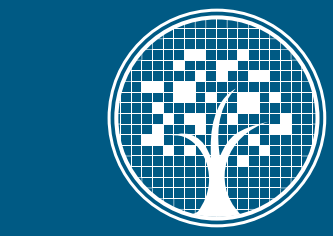

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HCUP Methods Series

Methods Applying AHRQ Quality Indicators to Healthcare Cost and Utilization Project (HCUP) Data for the Second (2004) National Healthcare Quality Report

Report # 2004-07

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Methods Applying AHRQ Quality Indicators to Healthcare Cost and Utilization Project (HCUP) Data for the Second (2004) National Healthcare Quality Report

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May 19, 2005

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, 2004).

- 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, 2004).

- Patient Safety Indicators (PSIs) reflect quality of care inside hospitals, by focusing on surgical complications and other iatrogenic events (AHRQ, 2005).

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 (33 States in the 2001 NIS).

- The HCUP Statewide Inpatient Databases (SID), a *census* of hospitals (with all of their discharges) from 33 participating States.

For the most recent year, the NIS contains roughly 7 million discharges from about 1000 hospitals and the SID contains almost 30 million discharges (more than 80 percent of the 37 million discharges in the United States). Data from 1994, 1997, 2000, and 2001 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) general 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 (revision 2, January 2003), IQI Version 2.1 (revision 2, September 2003), and PSI Version 2.1 (revision 1, May 2003). 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, Houchens, Coffey, et al., 2003). 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. Population ZIP-Code-level counts by age and gender from Claritas (a vendor that compiles and adds value to Bureau of Census data for sale) were used for denominator counts for QIs that related to geographic areas. Claritas uses intra-census methods to estimate ZIP-Code-level statistics (Claritas, Inc., 2001). 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 2001 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.

4. **Statistical Methods.** Statistical issues involved age-gender adjustment for all QIs, and severity/comorbidity adjustment for the discharge-based IQIs and PSIs, and derivation of standard errors and appropriate hypothesis tests. For the PQIs and area-based IQIs and PSIs, age-gender adjustments were made for age and gender differences across population subgroups and were based on methods of direct standardization (Fleiss, 1973). Standard errors calculations for the rates were based on the HCUP report entitled "Calculating Nationwide Inpatient Sample (NIS) Variances" (HCUP, 2002). There is no sampling error associated with Claritas census population counts. The appropriate statistics were obtained through the Statistical Analysis System (SAS) procedure called PROC SURVEYMEANS. 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. For the discharge-based IQIs, adjustments were made for age, gender, age-gender interaction, and 3M™ All Patient Refined Diagnosis Related Groups (APR-DRGs) risk of mortality or severity score using a regression-based standardization developed by UCSF-Stanford. 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 and 2001 NIS but included in the 1994 and 1997 NIS because of the change in the NIS sampling strategy (beginning in the 1998 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 and 2001 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. The two PSIs that use secondary procedure day were modified to not use this information for any State. Admission type of elective and newborn are used in four PSIs. For all but two States (i.e., CA and KS), we imputed the missing admission type using an algorithm developed by UCSF-Stanford. This algorithm used the admission source and DRG to identify emergency, trauma-related, transfer and newborn/delivery admissions as "non-elective" and all other admissions as "elective". In Kansas, admission source was not available for imputing the missing admission type. Using only the DRG aspect of the UCSF-Stanford algorithm, about 500 discharges were assigned an admission type of “elective”. Some of these records might have been assigned to “emergency” or “urgent” if admission source was available. For California, which did not provide any information on admission type, information on scheduled admissions was used to identify elective admissions and DRGs were used to identify newborn admissions. Because the Kansas data did not identify admission source, transfers into the hospital could not be excluded for many of the QIs. 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. Eight of the 26 Patient Safety Indicators use external cause of injury (E code) data to help identify complications of care or to exclude cases (e.g., poisonings, self-inflicted injury, trauma) from numerators and denominators, as shown in Table 4 at the end of this methods section. Although E codes in the AHRQ PSI software have been augmented wherever possible with the related non-E codes in the ICD-9-CM system, see Table 4 for specific details. E codes are still included in some AHRQ PSI definitions, and uneven capture of these data has the potential (although now lessened in the Version 2.1 PSI software compared to the previous PSI software) of affecting some PSI rates and should be kept in mind when judging the level of these events.

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
2000 – 2001	MI, MN, NE, RI, VT

For the 2003 NHQR, 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.

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 (with each tested separately because of the limited number of observations) 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 Selected for the National Healthcare Quality Report

QI No.	Description
	Prevention Quality Indicators
PQI 1	Admissions for diabetes with short-term complications* (excluding obstetric admissions and transfers from other institutions) per 100,000 population, age 18 years and older * Ketoacidosis, hyperosmolarity, or coma.
PQI 3	Admissions for diabetes with long-term complications* (excluding obstetric admissions and transfers from other institutions) per 100,000 population, age 18 years and older * Renal, eye, neurological, circulatory, or other unspecified complications.
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 6	Admissions for pediatric gastroenteritis (excluding obstetric and neonatal admissions and transfers from other institutions) per 100,000 population, age less than 18 years
PQI 8	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 14	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 * Without short-term (ketoacidosis, hyperosmolarity, coma) or long-term (renal, eye, neurological, circulatory, other unspecified) complications.
PQI 15	Adult asthma admissions (excluding obstetric admissions and transfers from other institutions) per 100,000 population, age 18 years and older
PQI 15 (modified)	Asthma admissions (excluding obstetric admissions and transfers from other institutions) per 100,000 population, age 65 years and older
PQI 16	Lower extremity amputations among patients with diabetes (excluding trauma, obstetric admissions, and transfers from other institutions) per 100,000 population, age 18 years and older
(Added)	Immunization-preventable influenza admissions (excluding transfers from other institutions) per 100,000 population, age 65 years and older
	Inpatient Quality Indicators
IQI 8	Deaths per 1000 admissions with esophageal resection for cancer (excluding obstetric and neonatal admissions and transfers to another hospital)
IQI 9	Deaths per 1000 admissions with pancreatic resection for cancer (excluding obstetric and neonatal admissions and transfers to another hospital)
IQI 10	Deaths per 1000 pediatric heart surgery admissions, patients age less than 18 years (excluding obstetric admissions, patients with patent ductus arteriosus (PDA) ligation as a single cardiac procedure, patients with prosthetic closures of septal defects without bypass, patients with only PDA closure with catheterization, and patients with occlusion of thoracic vessel without congenital heart defect, and transfers to another hospital)
IQI 11	Deaths per 1000 admissions with abdominal aortic aneurysm (AAA) repair (excluding obstetric and neonatal admissions and transfers to another hospital)
IQI 12	Deaths per 1000 admissions with coronary artery bypass graft (CABG), age 40 and older (excluding obstetric and neonatal admissions and transfers to another hospital)
IQI 15	Deaths per 1000 admissions with acute myocardial infarction (AMI) as principal diagnosis, age 18 and older (excluding obstetric and neonatal admissions and transfers to another hospital)
IQI 16	Deaths per 1000 admissions with congestive heart failure (CHF) as principal diagnosis, age 18 and older (excluding obstetric and neonatal admissions and transfers to another hospital)
IQI 20	Deaths per 1000 admissions with pneumonia as principal diagnosis, age 18 and older (excluding obstetric and neonatal admissions and transfers to another hospital)
IQI 30	Deaths per 1000 adult admissions age 40 and older with percutaneous transluminal coronary angioplasties (PTCA) (excluding obstetric and neonatal admissions and transfers to another hospital)
	Patient Safety Indicators

QI No.	Description
PSI 1	Complications of anesthesia per 1000 surgical discharges (excluding patients with such complications who also have substance use disorders)
PSI 2	Deaths per 1000 admissions in low mortality DRGs (DRGs with a NIS 1997 benchmark of less than 0.5% mortality, excluding trauma, immunocompromised, and cancer patients)
PSI 3	Decubitus ulcers per 1000 discharges of length 5 or more days (excluding paralysis patients, patients admitted from long-term-care facilities, patients with skin, subcutaneous tissue and breast diseases, neonates, and obstetrical admissions)
PSI 4	Failure to rescue or deaths per 1000 discharges having developed specified complications of care during hospitalization (excluding patients transferred in or out, patients admitted from long-term-care facilities, neonates, and patients over 74 years old)
PSI 5	Foreign body accidentally left in during procedure per 1000 medical and surgical discharges (excluding neonates*) * Also excludes admissions specifically for treatment of foreign body left, such as cases from earlier admissions or from other hospitals.
PSI 6	Latrogenic pneumothorax per 1000 discharges (excluding neonates, obstetrical admissions, and patients with trauma, thoracic surgery, lung or pleural biopsy, or cardiac surgery*) * Also excludes admissions specifically for iatrogenic pneumothorax, such as cases from earlier admissions or from other hospitals. Includes barotrauma (including acute respiratory distress syndrome) and central line placement.
PSI 7	Selected infections due to medical care per 1000 discharges* (excluding immunocompromised and cancer patients and neonates) * Also excludes admissions specifically for such infections, such as cases from earlier admissions, from other hospitals, or from other settings.
PSI 8	Postoperative hip fracture for adults per 1000 surgical patients age 18 years and older who were not susceptible to falling* (excluding obstetrical admissions) * 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 9	Postoperative hemorrhage or hematoma with surgical drainage or evacuation, not verifiable as following surgery*, per 1000 surgical discharges (excluding obstetrical admissions) * Postoperative hemorrhage or hematoma is not verifiable as following surgery because information on day of procedure is not available for all discharges. Also, excludes admissions specifically for such problems, such as cases from earlier admissions, from other hospitals, or from other settings.
PSI 10	Postoperative physiologic and metabolic derangements per 1000 elective surgical discharges (excluding some serious disease* and obstetric admissions) * 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 surgical discharges (excluding patients with respiratory disease, circulatory disease, and obstetric conditions)
PSI 12	Postoperative pulmonary embolus (PE) or deep vein thrombosis (DVT) per 1000 surgical discharges (excluding patients admitted for DVT, obstetrics, and plication of vena cava before or after surgery*) * Also excludes admissions specifically for such thromboembuli, such as cases from earlier admissions, from other hospitals, or from other settings.
PSI 13	Postoperative sepsis per 1000 elective-surgery discharges of longer than 3 days (excluding patients admitted for infection; patients with cancer or immunocompromised states, and obstetric conditions)
PSI 14	Reclosure of postoperative disruption of abdominal wall (postoperative abdominal wound dehiscence) per 1000 abdominopelvic-surgery discharges (excluding obstetric conditions*) * Also excludes admissions specifically for such wound dehiscence, such as cases from earlier admissions or from other hospitals.
PSI 15	Accidental puncture or laceration during procedures per 1000 discharges (excluding obstetric admissions*) * Also excludes admissions specifically for such problems, such as cases from earlier admissions or from other hospitals.

QI No.	Description
PSI 16	Transfusion reactions per 1000 discharges (excluding neonates*) * Also excludes admissions specifically for transfusion reactions, such as cases from earlier admissions or from other hospitals.
PSI 17	Birth trauma - injury to neonate per 1000 live births (excluding preterm and osteogenesis imperfecta births)
PSI 18	Obstetric trauma per 1000 instrument-assisted vaginal deliveries
PSI 19	Obstetric trauma per 1000 vaginal deliveries without instrument assistance
PSI 20	Obstetric trauma per 1000 Cesarean deliveries
PSI 21	Foreign body accidentally left in during procedure* per 100,000 population (excluding neonatal procedures) * Includes admissions specifically for treatment of foreign body left, such as cases from earlier admissions or from other hospitals.
PSI 22	Iatrogenic pneumothorax cases* per 100,000 population (excluding neonates, obstetrical admissions, and patients with trauma, thoracic surgery, lung or pleural biopsy, or cardiac surgery) * Includes admissions specifically for iatrogenic pneumothorax, such as cases from earlier admissions or from other hospitals. Also, includes barotrauma (including acute respiratory distress syndrome) and central line placement.
PSI 23	Selected infections due to medical care* per 100,000 population (excluding immunocompromised or cancer patients and neonates) * Includes admissions specifically for such infections, such as cases from earlier admissions, from other hospitals, or from other settings.
PSI 24	Reclosure of postoperative disruption of abdominal wall (postoperative abdominal wound dehiscence*) per 100,000 population (excluding obstetric conditions) * Includes admissions specifically for such wound dehiscence, such as cases from earlier admissions or from other hospitals.
PSI 25	Accidental puncture or laceration during procedures* per 100,000 population (excluding obstetric admissions) * Includes admissions specifically for such problems, such as cases from earlier admissions or from other hospitals.
PSI 26	Transfusion reactions* per 100,000 population (excluding neonates) * 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 Department of Public Health
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
Minnesota	Minnesota Hospital Association
Missouri	Hospital Industry Data Institute
Nebraska	Nebraska Hospital Association
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	Office for Oregon Health Policy & Research
Pennsylvania	Pennsylvania Health Care Cost Containment Council
Rhode Island	Rhode Island Department of Health
South Carolina	South Carolina State Budget & Control Board
Tennessee	Tennessee Hospital Association
Texas	Texas Health Care Information Council
Utah	Utah Department of Health
Vermont	Vermont Association of Hospitals and Health Systems
Virginia	Virginia Health Information
Washington	Washington State Department of Health
West Virginia	West Virginia Health Care Authority
Wisconsin	Wisconsin Department of Health & Family Services

Table 3. Number of diagnosis and procedure fields by State

State	Maximum number of diagnoses	Maximum number of procedures
Arizona	11	6
California	30	21
Colorado	15	15
Connecticut	30	30
Florida	10	10
Georgia	10	6
Hawaii	11	10
Illinois	9	6
Iowa	11	6
Kansas	30	25
Kentucky	10	6
Maine	10	6
Maryland	16	15
Massachusetts	16	15
Michigan	30	30
Minnesota	10	6
Missouri	30	25
Nebraska	10	6
New Jersey	10	8
New York	17	15
North Carolina	17	11
Oregon	11	6
Pennsylvania	10	6
Rhode Island	12	11
South Carolina	12	10
Tennessee	10	6
Texas	10	6
Utah	10	6
Vermont	21	20
Virginia	10	6
Washington	10	6
West Virginia	10	6
Wisconsin	10	6

Table 4. Use of E codes in the Patient Safety Indicators, Version 2.1, Release 1

PSI *	Codes used for defining the numerator		Codes used for defining exclusions	
	E codes	Similar ICD-9-CM codes	E codes	Similar ICD-9-CM codes
1	E8763, E8551, E9381 – E9389	9681-9684, 9687	Self-inflicted injury (E95nn)	None
5	E8710 – E8719	9984, 9987	None	None
8	None	None	Poisoning (E85nn, E86nn, E95nn, E96nn, E98nn)	9600-9799
15	E8700 – E8709	9982	None	None
16	E8760	9996-9997	None	None
21	E8710 – E8719	9984, 9987	None	None
25	E8700 – E8709	9982	None	None
26	E8760	9996-9997	None	None

* All other PSIs do not use E codes.

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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 Claritas (a vendor that compiles and adds value to Bureau of Census data). For NIS estimates, the standard errors are calculated as described in the HCUP report entitled "Calculating Nationwide Inpatient Sample (NIS) Variances" (Houchens, et al., 2004). 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 Claritas data, 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 Claritas Population Data

a. Standard error estimates for discharge rates per 100,000 population using the 2001 Claritas population data.

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 2001 Claritas population data.

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. 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):

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

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., females, 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:

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

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

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

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: State-Level Bivariate Analysis - State PQI Rates Related to Other Factors, Taken One at a Time

This appendix shows the factors for which State-specific data could be found to compare to the State-specific Prevention Quality Indicators (PQI) included in the 2004 NHQR based on 2001 discharge data from the SID. State-level PQI rates are shown below with whether or not they were correlated with these factors. The results shaded in yellow below denote statistically significant correlations. The direction of the relationship and the percent of variation across States explained by the data element are also shown.

(Highlighted text denotes statistically significant results)

Key to Conclusions about Associations Found in Appendix A, Tables 1-3, column 3:

\+ = positive association, statistically significant at $p<0.05$, between QI rates and rates of the other characteristics across the states

– = negative association, statistically significant as explained above

ns = "Not Significant", denotes a statistically insignificant association.

Additional Notations:

** Number of cases reported by States was insufficient to complete analysis

*** Data unavailable for four (4) States; regressions run using remaining 29 States

State-Level Bivariate Analysis of AHRQ Prevention Quality Indicators (PQIs) based on 2001 Discharge Data Reported in the 2004 NHQR

AHRQ Prevention Quality Indicators (PQIs)	Characteristics of State Populations	Conclusions About Associations	Percent of State Variation Explained (R-square)
PQI 1 – Adult Admissions for Short-term Diabetes Complications	Prevalence of Obesity in Adults	+	43.63%
	Adult Diabetes Prevalence (Diagnosed)	+	25.92%
	Percent of Population 65 Years and Over	ns	0.24%
	Source of Insurance: Uninsured (as a Percent of the Population)	+	12.09%
	Percent of People Below the Poverty Line in the Past 12 Months	+	33.70%
	Hospital Bed Supply (Rate/100,000)	ns	5.21%
	Race/Ethnicity: White (as a Percent of the Population)	ns	0.38%
	Race/Ethnicity: Black (as a Percent of the Population)	+	46.13%
	Race/Ethnicity: Hispanic (as a Percent of the Population)	ns	1.32%
	Race/Ethnicity: API (as a Percent of the Population)	-	12.52%
	Race/Ethnicity: Other (as a Percent of the Population)	ns	3.96%
	Race/Ethnicity: Minority (as a Percent of the Population)	ns	0.38%
PQI 3 – Adult Admissions for Long-term Diabetes Complications	Percent of Adult Population at Risk for Heart Disease***	+	15.28%
	Cardiac Deaths (Rate/100,000)	+	55.56%
	Prevalence of Obesity in Adults	+	28.29%
	Adult Diabetes Prevalence (Diagnosed)	+	32.36%
	Percent of Population 65 Years and Over	ns	3.18%
	Source of Insurance: Uninsured (as a Percent of the Population)	ns	8.41%
	Percent of People Below the Poverty Line in the Past 12 Months	+	26.40%
	Hospital Bed Supply (Rate/100,000)	ns	10.75%
	Race/Ethnicity: White (as a Percent of the Population)	ns	5.69%
	Race/Ethnicity: Black (as a Percent of the Population)	+	28.56%
	Race/Ethnicity: Hispanic (as a Percent of the Population)	ns	0.45%
	Race/Ethnicity: API (as a Percent of the Population)	ns	1.38%
	Race/Ethnicity: Other (as a Percent of the Population)	ns	8.82%
	Race/Ethnicity: Minority (as a Percent of the Population)	ns	5.69%

AHRQ Prevention Quality Indicators (PQIs)	Characteristics of State Populations	Conclusions About Associations	Percent of State Variation Explained (R-square)
PQI 4 – Pediatric Asthma Admissions	Adult Asthma Prevalence	ns	1.23%
	Emphysema Prevalence	ns	0.97%
	Chronic Bronchitis Prevalence	ns	5.38%
	Percent Reporting Cigarette Use in the Past Month	+	13.57%
	HMO Penetration	ns	2.65%
	Percent of People Below the Poverty Line in the Past 12 Months	ns	7.44%
	Percent Without Telephone Access	+	15.27%
	Source of Insurance: Uninsured (as a Percent of the Population)	ns	3.25%
	Hospital Bed Supply (Rate/100,000)	ns	4.22%
	Air Quality - Particulate Annual Mean	ns	0.96%
	Air Quality - Particulate 24 Hour Average	ns	0.64%
	Air Quality - Ozone 1 Hour Average	+	16.99%
	Race/Ethnicity: White (as a Percent of the Population)	ns	5.35%
	Race/Ethnicity: Black (as a Percent of the Population)	+	38.75%
	Race/Ethnicity: Hispanic (as a Percent of the Population)	ns	0.00%
	Race/Ethnicity: API (as a Percent of the Population)	ns	1.63%
	Race/Ethnicity: Other (as a Percent of the Population)	-	20.45%
	Race/Ethnicity: Minority (as a Percent of the Population)	ns	5.35%
PQI 6 – Pediatric Gastroenteritis Admissions	HMO Penetration	ns	6.86%
	Percent of People Below the Poverty Line in the Past 12 Months	+	24.91%
	Percent of Population that is Foreign-Born	ns	1.78%
	Source of Insurance: Uninsured (as a Percent of the Population)	ns	2.78%
	Hospital Bed Supply (Rate/100,000)	+	40.32%
	Race/Ethnicity: White (as a Percent of the Population)	ns	0.25%
	Race/Ethnicity: Black (as a Percent of the Population)	+	12.06%
	Race/Ethnicity: Hispanic (as a Percent of the Population)	ns	2.32%
	Race/Ethnicity: API (as a Percent of the Population)	ns	0.37%
	Race/Ethnicity: Other (as a Percent of the Population)	ns	10.38%
	Race/Ethnicity: Minority (as a Percent of the Population)	ns	0.25%
PQI 8 – Adult Admissions for Congestive Heart Failure	Percent of Adult Population at Risk for Heart Disease***	+	41.70%
	Cardiac Deaths (Rate/100,000)	+	76.95%
	Percent Reporting Cigarette Use in the Past Month	+	27.46%
	Percent Reporting Past Month 'Binge' Alcohol Use	ns	2.92%
	Percent of Population 65 Years and Over	ns	8.62%

AHRQ Prevention Quality Indicators (PQIs)	Characteristics of State Populations	Conclusions About Associations	Percent of State Variation Explained (R-square)
PQI 8 – cont'd	HMO Penetration	ns	0.51%
	Percent of People Below the Poverty Line in the Past 12 Months	+	18.67%
	Percent of Population that is Foreign-Born	ns	2.57%
	Physician Specialist (Rate/100,000)	ns	0.99%
	Medicare Hospital Payment per Beneficiary	+	47.98%
	Race/Ethnicity: White (as a Percent of the Population)	ns	0.33%
	Race/Ethnicity: Black (as a Percent of the Population)	+	34.20%
	Race/Ethnicity: Hispanic (as a Percent of the Population)	ns	3.43%
	Race/Ethnicity: API (as a Percent of the Population)	ns	4.07%
	Race/Ethnicity: Other (as a Percent of the Population)	-	25.83%
	Race/Ethnicity: Minority (as a Percent of the Population)	ns	0.33%
PQI 14 – Adult Admissions for Uncontrolled Diabetes Without Complications	Prevalence of Obesity in Adults	+	35.10%
	Adult Diabetes Prevalence (Diagnosed)	+	12.38%
	Percent of Population 65 Years and Over	ns	4.62%
	Source of Insurance: Uninsured (as a Percent of the Population)	ns	9.16%
	Percent of People Below the Poverty Line in the Past 12 Months	+	27.49%
	Hospital Bed Supply (Rate/100,000)	+	25.47%
	Race/Ethnicity: White (as a Percent of the Population)	ns	3.29%
	Race/Ethnicity: Black (as a Percent of the Population)	+	35.54%
	Race/Ethnicity: Hispanic (as a Percent of the Population)	ns	0.01%
	Race/Ethnicity: API (as a Percent of the Population)	ns	3.94%
	Race/Ethnicity: Other (as a Percent of the Population)	-	14.55%
	Race/Ethnicity: Minority (as a Percent of the Population)	ns	3.29%
PQI 15 – Adult Asthma Admissions	Adult Asthma Prevalence	ns	0.02%
	Emphysema Prevalence	ns	0.25%
	Chronic Bronchitis Prevalence	-	12.23%
	Percent Reporting Cigarette Use in the Past Month	+	12.29%
	HMO Penetration	ns	1.28%
	Percent of People Below the Poverty Line in the Past 12 Months	ns	6.86%
	Percent Without Telephone Access	+	15.69%
	Source of Insurance: Uninsured (as a Percent of the Population)	ns	0.05%
	Hospital Bed Supply (Rate/100,000)	ns	9.98%
	Percent of Population 65 Years and Over	+	11.24%
	Air Quality - Particulate Annual Mean	ns	2.31%
	Air Quality - Particulate 24 Hour Average	ns	1.64%
	Air Quality - Ozone 1 Hour Average	ns	8.06%
	Race/Ethnicity: White (as a Percent of the Population)	ns	6.46%

AHRQ Prevention Quality Indicators (PQIs)	Characteristics of State Populations	Conclusions About Associations	Percent of State Variation Explained (R-square)
PQI 15 – cont'd	Race/Ethnicity: Black (as a Percent of the Population)	+	27.39%
	Race/Ethnicity: Hispanic (as a Percent of the Population)	ns	0.60%
	Race/Ethnicity: API (as a Percent of the Population)	ns	0.19%
	Race/Ethnicity: Other (as a Percent of the Population)	-	19.90%
	Race/Ethnicity: Minority (as a Percent of the Population)	ns	6.46%
PQI 15-65 – Adult Asthma Admissions, Age 65+	Adult Asthma Prevalence	ns	4.23%
	Emphysema Prevalence	ns	3.02%
	Chronic Bronchitis Prevalence	ns	10.90%
	Percent Reporting Cigarette Use in the Past Month	ns	0.60%
	HMO Penetration	ns	0.05%
	Percent of People Below the Poverty Line in the Past 12 Months	ns	10.92%
	Percent Without Telephone Access	+	11.62%
	Source of Insurance: Uninsured (as a Percent of the Pop.)	ns	3.71%
	Hospital Bed Supply (Rate/100,000)	ns	3.69%
	Percent of Population 65 Years and Over	ns	0.37%
	Air Quality - Particulate Annual Mean	ns	0.39%
	Air Quality - Particulate 24 Hour Average	ns	0.01%
	Air Quality - Ozone 1 Hour Average	ns	2.73%
	Race/Ethnicity: White (as a Percent of the Population)	-	28.23%
	Race/Ethnicity: Black (as a Percent of the Population)	+	21.23%
	Race/Ethnicity: Hispanic (as a Percent of the Population)	ns	0.79%
	Race/Ethnicity: API (as a Percent of the Population)	+	12.93%
	Race/Ethnicity: Other (as a Percent of the Population)	-	14.27%
	Race/Ethnicity: Minority (as a Percent of the Population)	+	28.23%
PQI 16 - Diabetes-Related Lower Extremity Amputations	PQI 14: Adult Admissions for Uncontrolled Diabetes Without Complications	+	30.61%
	PQI 1: Adult Admissions for Short-term Diabetes Complications	+	42.17%
	PQI 3: Adult Admissions for Long-term Diabetes Complications	+	60.26%
	Percent of Adult Population at Risk for Heart Disease***	+	13.16%
	Cardiac Deaths (Rate/100,000)	+	33.45%
	Prevalence of Obesity in Adults	+	15.71%
	Adult Diabetes Prevalence (Diagnosed)	+	25.88%
	Percent of Population 65 Years and Over	ns	0.00%
	Source of Insurance: Uninsured (as a Percent of the Pop.)	ns	3.60%
	Percent of People Below the Poverty Line in the Past 12 Months	ns	8.30%
	Hospital Bed Supply (Rate/100,000)	ns	0.61%
	HMO Penetration	ns	0.93%

AHRQ Prevention Quality Indicators (PQIs)	Characteristics of State Populations	Conclusions About Associations	Percent of State Variation Explained (R-square)
PQI 16 – cont'd	Race/Ethnicity: White (as a Percent of the Population)	-	14.17%
	Race/Ethnicity: Black (as a Percent of the Population)	+	48.27%
	Race/Ethnicity: Hispanic (as a Percent of the Population)	ns	0.54%
	Race/Ethnicity: API (as a Percent of the Population)	ns	0.62%
	Race/Ethnicity: Other (as a Percent of the Population)	-	19.00%
	Race/Ethnicity: Minority (as a Percent of the Population)	+	14.17%
PQI 18 - Immunization-Preventable Influenza Admissions Among Elderly	Percent of Adult Population at Risk for Heart Disease***	+	20.95%
	Cardiac Deaths (Rate/100,000)	ns	5.26%
	Emphysema Prevalence	ns	0.99%
	Chronic Bronchitis Prevalence	ns	0.89%
	Percent Reporting Cigarette Use in the Past Month	ns	6.70%
	Percent Reporting Past Month 'Binge' Alcohol Use	ns	9.58%
	Source of Insurance: Uninsured (as a Percent of the Population)	ns	1.90%
	HMO Penetration	-	17.28%
	Percent of People Below the Poverty Line in the Past 12 Months	ns	11.02%
	Race/Ethnicity: White (as a Percent of the Population)	ns	5.74%
	Race/Ethnicity: Black (as a Percent of the Population)	ns	2.27%
	Race/Ethnicity: Hispanic (as a Percent of the Population)	-	14.01%
	Race/Ethnicity: API (as a Percent of the Population)	ns	0.81%
	Race/Ethnicity: Other (as a Percent of the Population)	ns	2.90%
	Race/Ethnicity: Minority (as a Percent of the Population)	ns	5.74%