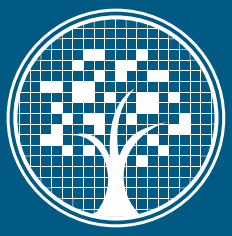

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HEALTHCARE COST AND UTILIZATION PROJECT

HCUP Methods Series

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

Report # 2004-05

Agency for Healthcare Research and Quality

U.S. Department of Health and Human Services
Agency for Healthcare Research and Quality

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

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September 17, 2004

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 University (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.

The 2001 HCUP Statewide Inpatient Databases (SID), a *census* of hospitals (with all of their discharges), from 22 participating States were used to create a disparities analysis file designed to provide national estimates on disparities for this report. A sample of hospitals from the following States were included Arizona, California, Colorado, Connecticut, Florida, Georgia, Hawaii, Kansas, Maryland, Massachusetts, Michigan, Missouri, New Jersey, New York,

Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Virginia, Vermont, and Wisconsin. 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, 4) special methods for race/ethnicity reporting, and 4) identification of statistical methods. These steps, described briefly below, are presented in detail in the Technical Specifications for HCUP Measures in the Second National Healthcare Quality Report and the National Healthcare Disparities Report (Barrett, Houchens, Coffey, et al., 2004), 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 these software modules did not include all of the reporting categories needed for the NHDR, some changes to the QI calculations were necessary. (For details, see Barrett, Houchens, Coffey, et al., 2004). We also added two indicators: immunization-preventable pneumococcal pneumonia and 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 the QI rates, we needed 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 discharge denominator counts for QIs that related to providers. Population ZIP-Code-level counts by age, gender, race, and ethnicity from Claritas 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. **Special Methods for Race/Ethnicity Reporting:** Race and ethnicity measures can be problematic in hospital discharge databases. Many hospitals do not code race and ethnicity completely. Because race/ethnicity is a pivotal measure for the NHDR, we explored the reporting of the race/ethnicity data in the 33 States that participate in 2001 HCUP SID. Eight States did not provide information on patient race to HCUP. Two States did not report Hispanic ethnicity, and one State only reports patient race as white, non-white, and Hispanic. The remaining twenty-two States were used for the creation of the disparities analysis file. The following table demonstrates the representation by region of the 22 States.

Region	Number of States used for the disparities analysis file	Number of States in the region	Percent of States in the region included in the disparities analysis file
Northeast	7	9	78%
Midwest	4	12	33%
South	7	16	44%
West	4	13	31%
Total	22	50	44%

The table below compares aggregated totals of various measures for the 22 States as a percent of the national measure. In 2001, the 22 States accounted for 65 percent of U.S. hospital discharges (based on the American Hospital Association's Annual Survey). They accounted for about 60 percent of various subgroups of the nation (based on 2001 Claritas data), with the exception of Asian/Pacific Islanders; the 22 States included 76 percent of the Asian/Pacific Islander population.

Measure	Total of 22 HCUP States with race/ethnicity as a percent of national total
Hospital discharges	65%
Total resident population	56%*
Population by race/ethnicity:	
White	57%*
African American	60%*
Asian/Pacific Islander	76%*
Hispanic	65%*
Population by age:	
Population under age 18	57%*
Population age 18-64	59%*
Population over age 64	60%*
Population with income under the poverty level	68%**

*Calculated using 2001 Claritas and 1990 Census race definitions.
**Calculated using Urban Institute and Kaiser Commission on Medicaid and the Uninsured estimates based on pooled March 2002 and 2003 Current Population Surveys.

Data on Hispanics is collected differently among the States and also can differ from the Census methodology of collecting information on race (White, African American, Asian, American Native) separately from ethnicity (Hispanic, non-Hispanic). States often collect Hispanic ethnicity as one of several categories that include race. Clerks use these combined race/ethnicity categories to classify patients on admission to the hospital, often by observing rather than asking the patient. The HCUP databases maintain the combined categorization of race and ethnicity. When a State and its hospitals collect Hispanic

ethnicity separately from race, HCUP processing for a uniform database, uses Hispanic ethnicity to override any other race category.

4. **Preparation of HCUP Data and Development of the Disparities Analysis File.** Several HCUP data issues had to be resolved before applying the QI algorithms. First, we selected community[1] hospitals only from the 22 States and eliminated rehabilitation hospitals in the 2001 SID because the completeness of reporting for rehabilitation hospitals was inconsistent across States. Second, community hospitals from these 22 States were sampled to approximate a 20-percent stratified sample of U.S. community hospitals. The sampling strata were defined based on five hospital characteristics: geographic region, hospital control (i.e., public, private not-for-profit, and proprietary), urbanized location, teaching status, and bed size. Hospitals were excluded from the sampling frame if the coding of patient race was suspect (i.e., more than 30% of the discharges in the hospital had the race reported as "other", more than 50% of the discharges in the hospital had no information on the race of the patient, all of the discharges in the hospital had race coded as white, other, or missing, or 100% of the discharges in the hospital had race coded as white and the hospital had more than 50 beds). Once the 20-percent sample was drawn, discharge-level weights were developed to produce national-level estimates when applied to the disparities analysis file. The sampling and weighting strategy used for the disparities analysis file is similar to the method used to create the HCUP Nationwide Inpatient Sample (NIS), except that the disparities analysis file samples from 22 of the 33 States included in the 2001 NIS. The final disparities analysis file included almost 8 million hospital discharges from 976 hospitals. Third, for missing age, gender, ZIP Code, race/ethnicity, 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. Fourth, 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.

5. **Statistical Methods.** Statistical issues involved age-gender adjustment for all QIs, 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 other population subgroups and were based on methods of direct standardization (Fleiss, 1973). Standard errors calculations for the disparities analysis file were based on the HCUP report entitled "Calculating Nationwide Inpatient Sample (NIS) Variances" (HCUP, 2002). There is no sampling error associated with Claritas 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

[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, long-term hospitals, psychiatric hospitals, and alcoholism/chemical dependency treatment facilities.

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. (2004).

Caveats

Some caution should be used in interpreting the AHRQ QI statistics presented in this report. The caveats relate to inter-State differences in data collection:

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. Seven of the 22 States (i.e., AZ, CO, FL, KS, MI, VA, WI) in the NHDR analysis file were missing information on secondary procedure day. 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, that 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.

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). The SID for different States contain 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) of affecting some PSI rates and should be kept in mind when judging the level of these events.

Race/ethnicity coding: Even excluding hospitals with a large proportion of race/ethnicity coding that was missing, there may still remain differences in racial and ethnicity coding among States that affect estimates. For example, some States include Hispanic ethnicity as a category among racial categories, some ask about Hispanic ethnicity separately from race. At the hospital-level, policies vary on methods for collecting such data. Some hospitals ask the patient to identify their race and ethnicity, some determine it from observation. The effect of these and other unmeasured differences in coding of race and ethnicity across the States and hospitals cannot be assessed.

Table 1. AHRQ Quality Indicators Selected for the National Healthcare Disparities 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 2	Admissions with perforated appendix per 1000 admissions with appendicitis (excluding obstetric and neonatal admissions and transfers from other institutions)
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 5	Admissions for chronic obstructive pulmonary disease (COPD) (excluding obstetric admissions and transfers from other institutions) per 100,000 population, age 18 years and older
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 7	Admissions for hypertension (excluding patients with cardiac procedures, obstetric and neonatal conditions, and transfers from other institutions) per 100,000 population, age 18 years and older
PQI 11	Bacterial pneumonia admissions (excluding sickle cell or hemoglobin-S conditions, transfers from other institutions, and obstetric and neonatal admissions) per 100,000 population
PQI 13	Admissions for angina without procedure (excluding surgical patients, transfers from other institutions, and obstetric and neonatal admissions) 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.
(Added)	Immunization-preventable influenza admissions (excluding transfers from other institutions) per 100,000 population, age 65 years and older
	Inpatient Quality Indicators
IQI 9	Deaths per 1000 admissions with pancreatic resection for cancer (excluding obstetric and neonatal admissions 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 21	Cesarean deliveries per 1000 deliveries
IQI 22	Vaginal birth after cesarean (VBAC) per 1000 women with previous cesarean deliveries
IQI 26	Coronary artery bypass grafts (CABG) for adults age 40 years and older (excluding obstetric admissions) per 100,000 population age 40 and older
IQI 27	Percutaneous transluminal coronary angioplasties (PTCA) for adults age 40 years and older (excluding obstetric admissions) per 100,000 population age 40 and older
IQI 28	Hysterectomies for adults (excluding obstetric conditions, genital cancer, and pelvic trauma) per 100,000 female population age 18 years and older
IQI 29	Laminectomies or spinal fusions for adults (excluding obstetric conditions) per 100,000 population age 18 years and older

QI No.	Description
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
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

QI No.	Description
	other hospitals.
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

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
Kansas	Kansas Hospital Association
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
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
Vermont	Vermont Association of Hospitals and Health Systems
Virginia	Virginia Health Information
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
AZ	11	6
CA	30	21
CO	15	15
CT	30	30
FL	10	10
GA	10	6
HI	11	10
KS	30	25
MA	16	15
MD	16	15
MI	30	30
MO	30	25
NJ	10	8
NY	17	15
PA	10	6
RI	12	11
SC	12	10
TN	10	6
TX	10	6
VA	10	6
VT	21	20
WI	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 the disparities analysis file created from the HCUP SID and Claritas. For disparities analysis file 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 disparities analysis file sample design when calculating these statistics using the SAS procedure PROC SURVEYMEANS. For Claritas population counts, there is no sampling error.

Even though the disparities analysis file contains discharges from a finite sample of hospitals, we treat the sample as though it was 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 disparities analysis file to be a sample 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 discharge weight and variable of interest for patient i in the disparities analysis file. To obtain the estimate of *S* and its standard error, SE_S, we followed instructions in the NIS Variance Report.

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 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 a 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):

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

g = index for the 36 age/sex cells.
$N_{g,std}$ = Standard population for cell g (year 2000 total U.S. population in cell g).
$N_{g,obs}$ = Observed population for cell g (year 2001 subpopulation in cell g, e.g., Medicare insureds, age greater than 65, 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).
$w_{g,i}$ = Disparities analysis file 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 to account for the weighting for direct standardization and the discharge weight 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, we used PROC SURVEYMEANS to obtain the estimate of S^* (A.3), the weighted sum in the numerator using the revised weights (A.4), and the estimate SE_{S^*}, the standard error of the weighted sum S^*. The denominator of the rate 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 (Disparities Analysis File**)**

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, we used PROC SURVEYMEANS to obtain estimates of the discharge weighted mean, *S/N*, and the standard error of that 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 2000 Nationwide Inpatient 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:

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

g = index for the 36 age/sex cells.
$\hat{N}_{g,std}$ = Standard inpatient population for cell g (Estimate of year 2000 total U.S. 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.
$w_{g,i}$ = Disparities analysis file discharge weight for observation i in cell g.

Note that $\hat{P}_{g,std} = \dfrac{\hat{N}_{g,std}}{\sum_{g=1}^{36} \hat{N}_{g,std}}$ 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:

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

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:

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

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

Following instructions in the HCUP NIS Variance Report, we used PROC SURVEYMEANS to obtain estimates of the discharge- and standardization-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:

$$t = \frac{R_1 - R_2}{\sqrt{SE_1^2 + SE_2^2}}$$

$$p = 2 * \text{Prob}(Z > |t|) \quad \text{(A.10)}$$

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))