPAS-4+ COR ART		

Exclude:

Patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and other neonates).

Craniotomy Mortality Rate**Numerator:**

Number of deaths with DRG 001 (craniotomy, except for trauma).

Denominator:

All discharges with DRG code for craniotomy (DRG 001 Craniotomy Age >17, Except for Trauma).

Exclude:

Patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and other neonates).

Hip Replacement Mortality Rate

Numerator:

Number of deaths with a code of partial or full hip replacement in any procedure field.

Denominator:

All discharges with a procedure code of partial or full hip replacement in any field.

ICD-9-CM hip replacement procedure codes:

8151 TOTAL HIP REPLACEMENT
8152 PARTIAL HIP REPLACEMENT
8153 REVISION HIP REPLACEMENT

Include only discharges with uncomplicated cases: diagnosis codes for osteoarthritis of hip in any field.

ICD-9-CM osteoarthritis diagnosis codes:

71500	GENL OSTEOARTHROSIS NOS	71595	OSTEOARTHROS NOS_PELVIS
71509	GENL OSTEOARTHROSIS MULT	71598	OSTEOARTHRO NOS_OTH SITE
71510	LOC PRIM OSTEOART_UNSPEC	71650	POLYARTHRTIS NOS_UNSPEC
71515	LOC PRIM OSTEOART_PELVIS	71655	POLYARTHRTIS NOS_PELVIS
71518	LOC PRIM OSTEOARTHROS NEC	71658	POLYARTHRTIS NOS_NEC
71520	LOC 2ND OSTEOARTH_UNSPEC	71659	POLYARTHRTIS NOS_MULT SITE
71525	LOC 2ND OSTEOARTH_PELVIS	71660	MONOARTHRTIS NOS_UNSPEC
71528	LOC 2ND OSTEOARTHROS NEC	71665	MONOARTHRTIS NOS_PELVIS
71530	LOC OSTEOARTH NOS_UNSPEC	71668	MONOARTHRTIS NOS_NEC
71535	LOC OSTEOARTH NOS_PELVIS	71669	MONOARTHRTIS NOS_MULT SITE
71538	LOC OSTEOAR NOS_SITE NEC	71690	ARTHROPATHY NOS_UNSPEC
71580	OSTEOARTHROSIS_MULT SITE	71695	ARTHROPATHY NOS_PELVIS
71589	OSTEOARTHROSIS_MULT SITE	71698	ARTHROPATHY NOS_NEC
71590	OSTEOARTHROS NOS_UNSPEC	71699	ARTHROPATHY NOS_MULT SITE

Exclude:

Patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and other neonates).

Mortality Indicators for Inpatient Conditions

Acute Myocardial Infarction (AMI) Mortality Rate	
Numerator:	
Number of deaths with a principal diagnosis code of AMI.	
Denominator:	
All discharges with a principal diagnosis code of AMI, age 18 years and older.	
ICD-9-CM AMI diagnosis codes:	
41001 AMI ANTEROLATERAL, INIT	41051 AMI LATERAL NEC, INITIAL
41011 AMI ANTERIOR WALL, INIT	41061 TRUE POST INFARCT, INIT
41021 AMI INFEROLATERAL, INIT	41071 SUBENDO INFARCT, INITIAL
41031 AMI INFEROPOST, INITIAL	41081 AMI NEC, INITIAL
41041 AMI INFERIOR WALL, INIT	41091 AMI NOS, INITIAL
Exclude:	
Patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and other neonates).	

Congestive Heart Failure (CHF) Mortality Rate

Numerator:

Number of deaths with a principal diagnosis code of CHF.

Denominator:

All discharges with principal diagnosis code of CHF, age 18 years and older.

ICD-9-CM CHF diagnosis codes:

39891	RHEUMATIC HEART FAILURE	40413	BEN HYP HRT/REN W CHF&RF
40201	MAL HYPERT HRT DIS W CHF	40491	HYPER HRT/REN NOS W CHF
40211	BENIGN HYP HRT DIS W CHF	40493	HYP HT/REN NOS W CHF&RF
40291	HYPERTEN HEART DIS W CHF	4280	CONGESTIVE HEART FAILURE
40401	MAL HYPER HRT/REN W CHF	4281	LEFT HEART FAILURE
40403	MAL HYP HRT/REN W CHF&RF	4289	HEART FAILURE NOS
40411	BEN HYPER HRT/REN W CHF		

Exclude:

Discharges with cardiac procedure codes in any field, patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and other neonates).

ICD-9-CM cardiac procedure codes:

3601	PTCA-1 VESSEL W/O AGENT	3619	HRT REVAS BYPS ANAS NEC
3602	PTCA-1 VESSEL WITH AGNT	375	HEART TRANSPLANTATION
3605	PTCA-MULTIPLE VESSEL	3770	INT INSERT PACEMAK LEAD
3606	INSERT OF COR ART STENT OCT95-	3771	INT INSERT LEAD IN VENT
3610	AORTOCORONARY BYPASS NOS3772		INT INSER LEAD ATRI-VENT
3611	AORTOCOR BYPAS-1 COR ART	3773	INT INSER LEAD IN ATRIUM
3612	AORTOCOR BYPAS-2 COR ART	3774	INT OR REPL LEAD EPICAR
3613	AORTOCOR BYPAS-3 COR ART	3775	REVISION OF LEAD
3614	AORTCOR BYPAS-4+ COR ART	3776	REPL TV ATRI-VENT LEAD
3615	1 INT MAM-COR ART BYPASS	3777	REMOVAL OF LEAD W/O REPL
3616	2 INT MAM-COR ART BYPASS	3778	INSER TEMP PACEMAKER SYS
3617	ABD-CORON ART BYPASS OCT96-	3779	REVIS OR RELOCATE POCKET

Acute Stroke Mortality Rate

Numerator:

Number of deaths with a principal diagnosis code of stroke.

Denominator:

All discharges with principal diagnosis code for stroke, age 18 years and older.

ICD-9-CM stroke diagnosis codes:

430	SUBARACHNOID HEMORRHAGE	43331	MULT PRECER OCCL W/ INFRCT
431	INTRACEREBRAL HEMORRHAGE	43381	PRECER OCCL NEC W/ INFRCT
4320	NONTRAUM EXTRADURAL HEM	43391	PRECER OCCL NOS W/ INFRCT
4321	SUBDURAL HEMORRHAGE	43401	CERE THROMBOSIS W/ INFRCT
4329	INTRACRANIAL HEMORR NOS	43411	CERE EMBOLISM W/ INFRCT
43301	BASI ART OCCL W/ INFARCT	43491	CEREB OCCL NOS W/ INFRCT
43311	CAROTD OCCL W/ INFRCT	436	CVA
43321	VERTB ART OCCL W/ INFRCT		

Exclude:

Patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and other neonates).

Gastrointestinal Hemorrhage Mortality Rate

Numerator:

Number of deaths with a principal diagnosis code of gastrointestinal hemorrhage.

Denominator:

All discharges with principal diagnosis code for gastrointestinal hemorrhage, age 18 years and older.

ICD-9-CM gastrointestinal hemorrhage diagnosis codes:

4560	ESOPH VARICES W HEM	53361	CHR PEPT ULC HEM/PERF-OB
5307	GASTROESOPH LACER W HEM	53400	AC MARGINAL ULCER W HEM
53082	ESOPHAGEAL HEM	53401	AC MARGIN ULC W HEM-OBST
53100	AC STOMACH ULCER W HEM	53420	AC MARGIN ULC W HEM/PERF
53101	AC STOMAC ULC W HEM-OBST	53421	AC MARG ULC HEM/PERF-OBS
53120	AC STOMAC ULC W HEM/PERF	53440	CHR MARGINAL ULCER W HEM
53121	AC STOM ULC HEM/PERF-OBS	53441	CHR MARGIN ULC W HEM-OBS
53140	CHR STOMACH ULC W HEM	53460	CHR MARGIN ULC HEM/PERF
53141	CHR STOM ULC W HEM-OBSTR	53461	CHR MARG ULC HEM/PERF-OB
53160	CHR STOMACH ULC HEM/PERF	53501	ACUTE GASTRITIS W HMRHG
53161	CHR STOM ULC HEM/PERF-OB	53511	ATRPH GASTRITIS W HMRHG
53200	AC DUODENAL ULCER W HEM	53521	GSTR MCSL HYPRT W HMRG
53201	AC DUODEN ULC W HEM-OBST	53531	ALCHL GSTRITIS W HMRHG
53220	AC DUODEN ULC W HEM/PERF	53541	OTH SPF GASTRT W HMRHG
53221	AC DUOD ULC HEM/PERF-OBS	53551	GSTRDDNTS NOS W HMRHG
53240	CHR DUODEN ULCER W HEM	53561	DUODENITIS W HMRHG
53241	CHR DUODEN ULC HEM-OBSTR	53783	ANGIODYS STOM DUOD W HEM
53260	CHR DUODEN ULC HEM/PERF	56202	DIVERTICULOS SM INT W HEM
53261	CHR DUOD ULC HEM/PERF-OB	56203	DIVERTICULIT SM INT W HEM
53300	AC PEPTIC ULCER W HEMORR	56212	DIVERTICULOS COLON W HEM
53301	AC PEPTIC ULC W HEM-OBST	56213	DIVERTICULIT COLON W HEM
53320	AC PEPTIC ULC W HEM/PERF	5693	HEMORRHAGE RECT/ANUS
53321	AC PEPT ULC HEM/PERF-OBS	56985	ANGIODYS INTEST W HEM
53340	CHR PEPTIC ULCER W HEM	5780	HEMATEMESIS
53341	CHR PEPTIC ULC W HEM-OBS	5781	BLOOD IN STOOL
53360	CHR PEPT ULC W HEM/PERF	5789	GASTROINTEST HEMORR NOS

Exclude:

Patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and other neonates).

Hip Fracture Mortality Rate

Numerator:

Number of deaths with a principal diagnosis code of hip fracture.

Denominator:

All discharges with principal diagnosis code for hip fracture, age 18 years and older.

ICD-9-CM hip fracture diagnosis codes:

82000	FX FEMUR INTRCAPS NOS-CL	82019	FX FEMUR INTRCAP NEC-OPN
82001	FX UP FEMUR EPIPHY-CLOS	82020	TROCHANTERIC FX NOS-CLOS
82002	FX FEMUR, MIDCERVIC-CLOS	82021	INTERTROCHANTERIC FX-CL
82003	FX BASE FEMORAL NCK-CLOS	82022	SUBTROCHANTERIC FX-CLOSE
82009	FX FEMUR INTRCAPS NEC-CL	82030	TROCHANTERIC FX NOS-OPEN
82010	FX FEMUR INTRCAP NOS-OPN	82031	INTERTROCHANTERIC FX-OPN
82011	FX UP FEMUR EPIPHY-OPEN	82032	SUBTROCHANTERIC FX-OPEN
82012	FX FEMUR, MIDCERVIC-OPEN	8208	FX NECK OF FEMUR NOS-CL
82013	FX BASE FEMORAL NCK-OPEN	8209	FX NECK OF FEMUR NOS-OPN

Exclude:

Patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and other neonates).

Pneumonia Mortality Rate

Numerator:

Number of deaths with a principal diagnosis code of pneumonia.

Denominator:

All discharges with a principal diagnosis code of pneumonia, age 18 years and older.

ICD-9-CM pneumonia diagnosis codes:

00322	SALMONELLA PNEUMONIA	48239	OTH STREP PNEUMONIA
0212	PULMONARY TULAREMIA	4824	STAPHYLOCOCCAL PNEUMONIA
0391	PULMONARY ACTINOMYCOSIS	48240	STAPH PNEUMONIA UNSP OCT98-
0521	VARICELLA PNEUMONITIS	48241	STAPH AUREUS PNEUMON OCT98-
0551	POSTMEASLES PNEUMONIA	48249	STAPH PNEUMON OTH OCT98-
0730	ORNITHOSIS PNEUMONIA	48281	ANAEROBIC PNEUMONIA
1124	CANDIDIASIS OF LUNG	48282	E COLI PNEUMONIA
1140	PRIMARY COCCIDIOIDOMYCOS	48283	OTH GRAM NEG PNEUMONIA
1144	CHRONIC PULMON COCCIDIOIDOMYCO	48284	LEGIONNAIRES DX OCT97-
1145	UNSPEC PULMON COCCIDIOIDOMYCO	48289	BACT PNEUMONIA NEC
11505	HISTOPLASM CAPS PNEUMON	4829	BACTERIAL PNEUMONIA NOS
11515	HISTOPLASM DUB PNEUMONIA	4830	MYCOPLASMA PNEUMONIA
11595	HISTOPLASMOSIS PNEUMONIA	4831	CHLAMYDIA PNEUMONIA OCT96-
1304	TOXOPLASMA PNEUMONITIS	4838	OTH SPEC ORG PNEUMONIA
1363	PNEUMOCYSTOSIS	4841	PNEUM W CYTOMEG INCL DIS
4800	ADENOVIRAL PNEUMONIA	4843	PNEUMONIA IN WHOOP COUGH
4801	RESP SYNCYT VIRAL PNEUM	4845	PNEUMONIA IN ANTHRAX
4802	PARINFLUENZA VIRAL PNEUM	4846	PNEUM IN ASPERGILLOSIS
4808	VIRAL PNEUMONIA NEC	4847	PNEUM IN OTH SYS MYCOSES
4809	VIRAL PNEUMONIA NOS	4848	PNEUM IN INFECT DIS NEC
481	PNEUMOCOCCAL PNEUMONIA	485	BRONCOPNEUMONIA ORG NOS
4820	K. PNEUMONIAE PNEUMONIA	486	PNEUMONIA, ORGANISM NOS
4821	PSEUDOMONAL PNEUMONIA	5070	PNEUMONITIS, ASP FOOD VOMIT
4822	H.INFLUENZAE PNEUMONIA	5100	EMPHYEMA W FISTULA
48230	STREP PNEUMONIA UNSPEC	5109	EMPHYEMA W/O FISTULA
48231	GRP A STREP PNEUMONIA	5110	PLEURISY W EFF, BACT NOT TB
48232	GRP B STREP PNEUMONIA	5130	ABSCESS OF LUNG

Exclude:

Patients transferring to another short-term hospital, MDC 14 (pregnancy, childbirth, and puerperium), and MDC 15 (newborns and other neonates).

Procedure Utilization Indicators

Cesarean Section Delivery Rate			
Numerator:			
Number of Cesarean sections.			
Cesarean section delivery DRGs:			
370	Cesarean section w/CC		
371	Cesarean section w/o CC		
Denominator:			
All deliveries.			
All delivery DRGs:			
370	CESAREAN SECTION W CC	373	VAG DELIVERY W/O COMPL
371	CESAREAN SECTION W/O CC	374	VAG DELIV W STERIL OR DC
372	VAGINAL DELIVERY W COMPL	375	VAG DELIV W OTH OR PROC

Vaginal Birth After Cesarean Section (VBAC) Delivery Rate			
Numerator:			
Number of vaginal births in women with a diagnosis of previous Cesarean section.			
Vaginal delivery DRGs:			
372	VAGINAL DELIVERY W/ CC		
373	VAGINAL DELIVERY W/O CC		
374	VAGINAL DELIVERY W/ STERILIZATION OR D&C		
375	VAGINAL DELIVERY W/ OTHER O.R. PROCEDURE		
Denominator:			
All deliveries with a previous Cesarean section diagnosis in any diagnosis field.			
All delivery DRGs:			
370	CESAREAN SECTION W CC	373	VAG DELIVERY W/O COMPL
371	CESAREAN SECTION W/O CC	374	VAG DELIV W STERIL OR DC
372	VAGINAL DELIVERY W COMPL	375	VAG DELIV W OTH OR PROC
ICD-9-CM previous Cesarean section diagnosis codes:			
65420	PREV C-SECT NOS-UNSPEC		
65421	PREV C-SECT NOS-DELIVER		
65423	PREV C-SECT NOS-ANTEPART		

Laparoscopic Cholecystectomy Rate

Numerator:

Number of laparoscopic cholecystectomies (any procedure field).

ICD-9-CM laparoscopic cholecystectomy procedure code:

5123 LAPAROSCOPIC CHOLE

Denominator:

All discharges with cholecystectomy in any procedure field.

ICD-9-CM procedure cholecystectomy codes:

5122 CHOLECYSTECTOMY
5123 LAPAROSCOPIC CHOLE

Include:

Only discharges with uncomplicated cases: cholecystitis and/or cholelithiasis in any diagnosis field.

ICD-9-CM uncomplicated cholecystitis and/or cholelithiasis diagnosis codes:

57400	CHOLELITH W/ AC CHOLECYS	5750	ACUTE CHOLECYSTITIS
57401	CHOLELITH W/ AC CHOLECYS	5751	CHOLECYSTITIS NEC -OCT96
57410	CHOLELITH W CHOLECYS NEC	57510	CHOLECYSTITIS NOS OCT96-
57411	CHOLELITH W CHOLECYS NEC	57511	CHRONIC CHOLECYSTITIS OCT96-
57420	CHOLELITH NOS W/O OBSTRUC	57512	ACUTE & CHR CHOLECYSTITIS OCT96-
57421	CHOLELITH NOS W/ OBSTRUC		

Exclude:

MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and other neonates).

Incidental Appendectomy Among the Elderly Rate

Numerator:

Number of incidental appendectomies (any procedure field).

ICD-9-CM incidental appendectomy procedure codes:

471 INCIDENTAL APPENDECTOMY -OCT96
4711 LAP INCID APPENDECTOMY OCT96-
4719 OTHER INCID APPENDECTOMY OCT96-

Denominator:

All discharges age 65 years and older with intra-abdominal procedure.

Intra-abdominal procedure DRGs:

146	RECTAL RESECTION W CC		193	BILIARY PROC W/ CC
147	RECTAL RESECTION W/O CC		194	BILIARY PROC W/O CC
148	MAJ BOWEL PROC W CC		195	CHOLE W/ CDE W/ CC
149	MAJ BOWEL PROC W/O CC		196	CHOLE W/ CDE W/O CC
150	PERITONEAL ADHES W CC		197	CHOLE W/ CC
151	PERITONEAL ADHES W/O CC		198	CHOLE W/O CC
152	MIN BOWEL PROC W CC	201		OTH BILIARY/PANC PROC
153	MIN BOWEL PROC W/O CC		354	UTER PROC MALIG W/ CC
154	UGI PROC AGE >17 W CC		355	UTER PROC MALIG W/O CC
155	UGI PROC AGE >17 W/O CC		356	FEMALE REPROD RECONSTR
170	OTH GI OR PROC W CC		357	UTER PROC OVARIAN MALIG
171	OTH GI OR PROC W/O CC		358	UTER PROC NONMALIG W/ CC
191	PANC LVR SHNT PRC W CC		359	UTER PROC NONMALI W/O CC
192	PANC LVR SHNT PRC W/O CC		365	OTH FEMAL REPROD PROC

Exclude:

MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and other neonates).

Bilateral Cardiac Catheterization Rate

Numerator:

Number of simultaneous right and left heart catheterizations (in any procedure field).

ICD-9-CM procedure code:

3723 RT/LEFT HEART CARD CATH

Exclude:

Valid indications for right-sided catheterization in any diagnosis field.

ICD-9-CM indications for right-sided catheterization diagnosis codes:

3910	ACUTE RHEUMATIC PERICARD	7454	VENTRICULAR SEPT DEFECT
3911	ACUTE RHEUMATIC ENDOCARD	7455	SECUNDUM ATRIAL SEPT DEF
3912	AC RHEUMATIC MYOCARDITIS	74560	ENDOCARD CUSHION DEF NOS
3918	AC RHEUMAT HRT DIS NEC	74561	OSTIUM PRIMUM DEFECT
3919	AC RHEUMAT HRT DIS NOS	74569	ENDOCARD CUSHION DEF NEC
3920	RHEUM CHOREA W HRT INVOL	7457	COR BILOCULARE
3929	RHEUMATIC CHOREA NOS	7458	SEPTAL CLOSURE ANOM NEC
393	CHR RHEUMATIC PERICARD	7459	SEPTAL CLOSURE ANOM NOS
3940	MITRAL STENOSIS	74600	PULMONARY VALVE ANOM NOS
3941	RHEUMATIC MITRAL INSUFF	74601	CONG PULMON VALV ATRESIA
3942	MITRAL STENOSIS W INSUFF	74602	CONG PULMON VALVE STENOS
3949	MITRAL VALVE DIS NEC/NOS	74609	PULMONARY VALVE ANOM NEC
3960	MITRAL/AORTIC STENOSIS	7461	CONG TRICUSP ATRES/STEN
3961	MITRAL STENOS/AORT INSUF	7462	EBSTEIN'S ANOMALY
3962	MITRAL INSUF/AORT STENOS	7463	CONG AORTA VALV STENOSIS
3963	MITRAL/AORTIC VAL INSUFF	7464	CONG AORTA VALV INSUFFIC
3968	MITR/AORTIC MULT INVOLV	7465	CONGEN MITRAL STENOSIS
3969	MITRAL/AORTIC V DIS NOS	7466	CONG MITRAL INSUFFICIENC
3970	TRICUSPID VALVE DISEASE	7467	HYPOPLAS LEFT HEART SYND
3971	RHEUM PULMON VALVE DIS	74681	CONG SUBAORTIC STENOSIS
3979	RHEUM ENDOCARDITIS NOS	74682	COR TRIARIATUM
3980	RHEUMATIC MYOCARDITIS	74683	INFUNDIB PULMON STENOSIS
39890	RHEUMATIC HEART DIS NOS	74684	OBSTRUCT HEART ANOM NEC
39891	RHEUMATIC HEART FAILURE	74685	CORONARY ARTERY ANOMALY
39899	RHEUMATIC HEART DIS NEC	74686	CONGENITAL HEART BLOCK
40200	MAL HYPERTEN HRT DIS NOS	74687	MALPOSITION OF HEART
40201	MAL HYPERT HRT DIS W CHF	74689	CONG HEART ANOMALY NEC
40210	BEN HYPERTEN HRT DIS NOS	7469	CONG HEART ANOMALY NOS
40211	BENIGN HYP HRT DIS W CHF	7470	PATENT DUCTUS ARTERIOSUS
40290	HYPERTENSIVE HRT DIS NOS	74710	COARCTATION OF AORTA
40291	HYPERTEN HEART DIS W CHF	74711	INTERRUPT OF AORTIC ARCH
4150	ACUTE COR PULMONALE	74720	CONG ANOM OF AORTA NOS
4151	PULM EMBOLISM/INFARCT -OCT95	74721	ANOMALIES OF AORTIC ARCH
41511	IATROGEN PULM EMB/INFARC OCT95-	74722	AORTIC ATRESIA/STENOSIS
41519	PULM EMBOL/INFARCT NEC OCT95-	74729	CONG ANOM OF AORTA NEC
4160	PRIM PULM HYPERTENSION	7473	PULMONARY ARTERY ANOM
4161	KYPHOSCOLIOTIC HEART DIS	74740	GREAT VEIN ANOMALY NOS
4168	CHR PULMON HEART DIS NEC	74741	TOT ANOM PULM VEN CONNEC
4169	CHR PULMON HEART DIS NOS	74742	PART ANOM PULM VEN CONN
4170	ARTERIOVEN FISTU PUL VES	74749	GREAT VEIN ANOMALY NEC
4171	PULMON ARTERY ANEURYSM	7475	UMBILICAL ARTERY ABSENCE
4178	PULMON CIRCULAT DIS NEC	74760	UNSP PRPHERL VASC ANOMAL
4179	PULMON CIRCULAT DIS NOS	74761	GSTRONTEST VESL ANOMALY
4242	NONRHEUM TRICUSP VAL DIS	74762	RENAL VESSEL ANOMALY
4243	PULMONARY VALVE DISORDER	74763	UPR LIMB VESSEL ANOMALY
7450	COMMON TRUNCUS	74764	LWR LIMB VESSEL ANOMALY
74510	COMPL TRANSPOS GREAT VES	74769	OTH SPCF PRPH VSCL ANOML

Bilateral Cardiac Catheterization Rate

74511	DOUBLE OUTLET RT VENTRIC	74781	CEREBROVASCULAR ANOMALY
74512	CORRECT TRANSPOS GRT VES	74782	SPINAL VESSEL ANOMALY
74519	TRANSPOS GREAT VESS NEC	74789	CIRCULATORY ANOMALY NEC
7452	TETRALOGY OF FALLOT	7479	CIRCULATORY ANOMALY NOS
7453	COMMON VENTRICLE		

Denominator:

All discharges with heart catheterization in any procedure field.

ICD-9-CM heart catheterization procedure codes:

3722	LEFT HEART CARDIAC CATH
3723	RT/LEFT HEART CARD CATH

Include:

Only coronary artery disease.

ICD-9-CM coronary artery disease diagnosis codes:

41000	AMI ANTEROLATERAL, UNSPEC	41081	AMI NEC, INITIAL
41001	AMI ANTEROLATERAL, INIT	41082	AMI NEC, SUBSEQUENT
41002	AMI ANTEROLATERAL, SUBSEQ	41090	AMI NOS, UNSPECIFIED
41010	AMI ANTERIOR WALL, UNSPEC	41091	AMI NOS, INITIAL
41011	AMI ANTERIOR WALL, INIT	41092	AMI NOS, SUBSEQUENT
41012	AMI ANTERIOR WALL, SUBSEQ	4110	POST MI SYNDROME
41020	AMI INFEROLATERAL, UNSPEC	4111	INTERMED CORONARY SYND
41021	AMI INFEROLATERAL, INIT	41181	CORONARY OCCLSN W/O MI
41022	AMI INFEROLATERAL, SUBSEQ	41189	AC ISCHEMIC HRT DIS NEC
41030	AMI INFEROPOST, UNSPEC	412	OLD MYOCARDIAL INFARCT
41031	AMI INFEROPOST, INITIAL	4130	ANGINA DECUBITUS
41032	AMI INFEROPOST, SUBSEQ	4131	PRINZMETAL ANGINA
41040	AMI INFERIOR WALL, UNSPEC	4139	ANGINA PECTORIS NEC/NOS
41041	AMI INFERIOR WALL, INIT	4140	COR ATHEROSCLEROSIS -OCT94
41042	AMI INFERIOR WALL, SUBSEQ	41400	COR ATH UNSP VSL NTV/GFT OCT94-
41050	AMI LATERAL NEC, UNSPEC	41401	CRNRY ATHRSCL NATVE VSSL OCT94-
41051	AMI LATERAL NEC, INITIAL	41402	CRN ATH ATLG VN BPS GRFT OCT94-
41052	AMI LATERAL NEC, SUBSEQ	41403	CRN ATH NONATLG BLG GRFT OCT94-
41060	TRUE POST INFARCT, UNSPEC	41404	COR ATH ARTRY BYPAS GRFT OCT96-
41061	TRUE POST INFARCT, INIT	41405	COR ATH BYPASS GRAFT NOS OCT96-
41062	TRUE POST INFARCT, SUBSEQ	41410	ANEURYSM, HEART (WALL)
41070	SUBENDO INFARCT, UNSPEC	41411	CORONARY VESSEL ANEURYSM
41071	SUBENDO INFARCT, INITIAL	41419	ANEURYSM OF HEART NEC
41072	SUBENDO INFARCT, SUBSEQ	4148	CHR ISCHEMIC HRT DIS NEC
41080	AMI NEC, UNSPECIFIED	4149	CHR ISCHEMIC HRT DIS NOS

Exclude:

MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and other neonates).

Area-Level Indicators

Coronary Artery Bypass Graft (CABG) Area Rate			
Numerator:			
Number of CABGs in any procedure field.			
All discharges age 40 years and older.			
ICD-9-CM CABG procedure codes:			
3610	AORTOCORONARY BYPASS NOS	3615	1 INT MAM-COR ART BYPASS
3611	AORTOCOR BYPAS-1 COR ART	3616	2 INT MAM-COR ART BYPASS
3612	AORTOCOR BYPAS-2 COR ART	3617	ABD-CORON ART BYPASS OCT96-
3613	AORTOCOR BYPAS-3 COR ART	3619	HRT REVAS BYPS ANAS NEC
3614	AORTCOR BYPAS-4+ COR ART		
Exclude:			
MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and other neonates).			
Denominator:			
Population in MSA or county, age 40 years and older.			

Percutaneous Transluminal Coronary Angioplasty (PTCA) Area Rate	
Numerator:	
Number of PTCAs in any procedure field.	
All discharges age 40 years and older.	
ICD-9-CM PTCA procedure codes:	
3601	PTCA-1 VESSEL W/O AGENT
3602	PTCA-1 VESSEL WITH AGNT
3605	PTCA-MULTIPLE VESSEL
3606	INSERT OF COR ART STENT
Exclude:	
MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and other neonates).	
Denominator:	
Population in MSA or county, age 40 years and older.	

Hysterectomy Area Rate

Numerator:

Number of hysterectomies in any procedure field.

All discharges of females age 18 years and older.

ICD-9-CM hysterectomy procedure codes:

683	SUBTOT ABD HYSTERECTOMY	6859	OTHER VAG HYSTERECTOMY OCT96-
684	TOTAL ABD HYSTERECTOMY	686	RADICAL ABD HYSTERECTOMY
685	VAGINAL HYSTERECTOMY -OCT96	687	RADICAL VAG HYSTERECTOMY
6851	LAP AST VAG HYSTERECTOMY OCT96-	689	OTHER/UNSP HYSTERECTOMY

Exclude:

Discharges with genital cancer or pelvic or lower abdominal trauma in any diagnosis field.

MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and other neonates).

ICD-9-CM female genital cancer diagnosis codes:

179	MALIG NEOPL UTERUS NOS	1839	MAL NEO ADNEXA NOS
1800	MALIG NEO ENDOCERVIX	1840	MALIGN NEOPL VAGINA
1801	MALIG NEO EXOCERVIX	1841	MAL NEO LABIA MAJORA
1808	MALIG NEO CERVIX NEC	1842	MAL NEO LABIA MINORA
1809	MAL NEO CERVIX UTERI NOS	1843	MALIGN NEOPL CLITORIS
181	MALIGNANT NEOPL PLACENTA	1844	MALIGN NEOPL VULVA NOS
1820	MALIG NEO CORPUS UTERI	1848	MAL NEO FEMALE GENIT NEC
1821	MAL NEO UTERINE ISTHMUS	1849	MAL NEO FEMALE GENIT NOS
1828	MAL NEO BODY UTERUS NEC	2331	CA IN SITU CERVIX UTERI
1830	MALIGN NEOPL OVARY	2332	CA IN SITU UTERUS NEC
1832	MAL NEO FALLOPIAN TUBE	2333	CA IN SITU FEM GEN NEC
1833	MAL NEO BROAD LIGAMENT	2360	UNCERT BEHAV NEO UTERUS
1834	MALIG NEO PARAMETRIUM	2361	UNC BEHAV NEO PLACENTA
1835	MAL NEO ROUND LIGAMENT	2362	UNC BEHAV NEO OVARY
1838	MAL NEO ADNEXA NEC	2363	UNC BEHAV NEO FEMALE NEC

ICD-9-CM pelvic or lower abdominal trauma diagnosis codes:

8674	UTERUS INJURY-CLOSED	86819	INTRA-ABDOM INJ NEC-OPEN
8675	UTERUS INJURY-OPEN	8690	INTERNAL INJ NOS-CLOSED
8676	PELVIC ORGAN INJ NEC-CL	8691	INTERNAL INJURY NOS-OPEN
8677	PELVIC ORGAN INJ NEC-OPN	8796	OPEN WOUND OF TRUNK NEC
8678	PELVIC ORGAN INJ NOS-CL	8797	OPEN WND TRUNK NEC-COMPL
8679	PELVIC ORGAN INJ NOS-OPN	8798	OPEN WOUND SITE NOS
86800	INTRA-ABDOM INJ NOS-CLOS	8799	OPN WOUND SITE NOS-COMPL
86803	PERITONEUM INJURY-CLOSED	9060	LT EFF OPN WND HEAD/TRNK
86804	RETROPERITONEUM INJ-CL	9081	LATE EFF INT INJ ABDOMEN
86809	INTRA-ABDOM INJ NEC-CLOS	9082	LATE EFF INT INJURY NEC
86810	INTRA-ABDOM INJ NOS-OPEN	9391	FOREIGN BODY UTERUS
86813	PERITONEUM INJURY-OPEN	9474	BURN OF VAGINA & UTERUS
86814	RETROPERITONEUM INJ-OPEN		

Denominator:

Female population in MSA or county, age 18 years and older.

Laminectomy or Spinal Fusion Area Rate

Numerator:

Number of laminectomies or spinal fusions in any procedure field.

All discharges age 18 years and older.

ICD-9-CM laminectomy or spinal fusion procedure codes:

0302	REOPEN LAMINECTOMY SITE	8103	OTH CERV FUSION, POSTER
0309	SPINAL CANAL EXPLOR NEC	8104	DORSAL FUSION, ANTERIOR
8050	EXC/DEST INTVRT DISC NOS	8105	DORSAL FUSION, POSTERIOR
8051	EXCISION INTERVERT DISC	8106	LUMBAR FUSION, ANTERIOR
8059	OTH EXC/DEST INTVRT DISC	8107	LUMBAR FUSION, LATERAL
8100	SPINAL FUSION NOS	8108	LUMBAR FUSION, POSTERIOR
8101	ATLAS-AXIS FUSION	8109	REFUSION OF SPINE
8102	OTH CERV FUSION, ANTER		

Exclude:

MDC 14 (pregnancy, childbirth, and puerperium) and MDC 15 (newborns and other neonates).

Denominator:

Population in MSA or county, age 18 years and older.

Appendix B: Detailed Methods

This appendix describes the methods used by the University of California-San Francisco (UCSF) Evidence-based Practice Center to refine the Healthcare Cost and Utilization Project (HCUP) quality indicators.

Semi-structured Interviews

The project team and previous developers of the HCUP Quality Indicators (HCUP QIs) developed a contact list of individuals associated with hospital associations, business coalitions, State data groups, and Federal agencies. This list was designed to include QI users and potential users from a broad spectrum of organizations in both the public and private sectors; it was not intended as a representative sample. All contacts were faxed an introductory letter and asked to participate as advisors on the project with a short telephone interview. This request was well received; only six out of 37 declined participation themselves without suggesting an alternative respondent. Overall, the 31 contacts phoned expressed interest in the study, offering many suggestions and comments. The composition of the 31 interviewees is as follows: three consultants, two Federal agency employees, one health plan medical director, five representatives of hospital associations, one international academic researcher, four representatives of private accreditation groups, two representatives of private data groups, two members of professional organizations, five representatives of provider and other private organizations, three representatives of State data groups, and three representatives of other health care organizations.

The semi-structured interviews were designed to identify potential indicators, concerns of end users, and other factors important in the development of quality indicators that may not be captured in the published literature. Thus, academic researchers, whose work is more likely to appear in peer-reviewed journals, were reserved as peer reviewers for the final document. As a result, the results of the semi-structured interviews are not intended to be a non-biased representation of the opinions regarding quality indicators, but rather a sampling of those opinions not likely to be available in the peer-reviewed literature.

The interviewers solicited information on the development and use of quality indicators by the targeted organizations, as well as other known measures and additional contacts. Interviewers used a semi-structured interview and recorded information from the interview on a data-collection form. Further, some advisors provided the project team with materials regarding quality indicators and the use of HCUP QIs.

Quality Indicators Evaluation Framework

Six areas were considered essential for evaluating the reliability and validity of a proposed quality indicator. Several sources contributed to the development of the evaluation criteria framework: (1) results of the semi-structured interviews, including the interests and concerns of HCUP QI users, (2) task order document describing the Agency for Healthcare Research and Quality's (AHRQ) interests, (3) evidence available in the policy and research literature and (4) evidence available through statistical analyses. The six criteria were quite similar to the criteria for "testing the scientific strength of a measure" proposed by McGlynn and Asch. [1] They describe a measure as reliable "if, when repeatedly applied to the same population, the same result is obtained a high proportion of the time." They propose evaluating validity in terms of face validity, criterion validity ("an objective assessment of the ability of the measure to predict a score on some other measure that serves as the evaluation criterion"), and construct validity ("whether the correlations between the measure and other measures are of the right magnitude and in the right direction"). Criterion validity was viewed as an assessment of

bias (criterion #3), where the “gold standard” measure is purged of bias due to severity of illness. Face validity captures a variety of concepts discussed by McGlynn and Siu, including the importance of the condition, the efficacy of available treatments (e.g., the ability of providers to improve outcomes), and the potential for improvement in quality of care. [2]

Evidence supporting the use of current and candidate quality indicators was assembled in terms of the following six areas.

1. Face validity: Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?
2. Precision: Is there a substantial amount of provider or community level variation that is not attributable to random variation?
3. Minimum bias: Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?
4. Construct validity: Does the indicator perform well in identifying true (or actual) quality of care problems?
5. Fosters real quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?
6. Application: has the measure been used effectively in practice? Does it have potential for working well with other indicators?

In addition to the above framework, the Donabedian paradigm of structure, process, and outcome was followed to categorize current (HCUP) and candidate QIs. [3, 4] For example, potentially inappropriate utilization falls into the category of process, while in-hospital mortality, adverse events, and complication rates represent outcome measures.

Three broad audiences for the quality measures were considered: health care providers and managers, who would use the quality measures to assist in initiatives to improve quality; public health policy-makers, who would use the information from indicators to target public health interventions; and health care purchasers and consumers, who would potentially use the measures to guide decisions about health policies and providers. Because of the limitations of quality indicators derived based on administrative data, the focus was primarily on applications oriented to “screening for potential quality problems.” For the purpose of the Evaluation Framework, indicators must at least pass tests indicating that they are appropriate for the use of screening. The rest of this section provides a more detailed explanation of each part of the Evaluation Framework, considering these three audiences wherever differences have been noted in the literature.

- 1. Face validity: does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control?**

This question considers the degree to which potential users view the quality indicator as important and informative. There are two parts to this question: Does the indicator relate to an aspect of health care that users regard as important? And does performance on the measure credibly indicate high-quality care? Obviously, face validity will be influenced by how well the indicator performs in the other areas covered in the Evaluation Framework. Clinicians tend to distrust outcome measures because of concerns over the adequacy of risk adjustment and the multiple factors beyond providers’ control that contribute to poor outcomes. Other critics add that outcome measures suffer from imprecision (with random noise outweighing provider differences)

and important selection biases (e.g., due to variations in admitting practices). Addressing this issue at the outset serves as a point of reference for the findings of the literature review and empirical analysis.

Broadly speaking, consumers, health care payers, regulators, and public health officials are likely to be most interested in measures based on outcomes that are relatively frequent, costly, or have serious implications for an individual's health. In addition, there should be reason to believe that the outcome may be (at least somewhat) under providers' control (in other words, controlled trials or well-designed cohort studies have shown that specific diagnostic or therapeutic modalities may reduce its frequency or severity). Outcome measures might include operative mortality rates or mortality after hospitalization with serious acute illnesses such as a heart attack. These measures seem most intuitive, since they assess the main outcomes that medical treatments are intended to affect.

Perhaps surprisingly, however, reports of hospital mortality rates appear to have little effect on where patients seek their care. [5, 6] One reason may be that many patients describe difficulty in interpreting indicators involving mortality and morbidity rates, and consequently view them as unhelpful. [7] Another reason may be that providers prefer measures of process, particularly if there is reason to believe (generally from randomized controlled trials) that certain processes truly lead to better patient outcomes. Patients appear to prefer reports of other patients' satisfaction with care, and especially informal recommendations from family, friends, and their own physicians. [7] Thus, developing indicators with high face validity for patients may require active participation from patients, targeting aspects of care identified as important in patient surveys, or taking additional steps to enhance provider perceptions about the validity of outcome measures. [8-17]

Many providers view outcome-based QIs with considerable skepticism. [18] For most outcomes, the impacts of random variation and patient factors beyond providers' control often overwhelm differences attributable to provider quality. [19-24] Consequently, providers tend to support measures of quality based on processes of care that have been documented in clinical trials to lead to better health outcomes in relatively broad groups of patients — for example, the processes of acute MI care measured in the Cooperative Cardiovascular Project. [25-30] Such process measures focus precisely on the aspects of care under providers' control. As long as the process measures are based on evidence of effectiveness, they serve as useful proxies for outcome measures that would otherwise be difficult to observe or measure. For example, when using inpatient discharge data only, it is not possible to ascertain out-of-hospital mortality. In general, process measures are not as noisy as outcome measures, because they are less subject to random variation. They also suggest specific steps that providers may take to improve outcomes or reduce costs — even if such outcome improvements are difficult to document at the level of particular providers.

The relationship between some structural quality measures and important outcomes has been well-documented, although some concerns remain about the interpretation of the measures. [3, 4, 31, 32] These measures include measures of hospital volume for volume-sensitive conditions, technological capabilities (e.g., ability to perform certain intensive procedures like coronary angioplasty), and teaching status. [33-61] All of these measures have limited face validity, because they are widely acknowledged to be weak surrogates for true quality of care. [62] For example, many low-volume hospitals have been shown to achieve excellent outcomes, whereas many high-volume hospitals have surprisingly poor outcomes.

2. Precision: is there a substantial amount of provider or community level variation that is not attributable to random variation?

The impact of chance on apparent provider or community health system performance must be considered. Unobserved patient and environmental factors may result in substantial differences in performance among providers in the absence of true quality differences. Moreover, the same providers may appear to change from year to year, in the absence of

changes in the care they deliver. Thus, using “raw” quality data will often result in poorly reproducible, or imprecise, measurements, giving an incorrect impression of provider quality.

An extensive literature on the importance of random variations in quality measures now exists. [19, 21-24, 63-68] In general, random variation is most problematic when there are relatively few observations per provider, when adverse outcome rates are relatively low, and when providers have little control over patient outcomes or when variation in important processes of care is minimal. If a large number of patient factors that are difficult to observe influence whether or not a patient has an adverse outcome, it may be difficult to separate the “quality signal” from the surrounding noise. The evidence on the precision of each of the evaluated QIs was reviewed. Empirical methods can be used to assess both the importance of sample size and the importance of provider effects (versus patient and area effects) in explaining observed variation in the measure.

But this is not entirely a statistical question, and considerations of mechanisms and concerns related to face validity can also be helpful in assessing the precision of a measure. For example, if better hospitals invariably admit sicker patients, then the apparent variation in a measure at the hospital level will be significantly less than the true variation (see the discussion of unbiasedness below). In such a case, other sources of evidence suggesting that a measure is valid or that such bias exists can be helpful in assessing the quality measure. The literature review encompasses both empirical and other sources of evidence on measure precision, and the empirical analysis presents systematic evidence on the extent of provider-level or area-level variation in each quality measure.

Statistical techniques can account for random variations in provider performance by estimating the extent to which variation across providers appears to be clustered at the provider level, versus the extent to which it can be explained by patient and area effects. [68-71] Under reasonable statistical assumptions, the resulting estimates of the extent to which quality truly varies at the provider or area level can be used to “smooth” or “shrink” estimates of the quality of specific providers or areas. The methods are Bayesian: the data used to construct the quality measures are used to update a “prior” distribution of provider quality estimates, so that the “posterior” or smoothed estimate of a provider’s (or area’s) quality is a best guess, reflecting the apparent patient- and provider-level (or area-level) variance of measure performance.

3. Minimum Bias: is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

A QI may exhibit precision, but nonetheless yield inaccurate results due to systematic measurement biases. Extensive research has documented the importance of *selection problems* in interpreting many quality measures, especially measures related to mortality. [72-76] Such biases may have two basic forms: differences in admitting practices between two hospitals produce non-random samples from the same underlying patient population (selection biases) or the patient populations may in fact contain different case-mixes. Selection effects presumably exert a greater influence on measures involving elective admissions and procedures, for which physician admission and treatment practice styles show marked variation. [56, 57] Nonetheless, selection problems exist even for conditions involving urgent “non-discretionary” admissions, likely due to modest practice variation, and non-random distribution of patient characteristics across hospital catchment areas. [59, 77] The attention of researchers and quality analysts has focused on developing valid models to adjust for patient factors, especially when comparing hospital mortality. [72, 74]

The principal statistical approach to address concerns about bias is risk adjustment. [78, 79, 60, 61, 80-86] Numerous risk adjustment instruments currently exist, but current methods are far from perfect. [79, 87] In general, risk adjustment methods are based on data drawn from administrative data and medical chart reviews. [78] Previous studies suggest that administrative data have at least two major limitations. First, coding errors and variations are common; some

diagnoses are frequently entered with errors and with some inconsistency across hospitals. [88-90] Factors affecting the accuracy of these codes include restrictions on the number of secondary diagnoses permitted, as well as systematic biases in documentation and coding practices introduced by awareness that risk-adjustment and reimbursement are related to the presence of particular complications. [91-96]

Second, most administrative data sources do not distinguish disorders that can be in-hospital complications from pre-existing comorbidities. [78, 97] To the extent that diagnoses such as shock and pulmonary edema may result from poor quality of care, their incorporation in prediction models may bias estimates of expected mortality, and even favor hospitals whose care results in more complications. One proprietary risk-adjustment system has been shown to be significantly biased by its inclusion of conditions that actually developed after admission, but this study was limited to one condition (acute MI) and its conclusions are somewhat controversial. [98, 99] In another study, estimates of mortality differences between municipal and voluntary hospitals in New York City were substantially affected by whether potential complications were excluded from risk-adjustment. [61] New York and California have recently added a “6th digit” to ICD-9-CM codes to distinguish secondary diagnoses present at admission from those that developed during hospitalization. This refinement may allow valid comparisons of risk-adjusted mortality using administrative data for certain conditions, although the accuracy of the “6th digit” has not been established. [100]

Clinically based risk adjustment systems supplement hospital discharge data with information available from medical records. Because exact clinical criteria can be specified for determining whether a diagnosis is present, coding errors are diminished. In addition, complications can be distinguished from comorbidities focusing on whether the diagnosis was present at admission. [79] Because the number of clinical variables that may potentially influence outcomes is small, and because these factors differ to some extent across diseases and procedures, progress in risk-adjustment has generally occurred by focusing on patients with specific conditions. Thus, sophisticated chart-based risk adjustment methods have been developed and applied for interpreting mortality rates for patients undergoing cardiac surgery and interventional cardiology procedures; critically ill patients; patients undergoing general surgery; and medical patients with acute myocardial infarction, community-acquired pneumonia, and upper gastrointestinal hemorrhage. [29, 36, 85, 101-107]

However, chart-based risk adjustment methods are not without their own limitations. First, especially for severely ill patients and those who die soon after admission — some of the most important patients for computing many quality measures — complete diagnosis information may not have been ascertained prior to death, and therefore would not be in the patient’s medical record. Important observations might be missing for such patients, resulting in biased estimates in the risk-adjusted model. Second, medical chart reviews are very costly, and so routine collection of detailed risk information is not always feasible. As a result, the impact of chart-based risk adjustment may vary across measures. For some measures, its impact is modest and does not substantially alter relative rankings of providers. [113-116] For others, it is much more important. [79, 97, 108-112] Of course, because all risk adjustment methods generally leave a substantial amount of outcome variation unexplained, it is possible that unmeasured differences in patient mix are important even in the most detailed chart-based measures.

For each quality measure, this report reviews the evidence on whether important systematic differences in patient mix exist at the provider and community level, and whether various risk adjustments significantly alter the quality measure for particular providers. A distinction is made between risk adjustment methods that rely only on administrative data and have been validated with clinical data, and those that are not validated. Risk adjustment methods requiring clinical data cannot be applied to the HCUP data, and therefore are not covered in this report. The empirical analysis then assesses whether a common approach to risk adjustment using administrative data — the All Patient Refined Diagnosis Related Groups (APR-DRG) system developed by 3M™ — significantly alters the quality measure for specific

providers. Emphasis is placed on the impact on *relative* measures of performance (whether risk adjustment affects which hospitals are regarded as high- or low-quality) rather than *absolute* measures of performance (whether risk adjustment affects a hospital's quantitative performance on the quality measure). As noted above, this system is not ideal, because it provides only four severity levels within each base APR-DRG, omits important physiologic and functional predictors, and potentially misadjusts for iatrogenic complications.

A remaining methodological issue concerns the appropriateness of adjusting for certain "risk factors." [117-126] For example, "Do Not Resuscitate" status may be associated with differences in care that not only reflect patient preferences (e.g., less use of intensive treatments) but also true differences in quality of care (e.g., inadequate physician visits), resulting in increased complications that would result in a "Do Not Resuscitate" order, and increased mortality. [127] Importantly, the prevalence of patients with DNR status may vary nonrandomly between hospitals, with large referral centers having greater percentages of patients seeking (and receiving) aggressive medical care. [128]

Adjusting for race implies that patients of different races respond differently to the same treatments, when patients of different races may actually receive different treatments. A substantial literature documents systematic differences in the care delivered to patients by race and gender. [116, 129-135] For example, African-American diabetics undergo limb amputations more often than do diabetics of other races. [136] Thus, wherever possible it is noted if review of the literature indicates particularly large differences in a quality measure by race or gender. Some gender or race differences may be due to either patient preference or physiological differences that would be appropriate to include in a risk adjustment model. In other cases, differences denote lower quality care, and in this case race and gender should not be included in the risk adjustment model. Where applicable, this is noted in the literature review.

4. Construct validity: does the indicator perform well in identifying providers with quality problems?

Ideally, a hospital will perform well on a quality measure if and only if it does not have a significant quality problem, and will perform poorly if and only if it does. In practice, of course, no measure performs that well. The analyses of noise and bias problems with each measure are intended to assess two of the principal reasons why a hospital might appear relatively good or bad (or not appear so) when it really is not (or really is). Detecting quality problems is further complicated by the fact that adverse outcomes are often the result of the course of an illness, rather than an indication of a quality problem at a hospital. Formally, one would like to know the sensitivity and specificity of a quality measure, or at least the positive predictive value (PPV) of a quality measure for detecting a true hospital quality problem.⁹⁹

When available, for each measure, any existing literature was reviewed on its sensitivity or PPV for true provider quality problems. In most cases, however, no true gold standard, or ideal measure of quality, was found. Therefore, construct validity was tested – i.e., the construct is that different measures of quality, on the same patients, should be related to each other at the provider level, even if it is not always clear which measure is better. It may be easier to ask "is the indicator correlated with other, accepted measures of quality at the provider level?" rather than "does the indicator perform well in identifying providers with quality problems?" For example, studies have validated survey rankings of "best" hospitals by examining the relation with actual process and outcome measures for AMI, and peer review failure rates with HCFA risk-adjusted mortality rates. [137, 138]

⁹⁹The PPV represents that the chance that a positive test result reflects a "true positive." It combines the properties of the test itself (e.g., sensitivity and specificity for detecting quality problems) with the prevalence of true quality problems in the target population.

5. Fosters real quality improvement: Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Ideally, when quality measures are used to guide quality improvement initiatives or reward good providers, the best way for a provider to perform well on the measure is to provide high-quality care. Unfortunately, many quality indicators appear to at least leave open the possibility of improving *measured* performance without improving *true* quality of care.

In measures that are risk-adjusted, measured performance can be improved by “upcoding” — including more comorbid diagnoses in order to increase apparent severity of illness. [68, 96] Systematic biases in diagnostic codes were observed after the introduction of the Prospective Payment System and may also explain much of the apparent reduction in adjusted mortality attributed to the Cardiac Surgery Reporting System in New York. [93-96] The extent to which upcoding is a problem probably increases with the ambiguity of the specific data element, and decreases when auditing programs maximize the reliability and validity of submitted data. In recent years, an aggressive auditing program has significantly reduced the extent to which comorbidities not substantiated by the medical chart are recorded for Medicare patients, leading some analysts to conclude that “upcoding” is no longer as substantial of a problem for Medicare patients. [139] However, such audit standards have generally not been imposed on the State discharge databases used in the HCUP project. In this review, indicators for which risk adjustment appears to be important are noted, and thus upcoding is a potentially important problem.

Indicators capturing patient morbidity, such as adverse events and complications, must overcome a reporting bias in the reverse direction (i.e., toward under-reporting). With some exceptions, most hospitals in most States rely on voluntary incident reporting for adverse events. Such methods are known to detect only a fraction of true adverse drug events (ADEs). [140] The Institute of Medicine has recently recommended mandatory reporting systems for adverse events emanating from certain egregious errors. [141] However, the JCAHO’s sentinel reporting system tracks many of these same errors (e.g., operating on the wrong patient or body part, suicide or rape of an inpatient), and it was received very negatively by hospitals, despite being a voluntary system. Thus, the degree to which mandatory reporting requirements alleviate or exacerbate reporting bias for adverse events remains to be seen. In addition, high-quality hospitals with sophisticated error detection systems may report errors more frequently, leading to high apparent complication rates in hospitals that may have superior quality in other dimensions. [142-144]

Perverse incentives may arise from the criteria used to define or identify the target patient population. For instance, restricting mortality measures to inpatient deaths potentially allows hospitals to lower their mortality rates simply by discharging patients to die at home or in other institutions. [91, 100, 145, 146] Measures of surgical site infections and other complications of hospital care that only capture in-hospital events will similarly reward hospitals that merely reduce length of stay by discharging or transferring high-risk cases. [147-149] Early concerns that surgeons in New York avoided operating on high-risk patients may have proved unfounded, though this issue remains unsettled. [150-153] In general, the incentive for providers to avoid treating sicker patients remains a significant concern for outcome-based quality measures. [68]

The available evidence on each of these possible undesirable responses to the use of each quality measure was reviewed. For the most part, evidence was lacking on responses to indicators, particularly since many of the proposed indicators have not been subjected to public reporting. Potential responses were noted when appropriate.

6. Prior use: Has the measure been used effectively in practice? Does it have potential for working well with other indicators?

While important problems exist with many specific applications of HCUP QIs and other quality indicators, they have been applied in a range of settings. As noted in the section on face validity, these applications broadly include initiatives to improve provider quality and initiatives to provide quality-related information to providers and consumers. Studies describing its use in these activities were reviewed for each quality indicator. However, a thorough review of the non-peer reviewed literature was not conducted. Therefore, indicators may have been adopted, and may continue to be used, by many provider organizations or Government agencies.

A recent systematic review more comprehensively summarizes the literature on the impact of performance reports on consumers, providers, and purchasers. [154] Useful and accurate information on quality remains a desirable goal for consumers and providers alike. The interest in quality and the resulting data and research has had some impact on the field of health services research. For instance, the HCUP project has provided a valuable resource for a number of studies in health services research. [124-126, 155-169]

Literature Review of Quality Indicators

A literature review was conducted to identify quality indicators reported as such and potential quality measures. The result of this first stage was a comprehensive list of measures that could be defined based on routinely collected hospital discharge data. In the second phase, the literature was searched for further evidence on these indicators to provide information on their suitability for the new QI set. This second phase resulted in a comprehensive bibliography for each indicator. In addition, a sub-set of the entire indicator list was selected for detailed review using specific evaluation criteria. The entire process for this systematic review of the literature is described in the following sections.

Phase 1: Identification of Indicators

Step 1: Selecting the articles. To locate literature pertaining to quality indicators, a strategic literature search was conducted using the Medline database. Over 30 search strategies were compared using Medical Subject Headings (MeSH) based on their ability to retrieve a set of key articles known to the project team. Successful combinations of MeSH term searches returned all the key articles. The final MeSH terms used were “hospital, statistic and methods” and “quality indicators.” Articles were also limited to those published in 1994 or later. Articles prior to 1994 had been reviewed for the original QI development. This search returned approximately 2,600 articles — the highest number of known key articles in the most concise manner.

Articles were screened using the titles and abstracts for preliminary abstraction. To qualify for preliminary abstraction, the articles must have described a potential indicator or quality relationship that could be adequately defined using administrative data, and be generalizable to a national data set. For the purpose of this study, a quality indicator was defined as an explicit measure (defined by the developer) of some aspect of health care quality. Some literature defines only a quality relationship, in that the article expounds on a process or structural aspect of a health care provider that is related to better outcomes. However, the author does not specifically define or recommend that the relationship be used as a quality measure. In this case, the article only describes a quality relationship, not a quality indicator. Only 181 articles met the criteria for preliminary abstraction. This reflects the small number of quality indicators with published formal peer-reviewed evaluations.

Step 2: Preliminary abstraction. The preliminary round was designed to screen articles for applicability and quality, to obtain and assess the clinical rationale of the indicators, and to identify those articles with enough detail for a more comprehensive abstraction. Nine abstractors participated in this phase. Five of these abstractors were medical doctors with health services research training. The remaining four abstractors were familiar with the project and the literature,

and included a project manager, the research coordinator, and two undergraduate research assistants.

The articles were sorted into clinical groupings. The research coordinator rated these clinical groupings according to the amount of clinical knowledge required to abstract the articles. Those requiring the most clinical knowledge were assigned to physicians, while those requiring the least clinical knowledge were assigned to the undergraduate research assistants. Abstractors selected clinical groupings that were of interest or that corresponded to their clinical specialties.

Abstractors recorded information about each article on a one-page abstraction form. Information coded included:

- Indicator type (i.e. mortality, readmission, potentially overused procedures)
- Clinical domain (i.e. medical, surgical, obstetric, pediatric, and psychiatric)
- Measure category (i.e. structure, process, proxy-outcome, and outcome)
- Clinical rationale for the indicators.
- Use of longitudinal data.
- Use of data beyond hospital discharge data.
- Strengths and weaknesses identified by the author.
- Strengths and weaknesses not identified by the author.

Each abstraction form was reviewed by the research coordinator for quality of the abstraction and for accuracy of the coding. All data were then entered into a Microsoft Access database.

Step 3: Full abstraction. The purpose of the full abstraction phase was to identify potential indicators for the new QI set, and to assess the evidence for validity of existing indicators. To accomplish this, only articles that described an indicator in conjunction with specific and comprehensive information on its validity were fully abstracted. Four of the original abstractors participated in this phase of the abstraction. Three of these abstractors were medical doctors, the fourth a master's level research coordinator.

Each of the articles for preliminary abstraction and the corresponding abstraction form was reviewed by both the research coordinator and the project manager independently. To qualify for full abstraction, the articles needed to meet the previously noted criteria and the following criteria:

- Define a quality indicator, as opposed to only a relationship that was not formulated or explicitly proposed as a measurement tool.
- Discuss a novel indicator, as opposed to indicators defined elsewhere and used in the article only to discuss its relationship with another variable (i.e., socioeconomic status, race, urbanization).
- Define an indicator based on administrative data only.

Only 27 articles met these formal criteria. This highlights an important aspect of the literature on quality indicators: most indicators are based on published clinical literature to identify important patient and provider characteristics and processes of care for specific clinical conditions; there is also a substantial literature on technical aspects such as severity adjustment, coding, and data collection. It should be noted that, while only 27 articles qualified for formal abstraction, these are not the only useful articles. Many articles provide important information about quality measurement. However, few quality indicators are specifically defined, evaluated, and reported in the literature besides descriptive information on the process of development. (The Complication Screening Program is a noteworthy and laudable exception that has been extensively validated in the published literature, mostly by the developers). This evidence report will be an important contribution to the paucity of literature on indicator validation.

An abstraction form was filled out for each indicator defined in an article. The abstraction form coded the following information:

- All the information coded in the preliminary abstraction form.
- Measure administrative information (i.e. developer, measure set name, year published).
- Level of care (primary (prevention), secondary (screening or early detection) or tertiary (treatment to prevent mortality/morbidity)).
- Scoring method (i.e. rate, ratio, mean, proportion).
- A priori suggested quality standard (i.e. accepted benchmark, external comparison, and internal comparison).
- Indicator definition (numerator, denominator statements, inclusions, and exclusions).
- Extent of prior use.
- Current status (i.e. measure defined, pilot tested, implemented, discontinued).
- Scientific support for measure (i.e. published guidelines, clinician panel, literature review, revision of pre-existing instruments, theory only).
- Other essential references for the measure.
- Validity testing.
- Risk adjustment.

If the measure included risk adjustment, a separate form for the risk adjustment method was filled out. This included:

- Method administrative information.
- Adjustment rationale.
- Classification or analytic approach (i.e. stratification, logistic or linear regression)
- System development method (i.e. logistic regression, score based on empirical model, a priori/clinical judgement).
- Published performance for discrimination and calibration.
- Use of comorbidities, severity of illness, or patients demographics.
- Use of longitudinal data, or additional data sources beyond discharge data.
- Extent of current use.
- Other essential references for the method.
- Abstractor comments.

The abstraction forms were reviewed by the research coordinator and entered into a Microsoft Access database.

Parallel Step: Supplementing literature review using other sources. Because the literature in this area is not the primary source for reporting the use of quality indicators, a list of suitable indicators was compiled from a variety of sources. As previously noted, the phone interviews with project advisors led to information on some indicators. In addition, the Internet sites of known organizations using quality indicators; the CONQUEST database; National Library of Healthcare Indicators (NLHI), developed by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO); and a list of ORYX-approved indicators provided by the JCAHO were searched. Indicators that could be defined using administrative data were recorded in an indicator database.

Breakdown of indicators by primary source. During Phase 1, no one literature search was sufficiently sensitive for the purpose of identifying either quality indicators or quality relationships. In addition, there was relatively little literature defining quality indicators. Web sites, organizations, and additional literature describing quality indicators were searched to be confident that a large percentage of the quality indicators in use were identified. In general, most volume, utilization, and ACSC indicators have been described primarily in the literature. On the other hand, the primary sources for most mortality and length of stay indicators were current users or databases of indicators. However, many indicators found in the literature were also

reported by organizations, and vice versa. Thus, it is difficult to delineate which indicators were derived only from the literature and which were derived from the parallel step described above.

Phase 2: Evaluation of Indicators

The result of Phase 1 was a list of potential indicators with varied information on each depending on the source. Since each indicator relates to an area that potentially screens for quality issues, a structured evaluation framework was developed to determine measurement performance. A series of literature searches were then conducted to assemble the available scientific evidence on the quality relationship each indicator purported to measure. Due to limited resources, not all of the indicators identified in Phase 1 could be reviewed, and therefore some were selected for detailed review using the evaluation framework. The criteria used to select these indicators are described later.

Step 1. Development of evaluation framework. As described previously, a structured evaluation of each indicator was developed and applied to assess indicator performance in six areas:

- Face validity
- Precision
- Minimum bias
- Construct validity
- Fosters real quality improvement
- Prior use

Step 2. Identification of the evidence. The literature was searched for evidence in each of the six areas of indicator performance described above, and in the clinical areas addressed by the indicators. The search strategy used for Phase 2 began with extensive electronic searching of MEDLINE, PsycINFO, and the Cochrane Library. [170-172] (A decision was made not to search EMBASE on the grounds that the studies of quality measurement necessarily must take into account the particular health care system involved. [173]) In contrast to conducting systematic reviews of purely clinical topics, it was reasoned that the European literature not captured in the Medline database or Cochrane Library would almost certainly represent studies of questionable relevance to the U.S. health system.

The extensive electronic search strategy involved combinations of MeSH terms and keywords pertaining to clinical conditions, study methodology, and quality measurement (Figure 1).

Additional literature searches were conducted using specific measure sets as “keywords”. These included “Maryland Quality Indicators Project,” “HEDIS and low birth weight, or cesarean section, or frequency, or inpatient utilization,” “IMSystem,” “DEMPAQ,” and “Complications Screening Program.”

The bibliographies of key articles were searched, and the Tables of Contents of general medical journals were hand searched, as well as journals focusing in health services research or in quality measurement. This list of journals included *Medical Care*, *Health Services Research*, *Health Affairs*, *Milbank Quarterly*, *Inquiry*, *International Journal for Quality in Healthcare*, and *the Joint Commission Journal on Quality Improvement*. These literature searches and on-line screening for relevancy retrieved over 2,000 additional articles, which were added to the project database. These articles were used for evaluations of individual indicators.

The use of medical literature databases likely eliminated much of the “gray literature” that may be applicable to this study. Given the limitations and scope of this study, a formal search of the “gray literature” was not completed beyond that which was previously known by the project team or resulted from telephone interviews.

Figure 1. Example Search

Mortality Following Stroke	
Medline Search String	Number of References Retrieved
1. Cerebrovascular disorders [MeSH terms]	47,264
2. Epidemiologic studies [MeSH terms] OR clinical trials [MeSH terms]	32,630
3. Search mortality [MeSH Terms] OR prognosis [MeSH terms]	18,460
4. #1 AND #2 AND #3	2,410
5. #4 AND stroke [title]	524
6. Quality of health care [MeSH term]	852,714
7. #1 AND #2 AND (#3 OR #6)	1,988
8. Reproducibility of results [MeSH terms] OR sensitivity and specificity [MeSH terms]	110,384
9. Records [MeSH terms] OR hospitalization [MeSH terms]	55,739
10. #8 AND #9	3,835
11. #1 AND #10	106

Note: The results of searches 5 and 11 were scanned (titles and abstracts) to pull relevant studies, and the bibliographies of these studies were hand-searched for additional references.

All searches included limits: Publication date from 1990 to 2000 and language English.

Step 3. Selection of a sub-set of indicators. Since there were too many indicators identified in Phase 1 (literature search and parallel steps) for detailed evaluation using the Evaluation Framework, criteria were developed to select a group for further evaluation. These criteria were intended to be top-level evaluations of the face validity and precision of the indicators. A subset of indicators was selected for preliminary empirical evaluation. To do this, first the indicators related to complications were disqualified for this particular report, since they will be included in an expansion to the report that will include patient safety indicators. Second, all of the current HCUP QIs (except those related to complications of care) were selected for empirical evaluation. Third, the priority of clinical areas well covered by the current HCUP indicator set was lowered (for example, obstetrical indicators). Finally, a set of criteria for selection was applied to the remaining indicators.

The following were specific criteria for evaluation for all indicators:

- Indicator must be definable with HCUP data (i.e., uses only administrative data available in HCUP data set).
- Conditions that affect at least 1% of hospitalized patients or 20% of providers, as tested using the Nationwide Inpatient Sample data set.
- Conditions that are the subject of public reporting, previous use, or large dollar volume.
- Clear relationship to quality apparent as evaluated by clinical judgment of health services researchers and medical doctors.

In addition, several specific criteria were noted for the indicator types:

- Volume:
 - Widely documented volume-outcome relationship
 - Recent evidence regarding volume-outcome relationship
- Utilization rates:
 - Condition must have an alternative surgical or medical therapy with lower/higher morbidity or mortality
- Ambulatory care sensitive conditions:
 - Differences in patient management practices for that condition
 - Existence of treatment guidelines, and evidence of failure to comply
- In-hospital mortality
 - Relatively homogenous group

When selecting between competing alternatives that met all the above criteria, the choice was made to evaluate clinical areas in depth rather than evaluating a large breadth of indicators. To do this, multiple aspects in one clinical domain were evaluated (i.e., evaluations of CABG, PTCA, and AMI; stroke and carotid endarterectomy). In these clinical areas, at least two different types of indicators were evaluated (i.e., mortality and utilization).

The selected indicators were then evaluated empirically, using preliminary tests of precision. Those demonstrating adequate precision were then evaluated by a literature review (Phase 2), as well as further empirical analysis.

Step 4. Evaluation of evidence. The abstracts from relevant articles for each indicator were reviewed and selected according to the following criteria:

- The article addressed some aspect of the six areas of indicator performance.
- The article was relevant to a national sample, rather than a local population.

Based on this literature, a team member or clinician developed a draft write-up of the indicator following the evaluation framework. The literature review strategy is depicted in the flow diagram in Figure 2.

Risk Adjustment of HCUP Quality Indicators

“Raw” unadjusted measures of hospital or area performance for each indicator are simple means constructed from the HCUP discharge data and census population counts. Obviously, simple means do not account for differences in the indicators that are attributable to differences in patient mix across hospitals that are measured in the discharge data, or demographic differences across areas. In general, risk adjustment involves conducting a multivariate regression to adjust expected performance for these measured patient and population characteristics. Although complex, multivariate regression methods are the standard technique for risk-adjustment because they permit the simultaneous consideration of multiple patient characteristics and interaction among those characteristics. The interpretation of the risk-adjusted estimate is straightforward: it is the value of the indicator expected at that hospital if the hospital had an “average” patient case-mix.

This section contains the methods for the evaluation of risk adjustment systems, leading to the decision to use APR-DRGs. The purpose of this evaluation is to briefly outline the evidence regarding the use of risk adjustment systems for evaluating potential bias in indicators and for risk adjusting established indicators to compare provider performance. The first section discusses criteria used to evaluate the risk adjustment systems. Such criteria arise from the literature-based evidence on risk adjustment systems, as well as user criteria obtained through the semi-structured telephone interviews. Second, the methods used to implement APR-DRGs

empirically in the new QI set are outlined. The methods for risk-adjustment of the hospital level quality indicators are described. An analogous method was used for the area level quality indicators. However, the area level indicators account only for demographic differences.

Risk Adjustment Literature Review Methods

The literature review for risk adjustment of the HCUP QIs combined evaluation criteria common to evidence studies on the performance of risk adjustment systems with additional considerations of importance to the potential HCUP QI users. These considerations were determined through semi-structured interviews with users, discussed earlier in this report. In general, users viewed risk adjustment as an important component of the HCUP QIs' refinement. State data organizations and agencies involved in reporting of hospital performance measures especially tended to view risk-adjustment as essential for the validity of the results and acceptance by participating hospitals. Concerns that patient severity differed systematically among providers, and that this difference might drive the performance results, was frequently mentioned as a reason for limited reporting and public release of the HCUP QIs to date, especially for outcome-oriented measures like mortality following common elective procedures.

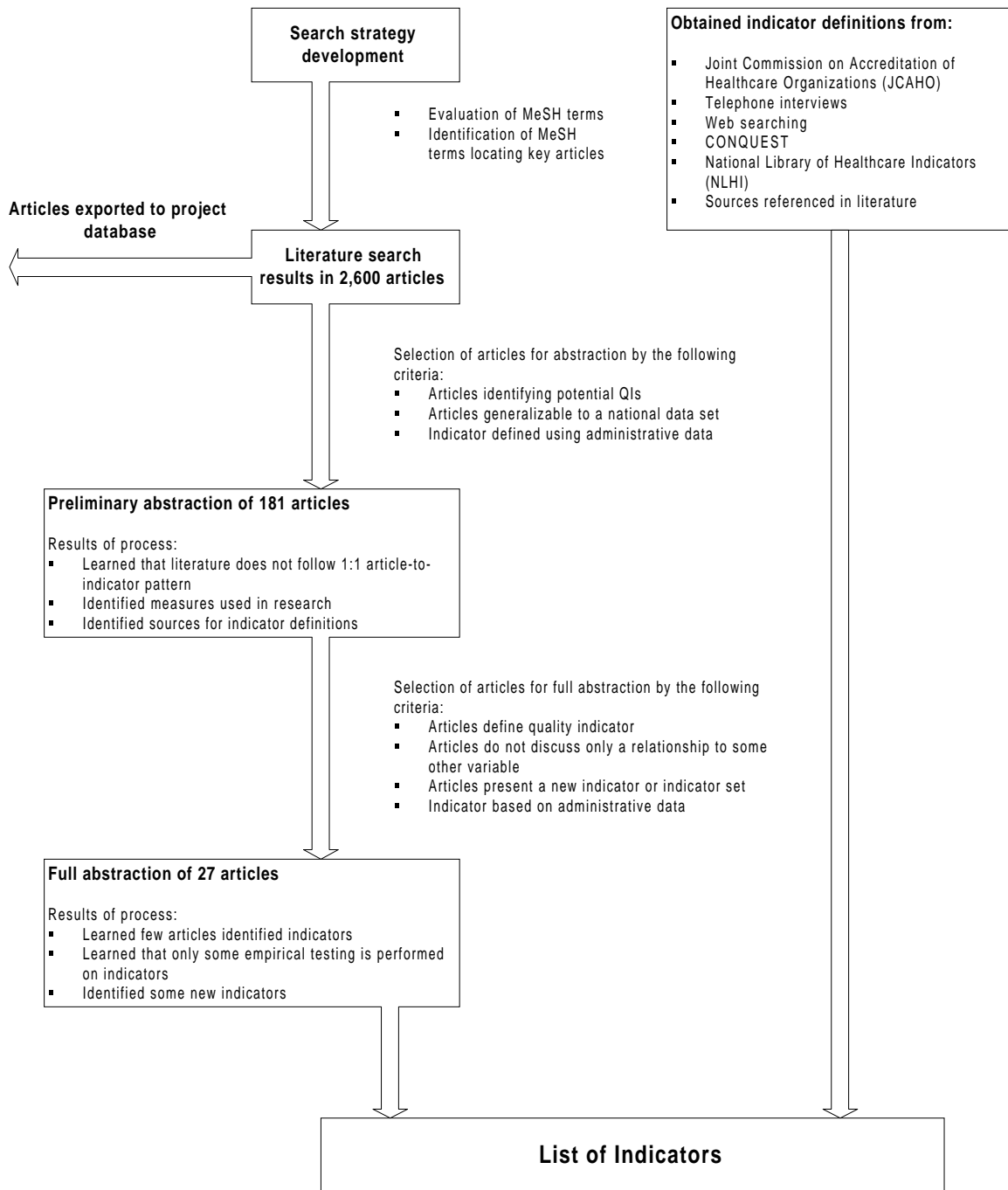
Literature-based Criteria for Evaluating Risk Adjustment Systems

HCUP QI users were concerned about the validity or performance of possible risk adjustment systems. Evidence was assessed on the performance of risk-adjustment systems from published reports using the following commonly applied criteria. [79, 87, 174]

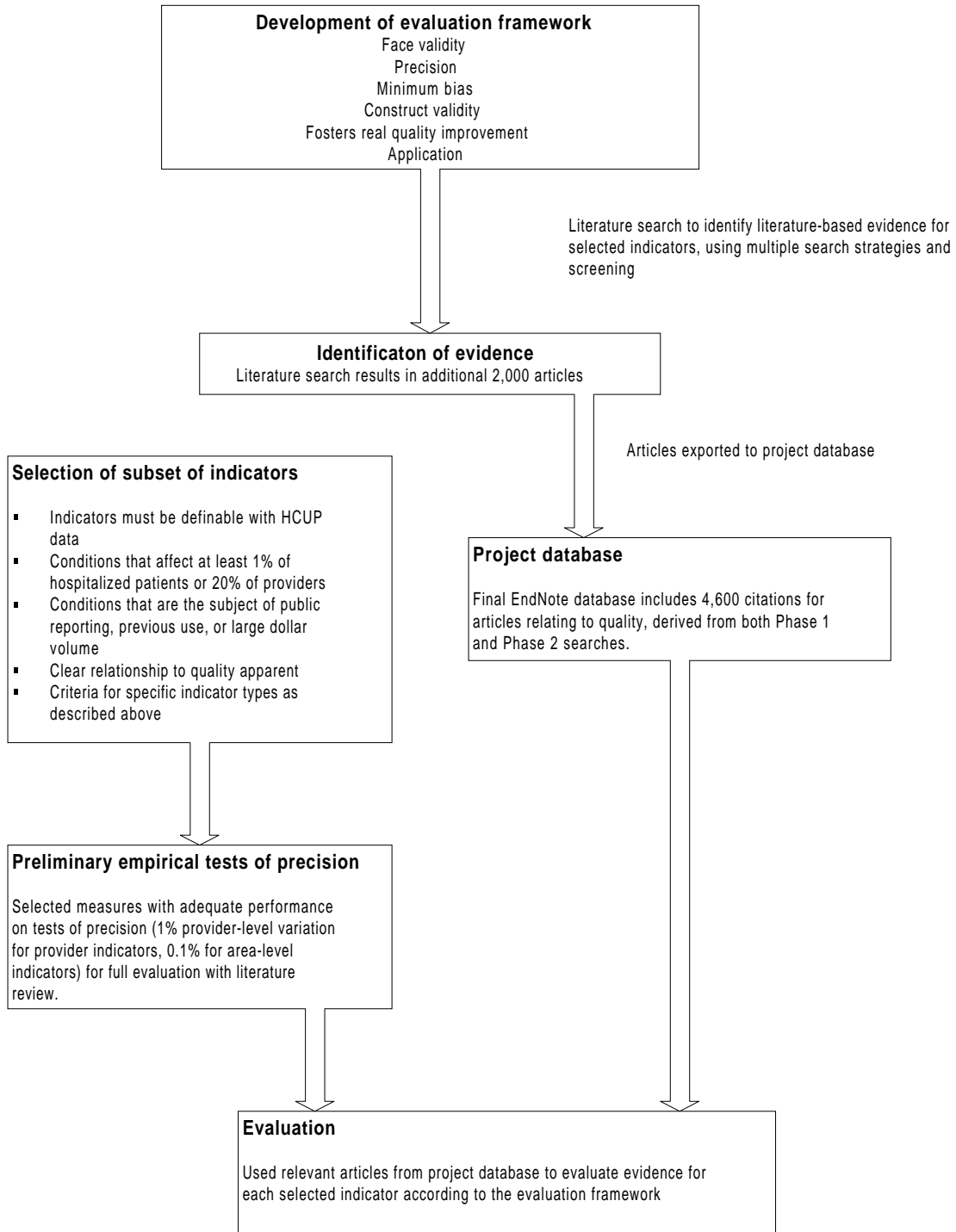
1. Classification and analytic approach. Risk adjustment systems have been developed to predict complications, resource use, and mortality. Alternative analytic approaches included stratification (assigning individuals to mutually exclusive cells), logistic regression, or linear regression (calculating an expected level of medical utilization based on a statistical model). Methods based on logistic or linear statistical models are generally able to consider more dimensions of patient characteristics than stratification. Even more effective approaches might involve combining multivariate adjustment and stratification through propensity score methods and accounting for the relationship between aspects of disease severity that are measured and those that are not. [175, 176] However, no currently available risk adjustment systems are based on these analytic methods.
2. System development method. Risk adjustment classifications may be based either on an empirical model clinical judgment or some combination. For example, an assessment of whether two heart attack patients are expected to have similar outcomes can be based on statistical tests or clinical expertise or both. [79]
3. Feasibility. Feasibility is largely determined by the data requirements of the risk-adjustment method. We reviewed whether a system required hospital data elements other than those found on the discharge abstract (e.g., data from medical charts or laboratory data) or non-hospital data (e.g., outpatient hospital or physician data). We also evaluated whether the method was likely to be enhanced with discharge data that included a unique patient identifier, so that risk adjusters could be developed based on data from multiple hospitalizations or encounters. Because only a subset of the States participating in HCUP collect supplementary data beyond discharge abstracts or unique patient identifiers for use in longitudinal analyses, a risk adjustment system was selected that did not depend on such information.

Figure 2. Literature Review Strategy

Phase 1. Identification of Indicators



Phase 2. Evaluation of Indicators



4. Empirical performance: discrimination. A critical aspect of the performance of a risk-adjustment model is the extent to which the model predicts a higher probability of an event for patients who actually experience the event. The statistical test of discrimination is generally expressed as a C-statistic or R^2 (how much of the variation in the patient level data the model explains). In general, systems that discriminate more have the potential to influence QI measures more substantially. Many severity-adjustment systems were designed primarily to predict in subsequent periods (e.g., resource consumption next year). However, for purposes of evaluating QI performance, the estimation of concurrent risk is more important (i.e., differences in the likelihood of experiencing an outcome in the current time period). Ideally, discrimination would be assessed using an R^2 or other statistic of predicted variation that is computed on a separate data source from the one used to develop the model, to avoid “over-fitting” (i.e., the model might appear to do well in part because it explains nonsystematic variations in the data used to develop it).
5. Empirical performance: calibration. Calibration is a measure of whether the mean of the predicted outcomes equals the mean of the actual outcomes for the entire population and for population subgroups. The statistical test is often expressed as a Chi-square or “goodness-of-fit” for the equivalence of means of population subgroups. Even if the severity-adjustment system does not predict well at the level of individuals, it may predict well at the aggregate (group) level of, say, women, 70-74 years of age. Over-fitting will be an issue here as well, unless a different data source is used to validate the model than was used to estimate the model.

Not many risk-adjustment systems have been evaluated in published reports using all of these criteria, nor have they been evaluated using consistent data sources. These limitations of the literature on risk adjustment complicate comparisons of risk adjustment systems based on performance criteria. In the end, the user-specified criteria determined a narrow set of potential risk adjustment systems to consider. The performance criteria delineated between these potential systems and informed the empirical evaluation of the impact of risk adjustment on the assessment of provider and area quality.

User-specified Criteria for Evaluating Risk Adjustment Systems

Evidence on the performance of a risk adjustment system is a primary consideration for HCUP QI users, and is essential to the validity of reported performance measures. However, users also cited other factors as potentially important determinants of the acceptance of HCUP QIs reporting by hospitals, State regulators and State legislatures, and other potential consumers of hospital performance data. These factors included the following:

1. “Open” systems preferable to “black box” systems. Although there was no specific prohibition against using proprietary systems vs. systems in the public domain, there was a preference for using “open” systems where the risk adjustment logic was published and available for scrutiny by interested parties.
2. Data collection costs minimized and well-justified. The widespread recognition that data collection was costly for hospitals meant that any risk-adjustment system that would be imposed on hospitals had to justify the cost of data collection by documenting that the additional information led to substantially different and more accurate inferences about performance. At least one State had stopped using a risk adjustment system that required medical chart review because the high cost of implementation was not considered worth the efficiency gained from improved accuracy.
3. Multiple-use coding system. Some risk adjustment systems were designed to categorize patients according to expected resource use, defined either as charges or length of stay, while others were designed to categorize patients according to

expected health outcomes, including mortality and complications. For example, several States calculated and reported mortality rates by diagnosis-related group (DRG). These users generally believed that a risk-adjustment system for health outcomes based on discharge records that relied on the same diagnostic groups used for reimbursement was more likely to be accurate than a system that relied on codes used for quality and health outcome comparisons only, since there would be less financial and audit incentives to record codes accurately for the latter. Thus, coding systems that affected reimbursement for at least some patients were likely to capture diagnoses and procedures reported in medical charts.

One potentially important limitation of relying on codes that are also used for payment is that changes in reimbursement-related coding practices (e.g., as a result of tighter Medicare rules implemented in 1996) may alter apparent severity. However, because of the financial implications of changes in coding practices, any significant changes are likely to be identified and reported by payers, and so can be considered in interpreting variations and trends in reported quality measures.

4. Official recognition. Many users indicated that systems that had been supported or otherwise recognized by Government agencies such as AHRQ were preferable to other systems, because such support facilitated acceptance by legislative and hospital groups. Adoption of the HCUP QIs themselves was often justified in part by their sponsorship by AHRQ. State agencies, especially those from smaller States, often cited the lack of staff resources and expertise needed to make independent evaluations of competing indicator sets and risk adjustment methods.

Risk Adjustment Empirical Methods

The APR-DRG system, with severity and risk of mortality classifications, was used in two ways:

- To evaluate the impact of measured differences in patient severity on the relative performance of hospitals and areas, by comparing QI measures with and without risk adjustment.
- To risk-adjust the hospital- and area-specific measures.

The available literature on the impact of risk adjustment on indicator performance is limited, but suggests that at least in some cases different systems may give different results. Problems of incomplete or inconsistent coding across institutions are probably important contributing factors to the differences in results. Thus, definitive risk adjustment for some indicators may require detailed reviews of medical charts and additional data sources (charts may also be incomplete), just as definitive quality measures for many indicators may require additional sources of information. However, the importance of random variations in patients means that whatever risk adjustment and quality measurement system is chosen should be used in conjunction with statistical methods that seek to minimize other sources of noise and bias.

The empirical analysis is intended to illustrate the approach of combining risk adjustment with smoothing techniques, including suggestive evidence on the importance of risk adjustment for potential new QIs, using a risk adjustment system that can be implemented on discharge data by most HCUP QI users. The empirical analysis is supplemented with a review of the clinical literature to identify additional clinical information that is important to consider for certain indicators. In particular, the literature review highlights a few indicators where risk adjustment with additional clinical data has been shown to be particularly important, and where important differences in case mix seem less likely to be related to the secondary diagnoses used to risk-adjust discharge data.

This section describes how risk-adjustment is implemented using patient demographics (age and sex) along with the APR-DRG classification system. The next section describes statistical methods used to account for additional sources of noise and bias not accounted for by observed patient characteristics. By applying these methods to all of the potential new QIs, the relative importance of both risk adjustment and smoothing can be evaluated in terms of the relative performance of hospitals (or areas) compared to the “raw” unadjusted QIs based on simple means from NIS discharge data. The simple means fail to account both for differences in the indicators that are attributable to systematic differences in measured and unmeasured patient mix across hospitals/areas that are measured in the discharge data, and for random variations in patient mix. A multivariate regression approach was adopted to adjust performance measures for measured differences in patient mix, which permits the inclusion of multiple patient demographic and severity characteristics.

Specifically, if it is denoted whether or not the event associated with a particular indicator Y^k ($k=1, \dots, K$) was observed for a particular patient i at hospital/area j ($j=1, \dots, J$) in year t ($t=1, \dots, T$), then the regression to construct a risk-adjusted “raw” estimate a hospital or area’s performance on each indicator can be written as:

$$(1) \quad Y_{ijt}^k = M_{jt}^k + Z_{ijt} \Pi_t^k + \varepsilon_{ijt}^k, \text{ where}$$

Y_{ijt}^k is the k^{th} quality indicator for patient i discharged from hospital/area j in year t (i.e., whether or not the event associated with the indicator occurred on that discharge);
 M_{jt}^k is the “raw” adjusted measure for indicator k for hospital/area j in year t (i.e., the hospital/area “fixed effect” in the patient-level regression);
 Z_{ijt} is a vector of patient covariates for patient i discharged from hospital/area j in year t (i.e., the patient-level measures used as risk adjusters);
 Π_t^k is a vector of parameters in each year t , giving the effect of each patient risk adjuster on indicator k (i.e., the magnitude of the risk adjustment associated with each patient measure); and
 ε_{ijt}^k is the unexplained residual in this patient-level model.

The hospital or area specific intercept M_{jt}^k is the “raw” adjusted measure of a hospital or area’s performance on the indicator, holding patient covariates constant. In most of the empirical analysis that follows, the patient-level analysis is conducted using data from all hospitals and areas. (The model shown implies that each hospital or area has data for all years, and with each year has data on all outcomes; however, this is not essential to apply risk adjustment methods.)

These patient-level regressions were estimated by linear ordinary least-squares (OLS). In general, the dependent variables in the regressions are dichotomous, which raises the question of whether a method for binary dependent variables such as logit or probit estimation might be more appropriate. However, previous work by McClellan and Staiger has successfully used OLS regression for similar analyses of hospital/area differences in outcomes. In addition, estimating logit or probit models with hospital or area fixed effects cannot be done with standard methods; it requires computationally intensive conditional maximum likelihood methods that are not easily extended to multiple years and multiple measures. [177]

A commonly used “solution” to this problem is to estimate a logit model without hospital or area effects, and then to use the resulting predictions as estimates of the expected outcome. However, this method yields biased estimates and predictions of hospital performance. In contrast, it is easy to incorporate hospital or area fixed effects into OLS regression analysis, the resulting estimates are not biased, and the hospital or area fixed effects provide direct and easily-interpretable estimates of the outcome rate for a particular hospital or area measure in a particular year, holding constant all observed patient characteristics.

Of course, it is possible that a linear probability model is not the correct functional form. However, as in earlier work, a very flexible functional form is specified, including full interactions among age and sex covariates as well as a full set of APR-DRG risk adjusters. In the sensitivity

analyses for selected quality measures, this flexible linear probability model produced estimates of the effects of the risk adjusters that did not differ substantially from nonlinear (logit and probit) models. Another potential limitation of the OLS approach is that it may yield biased estimates of confidence intervals, because the errors of a linear probability model are necessarily heteroskedastic. Given the large sample sizes for the parameters estimated from these regressions (most indicators involve thousands of “denominator” discharges per year), such efficiency is not likely to be an important concern. Nevertheless, models were estimated using Weighted Least Squares to account for heteroskedasticity, to see if estimates were affected [178]. Very similar estimates of adjusted indicator performance were obtained.

Specifically, in addition to age, sex, and age*sex interactions as adjusters, the model also included the APR-DRG category for the admission and the APR-DRG constructed severity subclass (or risk-of-mortality subclass for mortality measures). APR-DRGs are a refinement of the DRGs used by the Centers for Medicare and Medicaid Services (formerly the Health Care Financing Administration), with additional classifications for non-Medicare cases (e.g., neonates). The severity subclass evaluates the episode of care on a scale of 1 (minor) to 4 (extreme). In the APR-DRG Version 12, Severity of Illness is defined as the “extent of physiologic de-compensation or organ system loss of function.” The APR-DRG severity of illness subclass was designed principally to predict resource use, particularly length-of-stay. As such, because this risk-adjustment system was not designed to predict utilization rates, for example, the evaluation of each indicator does not consider lack of impact of risk-adjustment to be evidence of lack of real bias. However, impact of risk-adjustment is considered to be evidence of problems of potential bias. The literature review further informs potential sources of bias, and the prior use of each indicator may require collection of supplemental data for confounding clinical conditions.

For each indicator, the APR-DRG groupings in the Major Diagnostic Category (MDC) related to that indicator were excluded from the risk adjustment model. The groupings are either medical (based on diagnoses) or surgical (based on procedures), and groupings in the MDC of the same type were excluded. For example, for the Coronary Artery Bypass Graft rate indicator, all surgical APR-DRGs in MDC ‘05’ (‘Diseases and Disorders of the Circulatory System’) were excluded. For GI Hemorrhage mortality, all medical APR-DRGs in MDC ‘06’ (‘Diseases and Disorders of the Digestive System’) were excluded. Some of the indicators fall into only a few DRG categories. All discharges with carotid endarterectomy, for example, were within DRG ‘005’, (‘Extracranial Vascular Procedures’). These indicators relied primarily on the severity subclass, which is independent of the DRG.

Actual implementation of the model involves running a regression with potentially a few thousand variables (each DRG divided into four severity subclasses) on millions of observations, straining the capacity of most statistical software and computer systems. In order to limit the number of covariates (DRG groups) in the model, the total number was restricted to 165 categories (DRG by severity), which was for all indicators sufficient to include 80% of discharges. All severity or risk-of-mortality subgroups were maintained for each APR-DRG included in the model in the construction of the raw adjusted estimates. The adjusted estimates of hospital performance are reported and used to compute descriptive statistics for each indicator in each year. They are also used to construct smoothed estimates of each indicator.

The risk-adjusted estimates of hospital performance (age, gender, APR-DRG) and area performance (age, gender only) were used to construct descriptive statistics and smoothed estimates for each QI.

Empirical Methods

Analysis Approach

Data sources. The data sources used in the empirical evaluation were the 1995-97 Nationwide Inpatient Sample (NIS), which has been used for previous HCUP QI development,

and the complete State Inpatient Data (SID) for five HCUP participating States (California, Florida, Illinois, New York, and Pennsylvania). The annual NIS consists of about 6 million discharges and over 900 hospitals. The NIS contains all-payer data on hospital inpatient stays from selected States (Arizona, California, Colorado, Connecticut, Florida, Georgia, Hawaii, Illinois, Iowa, Kansas, Maryland, Massachusetts, Missouri, New Jersey, New York, Oregon, Pennsylvania, South Carolina, Tennessee, Utah, Washington, and Wisconsin). All discharges from sampled hospitals are included in the NIS database. The NIS is designed to approximate a 20% sample of U.S. community hospitals, defined as all non-Federal, short-term, general, and other specialty hospitals, excluding hospital units of institutions. Included among community hospitals are specialty hospitals such as obstetrics-gynecology, ear-nose-throat, short-term rehabilitation, orthopedic, and pediatric. Excluded are long-term hospitals, psychiatric hospitals, and alcoholism/chemical dependency treatment facilities. A complete description of the content of the NIS, including details of the participating States discharge abstracts, can be found on the Agency for Healthcare Research and Quality Web site (www.ahrq.gov/data/hcup/hcupnis.htm).

The SID sample consisted of 10 million discharges and over 1,300 hospitals in over 200 metropolitan areas. Only the SID empirical results are reported, because the provider-level results were similar in both data sources, and the SID data were needed for the direct construction of area measures. All of the quality indicators can be constructed from the NIS with two caveats: first, the area measures are based on a weighted sample of discharges and are less precise than if complete State discharge data are used, and second, even though hospital sampling for the NIS was supposed to allow construction of a representative sample at the State level, it is possible that the Metropolitan Service Area (MSA)-level samples are not representative (i.e., biased). These limitations are not applicable when using the software on the full data from the SID to construct measures based on complete data from area hospitals.

Reported quality indicators. All potential indicators were assessed empirically by developing and conducting statistical tests for evaluation framework criteria of precision, bias, and construct validity. For each statistical test, we calculated up to four different estimates of indicator performance. First, the raw indicator was the simple observed value (e.g., the rate or volume) for each provider or area. Second, the adjusted indicator was based on the use of multivariate regression to account for differences among providers in demographics and comorbidities (defined using the 3M APR-DRG) of patients, and among areas in demographics of the population. Third, univariate smoothing techniques were applied to estimate the amount of random error relative to the true difference in performance (the “reliability”) for each indicator. [68] Fourth, new multivariate signal extraction methods were applied by combining information from multiple indicators over several years to extract more quality signal from each individual indicator than is possible with the univariate methods. [179]

Overview of empirical analysis. The approach included several stages and generated a series of analyses on potential quality indicators that sequentially assessed some of the problems identified in the literature review. For reference, the “raw” or minimally adjusted indicator was constructed, based on the discharge data for each hospital and census data for each area. This measure was then “risk-adjusted” through a discharge-level regression that included controls for patient mix. The hospital-level and area-level fixed effects in these regressions are the estimates of quality indicators that are typically reported for particular hospitals and areas, and they typically reflect substantial noise. In the second stage of the analysis, these estimates were then “smoothed” using a Bayesian procedure to yield a best-guess estimate of true hospital or area performance on the indicator — the “signal” in the observed noisy measure. This was done in two ways. First, a univariate approach was used, in which the distribution of the indicator itself is used to construct the best guess. This is the smoothing or shrinkage approach most widely used in the literature on provider quality. [69-71] Second, a multivariate approach was used, in which the joint distribution of a large number of indicators (and the indicator of interest in previous time periods) is used to construct the best-guess estimate of performance. In general, the covariation among different indicators and within each indicator over time implies that much more precise estimates of true hospital or area quality can be generated using this multivariate signal extraction approach. All of the estimates of factor loadings and correlations are based on smoothed

estimates, which helps to improve the ability to detect correlations, thereby addressing the multidimensionality of quality. Finally, summary statistics are reported describing the performance of the indicator in terms of the principal domains described in the literature review: precision, bias, and construct validity.

Intuition Behind Univariate and Multivariate Methods

An important limitation of many quality indicators is their imprecision, which complicates the reliable identification of persistent differences among providers in performance. The imprecision in quality indicators arises from two sources. The first is sampling variation, which is a particular problem for indicators based on small numbers of patients per provider (where the particular patients treated by the provider in a given year are considered a “sample” of the entire population who might have been treated or will be treated in the near future). The amount of variation due to the particular sample of patients is often large relative to the total amount of provider-level variation that is observed in any given quality indicator. A second source of imprecision arises from non-persistent factors that are not sensitive to the size of the sample; for example, a severe winter results in higher than usual rates of pneumonia mortality. Both small samples and other one-time factors that are not sensitive to sample size can add considerable volatility to quality indicators. Also, it is not the absolute amount of imprecision that matters, but rather the amount of imprecision relative to the underlying signal (i.e., true provider-level variation) that dictates the reliability of any particular indicator. Even indicators based on relatively large samples with no non-persistent factors at work can be imprecise if the true level of variation among providers is negligible.

The approach to account for the imprecision or lack of reliability is a generalization of the idea of applying a “shrinkage factor” to each provider’s estimate so that less reliable estimates are shrunk toward the national average. These “reliability-adjusted” estimates are sometimes referred to as “smoothed” estimates (because provider performance is less volatile over time) or “filtered” estimates (because the methods filter out the non-systematic noise, much like a radio filters our background noise to improve the radio signal). If the observed provider variation = signal variation + noise variation, then the shrinkage factor would be $\text{signal variation} \div (\text{signal variation} + \text{noise variation})$. For example, suppose that the observed variation among providers in the in-hospital pneumonia mortality rate was a standard deviation of 10.2 percentage points, and the signal variation was a standard deviation of 5.0 percentage points. Then the shrinkage factor for this indicator is $0.240 = (0.050^2) \div (0.102^2)$. The generalization of this approach seeks to extract additional signal using information on the relationship among multiple indicators over time.

Many of the key ideas behind the reliability-adjusted or filtered estimates are illustrated through a simple example. Suppose that one wants to evaluate a particular provider’s performance based on in-hospital mortality rates among patients admitted with pneumonia, and data are available for the most recent 2 years. Consider the following three possible approaches: (1) use only the most recent mortality rate, (2) construct a simple average of the mortality rates from the 2 recent years, or (3) ignore the provider’s mortality rate and assume that mortality is equal to the national average. The best choice among these three approaches depends on two important considerations: the signal-to-noise ratio in the provider’s data and how strongly correlated performance is from one year to the next.

For example, suppose that the mortality rate for the provider was based on only a few patients, and one had reason to believe that mortality did not vary much across providers. Then one would be tempted to choose the last option and ignore the provider’s own data because of its low reliability (e.g., low signal-to-noise ratio). This is the idea of simple shrinkage estimators, in which less reliable estimates are shrunk toward the average for all providers. Alternatively, if one had reason to believe that provider mortality changed very slowly over time, one might choose the second option in hopes that averaging the data over 2 years would reduce the noise in the estimates by effectively increasing the sample size in the provider. Even with large numbers of patients, one might want to average over years if idiosyncratic factors (such as a bad winter)

affected mortality rates from any single year. Finally, one would tend to choose the first option, and rely solely on mortality from the most recent year, if such idiosyncratic factors were unimportant, if the provider admitted a large number of patients each year, and if mortality was likely to have changed from the previous year.

The method of creating filtered estimates formalizes the intuition from this simple example. The filtered estimates are a combination of the provider's own quality indicator, the national average, and the provider's quality indicators from past years or other patient outcomes. As suggested by the example, to form the optimal combination, one must know the amount of noise and signal variance in each indicator, as well as the correlation across indicators in the noise and signal variance.

The noise variance (and covariance) is estimated in a straightforward manner for each provider, based on the number of patients on which each indicator is based. To estimate the signal variance (and covariance) for each quality indicator, the noise variance is subtracted from the total variance observed in each indicator across providers (which reflects both signal and noise variance). In other words, the observed variation in quality indicators is sure to overstate the amount of actual variation across providers (because of the noise in the indicators). Therefore, the amount of true variation in performance is estimated based on how much the observed variation exceeded what would have been expected due to sampling error. Importantly, this method does not *assume* that provider performance is correlated from one year to the next (or that performance is correlated across indicators). Instead, these correlations are estimated directly from the data, and information from past years or other indicators is incorporated only to the extent that these empirically estimated correlations are large.

Smoothed Estimates of Hospital Performance

For each hospital, a vector of K adjusted indicator estimates was observed over T years from estimating the patient-level regressions (1) run separately by year for each indicator as described in the preceding section. Each indicator is a noisy estimate of true hospital quality; in other words, it is likely that hospitals that performed especially well or badly on the measure did so at least in part due to chance. This fact is incorporated in Bayesian methods for constructing best-guess "posterior" estimates of true provider performance based on observed performance and the within-provider noise in the measures.

In particular, let M_j be the $1 \times TK$ vector of estimated indicator performance for hospital j. Then:

$$(2) \quad M_j = \mu_j + \varepsilon_j$$

Where μ_j is a $1 \times TK$ vector of the true hospital intercepts for hospital j, and ε_j is the estimation error (which has a mean zero and is uncorrelated with μ_j). Note that the variance of ε_j can be estimated from the patient-level regressions, since this is simply the variance of the regression estimates M_j . In particular, $E(\varepsilon_{jt}' \varepsilon_{jt}) = \Omega_{jt}$ and $E(\varepsilon_{jt}' \varepsilon_{js}) = 0$ for $t \neq s$, where Ω_{jt} is the covariance matrix of the intercept estimates for hospital j in year t.

A linear combination of each hospital's observed indicators must be created in such a way that it minimizes the mean-squared prediction error. In other words, the following hypothetical regression should be run:

$$(3) \quad \mu_{jt}^k = M_j \beta_{jt}^k + v_{jt}^k$$

but cannot be run directly, since μ is unobserved and the optimal β varies by hospital and year. While equation (3) cannot be directly estimated, it is possible to estimate the parameters for this hypothetical regression. In general, the minimum mean squared error linear predictor of μ is given by $M_j \beta$, where $\beta = [E(M_j' M_j)]^{-1} E(M_j' \mu)$. This best linear predictor depends on two moment matrices:

$$(4.1) \quad E(M_j' M_j) = E(\mu_j' \mu_j) + E(\varepsilon_j' \varepsilon_j)$$

$$(4.2) \quad E(M_j' \mu_j) = E(\mu_j' \mu_j)$$

The required moment matrices are estimated directly as follows:

- Estimate $E(\varepsilon_j' \varepsilon_j)$ with the patient-level OLS estimate of the covariance matrix for the parameter estimates M_j . Call this estimate S_j . Note that S_j varies across hospitals.
- Estimate $E(\mu_j' \mu_j)$ by noting that $E(M_j' M_j - S_j) = E(\mu_j' \mu_j)$. If we assume that $E(\mu_j' \mu_j)$ is the same for all hospitals, then it can be estimated by the sample average of $M_j' M_j - S_j$. Note that it is easy to relax the assumption that $E(\mu_j' \mu_j)$ is the same for all hospitals by calculating $M_j' M_j - S_j$ for subgroups of hospitals.

With estimates of $E(\mu_j' \mu_j)$ and $E(\varepsilon_j' \varepsilon_j)$, one can form least squares estimates of the parameters in equation 3 which minimize the mean squared error. Analogous to simple regression, the prediction of a hospital's true intercepts is given by:

$$(5) \quad \hat{\mu}_j = M_j E(M_j' M_j)^{-1} E(M_j' \mu) = M_j [E(\mu_j' \mu) + E(\varepsilon_j' \varepsilon)]^{-1} E(\mu_j' \mu)$$

using estimates of $E(\mu_j' \mu_j)$ and $E(\varepsilon_j' \varepsilon_j)$ in place of their true values. One can use the estimated moments to calculate other statistics of interest as well, such as the standard error of the prediction and the r-squared for equation 3, based on the usual least squares formulas. Estimates based on equation (5) are referred to as "filtered" estimates, since the key advantage of such estimates is that they optimally filter out the estimation error in the raw quality indicators.

Equation 5 in combination with estimates of the required moment matrices provides the basis for estimates of hospital quality. Such estimates of hospital quality have a number of attractive properties. First, they incorporate information in a systematic way from many outcome indicators and many years into the predictions of any one outcome. Moreover, if the moment matrices were known, the estimates of hospital quality represent the optimal linear predictors, based on a mean squared error criterion. Finally, these estimates maintain many of the attractive aspects of existing Bayesian approaches, while dramatically simplifying the complexity of the estimation. [69] It is possible to construct univariate smoothed estimates of hospital quality, based only on empirical estimates for particular measures, using the models just described but restricting the dimension of M_j to only a particular indicator k and time period t . Of course, to the extent that the provider indicators are correlated with each other and over time, this will result in a less precise (efficient) estimate.

With many years of data, it helps to impose some structure on $E(\mu_j' \mu_j)$ for two reasons. First, this improves the precision of the estimated moments by limiting the number of parameters that need to be estimated. Second, a time series structure allows for out-of-sample forecasts. A non-stationary, first-order Vector Autoregression structure (VAR) is used. The VAR model is a generalization of the usual autoregressive model, and assumes that each hospital's quality indicators in a given year depend on the hospital's quality indicators in past years plus a contemporaneous shock that may be correlated across quality indicators. In most of what follows, a non-stationary first-order VAR is assumed for μ_{jt} ($1 \times K$), where:

$$(6) \quad \mu_{jt} = \mu_{j,t-1}\Phi + u_{jt}, \text{ with } V(u_{jt}) = \Sigma \text{ and } V(\mu_{j1}) = \Gamma.$$

Thus, estimates are needed of the lag coefficient (Φ), the variance matrix of the innovations (Σ), and the initial variance condition (Γ), where Σ and Γ are symmetric $K \times K$ matrices of parameters and Φ is a general $K \times K$ matrix of parameters, for a total of $2K^2 + K$ parameters. For example, 10 parameters must be estimated for a VAR model with two outcomes ($K=2$).

The VAR structure implies that $E(M_j' M_j - S_j) = E(\mu_j' \mu_j) = f(\Phi, \Sigma, \Gamma)$. Thus, the VAR parameters can be estimated by Optimal Minimum Distance (OMD) methods, i.e., by choosing the VAR parameters so that the theoretical moment matrix, $f(\Phi, \Sigma, \Gamma)$, is as close as possible to the corresponding sample moments from the sample average of $M_j' M_j - S_j$. More specifically, let d_j be a vector of the non-redundant (lower triangular) elements of $M_j' M_j - S_j$, and let \bar{d} be a vector of the corresponding moments from the true moment matrix, so that $\bar{d} = g(\Phi, \Sigma, \Gamma)$. [177] Then the OMD estimates of (Φ, Σ, Γ) minimize the following OMD objective function:

$$(7) \quad q = N[\bar{d} - g(\Phi, \Sigma, \Gamma)]' V^{-1}[\bar{d} - g(\Phi, \Sigma, \Gamma)]$$

where V is the sample estimate of the covariance matrix for d , and \bar{d} is the sample average of d . If the VAR model is correct, the value of the objective function, q , will be distributed $\chi^2(p)$ where p is the degree of over-identification (the difference between the number of elements in d and the number of parameters being estimated). Thus, q provides a goodness of fit statistic that indicates how well the VAR model fits the actual covariances in the data.

Finally, estimated R^2 statistics are used to evaluate the filtered estimates' ability to predict (in sample) and forecast (out-of-sample) variation in the true intercepts, and to compare methods used to conventional methods (e.g., simple averages, or univariate shrinkage estimators). If true hospital intercepts (μ) were observed, a natural metric for evaluating the predictions would be the sample R-squared:

$$(8) \quad R^2 = 1 - \frac{\left\{ \sum_{j=1}^N \hat{u}_j^2 \right\}}{\left\{ \sum_{j=1}^N \mu_j^2 \right\}}$$

where

$$\hat{u}_j = \mu_j - \hat{\mu}_j$$

is the prediction error. Of course μ is not observed. Therefore, an estimate is constructed using the estimate of $E(\mu_j' \mu_j)$ for the denominator, and the estimate of

$$E[(\mu_j - \hat{\mu}_j)' (\mu_j - \hat{\mu}_j)]$$

for the terms in the numerator (where this can be constructed from the estimated moment matrices in equations 4.1 and 4.2). Finally, a weighted R-squared is reported (weighting by the number of patients treated by each hospital).

As in earlier work using this method for cardiac care in the adult population, the indicators are validated using out-of-sample performance, based on forecasts (e.g., using the first 2 years of data to predict in subsequent year) and based on split-sample prediction (e.g., using one-half of the patient sample to predict outcome indicators in the other half of the sample). For evaluating out-of-sample forecasts, a modified R-squared of the forecast is constructed that estimates the fraction of the *systematic* (true) hospital variation in the outcome measure (M) that was explained:

$$(9) \quad \tilde{R}^2 = 1 - \frac{\left(\sum_{j=1}^N (\hat{v}_j^2 - S_j) \right)}{\left(\sum_{j=1}^N (M_j^2 - S_j) \right)}$$

where

$$\hat{v}_j = M_j - \hat{\mu}_j$$

is the forecast error and S_j is the OLS estimate of the variance of the estimate M_j . This modified R-squared estimates the amount of variance in the true hospital effects that has been forecast. Note that because these are out-of-sample forecasts, the R-squared can be negative, indicating that the forecast performed worse than a naive forecast in which one assumed that quality was equal to the national average at all hospitals.

Empirical Analysis Statistics

Using the methods just described, a set of statistical tests was constructed to evaluate precision, bias, and construct validity. Each of the key statistical test results for these evaluation criteria was summarized and explained in the beginning of this appendix. Tables 1-3 provides a summary of the statistical analyses and their interpretation. Indicators were tested for precision first, and ones that performed poorly were eliminated from further consideration. Bias and construct validity were assessed for all recommended indicators.

Table 1. Precision Tests

Measure	Statistic		Interpretation
Precision. Is most of the variation in an indicator at the level of the provider? Do smoothed estimates of quality lead to more precise measures?			
a. Raw variation in indicator	Provider Standard Deviation Signal Standard Deviation Provider/Area Share	Unadjusted Age-sex adjusted Age-sex+APR-DRG adjusted	Provider variation is signal variation + noise variation. What percentage of the total variation (patient + provider) is between-provider variation (a measure of how much variation is subject to provider control). Risk adjustment can either increase or decrease true variation.
b. Univariate smoothing	Signal/Signal-to-noise ratio: Unadjusted Age-sex adjusted Age-sex + APR-DRG adjusted		Estimates what percentage of the observed variation between providers reflects “true” quality differences versus random noise. Risk adjustment can increase or decrease estimates of “true” quality differences.
c. MSX methods	In-sample R-squared: Unadjusted Age-sex adjusted Age-sex + APR-DRG adjusted		To the extent that indicators are correlated with each other and over time, MSX methods can extract more “signal” (a higher percentage of observed variation between providers that reflects “true” quality).

Table 2. Bias Tests

Measure	Statistic	Interpretation
Bias. Does risk-adjustment change the assessment of relative provider performance, after accounting for reliability? Is the impact greatest among the best or worst performers, or overall? What is the magnitude of the change in performance?		
a. MSX methods: unadjusted vs. age, sex, APR-DRG risk adjustment	Rank correlation coefficient (Spearman)	Risk-adjustment matters to the extent that it alters the assessment of relative provider performance. This test determines the impact overall.
	Average absolute value of change relative to mean	This test determines whether the absolute change in performance was large or small relative to the overall mean.
	Percentage of the top 10% of providers that remains the same	This test measures the impact at the highest rates (in general, the worse performers, except for measures like VBAC).
	Percentage of the bottom 10% of providers that remains the same	This tests measure the impact at the lowest rates (in general, the best performers, except for measures like VBAC).
	Percentage of providers that move more than two deciles in rank (up or down)	This test determines the magnitude of the relative changes.

Table 3. Construct Validity Tests

Measure	Statistic	Interpretation
Construct validity. Is the indicator related to other indicators in a way that makes clinical sense? Do methods that remove noise and bias make the relationship clearer?		
a. Correlation of indicator with other indicators	Pearson correlation coefficient	Are indicators correlated with other indicators in the direction one might expect?
b. Factor loadings of indicator with other indicators	Factor loadings	Do indicators load on factors with other indicators that one might expect?

References for Appendix B

1. McGlynn EA, Asch SM. Developing a clinical performance measure. *Am J Prev Med* 1998;14(3 Suppl):14-21.
2. Siu AL, McGlynn EA, Morgenstern H, et al. Choosing quality of care measures based on the expected impact of improved care on health. *Health Serv Res* 1992;27(5):619-50.
3. Donabedian A. Explorations in Quality Assessment and Monitoring. The definition of quality and approaches to its assessment. Ann Arbor, MI: Health Administration Press; 1980.
4. Donabedian A. The quality of care: how can it be assessed? *JAMA* 1988;260(12):1743-1748.
5. Schneider EC, Epstein AM. Influence of cardiac-surgery performance reports on referral practices and access to care. A survey of cardiovascular specialists. *N Engl J Med* 1996;335(4):251-6.
6. Mennemeyer ST, Morrisey MA, Howard LZ. Death and reputation: how consumers acted upon HCFA mortality information. *Inquiry* 1997;34(2):117-28.
7. Hibbard JH, Jewett JJ. Will quality report cards help consumers? *Health Aff (Millwood)* 1997;16(3):218-28.
8. Normand SL, McNeil BJ, Peterson LE, et al. Eliciting expert opinion using the Delphi technique: identifying performance indicators for cardiovascular disease. *Int J Qual Health Care* 1998;10(3):247-60.
9. Veroff DR, Gallagher PM, Wilson V, et al. Effective reports for health care quality data: lessons from a CAHPS demonstration in Washington State. *Int J Qual Health Care* 1998;10(6):555-60.
10. Delbanco TL, Stokes DM, Cleary PD, et al. Medical patients' assessments of their care during hospitalization: insights for internists. *J Gen Intern Med* 1995;10(12):679-85.
11. Laine C, Davidoff F. Patient-centered medicine. A professional evolution. *JAMA* 1996;275(2):152-6.
12. Allen HM, Jr., Rogers WH. Consumer surveys of health plan performance: a comparison of content and approach and a look to the future. *Jt Comm J Qual Improv* 1996;22(12):775-94.
13. Cleary PD, Edgman-Levitan S. Health care quality. Incorporating consumer perspectives. *JAMA* 1997;278(19):1608-12.
14. Eye on patients: excerpts from a report on patients' concerns and experiences about the health care system. American Hospital Association and the Picker Institute. *J Health Care Finance* 1997;23(4):2-11.
15. Calnan MW. The patient's perspective. *Int J Technol Assess Health Care* 1998;14(1):24-34.
16. Tye L. Patient surveys show how Massachusetts hospitals stack up. *Boston Globe* 1998 November 13, 1998;Sect. A1, A34.
17. Finkelstein BS, Harper DL, Rosenthal GE. Patient assessments of hospital maternity care: a useful tool for consumers? *Health Serv Res* 1999;34(2):623-40.

18. Berwick DM, Wald DL. Hospital leaders' opinions of the HCFA mortality data. *JAMA* 1990;263(2):247-9.
19. Jencks SF, Daley J, Draper D, et al. Interpreting hospital mortality data. The role of clinical risk adjustment. *JAMA* 1988;260(24):3611-6.
20. Park RE, Brook RH, Kosecoff J, et al. Explaining variations in hospital death rates. Randomness, severity of illness, quality of care. *JAMA* 1990;264(4):484-90.
21. Localio AR, Hamory BH, Sharp TJ, et al. Comparing hospital mortality in adult patients with pneumonia. A case study of statistical methods in a managed care program. *Ann Intern Med* 1995;122(2):125-32.
22. Localio AR, Hamory BH, Fisher AC, et al. The public release of hospital and physician mortality data in Pennsylvania. A case study. *Med Care* 1997;35(3):272-286.
23. Hofer TP, Hayward RA. Identifying poor-quality hospitals. Can hospital mortality rates detect quality problems for medical diagnoses? *Med Care* 1996;34(8):737-53.
24. Thomas JW, Hofer TP. Accuracy of risk-adjusted mortality rate as a measure of hospital quality of care. *Med Care* 1999;37(1):83-92.
25. Mant J, Hicks N. Detecting differences in quality of care: the sensitivity of measures of process and outcome in treating acute myocardial infarction. *BMJ* 1995;311(7008):793-6.
26. Palmer RH. Process-based measures of quality: the need for detailed clinical data in large health care databases. *Ann Intern Med* 1997;127(8 Pt 2):733-8.
27. Eddy DM. Performance measurement: problems and solutions. *Health Aff (Millwood)* 1998;17(4):7-25.
28. Harr DS, Balas EA, Mitchell J. Developing quality indicators as educational tools to measure the implementation of clinical practice guidelines. *Am J Med Qual* 1996;11(4):179-85.
29. Ellerbeck EF, Jencks SF, Radford MJ, et al. Quality of care for Medicare patients with acute myocardial infarction. A four-state pilot study from the Cooperative Cardiovascular Project. *JAMA* 1995;273(19):1509-14.
30. Marciniak TA, Ellerbeck EF, Radford MJ, et al. Improving the quality of care for Medicare patients with acute myocardial infarction: results from the Cooperative Cardiovascular Project. *JAMA* 1998;279(17):1351-7.
31. Donabedian A. Evaluating the quality of medical care. *Milbank Mem Fund Q* 1966;44(3):Suppl:166-206.
32. Brook RH, McGlynn EA, Cleary PD. Quality of health care. Part 2: measuring quality of care. *N Engl J Med* 1996;335(13):966-70.
33. Luft HS, Bunker JP, Enthoven AC. Should operations be regionalized? The empirical relation between surgical volume and mortality. *N Engl J Med* 1979;301(25):1364-9.
34. Hughes RG, Garnick DW, Luft HS, et al. Hospital volume and patient outcomes. The case of hip fracture patients. *Med Care* 1988;26(11):1057-67.

35. Hannan EL, JF OD, Kilburn H, Jr., et al. Investigation of the relationship between volume and mortality for surgical procedures performed in New York State hospitals. *JAMA* 1989;262(4):503-10.
36. Hannan EL, Kilburn H, Jr., Bernard H, et al. Coronary artery bypass surgery: the relationship between inhospital mortality rate and surgical volume after controlling for clinical risk factors. *Med Care* 1991;29(11):1094-107.
37. Stone VE, Seage GRd, Hertz T, et al. The relation between hospital experience and mortality for patients with AIDS. *JAMA* 1992;268(19):2655-61.
38. Hosenpud JD, Breen TJ, Edwards EB, et al. The effect of transplant center volume on cardiac transplant outcome. A report of the United Network for Organ Sharing Scientific Registry. *JAMA* 1994;271(23):1844-9.
39. Jones A, O'Driscoll K, Luke LC. Head injuries and the observation ward [letter; comment]. *J Accid Emerg Med* 1995;12(2):160-1.
40. Phibbs CS, Bronstein JM, Buxton E, et al. The effects of patient volume and level of care at the hospital of birth on neonatal mortality. *JAMA* 1996;276(13):1054-9.
41. Ellis SG, Weintraub W, Holmes D, et al. Relation of operator volume and experience to procedural outcome of percutaneous coronary revascularization at hospitals with high interventional volumes. *Circulation* 1997;95(11):2479-84.
42. Jollis JG, Peterson ED, Nelson CL, et al. Relationship between physician and hospital coronary angioplasty volume and outcome in elderly patients. *Circulation* 1997;95(11):2485-91.
43. Hannan EL, Racz M, Ryan TJ, et al. Coronary angioplasty volume-outcome relationships for hospitals and cardiologists. *JAMA* 1997;277(11):892-8.
44. Dardik A, Burleyson GP, Bowman H, et al. Surgical repair of ruptured abdominal aortic aneurysms in the state of Maryland: factors influencing outcome among 527 recent cases. *J Vasc Surg* 1998;28(3):413-20.
45. Rosenthal GE, Shah A, Way LE, et al. Variations in standardized hospital mortality rates for six common medical diagnoses: implications for profiling hospital quality. *Med Care* 1998;36(7):955-64.
46. Cebul RD, Snow RJ, Pine R, et al. Indications, outcomes, and provider volumes for carotid endarterectomy. *JAMA* 1998;279(16):1282-7.
47. Begg CB, Cramer LD, Hoskins WJ, et al. Impact of hospital volume on operative mortality for major cancer surgery. *JAMA* 1998;280(20):1747-51.
48. Thiemann DR, Coresh J, Oetgen WJ, et al. The association between hospital volume and survival after acute myocardial infarction in elderly patients . *N Engl J Med* 1999;340(21):1640-8.
49. Pratt R, Burr G, Leelarthaepin B, et al. The effects of All-RN and RN-EN staffing on the quality and cost of patient care. *Aust J Adv Nurs* 1993;10(3):27-39.
50. Archibald LK, Manning ML, Bell LM, et al. Patient density, nurse-to-patient ratio and nosocomial infection risk in a pediatric cardiac intensive care unit. *Pediatr Infect Dis J* 1997;16(11):1045-8.

51. Blegen MA, Goode CJ, Reed L. Nurse staffing and patient outcomes. *Nurs Res* 1998;47(1):43-50.
52. Czaplinski C, Diers D. The effect of staff nursing on length of stay and mortality. *Med Care* 1998;36(12):1626-38.
53. Kovner C, Gergen PJ. Nurse staffing levels and adverse events following surgery in U.S. hospitals. *Image J Nurs Sch* 1998;30(4):315-21.
54. McCloskey JM. Nurse staffing and patient outcomes. *Nurs Outlook* 1998;46(5):199-200.
55. Bond CA, Raehl CL, Pitterle ME, et al. Health care professional staffing, hospital characteristics, and hospital mortality rates. *Pharmacotherapy* 1999;19(2):130-8.
56. Wennberg J, Gittelsohn. Small area variations in health care delivery. *Science* 1973;182(117):1102-8.
57. Wennberg J, Gittelsohn A. Variations in medical care among small areas. *Sci Am* 1982;246(4):120-34.
58. Markowitz JS, Pashko S, Gutterman EM, et al. Death rates among patients hospitalized with community-acquired pneumonia: a reexamination with data from three states. *Am J Public Health* 1996;86(8 Pt 1):1152-4.
59. Hofer TP, Wolfe RA, Tedeschi PJ, et al. Use of community versus individual socioeconomic data in predicting variation in hospital use. *Health Serv Res* 1998;33(2 Pt 1):243-59.
60. Jencks SF, Dobson A. Refining case-mix adjustment. The research evidence. *N Engl J Med* 1987;317(11):679-86.
61. Shapiro MF, Park RE, Keesey J, et al. The effect of alternative case-mix adjustments on mortality differences between municipal and voluntary hospitals in New York City. *Health Serv Res* 1994;29(1):95-112.
62. Halm EA, Lee C, Chassin MR. How is volume related to quality in health care? A systematic review of the research literature: Institute of Medicine, National Academy of Sciences, Division of Health Care Services, Committee on Quality of Care in America; 2000 May 1.
63. Thomas J, Holloway J, Guire K. Validating risk-adjusted mortality as an indicator for quality of care. *Inquiry* 1993;30(1):6-22.
64. Hofer TP, Hayward RA. Can early re-admission rates accurately detect poor-quality hospitals? *Med Care* 1995;33(3):234-45.
65. Thomas JW. Does risk-adjusted readmission rate provide valid information on hospital quality? *Inquiry* 1996;33(3):258-70.
66. Normand ST, Glickman ME, Sharma RG, et al. Using admission characteristics to predict short-term mortality from myocardial infarction in elderly patients. Results from the Cooperative Cardiovascular Project. *JAMA* 1996;275(17):1322-8.
67. Thomas JW, Hofer TP. Research evidence on the validity of risk-adjusted mortality rate as a measure of hospital quality of care. *Med Care Res Rev* 1998;55(4):371-404.

68. Hofer TP, Hayward RA, Greenfield S, et al. The unreliability of individual physician "report cards" for assessing the costs and quality of care of a chronic disease . *JAMA* 1999;281(22):2098-105.
69. Normand S, Glickman M, Gastonis C. Statistical methods for profiling providers of medical care: Issues and applications. *JASA* 1997;92(439):803-814.
70. O'Hagan A. Bayesian Inference. In: al. GPe, editor. *Kendall's Advanced Theory of Statistics*. New York: Halstead Press; 1994.
71. Goldstein H. *Multilevel Statistical Models*. 2nd ed. New York: Halstead Press; 1995.
72. Wennberg JE, Freeman JL, Shelton RM, et al. Hospital use and mortality among Medicare beneficiaries in Boston and New Haven. *N Engl J Med* 1989;321(17):1168-73.
73. Fisher ES, Wennberg JE, Stukel TA, et al. Hospital readmission rates for cohorts of Medicare beneficiaries in Boston and New Haven. *N Engl J Med* 1994;331(15):989-95.
74. Miller MG, Miller LS, Fireman B, et al. Variation in practice for discretionary admissions. Impact on estimates of quality of hospital care . *JAMA* 1994;271(19):1493-8.
75. Rosenthal GE, Harper DL, Shah A, et al. A regional evaluation of variation in low-severity hospital admissions. *J Gen Intern Med* 1997;12(7):416-22.
76. Fisher ES, Wennberg JE, Stukel TA, et al. Associations among hospital capacity, utilization, and mortality of US Medicare beneficiaries, controlling for sociodemographic factors. *Health Serv Res* 2000;34(6):1351-62.
77. McClellan M, McNeil BJ, Newhouse JP. Does more intensive treatment of acute myocardial infarction in the elderly reduce mortality? Analysis using instrumental variables. *JAMA* 1994;272(11):859-66.
78. Iezzoni LI, Ash AS, Shwartz M, et al. Judging hospitals by severity-adjusted mortality rates: the influence of the severity-adjustment method. *Am J Public Health* 1996;86(10):1379-87.
79. Iezzoni LI. The risks of risk adjustment. *JAMA* 1997;278(19):1600-7.
80. Iezzoni LI, Heeren T, Foley SM, et al. Chronic conditions and risk of in-hospital death. *Health Serv Res* 1994;29(4):435-60.
81. Jones RH, Hannan EL, Hammermeister KE, et al. Identification of preoperative variables needed for risk adjustment of short-term mortality after coronary artery bypass graft surgery. The Working Group Panel on the Cooperative CABG Database Project. *J Am Coll Cardiol* 1996;28(6):1478-87.
82. Khuri SF, Daley J, Henderson W, et al. Risk adjustment of the postoperative mortality rate for the comparative assessment of the quality of surgical care: results of the National Veterans Affairs Surgical Risk Study. *J Am Coll Surg* 1997;185(4):315-27.
83. Wray NP, Hollingsworth JC, Peterson NJ, et al. Case-mix adjustment using administrative databases: a paradigm to guide future research. *Med Care Res Rev* 1997;54(3):326-56.
84. Kuttner R. The risk-adjustment debate. *N Engl J Med* 1998;339(26):1952-6.
85. Block PC, Peterson EC, Krone R, et al. Identification of variables needed to risk adjust outcomes of coronary interventions: evidence-based guidelines for efficient data collection. *J Am Coll Cardiol* 1998;32(1):275-82.

86. Richardson D, Tarnow-Mordi WO, Lee SK. Risk adjustment for quality improvement. *Pediatrics* 1999;103(1 Suppl E):255-65.
87. Iezzoni LI. Risk adjustment for measuring healthcare outcomes. 2nd ed. Chicago, Ill.: Health Administration Press; 1997.
88. Iezzoni LI, Foley SM, Daley J, et al. Comorbidities, complications, and coding bias. Does the number of diagnosis codes matter in predicting in-hospital mortality? *JAMA* 1992;267(16):2197-203.
89. Green J, Wintfeld N. How accurate are hospital discharge data for evaluating effectiveness of care? *Med Care* 1993;31(8):719-31.
90. Malenka DJ, McLerran D, Roos N, et al. Using administrative data to describe casemix: a comparison with the medical record. *J Clin Epidemiol* 1994;47(9):1027-32.
91. Jencks SF, Williams DK, Kay TL. Assessing hospital-associated deaths from discharge data. The role of length of stay and comorbidities. *JAMA* 1988;260(15):2240-6.
92. Romano PS, Mark DH. Bias in the coding of hospital discharge data and its implications for quality assessment. *Med Care* 1994;32(1):81-90.
93. Simborg DW. DRG creep: a new hospital-acquired disease. *N Engl J Med* 1981;304(26):1602-4.
94. Keeler EB, Kahn KL, Draper D, et al. Changes in sickness at admission following the introduction of the prospective payment system. *JAMA* 1990;264(15):1962-8.
95. Hsia DC, Krushat WM, Fagan AB, et al. Accuracy of diagnostic coding for Medicare patients under the prospective-payment system. *N Engl J Med* 1988;318(6):352-355.
96. Green J, Wintfeld N. Report cards on cardiac surgeons. Assessing New York State's approach. *N Engl J Med* 1995;332(18):1229-32.
97. Hannan EL, Racz MJ, Jollis JG, et al. Using Medicare claims data to assess provider quality for CABG surgery: does it work well enough? *Health Serv Res* 1997;31(6):659-78.
98. Romano PS, Chan BK. Risk-adjusting acute myocardial infarction mortality: are APR-DRGs the right tool? *Health Serv Res* 2000;34(7):1469-89.
99. Goldfield N, Averill R. On "risk-adjusting acute myocardial infarction mortality: are APR-DRGs the right tool"? [comment]. *Health Serv Res* 2000;34(7):1491-5; discussion 1495-8.
100. Jollis JG, Romano PS. Pennsylvania's Focus on Heart Attack--grading the scorecard. *N Engl J Med* 1998;338(14):983-7.
101. O'Connor GT, Plume SK, Olmstead EM, et al. Multivariate prediction of in-hospital mortality associated with coronary artery bypass graft surgery. Northern New England Cardiovascular Disease Study Group. *Circulation* 1992;85(6):2110-8.
102. O'Connor GT, Plume SK, Olmstead EM, et al. A regional intervention to improve the hospital mortality associated with coronary artery bypass graft surgery. The Northern New England Cardiovascular Disease Study Group. *JAMA* 1996;275(11):841-6.
103. Hannan EL, Kilburn H, Jr., Racz M, et al. Improving the outcomes of coronary artery bypass surgery in New York State. *JAMA* 1994;271(10):761-6.

104. Knaus WA, Draper EA, Wagner DP, et al. An evaluation of outcome from intensive care in major medical centers. *Ann Intern Med* 1986;104(3):410-8.
105. Knaus WA, Wagner DP, Zimmerman JE, et al. Variations in mortality and length of stay in intensive care units. *Ann Intern Med* 1993;118(10):753-61.
106. Fine MJ, Auble TE, Yealy DM, et al. A prediction rule to identify low-risk patients with community-acquired pneumonia. *N Engl J Med* 1997;336(4):243-50.
107. Cooper GS, Chak A, Harper DL, et al. Care of patients with upper gastrointestinal hemorrhage in academic medical centers: a community-based comparison. *Gastroenterology* 1996;111(2):385-90.
108. Iezzoni LI, Ash AS, Shwartz M, et al. Predicting who dies depends on how severity is measured: implications for evaluating patient outcomes. *Ann Intern Med* 1995;123(10):763-70.
109. Iezzoni LI, Shwartz M, Ash AS, et al. Predicting in-hospital mortality for stroke patients: results differ across severity-measurement methods. *Med Decis Making* 1996;16(4):348-56.
110. Iezzoni LI, Shwartz M, Ash AS, et al. Using severity-adjusted stroke mortality rates to judge hospitals. *Int J Qual Health Care* 1995;7(2):81-94.
111. Iezzoni LI, Shwartz M, Ash AS, et al. Severity measurement methods and judging hospital death rates for pneumonia. *Med Care* 1996;34(1):11-28.
112. Iezzoni LI, Shwartz M, Ash AS, et al. Using severity measures to predict the likelihood of death for pneumonia inpatients. *J Gen Intern Med* 1996;11(1):23-31.
113. Pine M, Norusis M, Jones B, et al. Predictions of hospital mortality rates: a comparison of data sources. *Ann Intern Med* 1997;126(5):347-54.
114. Krumholz HM, Chen J, Wang Y, et al. Comparing AMI mortality among hospitals in patients 65 years of age and older: evaluating methods of risk adjustment. *Circulation* 1999;99(23):2986-92.
115. Luft H, Romano P, Remy L, et al. Second Report of the California Hospital Outcomes Project: Acute Myocardial Infarction. Office of Statewide Health Planning and Development.
116. Iezzoni LI, Ash AS, Shwartz M, et al. Differences in procedure use, in-hospital mortality, and illness severity by gender for acute myocardial infarction patients: are answers affected by data source and severity measure? *Med Care* 1997;35(2):158-71.
117. Hibbard JH, Jewett JJ, Legnini MW, et al. Choosing a health plan: do large employers use the data? *Health Aff (Millwood)* 1997;16(6):172-80.
118. Hibbard JH, Jewett JJ, Engelmann S, et al. Can Medicare beneficiaries make informed choices? *Health Aff (Millwood)* 1998;17(6):181-93.
119. Schneider EC, Epstein AM. Use of public performance reports: a survey of patients undergoing cardiac surgery. *JAMA* 1998;279(20):1638-42.
120. Booske BC, Sainfort F, Hundt AS. Eliciting consumer preferences for health plans. *Health Serv Res* 1999;34(4):839-54.

121. Rainwater JA, Romano PS, Antonius DM. The California Hospital Outcomes Project: how useful is California's report card for quality improvement? *Jt Comm J Qual Improv* 1998;24(1):31-9.
122. Romano PS, Rainwater JA, Antonius D. Grading the graders: how hospitals in California and New York perceive and interpret their report cards. *Med Care* 1999;37(3):295-305.
123. Palmer RH, Louis TA, Peterson HF, et al. What makes quality assurance effective? Results from a randomized, controlled trial in 16 primary care group practices. *Med Care* 1996;34(9 Suppl):SS29-39.
124. Duffy SQ, Farley DE. Patterns of decline among inpatient procedures. *Public Health Rep* 1995;110(6):674-81.
125. Rutledge R. Can medical school-affiliated hospitals compete with private hospitals in the age of managed care? An 11-state, population-based analysis of 351,201 patients undergoing cholecystectomy. *J Am Coll Surg* 1997;185(3):207-17.
126. Maynard C, Chapko MK, Every NR, et al. Coronary angioplasty outcomes in the Healthcare Cost and Utilization Project, 1993-1994. *Am J Cardiol* 1998;81(7):848-52.
127. Shepardson LB, Youngner SJ, Speroff T, et al. Increased risk of death in patients with do-not-resuscitate orders. *Med Care* 1999;37(8):727-37.
128. Layde PM, Broste SK, Desbiens N, et al. Generalizability of clinical studies conducted at tertiary care medical centers: a population-based analysis. *J Clin Epidemiol* 1996;49(8):835-41.
129. Hannan EL, Kilburn H, Jr., O'Donnell JF, et al. Interracial access to selected cardiac procedures for patients hospitalized with coronary artery disease in New York State. *Med Care* 1991;29(5):430-41.
130. Buckle JM, Horn SD, Oates VM, et al. Severity of illness and resource use differences among white and black hospitalized elderly. *Arch Intern Med* 1992;152(8):1596-603.
131. McBean AM, Gornick M. Differences by race in the rates of procedures performed in hospitals for Medicare beneficiaries. *Health Care Financ Rev* 1994;15(4):77-90.
132. McBean AM, Warren JL, Babish JD. Continuing differences in the rates of percutaneous transluminal coronary angioplasty and coronary artery bypass graft surgery between elderly black and white Medicare beneficiaries. *Am Heart J* 1994;127(2):287-95.
133. Williams JF, Zimmerman JE, Wagner DP, et al. African-American and white patients admitted to the intensive care unit: is there a difference in therapy and outcome? *Crit Care Med* 1995;23(4):626-36.
134. Phillips RS, Hamel MB, Teno JM, et al. Race, resource use, and survival in seriously ill hospitalized adults. The SUPPORT Investigators. *J Gen Intern Med* 1996;11(7):387-96.
135. Romano PS, Campa DR, Rainwater JA. Elective cervical discectomy in California: postoperative in-hospital complications and their risk factors. *Spine* 1997;22(22):2677-92.
136. Huber TS, Wang JG, Wheeler KG, et al. Impact of race on the treatment for peripheral arterial occlusive disease. *J Vasc Surg* 1999;30(3):417-25.
137. Chen J, Radford MJ, Wang Y, et al. Do "America's Best Hospitals" perform better for acute myocardial infarction? *N Engl J Med* 1999;340:286-92.

138. Hartz AJ, Gottlieb MS, Kuhn EM, et al. The relationship between adjusted hospital mortality and the results of peer review. *Health Serv Res* 1993;27(6):765-77.
139. Hsia DC, Ahern CA, Ritchie BP, et al. Medicare reimbursement accuracy under the prospective payment system, 1985 to 1988. *JAMA* 1992;268(7):896-899.
140. Cullen DJ, Bates DW, Small SD, et al. The incident reporting system does not detect adverse drug events: a problem for quality improvement. *Jt Comm J Qual Improv* 1995;21(10):541-8.
141. Kohn L, Corrigan J, Donaldson M, et al., editors. *To Err Is Human: Building a Safer Health System*. Washington, D.C.: National Academy Press; 2000.
142. Silber JH, Rosenbaum PR, Schwartz JS, et al. Evaluation of the complication rate as a measure of quality of care in coronary artery bypass graft surgery. *JAMA* 1995;274(4):317-23.
143. Silber JH, Rosenbaum PR, Ross RN. Comparing the contribution of predictors: which outcomes vary with hospital rather than patient characteristics? *J Am Stat Assoc* 1995;90:7-18.
144. Silber JH, Rosenbaum PR, Williams SV, et al. The relationship between choice of outcome measure and hospital rank in general surgical procedures: implications for quality assessment. *Int J Qual Health Care* 1997;9:193-200.
145. Kahn KL, Brook RH, Draper D, et al. Interpreting hospital mortality data. How can we proceed? *JAMA* 1988;260(24):3625-8.
146. Mullins RJ, Mann NC, Hedges JR, et al. Adequacy of hospital discharge status as a measure of outcome among injured patients. *JAMA* 1998;279(21):1727-31.
147. Sands K, Vineyard G, Platt R. Surgical site infections occurring after hospital discharge. *J Infect Dis* 1996;173(4):963-70.
148. Sands K, Vineyard G, Livingston J, et al. Efficient identification of postdischarge surgical site infections: use of automated pharmacy dispensing information, administrative data, and medical record information. *J Infect Dis* 1999;179(2):434-41.
149. Iezzoni LI, Mackiernan YD, Cahalane MJ, et al. Screening inpatient quality using post-discharge events. *Med Care* 1999;37(4):384-98.
150. Omoigui NA, Miller DP, Brown KJ, et al. Outmigration for coronary bypass surgery in an era of public dissemination of clinical outcomes. *Circulation* 1996;93(1):27-33.
151. Hannan EL, Siu AL, Kumar D, et al. Assessment of coronary artery bypass graft surgery performance in New York. Is there a bias against taking high-risk patients? *Med Care* 1997;35(1):49-56.
152. Petersen LA, Orav EJ, Teich JM, et al. Using a computerized sign-out program to improve continuity of inpatient care and prevent adverse events. *Jt Comm J Qual Improv* 1998;24(2):77-87.
153. Dranove. Information is good except when its bad. ,Stanford University Working Paper.
154. Marshall MN, Shekelle PG, Leatherman S, et al. The public release of performance data: what do we expect to gain? A review of the evidence. *JAMA* 2000;283(14):1866-74.

155. Johantgen M, Elixhauser A, Bali JK, et al. Quality indicators using hospital discharge data: state and national applications. *Jt Comm J Qual Improv* 1998;24(2):88-105.
156. Olfson M, Marcus S, Sackeim HA, et al. Use of ECT for the inpatient treatment of recurrent major depression. *Am J Psychiatry* 1998;155(1):22-9.
157. Meurer JR, Kuhn EM, George V, et al. Charges for childhood asthma by hospital characteristics. *Pediatrics* 1998;102(6):E70.
158. Lanska DJ, Hartz AJ. Measurement of quality in health care. *Neurology* 1998;50(3):584-7.
159. Lanska DJ, Kryscio RJ. In-hospital mortality following carotid endarterectomy. *Neurology* 1998;51(2):440-7.
160. Schnitzler MA, Lambert DL, Mundy LM, et al. Variations in healthcare measures by insurance status for patients receiving ventilator support. *Clin Perform Qual Health Care* 1998;6(1):17-22.
161. Niederman MS, McCombs JS, Unger AN, et al. The cost of treating community-acquired pneumonia. *Clin Ther* 1998;20(4):820-37.
162. Zhao SZ, Wong JM, Davis MB, et al. The cost of inpatient endometriosis treatment: an analysis based on the Healthcare Cost and Utilization Project Nationwide Inpatient Sample. *Am J Manag Care* 1998;4(8):1127-34.
163. Rentz AM, Halpern MT, Bowden R. The impact of candidemia on length of hospital stay, outcome, and overall cost of illness. *Clin Infect Dis* 1998;27(4):781-8.
164. Ritchie JL, Maynard C, Chapko MK, et al. Association between percutaneous transluminal coronary angioplasty volumes and outcomes in the Healthcare Cost and Utilization Project 1993-1994. *Am J Cardiol* 1999;83(4):493-7.
165. Best AE. Secondary data bases and their use in outcomes research: a review of the area resource file and the Healthcare Cost and Utilization Project. *J Med Syst* 1999;23(3):175-81.
166. Krumholz HM, Chen YT, Bradford WD, et al. Variations in and correlates of length of stay in academic hospitals among patients with heart failure resulting from systolic dysfunction. *Am J Manag Care* 1999;5(6):715-23.
167. Seifeldin R, Hantsch JJ. The economic burden associated with colon cancer in the United States. *Clin Ther* 1999;21(8):1370-9.
168. Williams GR, Jiang JG, Matchar DB, et al. Incidence and occurrence of total (first-ever and recurrent) stroke. *Stroke* 1999;30(12):2523-8.
169. Kirsner RS, Yang DG, Kerdel FA. Dermatologic disease accounts for a large number of hospital admissions annually. *J Am Acad Dermatol* 1999;41(6):970-3.
170. MEDLINE [database online]. Bethesda (MD), National Library of Medicine. 1985-Updated weekly. Available from: National Library of Medicine; BRS Information Technologies, McLean, VA; DIALOG information Services, Inc., Palo Alto, CA.
171. PsycINFO. Washington (DC), American Psychological Association. 1887-Updated monthly (journals), 1987-current (books and chapters). Available from: American Psychological Association, Washington DC; Ovid Technologies, New York, NY; Silverplatter Information, Norwood, MA.

172. The Cochrane Library. Oxford, England, Update Software, Ltd. Available from: Update Software, San Diego, CA.
173. EMBASE. The Netherlands, Elsevier Science Publishers B.V.1974-Updated weekly. Available from: Elsevier Science, Secondary Publishing Division, New York, NY.
174. Ingber MJ. The current state of risk adjustment technology for capitation. *J Ambulatory Care Manage* 1998;21(4):1-28.
175. Rosenbaum P, Rubin D. Reducing bias in observational studies using subclassification on the propensity score. *J Am Stat Assoc* 1894;79:516-24.
176. Glazer J, McGuire T. Minimum variance optimal risk adjustment. *American Economic Review* 1999; In Press.
177. Chamberlain G. Panel Data. In: Griliches Z, Intriligator M, editors. *Handbook of Economics*. New York: Elsevier Science; 1984. p. 1247-1318.
178. Green. *Economic Analysis*. 2nd ed. New Jersey: Prentice Hall; 1997.
179. McClellan M, Staiger D. The quality of health care providers. *National Bureau of Economic Research Working Paper #7327*.