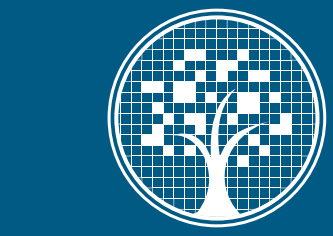

HEALTHCARE COST AND UTILIZATION PROJECT

HCUP Methods Series

Methods Applying AHRQ Quality Indicators to Healthcare Cost Utilization Project (HCUP) Data for the National Healthcare Quality Report

Report # 2003-05

Agency for Healthcare Research and Quality

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Agency for Healthcare Research and Quality

Contact Information:

Healthcare Cost and Utilization Project (HCUP)
Agency for Healthcare Research and Quality
540 Gaither Road
Rockville, MD 20850
http://www.hcup-us.ahrq.gov

For Technical Assistance with HCUP Products:

Email: hcup@ahrq.gov

or

Phone: 1-866-290-HCUP

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By Rosanna Coffey, Ph.D., Marguerite Barrett, M.S., Bob Houchens, Ph.D.,
Ed Kelley, Ph.D., Roxanne Andrews, Ph.D., Ernest Moy, M.D., M.P.H.,
Beth Kosiak, Ph.D., Denise Remus, Ph.D., R.N.

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Introduction

The Agency for Healthcare Research and Quality (AHRQ) Quality Indicators (QIs) were applied to the HCUP hospital discharge data for several measures in this report. The AHRQ QIs, originally developed by AHRQ staff (and termed the HCUP QIs), recently have been revised and improved by the University of California San Francisco and Stanford (UCSF-Stanford) under contract with AHRQ. The QIs are measures of quality associated with processes of care that occurred in an outpatient or an inpatient setting. The QIs rely solely on hospital inpatient administrative data and, for this reason, are screens for examining quality that may indicate the need for more in-depth studies. The AHRQ QIs include three sets of measures:

- Prevention Quality Indicators (PQIs)—or ambulatory care sensitive conditions—identify hospital admissions that evidence suggests could have been avoided, at least in part, through high-quality outpatient care (AHRQ, 2001; Davies et al., 2001).

- Inpatient Quality Indicators (IQIs) reflect quality of care inside hospitals and include measures of utilization of procedures for which there are questions of overuse, underuse, or misuse (AHRQ, 2002; Davies et al., 2001).

- Patient Safety Indicators (PSIs) reflect quality of care inside hospitals, by focusing on surgical complications and other iatrogenic events (AHRQ, 2003; McDonald et al., 2002).

The QI measures selected for this report are described in Table 1 at the end of this methods section.

The Healthcare Cost and Utilization Project (HCUP) is a family of healthcare databases and related software tools and products developed through a Federal-State-Industry partnership and sponsored by AHRQ. HCUP databases bring together the data collection efforts of State data organizations, hospital associations, private data organizations, and the Federal government to create a national information resource of discharge-level health care data. HCUP includes the largest collection of longitudinal hospital care data in the United States, with all-payer, encounter-level information beginning in 1988. These databases enable research on a broad range of health policy issues, including cost and quality of health services, medical practice patterns, access to health care programs, and outcomes of treatments at the national, State and local market levels.

Two HCUP discharge datasets were used in this report:

- The HCUP Nationwide Inpatient Sample (NIS), a nationally stratified *sample* of hospitals (with all of their discharges) from States that contribute data to the NIS dataset (28 States in the 2000 NIS).

- The HCUP Statewide Inpatient Databases (SID), a *census* of hospitals (with all of their discharges) from 29 participating States.

For the most recent year, the NIS contains roughly 7 million discharges from about 1000 hospitals and the SID contains almost 28 million discharges or nearly 80 percent of the 36 million discharges in the United States. Data from 1994, 1997, and 2000 were used in this report. Limited reporting was done at the state-specific level. For the list of the HCUP data sources, see Table 2 at the end of this methods section.

To apply the AHRQ Quality Indicators to HCUP hospital discharge data, several steps were taken: 1) QI software review and modification, 2) acquisition of population-based data, 3) preparation of HCUP data, and 4) identification of statistical methods. These steps, described briefly below, are presented in detail in the Technical Specifications for HCUP Measures in the National Healthcare Quality Report and the National Healthcare Disparities Report (Barrett, Houchens, Coffey, et al., 2003), available from AHRQ on request.

1. ***QI Software Review and Modification*.** For this report, we started with the following QI software versions: PQI Version 2.1, IQI Version 2.1, and PSI (beta test version, July 2002). Because each of these software modules was developed for State and hospital-level rates, rather than national rates, some changes to the QI calculations were necessary. (For details, see Barrett, et al., 2003). Also, because this was the inaugural use and included a longitudinal application of the QIs, we reviewed the ICD-9-CM coding of the QIs over the period 1994 through 2000 and made some minor modifications in consultation with the developers (UCSF-Stanford). Subsequently, USCF-Stanford is considering modifications to the QIs for future revisions of the software. QIs that may be affected by some of these revisions are identified in footnotes to the QI-related tables of the report. We also added one indicator particularly relevant to the structure of the NHQR: immunization-preventable influenza.

2. ***Acquisition of Population-Based Data*.** Generally, a QI as a measure of an event that occurs in a hospital requires a numerator count of the event of interest and a denominator count of the population (within the hospital or within the geographic area) to which the event relates. These denominator counts had to be located for all reporting categories and for all adjustment categories listed in the HCUP-based tables. Age-gender adjustments were made by 18 five-year increments of age by male-female gender. Thus, to develop State and national QI rates, we needed State- and national-level data for the QI denominators by each reporting category by the 36 classes for age-gender adjustments. The HCUP data were used for State- and national-level discharge denominator counts for QIs that related to providers. Two other sources were used for State- and national-level denominator counts for QIs that related to geographic areas. We obtained State and national population counts by age and gender from Census data. We obtained population ZIP-Code-level counts by age and gender from Claritas, which uses intra-census methods to estimate ZIP-Code-level statistics (Claritas, Inc., 2001) because the Census 2000 data by ZIP Code were not yet available. ZIP-Code-level

counts were necessary for statistics by median income and location of the patient's ZIP Code.

3. ***Preparation of HCUP Data.*** Several HCUP data issues had to be resolved before applying the QI algorithms. First, we selected community[1] hospitals only and eliminated rehabilitation hospitals in the 2000 SID. Rehabilitation hospitals were excluded from the NIS starting in 1998 because the completeness of reporting for rehabilitation hospitals was inconsistent across States. Rehabilitation hospitals could not be excluded from the 1994 and 1997 nationwide databases because the sample weights assumed the presence of these hospitals. (See "Caveats," below). Second, because some statewide data organizations do not report data for all community hospitals in the State, we weighted hospitals in the SID to the State's universe of hospitals in the American Hospital Association Annual Survey of Hospitals based on hospital characteristics. Third, discharges from hospitals operating for all quarters of the year but not contributing data for all quarters of a year were weighted up to annual estimates for that institution. Fourth, for missing age, gender, ZIP Code, and payer data that occurred on a small proportion of discharge records, we used a "hot deck" imputation method (which draws donors from strata of similar hospitals and patients) to assign values while preserving the variance within the data. Fifth, we assigned median household income and patient location based on ZIP Code data obtained from Claritas linked to patient ZIP Code in the HCUP databases. Sixth, we assessed the problem of non-resident discharges from individuals who primarily cross State lines for hospital services, but did not adjust for this problem because of the infeasibility of addressing the issue consistently across the States.

4. ***Statistical Methods.*** Statistical issues involved age-gender adjustment for all QIs, and severity/comorbidity adjustment for the discharge-based PSIs, and derivation of standard errors and appropriate hypothesis tests. For all but the discharge-based PSIs, age-gender adjustments were made for age and gender differences across population subgroups and were based on methods of direct standardization (Fleiss, 1973). For the discharge-based PSIs, adjustments were made for age, gender, age-gender interaction, DRG cluster, and comorbidity, using a regression-based standardization developed by UCSF-Stanford. Statistics for calculations of standard errors and hypothesis tests were based on HCUP data; there is no sampling error associated with Census population counts. HCUP standard errors were based on the HCUP report entitled "Calculating Nationwide Inpatient Sample (NIS) Variances" (HCUP, 2002). The appropriate statistics were obtained through the Statistical Analysis System (SAS) procedure called PROC SURVEYMEANS so that the HCUP-NIS sampling effects were taken into account. The threshold selected for reporting estimates in this report is at least 70 unweighted cases in the denominator. A sample of at least 70 discharges was required to assure a relative error routinely used in Federal sample surveys of less than 30 percent. Statistical calculations are explained in Appendix A to this report and in Barrett, Houchens, and Coffey et al. (2003).

[1] *Community* hospitals are defined by the AHA as "non-Federal, short-term, general, and other specialty hospitals, excluding hospital units of institutions." Specialty hospitals included among community hospitals are obstetrics-gynecology, ear-nose-throat, short-term rehabilitation, orthopedic, and pediatric institutions. Also included are public hospitals and academic medical centers. Excluded are short-term rehabilitation hospitals (beginning with 1998 HCUP data), long-term hospitals, psychiatric hospitals, and alcoholism/chemical dependency treatment facilities.

Caveats

Some caution should be used in interpreting the AHRQ QI statistics presented in this report. Some caveats relate to the how the QIs were applied, some relate to ICD-9-CM coding changes and inter-State differences in data collection, and others are more general issues:

***Rehabilitation Hospitals*:** These hospitals are excluded from the 2000 NIS but included in the 1994 and 1997 NIS because of the change in the sampling strategy for the 2000 NIS. Patients treated in rehabilitation hospitals tend to have lower mortality rates and longer lengths of stay than patients in other community hospitals, and the completeness of reporting for rehabilitation hospitals is very uneven across the States. The elimination of rehabilitation hospitals in 2000 may affect trends in the QIs but the effect is likely small since only 3 percent of community hospitals are involved.

***ICD-9-CM Coding Changes*:** A number of Quality Indicators are based on diagnoses and procedures for which ICD-9-CM coding has generally become more specific over the period of this study. Essentially all of the changes occur between the years 1994 and 1997. Thus, some 1994 estimates may not be comparable to the later estimates. These inconsistencies are noted for 3 of 17 PQIs and 10 of 24 PSIs in the footnotes of the tables with information on the direction of the bias when it can be determined.

***Data Collection Differences among States*:** Organizations that collect statewide data generally collect data using the Uniform Hospital Discharge Data Set (UHDDS) and the Uniform Bill (UB-92) formats. However, not every statewide data organization collects all data elements nor codes them the same way. For this report, uneven availability of a few data elements underlie some estimates, as noted next.

Data Elements Needed in Some QIs: Three data elements not available in every State that are required for certain QIs are: “secondary procedure day,” admission type” (elective, urgent, and emergency), and “admission source” (e.g., transfer from another institution, emergency room, etc). These data elements are used to exclude specific cases from some QI measures. These problems were overcome by 1) dropping “secondary procedure day” from two QIs for all States and 2) using additional data elements to work around the “admission type” problem in two States. For “admission source” for one State, admission source could not be identified, but at most only 7 percent of discharges in that State (and less than 0.1% of discharges for the NIS) were involved for any QI. All of the inconsistencies are noted in the footnotes of the tables with information on the direction of the bias when it can be determined.

Number of Clinical Fields: Another data collection issue relates to the number of fields that statewide data organizations permit for reporting patients’ diagnoses and procedures during the hospitalization and whether they specifically require coding of external-cause of injury (E-codes). States can provide as few as 6 or as many as 30 fields for reporting diagnoses and procedures, as shown in Table 3 at the end of this methods section. The more fields used the more quality-related events that can be captured in the statewide databases. However, even for States with 30 diagnosis fields available in the year 2000, 95 percent of their discharge records captured all of patients’ diagnoses in 10 to 13 data elements. For States with 30 procedure fields available, 95 percent of records captured all of patients’ procedures in 5 fields. Thus, limited numbers of fields available for reporting diagnoses and procedures are unlikely to have much effect on results, because all statewide data

organizations participating in HCUP allow at least 9 diagnoses and 6 procedures. We decided not to truncate artificially the diagnosis and procedure fields reported, so that the full richness of the databases would be used. Another issue relates to external cause of injury reporting. Many of the Patient Safety Indicators require external cause of injury (E-code) data to identify complications of care. The PSIs and other QIs also use E-codes to exclude cases (e.g., poisonings, self-inflicted injury, trauma) from numerators and denominators. The proportion of records with at least one PSI-related E-code across the States is as low 4.6 percent and as high as 15.3 percent, as shown in Table 3 at the end of this methods section. Uneven capture of these data may affect the PSI rates and should be kept in mind when comparing regions.

***Effects of Adding New States to the NIS over Time*:** Over time HCUP has expanded with the participation of additional statewide data organizations. Because each yearly NIS is a sample of hospitals from the States participating in that year (and weighted to the universe of community hospitals nationally), potential exists for different practice patterns across States to influence national measures over time related to clinical practice. The table below lists the States that were added to HCUP between the years used in this report.

Period	States Added
1994 – 1997	GA, HI, MO, TN, UT
1997 – 2000	KY, ME, NC, TX, VA, WV

We calculated QI rates using two methods to test this hypothesis, first with data from the full set of States in HCUP in 2000 and second with data from the set of States in HCUP in all three years, where that subset of States was re-weighted to obtain national estimates. For most QIs, the results differed very little. For QIs where the 2000 results were affected by the States included, we have noted the problem in a footnote to Table A, the QI time trends.

Variation among State QI Rates. Variation in State rates can be caused by many factors, including differences in practice patterns, underlying disease prevalence, health behaviors, access to health insurance, income levels of the population, demographics, spending on health services, supply of health care resources, coding conventions, and so on. To understand some of the variation in State rates, we analyzed the State rates in relation to these types of factors. Appendix B shows for each Prevention Quality Indicator included in the NHQR, the analyses performed and the result in terms of whether the factors were positively, negatively, or not significantly related to the QIs. This is intended to help readers understand some of the external factors that may be driving some of the State differences in PQI rates.

Table 1. **AHRQ Quality Indicators to be included in the National Healthcare Quality Report (in order by planned NHQR framework)**

AHRQ QI No.	Type of QI, Topic in NHQR, and Description of Measure
	Prevention Quality Indicators (PQIs)
	Management of diabetes:
PQI 14	Adult admissions for uncontrolled diabetes without complication† (excluding obstetric and neonatal admissions and transfers from other institutions) per 100,000 population age 18 years and older (PQI 14) † Without short-term (ketoacidosis, hyperosmolarity, coma) or long-term (renal, eye, neurological, circulatory, other unspecified) complications.
PQI 1	Adult admissions for diabetes with short-term complications† (excluding obstetric admissions and transfers from other institutions) per 100,000 population age 18 years and older (PQI 1) † Ketoacidosis, hyperosmolarity, or coma.
PQI 3	Adult admissions for diabetes with long-term complications† (excluding obstetric admissions and transfers from other institutions) per 100,000 population age 18 years and older (PQI 3) † Renal, eye, neurological, circulatory, or other unspecified complications.
PQI 16	Lower extremity amputations for adults with diabetes (excluding trauma, obstetric admissions, and transfers from other institutions) per 100,000 population age 18 years and older (PQI 16)
	Management of CHF:
PQI 8	Adult admissions for congestive heart failure (excluding patients with cardiac procedures, obstetric and neonatal conditions, and transfers from other institutions) per 100,000 population age 18 years and older (PQI 8)
	Treatment of pediatric gastroenteritis:
PQI 6	Pediatric gastroenteritis admissions (excluding obstetric and neonatal admissions and transfers from other institutions) per 100,000 population age less than 18 years (PQI 6)
	Immunization, influenza:
PQI 18	Immunization-preventable influenza admissions for elderly (excluding transfers from other institutions) per 100,000 patients age 65 years and older (added PQI 18)
	Management of asthma:
PQI 4	Pediatric asthma admissions (excluding obstetric and neonatal admissions and transfers from other institutions) per 100,000 population age less than 18 years (PQI 4)
PQI 15	Adult asthma admissions (excluding obstetric admissions and transfers from other institutions) per 100,000 population age 18 years and older (PQI 15)
	Patient Safety Indicators (PSIs)
	Surgical Complications:
PSI 1	Complications of anesthesia per 1000 surgical discharges (excluding patients with such complications who also have substance use disorders) (PSI 1)
PSI 5	Foreign body left in during procedure per 1000 medical and surgical discharges (excluding neonates; based on secondary diagnoses only) (PSI 5) (Note: Excludes admissions specifically for treatment of foreign body left, such as cases from earlier admissions or from other hospitals)

AHRQ QI No.	Type of QI, Topic in NHQR, and Description of Measure
PSI 21	Foreign body left in during procedure in hospital (excluding neonatal procedures; based on principal and secondary diagnoses) per 100,000 population (PSI 21) (Note: Also, includes admissions specifically for treatment of foreign body left, such as cases from earlier admissions or from other hospitals)
PSI 8	Postoperative hip fracture for adults per 1000 surgical patients age 18 years and older who were not susceptible to falling† (PSI 8) † That is, excluding patients with musculoskeletal disease; those admitted for seizures, syncope, stroke, coma, cardiac arrest, poisoning, trauma, delirium, psychoses, anoxic brain injury; patients with metastatic cancer, lymphoid malignancy, bone malignancy, and self-inflicted injury.
PSI 10	Postoperative physiologic and metabolic derangements per 1000 elective-surgery patients (excluding some serious disease† and obstetric and neonatal admissions) (PSI 10) † That is, excluding patients with diabetic coma and patients with renal failure who also were diagnosed with AMI, cardiac arrhythmia, cardiac arrest, shock, hemorrhage, or gastrointestinal hemorrhage.
PSI 11	Postoperative respiratory failure per 1000 elective-surgery discharges (excluding patients with respiratory disease, circulatory disease, and obstetric or neonatal conditions) (PSI 11)
PSI 13	Postoperative septicemia per 1000 elective-surgery discharges of longer than 3 days (excluding patients admitted for infection; patients with cancer or immunocompromised states, and obstetric and neonatal conditions) (PSI 13)
PSI 14	Postoperative abdominal wound dehiscence per 1000 abdominopelvic-surgery discharges (excluding obstetric and neonatal conditions; based on secondary diagnoses only) (PSI 14) (Note: Excludes admissions specifically for such wound dehiscence, such as cases from earlier admissions or from other hospitals)
PSI 24	Postoperative abdominal wound dehiscence in hospital (excluding obstetric and neonatal conditions; based on principal and secondary diagnoses) per 100,000 population (PSI 24) (Note: Also, includes admissions specifically for treatment of such wound dehiscence, such as cases from earlier admissions or from other hospitals)
	Obstetric Safety Indicators:
PSI 17	Birth trauma injury per 1000 live births (excluding preterm and osteogenesis imperfecta births) (PSI 17)
PSI 18	Obstetric trauma per 1000 instrument-assisted vaginal deliveries (PSI 18)
PSI 19	Obstetric trauma per 1000 vaginal deliveries without instrument assistance (PSI 19)
PSI 20	Obstetric trauma per 1000 Cesarean deliveries (PSI 20)
PQI 9	Low-weight births per 1000 neonates (excluding transfers from other institutions) (PQI 9) -- for reference to obstetric trauma

AHRQ QI No.	Type of QI, Topic in NHQR, and Description of Measure
	Other Hospital-Care Safety Indicators:
PSI 15	Accidental puncture or laceration during procedures per 1000 discharges (excluding obstetric and neonatal admissions; based on secondary diagnoses only) (PSI 15) (Note: Excludes admissions specifically for such problems, such as cases from earlier admissions or from other hospitals)
PSI 25	Accidental puncture or laceration during procedures in hospital (excluding obstetric and neonatal admissions; based on principal and secondary diagnoses) per 100,000 population (PSI 25) (Note: Also, includes admissions specifically for such problems, such as cases from earlier admissions or from other hospitals)
PSI 2	Deaths per 1000 admissions in low mortality DRGs (DRGs with a NIS 1997 benchmark of less than 0.5% mortality, excluding trauma, immuno-compromised, and cancer patients) (PSI 2)
PSI 3	Decubitus ulcers per 1000 discharges of length 4 or more days (excluding paralysis patients and patients admitted from long-term-care facilities and neonates) (PSI 3)
PSI 4	Failure to rescue (death) per 1000 discharges with complications potentially resulting from care (excluding transferred patients and those admitted from long-term-care facilities) (PSI 4)
PSI 6	Iatrogenic pneumothorax per 1000 discharges (excluding patients with trauma, thoracic surgery, lung or pleural biopsy, or cardiac surgery and neonates; based on secondary diagnoses only) (PSI 6) (Includes barotrauma (including acute respiratory distress syndrome) and central line placement. Excludes admissions specifically for iatrogenic pneumothorax, such as cases from earlier admissions or from other hospitals)
PSI 22	Iatrogenic pneumothorax discharges (excluding patients with trauma, thoracic surgery, lung or pleural biopsy, or cardiac surgery and neonates; based on principal and secondary diagnoses) per 100,000 population (PSI 22) (Includes barotraumas (including acute respiratory distress syndrome) and central line placement. Also, includes admissions specifically for iatrogenic pneumothorax, such as cases from earlier admissions or from other hospitals)
PSI 7	Infection due to intravenous lines or catheters per 1000 discharges (excluding immunocompromised or cancer patients and neonates; based on secondary diagnoses only) (PSI 7) (Note: Excludes admissions specifically for such infections, such as cases from earlier admissions, from other hospitals, or from other settings)
PSI 23	Infection due to intravenous lines or catheters (excluding immunocompromised or cancer patients and neonates; based on principal and secondary diagnoses) per 100,000 population (PSI 23) (Note: Also, includes admissions specifically for such infections, such as cases from earlier admissions, from other hospitals, or from other settings)

AHRQ QI No.	Type of QI, Topic in NHQR, and Description of Measure
PSI 9	Postoperative hemorrhage or hematoma with surgical drainage or evacuation (excluding obstetric discharges; based on secondary diagnoses only) per 1000 surgical discharges (PSI 9) (Note: Excludes admissions specifically for such problems, such as cases from earlier admissions, from other hospitals, or from other settings)
PSI 12	Postoperative pulmonary embolus or deep vein thrombosis (DVT) (excluding obstetric conditions; based on secondary diagnoses of DVT only) per 1000 surgical discharges (PSI 12) (Note: Excludes admissions specifically for such thromboemboli, such as cases from earlier admissions, from other hospitals, or from other settings)
PSI 16	Transfusion reactions per 1000 discharges (excluding neonates; based on secondary diagnoses only) (PSI 16) (Note: Excludes admissions specifically for transfusion reactions, such as cases from earlier admissions or from other hospitals)
PSI 26	Transfusion reactions in hospital (excluding neonates; based on principal and secondary diagnoses) per 100,000 population (PSI 26) (Note: Also, includes admissions specifically for transfusion reactions, such as cases from earlier admissions or from other hospitals)

Table 2. Sources of HCUP Data

State	Data Source
Arizona	Arizona Department of Health Services
California	Office of Statewide Health Planning & Development
Colorado	Colorado Health & Hospital Association
Connecticut	CHIME, Inc.
Florida	Florida Agency for Health Care Administration
Georgia	GHA: An Association of Hospitals & Health Systems
Hawaii	Hawaii Health Information Corporation
Illinois	Illinois Health Care Cost Containment Council
Iowa	Iowa Hospital Association
Kansas	Kansas Hospital Association
Kentucky	Kentucky Department for Public Health
Maine	Maine Health Data Organization
Maryland	Health Services Cost Review Commission
Massachusetts	Division of Health Care Finance and Policy
Michigan	Michigan Health & Hospital Association
Missouri	Hospital Industry Data Institute
New Jersey	New Jersey Department of Health & Senior Services
New York	New York State Department of Health
North Carolina	North Carolina Department of Health and Human Services
Oregon	Oregon Association of Hospitals & Health Systems
Pennsylvania	Pennsylvania Health Care Cost Containment Council
South Carolina	South Carolina State Budget & Control Board
Tennessee	Tennessee Hospital Association
Texas	Texas Health Care Information Council
Utah	Utah Department of Health
Virginia	Virginia Health Information
Washington	Washington State Department of Health
Wisconsin	Wisconsin Dept of Health & Family Services
West Virginia	West Virginia Health Care Authority

Table 3. Number of diagnosis and procedure fields and the percent of discharges that include PSI-related cause of injury codes (E-codes) by State

State	Maximum number of diagnoses	Maximum number of procedures	Percent of HCUP discharges with PSI-related E-codes
AZ	11	6	12.4
CA †	30	21	9.8
CO *	15	15	13.7
CT	30	30	11.9
FL	10	10	8.2
GA	10	6	11.4
HI *	11	10	8.0
IA *	11	6	9.1
IL *	9	6	5.4
KS *	30	25	8.2
KY	10	6	7.6
MA	16	15	11.5
MD	16	15	14.1
ME *	10	6	12.9
MI *	30	30	10.5
MO	30	25	15.3
NC *	15	10	12.5
NJ	10	8	8.4
NY	17	15	12.2
OR *	11	6	10.2
PA	10	6	13.3
SC †, ††	10	10	4.6
TN	10	6	11.1
TX *	10	6	8.1
UT	10	6	10.1
VA	10	6	10.5
WA †	10	6	11.2
WI	10	6	13.7
WV *	10	6	6.1

* These are states that do not have laws or mandates for the collection of external cause of injury coding (E-codes) in statewide hospital discharge systems. State health departments or other regulating bodies (for example, state hospital associations) may have the authority to monitor compliance of reporting E-codes through the electronic transfer to a centralized database. (Trauma Foundation/ San Francisco Injury Center, 1998).

† CA, WA, and SC percent of E-codes may be artificially low because these data sources do not require hospitals to report E-codes in the range 870-879 (“misadventures to patients during surgical and medical care”).

†† SC percent of E-codes may be artificially low because separate E-codes fields available in South Carolina source data were not obtained for HCUP; however, E-codes are present in other diagnosis fields in SC.

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Appendix A : Statistical Methods

This appendix explains the statistical methods and gives formulas for the calculations of standard errors and hypothesis tests. These statistics are derived from multiple databases: the NIS, the SID, and the U.S. census. For NIS estimates, the standard errors are calculated as described in the HCUP report entitled "Calculating Nationwide Inpatient Sample (NIS) Variances." We will refer to this report simply as the NIS Variance Report throughout this appendix. This method takes into account the cluster and stratification aspects of the NIS sample design when calculating these statistics using the SAS procedure PROC SURVEYMEANS. For the SID we used the same procedure omitting the cluster and stratification features. For population counts based on the US census, there is no sampling error.

Even though the NIS contains discharges from a finite sample of hospitals and most of the SID databases contain nearly all discharges from nearly all hospitals in the state, we treat the samples as though they were drawn from an infinite population. We do not employ finite population correction factors in estimating standard errors. We take this approach because we view the outcomes as a result of myriad processes that go into treatment decisions rather than being the result of specific, fixed processes generating outcomes for a specific population and a specific year. We consider the NIS and SID to be samples from a "super-population" for purposes of variance estimation. Further, we assume the counts (of QI events) to be binomial.

1. Area Population QIs using Census and Claritas Population Data

a. Standard error estimates for discharge rates per 100,000 population using the 2000 Census.

The observed rate was calculated as follows:

$$R = 100{,}000 \cdot \frac{\sum_{i=1}^{n} w_i x_i}{N} = 100{,}000 \cdot \frac{S}{N}. \qquad \text{(A.1)}$$

w_i and x_i, respectively, are the weight and variable of interest for patient i in the NIS or SID. To obtain the estimate of *S* and its standard error, SE_S, we followed instructions in the NIS Variance Report (modified for the SID, as explained above)

The population count in the denominator is a constant. Consequently, the standard error of the rate *R* was calculated as:

$$SE_R = 100{,}000 \; SE_S / N. \qquad \text{(A.2)}$$

b. Standard error estimates for age/sex adjusted inpatient rates per 100,000 population using the 2000 census.

We adjusted rates for age and sex using the method of direct standardization (Fleiss, 1973). We estimated the observed rates for each of 36 age/sex categories. We then calculated the weighted average of those 36 rates using weights proportional to the

percentage of a standard population in each cell. Therefore, the adjusted rate represents the rate that would be expected for the observed study population if it had the same age and sex distribution as the standard population.

For the standard population we used the age and sex distribution of the U.S. as a whole according to the year 2000 U.S. census. In theory, differences among adjusted rates were not attributable to differences in the age and sex distributions among the comparison groups because the rates were all calculated with a common age and sex distribution.

The adjusted rate was calculated as follows (and subsequently multiplied by 100,000):

$$\mathrm{A} = \frac{\sum_{g=1}^{36} N_{g,std} \sum_{i=1}^{n(g)} \frac{w_{g,i} x_{g,i}}{N_{g,obs}}}{\sum_{g=1}^{36} N_{g,std}} = \frac{\sum_{g=1}^{36} \sum_{i=1}^{n(g)} \frac{N_{g,std}}{N_{g,obs}} w_{g,i} x_{g,i}}{N_{std}} = \frac{\sum_{g=1}^{36} \sum_{i=1}^{n(g)} w^{*}_{g,i} x_{g,i}}{N_{std}} = \frac{S^{*}}{N_{std}}. \quad \text{(A.3)}$$

g = index for the 36 age/sex cells.
$N_{g,std}$ = Standard population for cell g (year 2000 total US population in cell g).
$N_{g,obs}$ = Observed population for cell g (year 2000 subpopulation in cell g, e.g., Medicare insureds, state of California, etc.).
$n(g)$ = Number in the sample for cell g.
$x_{g,i}$ = Observed quality indicator for observation i in cell g (e.g., 0 or 1 indicator).
$w_{g,i}$ = NIS or SID discharge weight for observation i in cell g.

The estimates for the numerator, S^*, and its standard error, SE_{S^*}, were calculated in similar fashion to the unadjusted estimates for the numerator S in formula A.1. The only difference was that the weight for patient i in cell g was redefined as:

$$w^{*}_{g,i} = \frac{N_{g,std}}{N_{g,obs}} \cdot w_{g,i} \quad \text{(A.4)}$$

Following instructions in the NIS Variance Report (modified for the SID, as explained above), we used PROC SURVEYMEANS to obtain the estimate of S^*, the weighted sum in the numerator using the revised weights, and the estimate SE_{S^*}, the standard error of the weighted sum S^*. The denominator is a constant. Therefore, the standard error of the adjusted rate, A, was calculated as

$$SE_A = 100{,}000 \; SE_{S^*} / N_{std}. \quad \text{(A.5)}$$

2. Provider-based QIs using Weighted Discharge Data (SID and NIS)

a. Standard error estimates for inpatient rates per 1,000 discharges using discharge counts in both the numerator and the denominator.

We calculated the observed rate as follows:

$$R = 1{,}000 \cdot \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i} = 1{,}000 \cdot \frac{S}{N}. \qquad \text{(A.6)}$$

Following instructions in the HCUP NIS Variance Report (modified for the SID, as explained above), we used PROC SURVEYMEANS to obtain estimates of the weighted mean, *S/N*, and the standard error of the weighted mean, $SE_{S/N}$. We multiplied this standard error by 1,000.

b. Standard error estimates for age/sex adjusted inpatient rates per 1,000 discharges using inpatient counts in both the numerator and the denominator.

We used the full NIS sample estimates for the standard inpatient population age-sex distribution. For each of the 36 age-sex categories, we estimated the number of U.S. inpatient discharges, $\hat{N}_{g,std}$, in category g. We calculated the directly adjusted rate:

$$\mathrm{A} = 1{,}000 \cdot \frac{\sum_{g=1}^{36} \hat{N}_{g,std} \frac{\sum_{i=1}^{n(g)} w_{g,i} x_{g,i}}{\sum_{i=1}^{n(g)} w_{g,i}}}{\sum_{g=1}^{36} \hat{N}_{g,std}} = 1{,}000 \cdot \sum_{g=1}^{36} \hat{P}_{g,std} \frac{\sum_{i=1}^{n(g)} w_{g,i} x_{g,i}}{\sum_{i=1}^{n(g)} w_{g,i}}. \qquad \text{(A.7)}$$

g = index for the 36 age/sex cells.
$\hat{N}_{g,std}$ = Standard inpatient population for cell g (NIS estimate of the total inpatient population for cell g).
n(g) = Number in the sample for cell g.
$x_{g,i}$ = Observed quality indicator for observation i in cell g.
$w_{g,i}$ = NIS or SID discharge weight for observation i in cell g.

Note that $\hat{P}_{g,std} = \frac{\hat{N}_{g,std}}{\sum_{g=1}^{36} \hat{N}_{g,std}}$ is the proportion of the standard inpatient population in cell g.

Consequently, the adjusted rate is a weighted average of the cell-specific rates with cell

weights equal to $\hat{P}_{g,std}$. These cell weights are merely a convenient, reasonable standard inpatient population distribution for the direct standardization. Therefore, we treat these cell weights as constants in the variance calculations:

$$SE(A) = \sqrt{Var(A)} = 1{,}000 \cdot \sqrt{Var\left(\sum_{g=1}^{36} \hat{P}_{g,std} \frac{\sum_{i=1}^{n(g)} w_{g,i} x_{g,i}}{\sum_{i=1}^{n(g)} w_{g,i}} \right)} = 1{,}000 \cdot \sqrt{\sum_{g=1}^{36} \hat{P}_{g,std}^2 \cdot Var\left(\frac{\sum_{i=1}^{n(g)} w_{g,i} x_{g,i}}{\sum_{i=1}^{n(g)} w_{g,i}} \right)}. \quad \text{(A.8)}$$

The variance of the ratio enclosed in parentheses was estimated separately for each cell g by squaring the SE calculated using the method of section 2.a:

$$SE(A) = 1{,}000 \cdot \sqrt{\sum_{g=1}^{36} \hat{P}_{g,std}^2 \cdot \left\{ SE(R_g) \right\}^2}$$

$$R_g = \frac{\sum_{i=1}^{n(g)} w_{g,i} x_{g,i}}{\sum_{i=1}^{n(g)} w_{g,i}} \quad \text{(A.9)}$$

Following instructions in the HCUP NIS Variance Report (modified for the SID, as explained above), we used PROC SURVEYMEANS to obtain estimates of the weighted means, R_g, and their standard errors.

3. Significance tests.

Let R_1 and R_2 be either observed or adjusted rates calculated for comparison groups 1 and 2, respectively. Let SE_1 and SE_2 be the corresponding standard errors for the two rates. We calculated the test statistic and (two-sided) p-value:

$$t = \frac{R_1 - R_2}{\sqrt{SE_1^2 + SE_2^2}} \quad \text{(A.10)}$$

$$p = 2 * \text{Prob}(Z > |t|)$$

where Z is a standard normal variate.

Note: the following functions calculate p in SAS and EXCEL:

SAS: p = 2 * (1 - PROBNORM(ABS(t)));

EXCEL: = 2*(1- NORMDIST(ABS(t),0,1,TRUE))

Appendix B: Analysis Summary - State PQI Rates Related to Other Factors

This appendix shows the factors for which State-specific data could be found to compare to the two State-specific Prevention Quality Indicators included in the NHQR. In a separate analysis (only shown below), State-level PQI rates were correlated with the factors indicated below with the results indicated. These were developed for preliminary analysis of the State-level results.

PQI and Factors Tested	Results
PQI 14 - Adult admissions for uncontrolled diabetes without complications	
Uncontrolled Diabetes = f(obesity)	+
Uncontrolled diabetes = f(diabetes prevalence)	+
Uncontrolled Diabetes = f(% pop 65+ years)	ns
Uncontrolled Diabetes = f(% uninsured)	ns
Uncontrolled Diabetes = f(% poverty)	+
Uncontrolled Diabetes = f(hospital beds)	+
PQI 4 - Pediatric asthma admissions	
Pediatric asthma = f(asthma prevalence)	ns
Pediatric asthma = f(emphysema)	ns
Pediatric asthma = f(chronic bronchitis)	ns
Pediatric asthma = f(cigarette use in past month)	+
Pediatric asthma = f(HMO prevalence)	ns
Pediatric asthma = f(% poverty)	+
Pediatric asthma = f(% without telephones)	+
Pediatric asthma = f(% uninsured)	ns
Pediatric asthma = f(hospital bed supply)	+
Pediatric asthma = f(air quality - PM annual mean)	ns
Pediatric asthma = f(air quality - PM 24-hr average)	ns
Pediatric asthma = f(air quality - ozone)	+