

# **Hospital-Wide All-Cause Unplanned Readmission Measure**

## **Final Technical Report**

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## GLOSSARY OF TERMS

Term	Definition
Index admission	Any eligible admission to an acute care hospital assessed in the measure for the outcome (readmitted or not within 30 days). (See Section 2.3.2)
Readmission	An admission to an acute care hospital within 30 days of discharge from an acute care hospital. (See Section 2.2). A readmission may in turn serve as an index admission.
Planned readmission	An intentional readmission within 30 days of discharge from an acute care hospital that is a scheduled part of the patient's plan of care. Planned readmissions are not counted as outcomes in this measure. (See Section 2.2.1)
Discharge diagnosis	ICD-9 level code of the <b>principal</b> reason for hospitalization.
Discharge condition category	A group of related discharge diagnosis ICD-9 codes (principal diagnoses), as grouped by the Agency for Healthcare Research and Quality (AHRQ) Clinical Classification Software (CCS). (See Section 2.3.1)
Procedure category	A group of related procedure codes, as grouped by the Agency for Healthcare Research and Quality (AHRQ) Clinical Classification Software (CCS). (See Section 2.4.3)
Specialty cohort	A group of index admissions for patients with related condition categories or procedure categories; this measure includes five cohorts, each with its own risk model. (See Section 2.4.3)
Measure population	The full set of patients with index admissions eligible for inclusion in the measure.
Comorbid risk variable	A variable in the risk-adjustment model intended to account for patient comorbid conditions or age. A risk variable may represent multiple conditions. Each condition is a group of ICD-9 diagnosis codes, as defined by the Centers for Medicare and Medicaid Services Condition Category groups (CCs). (See Section 2.5.3)
Condition risk variable	A variable in the risk-adjustment model intended to account for patient's discharge condition category. Every condition category with more than 1,000 admissions is included as a condition risk variable. Condition categories with fewer than 1,000 admissions are grouped together into a single "low frequency condition" risk variable. This occurs in the medicine, surgery/gynecology and neurology cohorts. (See Table 9, Table 10 and Table 13)
Case mix	The particular illness severity and age characteristics of the patients with index admissions at a given hospital.
Service mix	The particular conditions and procedures of the patients with index admissions at a given hospital.

# 1. INTRODUCTION

## 1.1 Overview of Measure

Readmission following hospitalization is a costly and often preventable event. During 2003 and 2004, almost one-fifth of Medicare beneficiaries – more than 2.3 million patients – were rehospitalized within 30 days of discharge.<sup>1</sup> Jencks et. al. estimated that readmissions within 30 days of discharge cost Medicare more than \$17 billion annually.<sup>1</sup> A 2006 Commonwealth Fund report estimated that if national readmission rates were lowered to the levels achieved by the top-performing regions, Medicare would save \$1.9 billion annually.<sup>2</sup>

Currently, the Centers for Medicare & Medicaid Services (CMS) publicly reports risk-standardized readmission rates (RSRRs) for heart failure, pneumonia and acute myocardial infarction.<sup>3-9</sup> CMS has also developed hospital readmission measures for stroke and for hip and knee replacement, and is developing them for chronic obstructive pulmonary disease and vascular procedures. While it is helpful to assess readmission rates for specific groups of patients, these conditions account for only a small proportion of total readmissions.<sup>10</sup> By contrast, a hospital-wide, all-condition readmission measure could provide a broader assessment of the quality of care at hospitals. Therefore, CMS has contracted with Yale New Haven Health Services Corporation/Center for Outcomes Research and Evaluation (YNHHSC/CORE) to develop a claims-based, risk-adjusted hospital-wide readmission (HWR) measure for public reporting that reflects the quality of care for hospitalized patients in the United States.

In this technical report we provide detailed information on the development of the HWR measure. Briefly, we developed the measure as an all-condition measure designed to capture unplanned readmissions within 30 days of discharge. The HWR measure complies with accepted standards for outcomes measure development, including appropriate risk adjustment and transparency of specifications. We exclude admissions for which we have insufficient data for risk adjustment, patients who leave against medical advice, admissions for medical cancer treatment or for conditions that are not typically cared for in short-stay acute care hospitals, and admissions to PPS-exempt cancer hospitals. The measure does not count planned readmissions in the measure outcome, since they do not represent a quality signal. The overall RSRR is derived from the weighted geometric mean of five statistical models built for groups of admissions that are clinically related: medicine, surgery/gynecology, cardiorespiratory, cardiovascular, and neurology. The five risk adjustment models were developed and validated using two randomly split sample datasets from data combining two calendar years (2007 and 2008). We also validated the performance of the five models using data from 2009. Although we developed the measure using Medicare data, the measure will also be tested in and adapted for all-payer datasets.

## 1.2 Hospital-wide Readmission as a Quality Indicator

Hospital readmission, for any reason, is disruptive to patients and caregivers, costly to the healthcare system, and puts patients at additional risk of hospital-acquired infections and complications. Readmissions are also a major source of patient and family stress and may contribute substantially to loss of functional ability, particularly in older patients.



Some readmissions are unavoidable and result from inevitable progression of disease or worsening of chronic conditions. However, readmissions may also result from poor quality of care or inadequate transitional care. Transitional care includes effective discharge planning, transfer of information at the time of discharge, patient assessment and education, and coordination of care and monitoring in the post-discharge period. Numerous studies have found an association between quality of inpatient or transitional care and early (typically 30-day) readmission rates for a wide range of conditions.<sup>11-18</sup>

Randomized controlled trials have shown that improvement in the following areas can directly reduce readmission rates: quality of care during the initial admission; improvement in communication with patients, their caregivers and their clinicians; patient education; predischARGE assessment; and coordination of care after discharge.<sup>19-34</sup> Successful randomized trials have reduced 30-day readmission rates by 20-40%. Widespread application of these clinical trial interventions to general practice has also been encouraging. Since 2008, 14 Medicare Quality Improvement Organizations have been funded to focus on care transitions, applying lessons learned from clinical trials. Several have been notably successful in reducing readmissions within 30 days.<sup>35</sup> Evidence that hospitals have been able to reduce readmission rates through these quality-of-care initiatives illustrates the degree to which hospital practices can affect readmission rates.

Despite these isolated successful interventions, the overall national readmission rate remains high, with a 30-day readmission following nearly one fifth of discharges. Furthermore, readmission rates vary widely across institutions.<sup>5,7,8</sup> Both the high baseline rate and the variability across institutions speak to the need for a quality measure to prompt more concerted and widespread action.

Given that studies have shown readmissions within 30 days to be related to quality of care, that interventions have been able to reduce 30-day readmission rates for a variety of specific conditions, and that high and variable readmission rates indicate opportunity for improvement, it is reasonable to consider an all-condition 30-day readmission rate as a quality measure.

### 1.3 Approach to Measure Development

We developed this measure in consultation with national guidelines for publicly reported outcomes measures, following the technical approach to outcomes measurement set forth in National Quality Forum (NQF) guidance for outcomes measures,<sup>36</sup> CMS Measure Management System guidance, and the guidance articulated in the American Heart Association scientific statement, “Standards for Statistical Models Used for Public Reporting of Health Outcomes.”<sup>3</sup> These standards include adequate risk adjustment and transparency. We sought and obtained expert input during measure development, both through CMS and consultation with clinical and statistical experts. We also received input from the general public during a public comment period.

## 2. METHODS

### 2.1 Overview

This measure reports the hospital-level, risk-standardized rate of unplanned readmission within 30 days of hospital discharge for any condition. The measure comprises a single summary score, derived from the results of five different models, one for each of the following specialty cohorts (groups of discharge condition categories or procedure categories): medicine, surgery/gynecology, cardiorespiratory, cardiovascular, and neurology, each of which will be described in greater detail below. The measure uses one year of data to assess hospital performance.

Hospitalizations are eligible for inclusion in the measure if the patient was age 65 or older, was hospitalized at a non-Federal short-stay acute-care hospital or critical access hospital, was continuously enrolled in fee-for-service (FFS) Medicare Part A for one month after discharge, was not discharged to another acute care hospital, and was alive upon discharge. These hospitalizations form the starting cohort. We exclude admissions for which we have insufficient data for risk adjustment (patients who were not enrolled in FFS Medicare Part A for 12 months prior to admission), patients who leave against medical advice, admissions for medical cancer treatment or for conditions that are not typically cared for in short-stay acute care hospitals (admissions with a primary psychiatric diagnosis or primary rehabilitation diagnosis), and admissions to PPS-exempt cancer hospitals. We exclude planned readmissions, which are not a quality signal. To compare readmission performance across hospitals, the measure accounts for differences in patient characteristics (patient case mix) as well as differences in mixes of services and procedures offered by hospitals (hospital service mix). The measure covers 93.1% of hospitalizations occurring in 2008 in the starting cohort, and includes 92.1% of readmissions following those hospitalizations (see Figure 2).

To define the conditions and procedures in the measure, we collapsed the more than 17,000 different International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes into 285 clinically-coherent, mutually-exclusive condition categories and 231 mutually-exclusive procedure categories using the Agency for Healthcare Research and Quality (AHRQ) Clinical Classification Software (CCS).<sup>37</sup>

We created five major specialty cohorts based on organization of care, and assigned each condition category to a cohort. Admissions that included major surgical procedures (regardless of condition category) were assigned to the surgery/gynecology cohort. We built a separate model for each one of these cohorts. We used a development dataset and logistic regression models to evaluate and select a single set of risk factors for readmission that was then applied to every model. We used hierarchical logistic regression to adjust for differences in hospital case mix and to account for the clustering of patients within a hospital. We adjusted for case mix differences among hospitals by risk-adjusting for patients' comorbid conditions identified in inpatient episodes of care for the 12 months prior to the index admission as well as those present at admission. We did not risk-adjust for diagnoses that may have been a complication of care during the index admission. We used CMS Condition Category groups (CMS-CCs) to define the comorbid risk adjusters and used a fixed set of comorbid risk variables across models. We risk-adjusted for service mix differences among hospitals within each major cohort by including indicator variables for discharge condition categories (as defined by AHRQ CCS) in each model.

Finally, we used each of the five models to calculate predicted and expected numbers of readmissions (as defined below in Section 2.6.1) for each hospital in each cohort. We then derived a single summary score from the results of the five models by calculating the volume-weighted log average (that is, the geometric mean) of the predicted over expected ratios from each model and multiplying the resulting ratio by the average national readmission rate. This approach allowed us to take into account the variation in hospital specialty cohort mix.

We evaluated the performance of the measure for various types of hospitals and groups of patients. We then tested the reliability of the measure by randomly splitting combined 2007 and 2008 data and comparing the performance in each split sample. For temporal validation, we also tested the measure's performance in 2009 data.

## 2.2 Outcome Definition

The outcome for this measure is unplanned all-cause 30-day readmission. We define a readmission as a subsequent inpatient admission to any acute care facility which occurs within 30 days of the discharge date of an eligible index admission. Any readmission is eligible to be counted as an outcome except those that are considered planned.

### 2.2.1 Planned readmissions

Readmissions may be either unplanned or planned. Unplanned readmissions are acute clinical events experienced by a patient that require urgent hospital admission. Higher than expected unplanned readmission rates suggest lower quality of care and are the focus of quality measurement as part of quality improvement efforts. Because planned readmissions are not a signal of quality of care, we chose to exclude planned readmissions from being considered as outcome. We developed an algorithm for identifying "planned readmissions" in claims data that will not count as readmissions in the measure. The algorithm was based on two main principles:

- a. We define "planned" readmissions as those in which one of a pre-specified list of procedures (presented below) took place, or those for maintenance chemotherapy or rehabilitation. Maintenance chemotherapy and rehabilitation are common planned readmissions that are reliably distinguishable in the data even though they are not accompanied by procedures. Although other readmissions may also be planned for medical reasons, these are rare, and there is no reliable means of identifying them in administrative claims data.
- b. Admissions for acute illness or for complications of care are not "planned." Any procedure completed during an admission for an acute illness is not likely to have been planned, even if that procedure is usually planned in other non-acute cases. We identify readmissions as acute or non-acute by considering the principal discharge condition.

We therefore developed an algorithm that uses procedure codes and discharge diagnosis categories for each readmission to identify planned readmissions. Readmissions that occur for planned procedures (listed below) and which are not for acute diagnoses or complications of care (listed below) are identified as planned.

The following examples illustrate this point:

Example 1:

- A readmission with a discharge condition category of biliary tract disease that included a cholecystectomy would be considered **planned**
- A readmission with a discharge condition category of septicemia that included a cholecystectomy would be considered **unplanned**
- A readmission with a discharge condition category of “complications of surgical procedures or medical care” that included a cholecystectomy would be considered **unplanned**

Example 2:

- A readmission with a discharge condition category of coronary atherosclerosis that included a percutaneous coronary intervention (PCI) would be considered **planned**
- A readmission with a discharge condition category of acute myocardial infarction that included PCI would be considered **unplanned**

Therefore, the HWR measure defines planned readmissions as any readmission that was either:

- A **non-acute** readmission in which one of 35 typically planned procedures occurs  
**or**
- A readmission for maintenance chemotherapy

All other readmissions are considered unplanned and are counted as readmissions in the measure.

#### *List of planned procedures*

In order to develop a list of planned procedures, we reviewed the full AHRQ CCS procedure category list and identified 32 procedure categories that are typically planned and require an inpatient stay. After receiving public comments, we added two procedure categories and a group of related ICD-9 procedure codes to this list. Readmissions in which any of these procedures are performed are considered planned if the discharge condition category is not acute or a complication of care (Table 1).

Table 1 – Procedure categories considered planned

AHRQ CCS	Description	Readmissions with no excluding diagnosis ("planned" readmissions)		Total readmissions	
		Number	Percent of total planned readmissions	Number	Percent of total planned readmissions
45	Percutaneous transluminal coronary angioplasty (PTCA)	12,038	13.8%	19,719	13.0%
	Rehabilitation (condition CCS 254)	9,973	11.5%	9,973	6.6%
84	Cholecystectomy and common duct exploration	7,191	8.3%	8,519	5.6%
157	Amputation of lower extremity	6,649	7.6%	9,989	6.6%
44	Coronary artery bypass graft (CABG)	6,290	7.2%	7,495	5.0%
78	Colorectal resection	4,719	5.4%	9,034	6.0%
51	Endarterectomy; vessel of head and neck	4,558	5.2%	5,033	3.3%
113	Transurethral resection of prostate (TURP)	3,752	4.3%	4,536	3.0%
99	Other OR gastrointestinal therapeutic procedures	3,475	4.0%	7,312	4.8%
48	Insertion; revision; replacement; removal of cardiac pacemaker or cardioverter/defibrillator	2,541	2.9%	23,231	15.4%
	Maintenance Chemotherapy (condition CCS 45)	2,312	2.7%	2,312	1.5%
211	Therapeutic radiology for cancer treatment	2,183	2.5%	3,293	2.2%
3	Laminectomy; excision intervertebral disc	2,065	2.4%	3,078	2.0%
43	Heart valve procedures	2,061	2.4%	2,503	1.7%
152	Arthroplasty knee	1,989	2.3%	3,393	2.2%
158	Spinal fusion	1,963	2.3%	2,859	1.9%
55	Peripheral vascular bypass	1,902	2.2%	2,606	1.7%
52	Aortic resection; replacement or anastomosis	1,529	1.8%	1,657	1.1%
36	Lobectomy or pneumonectomy	1,492	1.7%	1,880	1.2%
153	Hip replacement; total and partial	1,333	1.5%	9,484	6.3%
60	Embolectomy and endarterectomy of lower limbs	1,263	1.5%	2,645	1.7%
85	Inguinal and femoral hernia repair	981	1.1%	1,165	0.8%
104	Nephrectomy; partial or complete	921	1.1%	1,027	0.7%
1	Incision and excision of CNS	804	0.9%	3,577	2.4%
124	Hysterectomy; abdominal and vaginal	524	0.6%	555	0.4%
167	Mastectomy	474	0.5%	503	0.3%
10	Thyroidectomy; partial or complete	353	0.4%	413	0.3%
114	Open prostatectomy	338	0.4%	361	0.2%

74	Gastrectomy; partial and total	278	0.3%	499	0.3%
119	Oophorectomy; unilateral and bilateral	273	0.3%	390	0.3%
154	Arthroplasty other than hip or knee	229	0.3%	984	0.7%
	Radical laryngectomy, revision of tracheostomy, scarification of pleura (ICD-9 codes 30.4, 31.74, 34.6)	216	0.2%	678	0.4%
166	Lumpectomy; quadrantectomy of breast	117	0.1%	203	0.1%
64	Bone marrow transplant	100	0.1%	103	0.1%
105	Kidney transplant	70	0.1%	72	0.0%
176	Other organ transplantation	69	0.1%	116	0.1%
	Electroshock therapy (ICD-9 codes 94.26, 94.27)	30	0.0%	39	0.0%

\*Data from 2008 MedPAR file, incorporating all final inclusion and exclusion criteria for the measure

*List of discharge condition categories that are acute or complications of care*

According to our algorithm, admissions in which a planned procedure was performed are only considered “planned” if the patient was not admitted for an acute illness or complication of care. To develop a list of these acute and complication discharge condition categories, we reviewed the 10 most frequent discharge condition categories associated with each of our final set of 35 potentially planned procedures (Appendix A – Top 10 primary discharge diagnoses for each planned procedure). From this set of 350 condition categories, we identified those which could be categorized as acute illnesses or complications of medical care. Each discharge condition category includes a number of diagnosis ICD-9 codes. When a discharge condition category contained a mix of acute and chronic diagnoses, it was categorized as acute. Based on these criteria, we categorized 27 discharge condition categories as acute or complications of care, all listed within Table 2.

Table 2 – Discharge condition categories considered acute or complications of care

<b>AHRQ CCS</b>	<b>Description</b>	<b>30-day readmissions with this condition and one of the planned procedures</b>
237	Complication of device; implant or graft	11,689
106	Cardiac dysrhythmias	10,267
	Fracture (condition CCS 207, 225, 226, 227, 229, 230, 231, 232)	6,307
100	Acute myocardial infarction	5,643
238	Complications of surgical procedures or medical care	5,438
108	Congestive heart failure; nonhypertensive	5,119
2	Septicemia (except in labor)	3,372
146	Diverticulosis and diverticulitis	2,434
105	Conduction disorders	2,130
109	Acute cerebrovascular disease	1,886
145	Intestinal obstruction without hernia	1,341

233	Intracranial injury	1,271
116	Aortic and peripheral arterial embolism or thrombosis	1,115
122	Pneumonia (except that caused by TB or sexually transmitted disease)	710
131	Respiratory failure; insufficiency; arrest (adult)	678
157	Acute and unspecified renal failure	645
201	Infective arthritis and osteomyelitis (except that caused by TB or sexually transmitted disease)	608
153	Gastrointestinal hemorrhage	566
130	Pleurisy; pneumothorax; pulmonary collapse	510
97	Peri-; endo-; and myocarditis; cardiomyopathy	484
127	Chronic obstructive pulmonary disease and bronchiectasis	462
55	Fluid and electrolyte disorders	424
159	Urinary tract infections	410
245	Syncope	353
139	Gastroduodenal ulcer (except hemorrhage)	133
160	Calculus of urinary tract	98
112	Transient cerebral ischemia	88
	<b>All condition categories</b>	<b>64,181</b>

We quantified the impact of our decisions regarding the definition of planned readmissions on readmission rates. In 2008, there were 127,785 planned readmissions in the final cohort, accounting for 9% of all readmissions.

### 2.2.2 Thirty-day timeframe

We considered 30 days as a clinically reasonable timeframe for multiple reasons:

- a. Within a 30-day time frame, readmissions are more likely attributable to care received during the index hospitalization and during the transition to the outpatient setting. A number of studies have demonstrated that improvements in care at the time of patient discharge can reduce 30-day readmission rates.<sup>19,20,22,27-34,38</sup> Hospitals, in collaboration with their medical communities, can take a number of actions to reduce readmissions: ensure patients are clinically ready at discharge; reduce risk of infection; reconcile medications; improve communications among providers involved in transition of care; encourage strategies that promote disease management principles; and educate patients about symptoms to monitor, whom to contact with questions, and where and when to seek follow-up care.<sup>19,20,22,27-34,38</sup> Studies also show that it can take more than 14 days for the benefits of these interventions to appear.<sup>39</sup>
- b. The 30-day timeframe is consistent with the other CMS readmission measures approved by the National Quality Forum (NQF) and publicly reported by CMS.
- c. In addition to clinical judgment, we reviewed “time to event” curves of readmission over time to decide whether the 30-day timeframe captures the quality signal provided by readmission rates. The readmission “time-to-event curves” showed a very similar

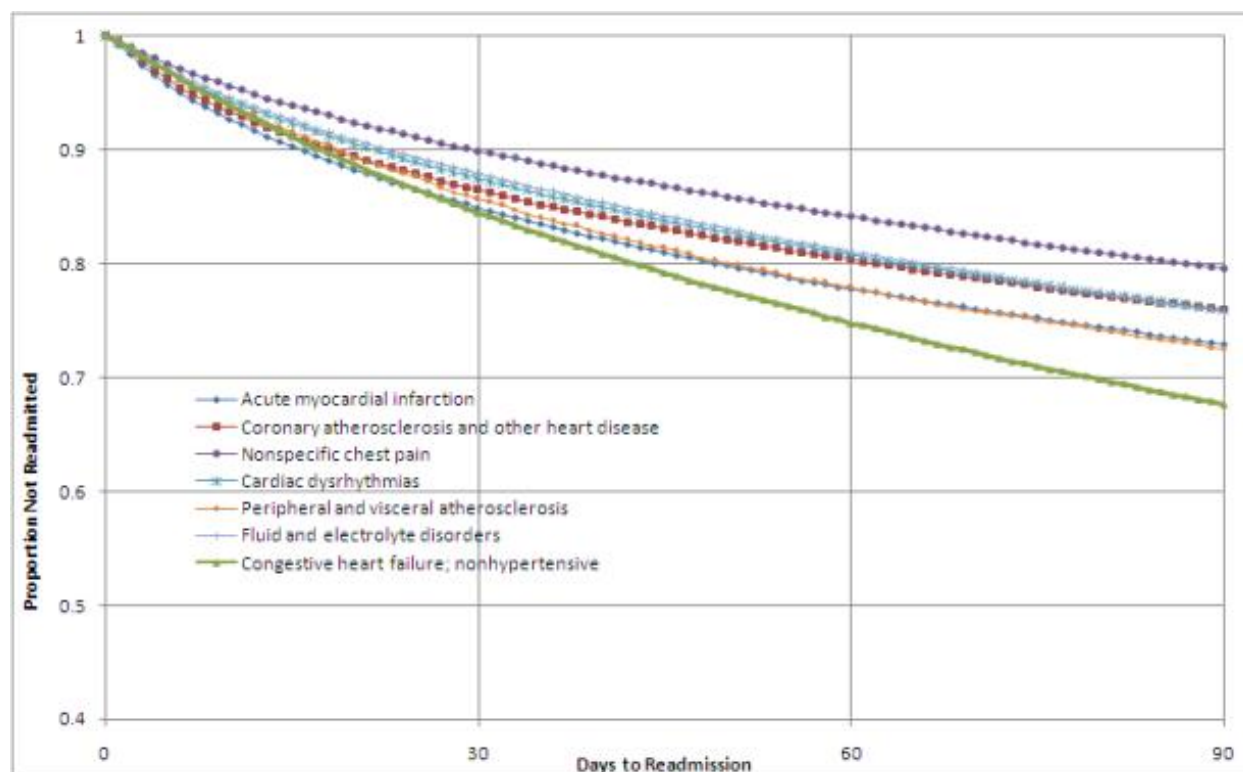


pattern for all discharge condition categories: a rapid early accrual of readmissions, with a stable and consistent readmission rate (slope) thereafter, likely reflecting patients' return to baseline admission risk. Curves typically stabilized within 30 days of discharge, indicating that a 30-day cutoff is clinically reasonable, although alternative time frames (e.g. 15 or 45 days) would also capture a quality signal. Time-to-event curves for 24 of the most common discharge condition categories are shown in Figure 1.

- d. We considered shorter but not longer time frames compared to 30 days given: (1) the literature findings showing the effectiveness of interventions designed to decrease 30-day rates and (2) the diminishing influence of hospital-initiated interventions on the post-discharge course for longer observation periods. We compared the proportion of total variation that was at the hospital level for both 15-day readmissions and 30-day readmissions (adjusted only for age and sex) to determine whether 30-day outcomes were less related to hospital care than 15-day readmissions. In fact, results were similar for both outcomes: the proportion of the total variation that was at the hospital level was 3.2% for 15-day readmissions and 2.8% for 30-day readmissions.
- e. In summary, we chose a post-discharge observation period of 30-days balancing considerations of empiric data findings, actionability, measure harmonization, and fairness of attribution.

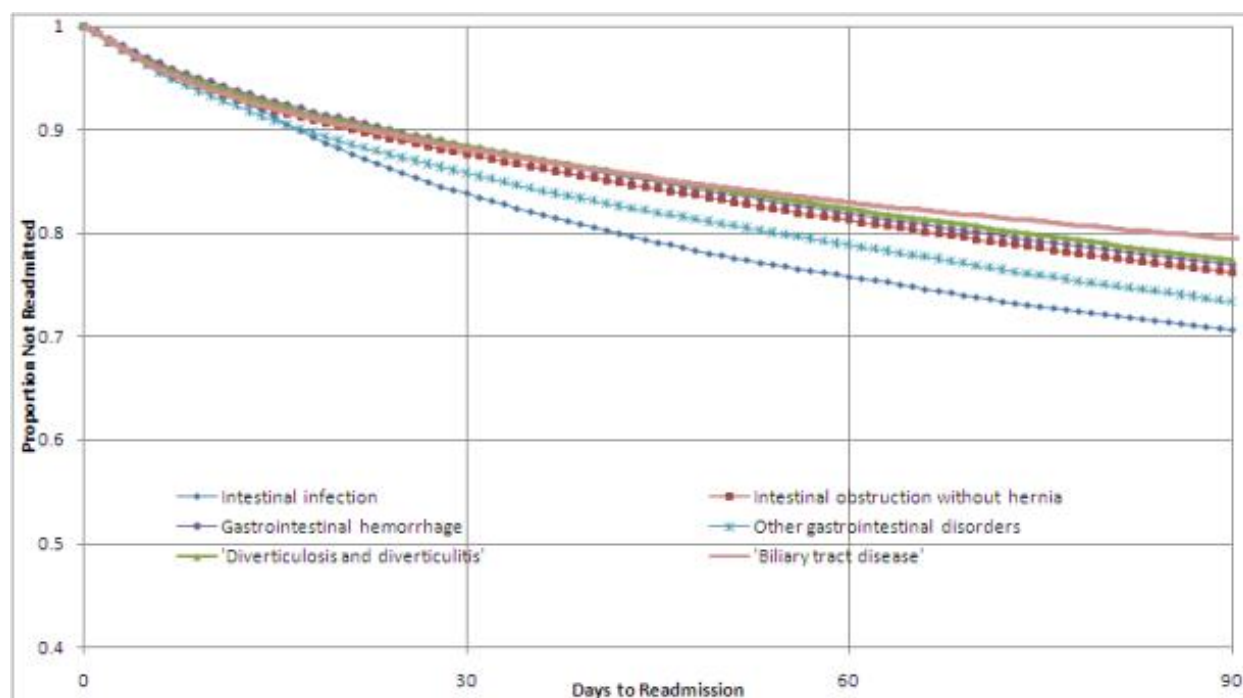
Figure 1 – Graphical representation of time to readmission

1a: Cardiovascular conditions

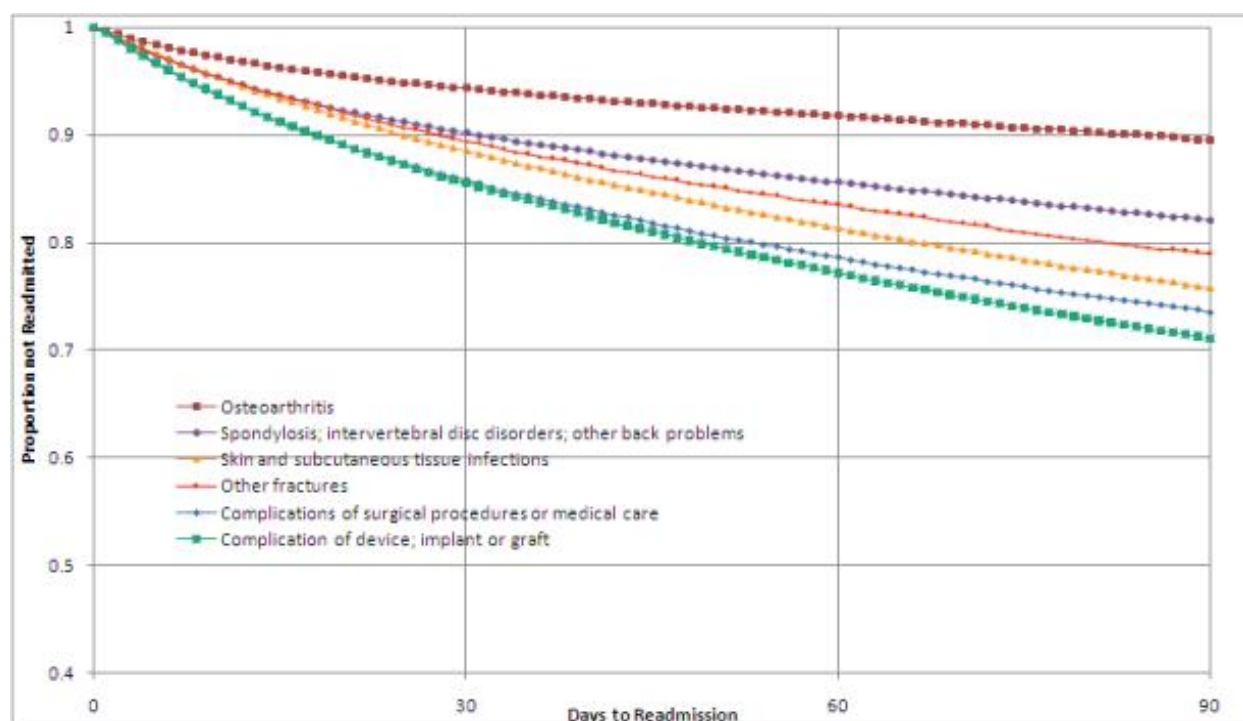




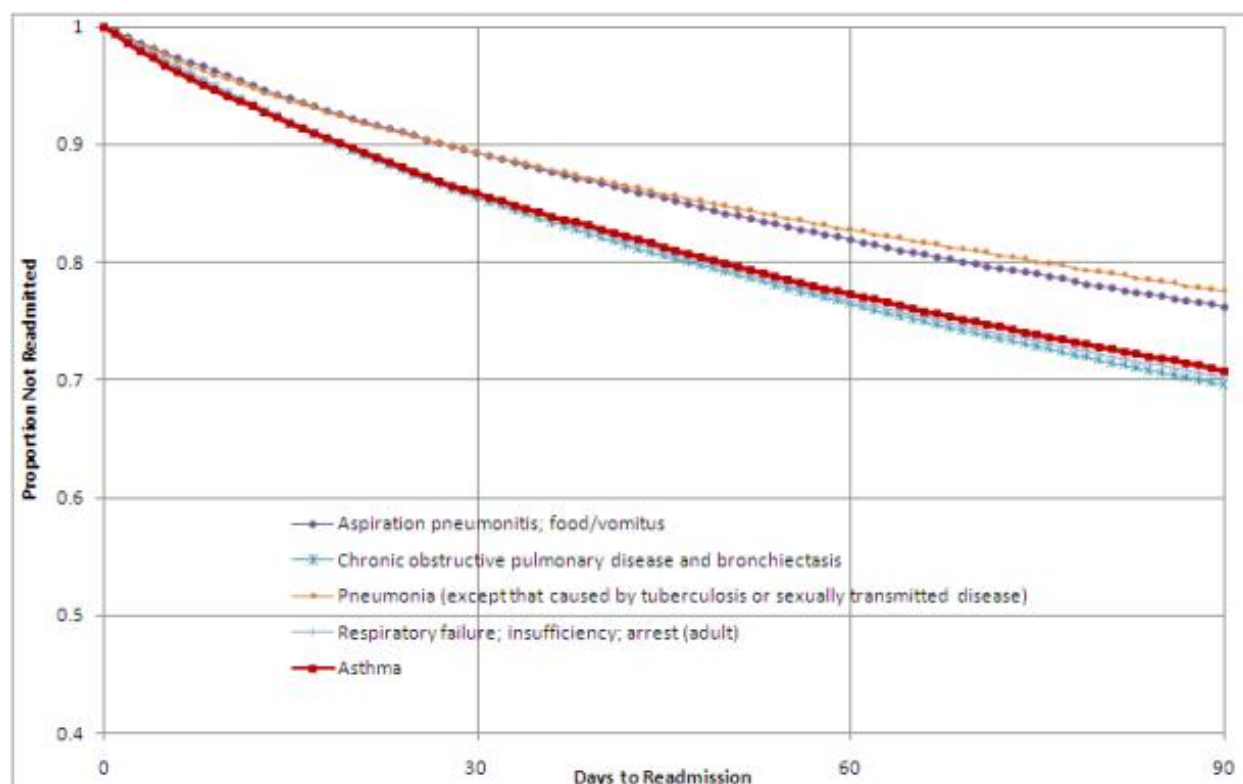
## 1b: Gastrointestinal conditions



## 1c: Orthopedic conditions and complications of care



## 1d: Pulmonary conditions



### 2.2.3 All-cause readmission

We defined the outcome as “all-cause” unplanned readmissions rather than readmissions related to the previous hospitalization for multiple reasons. First, from the patient perspective, readmission for any reason is likely to be an undesirable outcome of care. Furthermore, readmission for any reason exposes the patient to risks associated with hospitalization, such as iatrogenic errors. Second, there is no reliable way to determine whether a readmission is related to the previous hospitalization based on the documented cause of readmission. For example, a stroke patient who develops aspiration pneumonia may ultimately be readmitted for respiratory distress. It would be inappropriate to treat this readmission as unrelated to the care the patient received for stroke. Third, the range of potentially avoidable readmissions also includes those not directly related to the index condition category, such as those resulting from medication reconciliation errors, poor communication at discharge, or inadequate follow-up post-discharge. Creating a comprehensive list of potentially avoidable readmissions related to the previous hospitalization’s condition category would be arbitrary and, ultimately, challenging to implement. Fourth, all existing CMS readmission measures report all-cause readmission, making this approach consistent with existing measures. Fifth, research shows that readmission reduction interventions can reduce all-cause readmission, not only condition-specific readmission. Finally, defining the outcome as all-cause readmissions may encourage hospitals to implement broader initiatives aimed at improving the overall care within the hospital and transitions from the hospital setting instead of limiting the focus to a narrow set of condition-specific approaches.

## 2.3 Definition of Eligible Admissions

Our guiding principle for defining eligible admissions was that the measure should capture as many unplanned readmissions as possible across a maximum number of acute care hospitals. Therefore we included in the measure all admissions except those for which full data were not available or for which 30-day readmission cannot reasonably be considered a signal of quality of care.

### 2.3.1 Grouping patients into clinically coherent discharge condition categories by using AHRQ CCS

For our previous claims-based condition- and procedure-specific outcomes measures we have used individual ICD-9 codes of the index admission to define the cohort. For the HWR measure, using ICD-9 codes would have been very impractical because there are potentially thousands of ICD-9 codes that would have to be included. Therefore, we aggregated ICD-9 codes into clinically coherent conditions.

To aggregate these codes, we chose the AHRQ CCS. We selected CCS because it is well-known and widely used; it is based on the principal diagnosis and not on complications or events that occur during hospitalization (unlike the Medicare Severity Diagnosis Related Groups [MS-DRGs]); and because it was developed using Healthcare Cost and Utilization Project data (unlike CMS-CCs),<sup>40</sup> making it more applicable to all-payer data. The AHRQ CCS has been used by managed care plans, insurers and researchers for a variety of functions, such as assessing resource use, predicting future expenses, comparing procedure or condition rates among payers or hospitals, or profiling patients. There are a total of 285 mutually exclusive AHRQ condition categories, most of which are single, homogenous diseases such as pneumonia or acute myocardial infarction. Some are aggregates of conditions, such as “other bacterial infections.” Mental health and substance abuse categories are included. In addition, AHRQ provides 231 mutually exclusive procedure categories to group procedures a patient might have had during hospitalization.

### 2.3.2 Inclusion / exclusion criteria

Admissions are eligible for inclusion in the measure if:

- a. Patient is 65 or older  
**Rationale:** Younger Medicare patients represent a distinct population with dissimilar characteristics and outcomes. Of note, when the measure is applied to all-payer data, it will apply to patients 18 and older, including younger Medicare patients.
- b. Patient survives hospitalization  
**Rationale:** Patients who die during the initial hospitalization cannot be readmitted.
- c. Patient is discharged home or to a non-acute setting  
**Rationale:** In an episode of care in which patient is transferred among hospitals, responsibility for the readmission is assigned to the final discharging hospital. Therefore intermediate admissions within a single episode of care are not eligible for inclusion.

These inclusion criteria are consistent with existing CMS publicly reported measures for readmission.

We then applied several exclusion criteria to the measure population (“starting cohort”). Criteria a-c are consistent with existing measures; the remainder are unique to the HWR measure. See Figure 2.

- a. Admissions for patients without at least 30 days of post-discharge enrollment in FFS Medicare  
**Rationale:** This is necessary in order to identify the outcome (readmission) in the dataset.
- b. Admissions for patients not continuously enrolled in FFS Medicare for the 12 months prior to the index admission are excluded  
**Rationale:** This is necessary to ensure full historical data for risk adjustment
- c. Patients discharged against medical advice (AMA) are excluded  
**Rationale:** Hospitals had limited opportunity to implement high quality care
- d. Admissions for patients to a PPS-exempt cancer hospital are excluded  
**Rationale:** These hospitals care for a unique population of patients that cannot reasonably be compared to the patients admitted to other hospitals.
- e. Admissions for medical treatment of cancer are excluded  
**Rationale:** These admissions have a very different mortality and readmission profile than the rest of the Medicare population, and outcomes for these admissions do not correlate well with outcomes for other admissions. See Section 2.4.3 for details of this exclusion. As described in Section 2.4.3, patients with cancer who are admitted for other diagnoses or for surgical treatment of their cancer remain in the measure. See Table 3 for excluded CCS.

Table 3 – Cancer discharge condition categories excluded from the measure

AHRQ CCS	Description	Admits*
42	Secondary malignancies	45,319
19	Cancer of bronchus; lung	30,292
45	Maintenance chemotherapy; radiotherapy	21,522
44	Neoplasms of unspecified nature or uncertain behavior	10,160
17	Cancer of pancreas	8,462
38	Non-Hodgkin’s lymphoma	7,977
39	Leukemias	7,809
14	Cancer of colon	6,121
40	Multiple myeloma	4,624
35	Cancer of brain and nervous system	3,561
16	Cancer of liver and intrahepatic bile duct	3,491
13	Cancer of stomach	3,467
29	Cancer of prostate	3,100
15	Cancer of rectum and anus	3,030

18	Cancer of other GI organs; peritoneum	2,974
12	Cancer of esophagus	2,533
11	Cancer of head and neck	2,515
27	Cancer of ovary	2,081
33	Cancer of kidney and renal pelvis	1,863
32	Cancer of bladder	1,807
24	Cancer of breast	1,682
43	Malignant neoplasm without specification of site	1,451
25	Cancer of uterus	1,132
36	Cancer of thyroid	879
21	Cancer of bone and connective tissue	763
41	Cancer; other and unspecified primary	674
20	Cancer; other respiratory and intrathoracic	632
23	Other non-epithelial cancer of skin	593
26	Cancer of cervix	586
28	Cancer of other female genital organs	326
34	Cancer of other urinary organs	301
37	Hodgkin's disease	236
22	Melanomas of skin	212
31	Cancer of other male genital organs	34
30	Cancer of testis	4
	<b>Total</b>	<b>182,213*</b>

\*After all other exclusions applied

- f. Admissions for primary psychiatric disease are excluded  
**Rationale:** Patients admitted for psychiatric treatment are typically cared for in separate psychiatric or rehabilitation centers which are not comparable to acute care hospitals. See Table 4 for excluded CCS:

Table 4 – Psychiatric discharge condition categories excluded from the measure

AHRQ CCS	Description	Admits*
657	Mood disorders	7,874
659	Schizophrenia and other psychotic disorders	7,849
651	Anxiety disorders	3,153
670	Miscellaneous disorders	1,315
654	Developmental disorders	594
650	Adjustment disorders	399
658	Personality disorders	127
652	Attention-deficit, conduct, and disruptive behavior disorders	119
656	Impulse control disorders, NEC	27

655	Disorders usually diagnosed in infancy, childhood, or adolescence	16
662	Suicide and intentional self-inflicted injury	10
	<b>Total</b>	<b>21,483*</b>

\*After all other exclusions applied

- g. Admissions for “rehabilitation care; fitting of prostheses and adjustment devices” (CCS 254) are excluded  
**Rationale:** These admissions are not typically admitted to an acute care hospital and are not for acute care

Note that a readmission within 30-days will also be eligible as an index admission, if it meets all other eligibility criteria. This allows our measure to capture repeated readmissions for the same patient, whether at the same hospital or another. Since there are few patients with multiple admissions in the same year in the same specialty cohort, it is difficult to model the within patient variance; thus, we chose to treat these multiple admissions as statistically independent.

## 2.4 Administrative Model Development

### 2.4.1 Data sources

To develop the measure, we constructed three datasets:

1. The index dataset contains administrative inpatient hospitalization data for FFS Medicare beneficiaries, 65 and older on admission, hospitalized in 2008
2. The history dataset includes inpatient hospitalization data on each patient for the 12 months prior to the index admission
3. The post-index dataset contains inpatient hospitalization data on each patient in the 30 days following discharge.

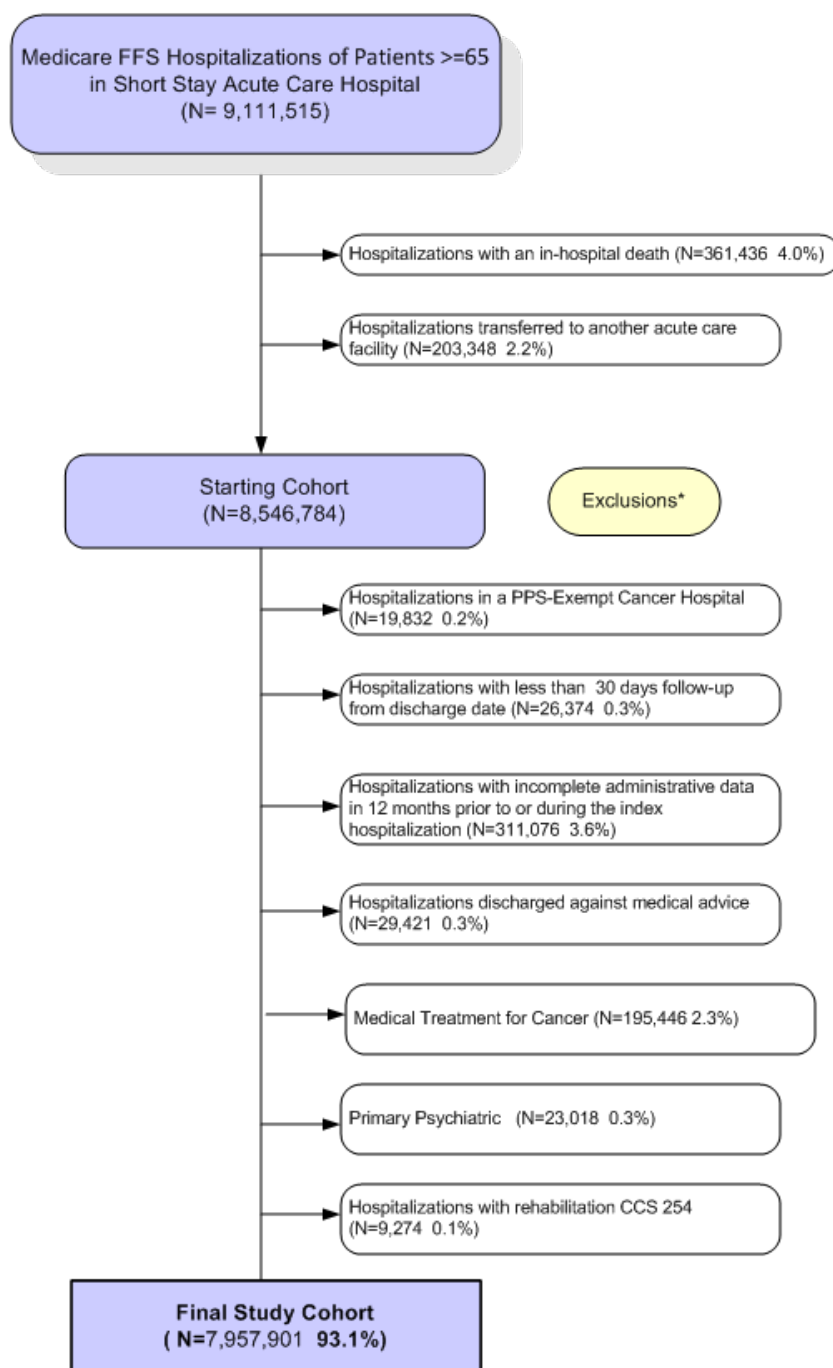
We obtained index admission, readmission, and in-hospital comorbidity data from the Medicare Provider Analysis and Review (MedPAR) file. Enrollment and post-discharge mortality status were obtained from the Medicare Enrollment Database, which contains beneficiary demographic, benefit, coverage, and vital status information.

Comorbidities were assessed using data from the index admission and any admissions in prior year. The Medicare physician (Part B) data were not included because 1) this was technically cumbersome, and 2) it would make expanding the measure later to an all-payer population very difficult (all-payer data typically includes only data for hospitalized patients, not office visits).

The selection of the final measure population is illustrated in Figure 2.

Figure 2 – Inclusion and exclusion criteria (numbers of admissions based on 2008 MedPAR data)

### Hospital Wide All Condition 30-Day All-Cause Readmission Measure



\* Not mutually exclusive

## 2.4.2 Modeling approach

Because the risk of readmission varies with patient factors, including age and comorbidities, hospital comparisons using readmission rates need to account for differences in these factors. To adjust for such “case mix” differences we used regression analysis, including age and comorbidity risk variables. Rather than assume that the effect of risk variables would be homogeneous across all discharge condition categories, we assessed the performance of a single model versus multiple models of groups of condition categories. Our analyses showed consistently that a single model was slightly inferior to multiple models for specialty cohorts. Using multiple models yielded better discrimination and predictive ability for readmission risk (Table 5). The Integrated Discrimination Improvement (IDI) score for the multiple model regression analysis was 0.001,  $P < 0.001$ .<sup>41</sup>

Table 5 – C statistics for single model and multiple models

Modeling approach	C statistic	95% confidence interval
Single overall model	0.656	0.655 – 0.656
Five models combined	0.658	0.657 – 0.658

Another consideration in grouping discharge condition categories into models for specialty cohorts rather than into a single model was that readmission risk varies according to discharge condition as well as according to age and comorbidities. Hospitals vary in their mix of conditions and procedures (“service mix”). By modeling readmission separately for different groups of conditions or procedures, we can better account for differences in service mix across hospitals.

In particular, we wanted to be careful to fully account for the differences in readmission risk between surgical and non-surgical patients. Our analyses found that even within the same discharge condition, patient risk was strongly affected by whether a surgical procedure was performed during hospitalization. Patients undergoing surgical procedures typically had better outcomes than patients who did not undergo a procedure but were admitted with the same discharge condition. Examples are shown in Table 6.

Table 6 – Example readmission rates for admissions with and without surgical procedures

AHRQ CCS	Description	Without surgical procedure			With surgical procedure		
		Total admits	Total readmits	Readmit rate	Total admits	Total readmits	Readmit rate
100	Acute myocardial infarction	116,810	25,035	21.40%	80,208	13,197	16.50%
149	Biliary tract disease	33,718	5,443	16.10%	66,034	7,444	11.30%
205	Spondylosis; intervertebral disc disorders; other back problems	46,916	7,395	15.80%	103,542	7,693	7.40%
237	Complication of device; implant or graft	81,549	18,771	23.00%	108,171	17,096	15.80%



In theory, estimating many more models, such as a separate model for each of the 285 condition categories, would provide the best discrimination of readmission risk at the patient level. However, if we did so, many hospitals would not be included in most such models; for all but the most common discharge condition categories, many hospitals would not have an index admission in that category during a given year. In addition, most other hospitals would have only very small numbers of index admissions in each discharge condition category, meaning that the model would contribute very little to their overall measurement. Thus, we balanced the desire for more models to maximize discrimination of readmission risk with the need to minimize models to ensure results would be obtainable for most hospitals, and developed five distinct models.

Finally, and most importantly, the multiple model approach, which combines individual measures from each model into a single measure, will increase the practical utility of the measure by illuminating differences in performance among specialty areas within hospitals. This attribute of the measure will allow hospitals to better target quality improvement efforts and received favorable public comments.

In summary, using five models rather than a single model marginally improves model performance and patient-level discrimination, and will significantly improve the usability of the measure. Using many more models was not feasible given the number of cases per hospital in each condition.

#### 2.4.3 Cohorts are defined by care team or clinical coherence

In this step we organized admissions into mutually exclusive cohorts. We created five cohorts: medicine, surgery/gynecology, cardiorespiratory, cardiovascular, and neurology. We examined but ultimately discarded the possibility of additional cohorts for gynecology patients, psychiatric patients, and medical cancer treatment patients. Instead, gynecology admissions were folded into the surgery category due to limited numbers, while admissions for primary psychiatric disease or medical cancer treatment were excluded altogether (see Section 2.3.2). Patients with psychiatric or cancer comorbidities admitted for other medical conditions or for surgical treatment remained in the measure (see Section 2.4.3b below). We built a separate model for each cohort.

- a. **Rationale for clinically-defined cohorts:** We expect the hospital component of readmission risk to be in part related to the care provided by a team of doctors, nurses, care coordinators, pharmacists, etc. Conditions typically cared for by the same team of clinicians would therefore be expected to experience similar added (or reduced) levels of readmission risk. Therefore, we grouped discharge condition categories typically cared for by the same group of clinicians into five cohorts: medicine, surgery/gynecology, cardiorespiratory, cardiovascular, and neurology. Organizing results by care team (specialty) in this way will allow hospitals to identify areas of strength and weakness if hospital performance varies across areas.
- b. **Rationale for excluding patients undergoing cancer treatment:** We initially developed a separate specialty cohort for patients admitted with a principal diagnosis condition of cancer who did not undergo a major surgical procedure. These are patients undergoing medical treatment of their cancer. We found that this cohort had more than twice the post-discharge mortality of any other cohort, indicating substantial competing risk of mortality in the post-discharge period. Such competing mortality risk raises

concern that readmission by itself is not a sufficient quality indicator in this population. Furthermore, this cohort had a planned readmission rate six times that of any other cohort – 41% of readmissions in this cohort were considered planned – raising concern that readmission in this population is a different phenomenon than for other cohorts. Most importantly, this cohort’s standardized readmission ratio (SRR) was poorly correlated with the composite hospital-wide SRR, especially compared to other cohorts (Table 7). See Section 2.6.2 for explanation of SRR. The internal consistency of the measure (Cronbach’s alpha) improved substantially when the cancer treatment cohort was removed (Table 7). Consequently, we elected to exclude this subset of cancer patients from the measure altogether (see Section 2.3.2). It is important to note that patients with secondary diagnoses of cancer admitted for other reasons are still included in this measure based on discharge diagnosis condition, as are patients with a primary or secondary diagnosis of cancer undergoing a procedure (i.e. a patient with a secondary diagnosis of lung cancer who was admitted with pneumonia would be in the cardiorespiratory cohort; a patient admitted for partial colectomy to treat colon cancer would be in the surgical cohort).

Table 7 – Correlation of model SRRs with composite SRR

<b>Model</b>	<b>Correlation with composite SRR*</b>	<b>Cronbach’s alpha of composite measure <i>without</i> model*</b>
Medicine	0.732	0.724
Surgery/gynecology	0.652	0.747
Cardiorespiratory	0.663	0.777
Cardiovascular	0.541	0.744
Neurology	0.553	0.772
Cancer treatment	0.228	0.835

\*higher number indicates a better correlation

#### 2.4.4 Approach to individual cohorts

(See Table 9, Table 10, Table 11, Table 12, and Table 13 for specific list of conditions in each cohort):

##### a. **Surgery/Gynecology**

This cohort includes admissions likely cared for by surgical or gynecologic teams. In order to be confident that these patients were actually cared for by surgical or gynecologic teams, we used AHRQ *procedure* categories (rather than AHRQ condition categories) to identify these patients. A patient could only be assigned to the surgery/gynecology cohort if s/he underwent a surgical procedure. We reviewed the list of AHRQ procedure categories and identified those which could typically result in surgical or gynecological teams caring for the patient. Minor procedures that would not have required a patient to be on the surgical service were not included in the list (for example: breast biopsy). Procedures that would generally accompany other, more major, procedures were also not included in the list on the assumption that patients undergoing these procedures would also undergo another procedure on the list (for example, intraoperative cholangiogram). The full list of procedures assigned to the

surgery/gynecology cohort is summarized in Appendix B – Procedure categories defining the surgery/gynecology cohort (2008 data). Any admission during which a procedure from the final list was performed was assigned to the surgery/gynecology cohort.

We elected not to subdivide the surgical cohort on the basis of elective vs. non-elective surgery because whether elective or non-elective, patients are still cared for by the same care teams. Our risk adjustment includes discharge condition category as a risk variable, which we expect to account for differences in risk according to why a procedure was performed.

We elected not to subdivide the surgical cohort on the basis of surgical subspecialty because many patients undergo procedures in more than one subspecialty and there is no reliable means of identifying which patients are on which teams. Furthermore, apart from the care provided by the surgeons themselves, most care provided to surgical patients is not sub-specialty-specific.

We elected not to treat gynecology patients as a separate cohort for several reasons. First, most hospitals had too few gynecology patients in the >65 age group to develop reliable models. Second, gynecology patients cannot reliably be distinguished from surgery patients on the basis of procedures since many undergo both surgical and gynecological procedures during the same admission. For example, 7% of gynecological procedures were performed during an admission for a gastrointestinal condition.

**b. Cardiorespiratory**

This cohort includes several conditions with very high readmission rates – pneumonia, chronic obstructive pulmonary disease, and heart failure – as well as admissions for other condition categories related to these three (asthma, acute bronchitis, pulmonary heart disease, cystic fibrosis and respiratory failure). We combined these patients into a single cohort because patients with these diseases are often clinically indistinguishable, are typically treated by the same care teams, and are often simultaneously treated for several of these diagnoses. Although patients with heart failure may be cared for by a separate cardiac or cardiovascular team, they are also often cared for by general medicine teams. Examination of our data revealed that 22.7% of admissions for heart failure included a secondary diagnosis of pneumonia or COPD, indicating a high degree of overlap between these three conditions. By contrast only 8.5% of admissions for heart failure included a secondary diagnosis of acute coronary syndrome or acute myocardial infarction.

**c. Cardiovascular**

This cohort includes cardiovascular condition categories such as acute myocardial infarction that in large hospitals might be cared for by a separate cardiac or cardiovascular team.

**d. Neurology**

This cohort includes neurologic condition categories such as stroke that in large hospitals might be cared for by a separate neurology team.

e. **Medicine**

This cohort includes all non-surgical patients who were not assigned to any of the cohorts above.

2.4.5 Assignment of admissions to cohorts

Admissions are first screened for the presence of an eligible surgical procedure category. Admissions with any of these procedures are assigned to the surgical cohort, regardless of the diagnosis code of the admission. The AHRQ procedure categories for the surgery/gynecology cohort are shown in Appendix B – Procedure categories defining the surgery/gynecology cohort (2008 data).

All remaining admissions are assigned to cohorts on the basis of the discharge condition category. The AHRQ discharge condition categories for the non-surgical groups are shown in Appendix C – Condition categories assigned to the specialty cohorts.

Summary results for the five cohorts are shown in Table 8.

Table 8 – Admissions, readmissions and mortality for the five cohorts (2008)

Specialty cohort	Admits	30-day unplanned readmits	Unadjusted 30-day unplanned readmit rate	30-day post-discharge deaths - without readmit	30-Day post-discharge mortality rate without readmit	Planned readmits	Unadj. planned 30-day readmit rate	% all readmits that are planned
	(A)	(R)	(=R/A)	(M)	(=M/A)	(P)	(=P/A)	(=P/R)
Medicine	3,086,792	556,131	18.0%	155,395	5.0%	34,492	1.1%	6%
Surgery/ gynecology	2,163,279	272,830	12.6%	37,678	1.7%	55,803	2.6%	17%
Cardio-respiratory	1,405,267	297,749	21.2%	74,674	5.3%	16,867	1.2%	5%
Cardio-vascular	843,373	128,224	15.2%	22,158	2.6%	15,912	1.9%	11%
Neurology	459,189	66,917	14.6%	30,308	6.6%	4,710	1.0%	7%
<b>Total</b>	<b>7,957,901</b>	<b>1,321,851</b>	<b>16.6%</b>	<b>298,072</b>	<b>3.7%</b>	<b>127,784</b>	<b>1.6%</b>	<b>9%</b>

2.5 Risk Adjustment

The goal of risk adjustment is to account for differences across hospitals in patient demographic and clinical characteristics that might be related to the outcome but are unrelated to quality of care. Risk adjustment for this measure is complicated by the fact that it includes many different discharge condition categories. We must therefore adjust both for case mix differences (clinical status of the patient, accounted for by adjusting for comorbidities) and service mix differences (the types of conditions/procedures cared for by the hospital, accounted for by adjusting for the discharge condition category). Consistent with NQF guidelines, we did not adjust for socioeconomic status, gender, race, or ethnicity because hospitals should not be held to different standards of care based on the demographics of their patients. We did not adjust for patients' admission source or discharge

disposition (e.g. skilled nursing facility) because these factors are associated with structure of the health care system, and may reflect the quality of care delivered by the system.

#### 2.5.1 Inpatient claims data

The HWR risk-adjustment models use only inpatient claims data (history and current) in order to make it feasible to implement with Medicare data, and to make it applicable to all-payer data, which are typically restricted to inpatient claims. The impact of not including outpatient data (Part B) on model performance has been studied for six publicly reported outcome measures (AMI, HF, and pneumonia 30-day risk-standardized mortality and readmission rates) and the results reported in a separate memo to CMS.<sup>42</sup>

The results showed that in absence of Part B data, the prevalence of most risk factors was lower, while the magnitude of effect for most risk factors was similar. A reclassification analysis comparing a model with full data to a model with only admission claims data demonstrated good patient-level risk prediction: for all six measures, over 95% of patients were in a similar risk category regardless of risk-adjustment dataset, and the integrated discrimination improvement (IDI) values were relatively low. The models' c statistics were also similar between the two approaches (0.713 vs. 0.725 for AMI mortality; 0.681 vs. 0.684 for HF mortality; 0.713 vs. 0.719 for pneumonia mortality; 0.619 vs. 0.614 for AMI readmission; 0.610 vs. 0.611 for HF readmission; and 0.632 vs. 0.628 for pneumonia readmission). Finally when comparing the model with full data and with only admission claims data, hospital-level risk-standardized rates were highly correlated (ICC=0.984 for AMI mortality; ICC=0.993 for HF mortality; ICC=0.989 for pneumonia mortality; ICC=0.950 for AMI readmission; ICC=0.978 for HF readmission; and ICC=0.985 for pneumonia readmission).

Consequently we expect that using only inpatient data in this measure has had minimal impact on model performance and predictive ability.

#### 2.5.2 Complications of hospitalization

Complications occurring during hospitalization are not comorbid illnesses, may reflect hospital quality of care, and therefore should **not** be used for risk adjustment. Although adverse events during hospitalization may increase the risk of readmission, including them as covariates in a risk-adjusted model could attenuate the measure's ability to characterize the quality of care delivered by hospitals. YNNHSC/CORE has previously reviewed every CMS-CC and identified those which, if they occur during the index hospitalization, would be considered potential complications rather than comorbidities. For example: fluid, electrolyte or base disorders; sepsis; and acute liver failure are all examples of CMS-CCs that could potentially be complications of care (see Appendix D – Conditions that are treated as complications if occurring during index admission for the complete list). For the HWR measure, we applied this pre-established list to all potential risk variables. CMS-CCs on this list were not counted as a risk factor in our analyses if they appeared only on the index admission. In the future, it may be possible to use "present on admission" codes to differentiate between comorbidities and complications during the index admission.

#### 2.5.3 Case mix adjustment: comorbid risk variables

We used CMS-CCs, the grouper used in previous CMS risk-standardized outcomes measures, to group ICD-9-CM codes into comorbid risk adjustment variables, since four

CMS condition-specific claims-based readmission models that use this grouper to define variables for risk adjustment have been validated against models that use medical record-abstracted data for risk adjustment.<sup>5,7,8</sup> We decided to use a fixed, common set of variables in all our models for simplicity and ease of data collection and analysis. We describe below the steps for variable selection:

- a. We developed a “starter” set of 30 variables drawn from previous readmission measures (AMI, heart failure, pneumonia, hip and knee arthroplasty, and stroke). In many cases, these variables included multiple CMS-CCs each.
- b. Next we reviewed all the remaining CMS-CCs and determined on a clinical basis whether they were likely to be relevant to an all-condition measure. We selected 11 additional CMS-CCs to consider. (See Appendix E –Candidate comorbid risk variables for complete set of starter variables).
- c. Using data from the index admission and any admission in the prior 12 months, we ran a standard logistic regression model for every discharge condition category with the full set of candidate risk adjustment variables. We compared odds ratios for different variables across different condition categories (excluding condition categories with fewer than 700 readmissions due to the number of events per variable constraints.<sup>43</sup>) We selected the final set of risk variables based on the following principles:
  - i. We excluded risk variables that were statistically significant for very few condition categories, given that they would not contribute much to the overall models.
  - ii. We excluded risk variables that behaved in clinically incoherent ways. For example, we dropped risk factors that increased risk for some condition categories and decreased risk for others, when we could not identify a clinical rationale for the differences.
  - iii. We excluded risk variables that were predominantly protective when we felt this protective effect was not clinically reasonable but more likely reflected coding factors. For example, drug/alcohol abuse without dependence (CC 53) and delirium and encephalopathy (CC 48) were protective for readmission risk although clinically they should increase patients’ severity of illness. It is possible these variables appeared falsely protective because they were coded more often in healthier patients who had few other comorbidities than in sicker patients who had more competing comorbidities to include in the billing form.
  - iv. Where possible, we combined risk variables that were clinically coherent and carried similar risks across condition categories. For example, we combined coronary artery disease (CCs 83-84) with cerebrovascular disease (CCs 98, 99, and 103).
  - v. We examined risk variables that had been combined in previous CMS publicly reported measures, and in one instance separated them: for cancers, the previous measures generally pool 5 categories of cancers (CCs 8 to 12), together. In our analysis, lung cancer (CC 8) and other severe cancers (CC 9) carried higher risks, so we separated them into a distinct risk variable and grouped other major cancers (CC 10), benign cancers (CC 11), and cancers of the urinary and GI tracts (CC 12)



together. Consistent with other publicly reported measures, we also left metastatic cancer/leukemia (CC 7) as a separate risk variable.

The final list containing 74 CMS-CCs, grouped into 31 risk variables, is shown in Appendix F – Final comorbid risk variables.

#### 2.5.4 Service mix adjustment: condition risk variables

For all condition categories with sufficient volume (defined as those with more than 1,000 admissions nationally each year), we included a condition-specific indicator in the model.

**Rationale:** Condition categories differ in their baseline readmission risks and hospitals will differ in their relative distribution of these condition categories (service mix) within each cohort. Therefore, adjusting for condition categories levels the playing field across hospitals with different service mixes.

## 2.6 Statistical Approach to Measure Development

We used a full year of admission data from 2008, with 12 months history data, to create the specialty cohorts and select risk variables. To assess reliability of the models' performance, we combined 2007 and 2008 data, randomly split this dataset and ran the models on each split sample. We also validated the performance of the models using 2009 data.

### 2.6.1 Models for each cohort of conditions

For model development we used logistic regression models with a logistic link function, with outcome  $Y_i$  for the  $i^{\text{th}}$  patient equal to 1 if the patient was readmitted within 30 days of discharge and 0 otherwise. In contrast with the final models described below for calculating the measure, logistic regression models are substantially less computationally intensive, and development using models with fully specified error structures would have taken prohibitively long. Also, by using logistic regression models, we were able to assess risk factors and model performance without reference to the variation in performance across hospitals.

For our final models we extended the logistic regression models to include an additional error term. That is, due to the natural clustering of observations within hospitals, we used hierarchical logistic regression to model the log-odds of readmission for each of the five cohorts.<sup>44</sup> Readmission within 30 days was modeled as a function of patient-level demographic and clinical characteristics and a random hospital-level intercept. This model specification accounts for within-hospital correlation of the observed outcomes and models the assumption that underlying differences in quality among the health care facilities being evaluated lead to systematic differences in outcomes. We estimated a separate hierarchical logistic regression model for each specialty cohort.

Specifically, for a given specialty cohort, we estimated a hierarchical logistic regression model as follows. Let  $Y_{ij}$  denote the outcome (equal to 1 if patient  $i$  is readmitted within 30 days, zero otherwise) for a patient in cohort  $C \subseteq \{1, \dots, 5$  at hospital  $j$ ;  $\mathbf{Z}_{ij}$  denotes a set of risk factors. Let  $M$  denote the total number of hospitals and  $m_j$  the number of index patient stays in hospital  $j$ . We assume the outcome is related linearly to the covariates via a logit function with dispersion:

$$\text{logit}(\text{Prob}(Y_i = 1)) = \alpha_j + \beta^* \mathbf{Z}_{ij} + \varepsilon_i \quad (1)$$

$$\alpha_j = \mu + \omega_j ; \omega_j \sim N(0, \tau^2)$$

where  $\mathbf{Z}_{ij} = (Z_1, Z_2, \dots, Z_k)$  is a set of  $k$  patient-level covariates.  $\alpha_j$  represents the hospital specific intercept;  $\mu$  is the adjusted average outcome over all hospitals; and  $\tau^2$  is the between hospital variance component and  $\varepsilon \sim N(0, \sigma^2)$  captures any over- or under-dispersion. The hierarchical logistic regression model for each cohort was estimated using the SAS software system (GLIMMIX procedure).

## 2.6.2 Hospital performance reporting

The previous section describes how the models for each specialty cohort are specified and estimated, using a separate hierarchical logistic regression model for that cohort. Each model is then used to calculate a standardized risk ratio (SRR) for each hospital which contributes index admissions to that model. These SRRs, weighted by volume, are then pooled for each hospital to create a composite hospital-wide SRR.

### *Standardized risk ratio for each specialty cohort*

We used the results of each hierarchical logistic regression model to calculate the predicted number of readmissions and the expected number of readmissions at each hospital. The predicted number of readmissions in each cohort was calculated, using the corresponding hierarchical logistic regression model, as the sum of the predicted probability of readmission for each patient, including the hospital-specific (random) effect. The expected number of readmissions in each cohort for each hospital was similarly calculated as the sum of the predicted probability of readmission for each patient, ignoring the hospital specific (random) effect. Using the notation of the previous section, the model specific risk standardized readmission ratio is calculated as follows. To calculate the predicted number of admissions  $\text{pred}_{Cj}$  for index admissions in cohort  $C=1, \dots, 5$  at hospital  $j$ , we used

$$\text{pred}_{Cj} = \sum \text{logit}^{-1}(\alpha_j + \beta^* \mathbf{Z}_{ij}) \quad (2)$$

where the sum is over all  $m_{Cj}$  index admissions in cohort  $C$  with index admissions at hospital  $j$ . To calculate the expected number  $\text{exp}_{Cj}$  we used

$$\text{exp}_{Cj} = \sum \text{logit}^{-1}(\mu + \beta^* \mathbf{Z}_{ij}) \quad (3)$$

Then, as a measure of excess or reduced readmissions among index admissions in cohort  $C$  at hospital  $j$ , we calculated the standardized risk ratio  $\text{SRR}_{Cj}$  as

$$\text{SRR}_{Cj} = \text{pred}_{Cj} / \text{exp}_{Cj} \quad (4)$$

### *Risk-standardized hospital-wide 30-day readmission rate*

To report a single readmission score, the separate specialty cohort SRRs were combined into a single value. We created a single score as follows.

For a given hospital,  $j$ , which has patients in some subset of cohorts  $C \subseteq \{1, \dots, 5\}$ , calculate the SRR as described above for each specialty cohort for which the hospital discharged patients. If the hospital does not have index admissions in a given cohort  $c$ , then  $m_{cj} = 0$  and we take  $\text{SRR}_{cj} = 1$ . Then, calculate the volume-weighted logarithmic mean:



$$SRR_j = \exp( (\sum m_{cj} \log(R_{cj})) / \sum m_{cj} ) \quad (5)$$

where the sums are over all specialty cohorts; note that if a hospital does not have index admissions in a given cohort ( $m_{cj} = 0$ ) then that cohort contributes nothing to the overall score  $SRR_j$ . **This value,  $SRR_j$ , is the hospital-wide standardized risk ratio** for hospital  $j$ . To aid interpretation, this ratio is then multiplied by the overall national raw readmission rate for all index admissions in all cohorts,  $\bar{Y}$ , to produce **the risk-standardized hospital-wide readmission rate (RSRR<sub>j</sub>)**.

$$RSRR_j = SRR_j * \bar{Y} \quad (6)$$

### 2.6.3 Creating interval estimates

Because the statistic described in Equation (5) is a complex function of parameter estimates, we used re-sampling and simulation techniques to derive an interval estimate for the final risk-standardized rate to characterize the uncertainty of the estimate. The bootstrapping simulation has the advantage of avoiding unnecessary distributional assumptions.

#### *Algorithm*

Let  $M$  denote the total number of hospitals in the sample. We repeat steps 1 – 4 below for  $b = 1, 2, \dots, B$  times:

1. Sample  $M$  hospitals with replacement.
2. Fit the five cohort hierarchical logistic regression models using all patients within each sampled hospital. We use as starting values the parameter estimates obtained by fitting the model to all hospitals. If some hospitals are selected more than once in a bootstrapped sample, we treat them as distinct so that we have  $M$  random effects to estimate the variance components. At the conclusion of Step 2, we have:
  - a.  $\beta^{(b)}$ , the vector of coefficients, and the corresponding variance covariance matrix  $\mathbf{V}$ .
  - b.  $\mu^{(b)}$ , the average hospital rate;  $\tau^{2(b)}$ , the between hospital variance, and
  - c. the set of hospital-specific intercepts and corresponding variances;  $\{\alpha_j^{(b)}, \text{var}[\alpha_j^{(b)}] : j = 1, 2, \dots, M\}$
3. We generate a hospital random effect by sampling from the distribution of the hospital-specific distribution obtained in Step 2c. We approximate the distribution for each random effect by a normal distribution. Thus, we draw  $\alpha_j^{(b*)} \sim N(\alpha_j^{(b)}, \text{var}[\alpha_j^{(b)}])$  for the unique set of hospitals sampled in Step 1.
4. Within each unique hospital  $j$  sampled in Step 1, and using index admissions  $i=1, \dots, m_j$  in that hospital, we calculate  $SRR_j^*$  and then  $RSRR_j^*$  as in equations (5) and (6).

Ninety-five percent interval estimates (or alternative interval estimates) for the hospital-standardized outcome can be computed by identifying the 2.5<sup>th</sup> and 97.5<sup>th</sup> percentiles of

randomly half of the B estimates (or the percentiles corresponding to the alternative desired intervals).

### 3. RESULTS

#### 3.1 Risk Variables

As described earlier, we developed five separate models, one for each specialty cohort. Table 9 to Table 13 show the full list of risk variables for each model, including the frequency in the dataset, and the odds ratio with 95% confidence intervals for readmission risk. Results were calculated using logistic regression models. Each table shows results for a single model. Each table contains results from two datasets: one used for development and the other used for validation. We pooled data from 2007 and 2008 and randomly split the dataset into two parts, a development sample and a validation sample. In each table, risk variables whose confidence intervals did not overlap in the development and validation samples are in bold. In general, condition risk variables were much more strongly associated with readmission than comorbidity risk variables.

Table 9 – Medicine model, risk variable frequencies, and odds ratios by sample datasets

	2007-2008 Development Sample N= 3,085,962		2007-2008 Validation Sample N=3,082,357	
Risk variable	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
Age, years	79.1 (8.0) <sup>1</sup>	1.00 (1.00, 1.01)	79.1 (8.0) <sup>1</sup>	1.00 (1.00, 1.01)
Metastatic cancer/acute leukemia	3.67	1.31 (1.29, 1.33)	3.64	1.34 (1.32, 1.36)
Severe Cancer	5.35	1.31 (1.29, 1.33)	5.33	1.30 (1.29, 1.32)
Other major cancers	7.81	1.08 (1.07, 1.09)	7.76	1.09 (1.08, 1.10)
Other hematological disorders	2.88	1.31 (1.29, 1.33)	2.87	1.29 (1.27, 1.31)
Coagulation defects and other specified hematological disorders	4.30	1.12 (1.11, 1.14)	4.31	1.13 (1.12, 1.15)
Iron deficiency	35.28	1.12 (1.12, 1.13)	35.24	1.12 (1.11, 1.13)
End-stage liver disease	1.98	1.33 (1.30, 1.36)	1.96	1.36 (1.33, 1.39)
Pancreatic disease	2.79	1.18 (1.16, 1.20)	2.79	1.16 (1.14, 1.18)
Dialysis status	1.87	1.36 (1.33, 1.38)	1.88	1.37 (1.34, 1.40)
Acute renal failure	18.45	1.20 (1.19, 1.22)	18.40	1.21 (1.20, 1.22)
Transplants	0.51	1.28 (1.24, 1.33)	0.50	1.25 (1.20, 1.29)
Severe Infection	1.38	1.17 (1.15, 1.20)	1.39	1.17 (1.14, 1.19)
Other infectious disease & pneumonias	22.88	<b>1.14 (1.14, 1.15)</b>	22.87	<b>1.15 (1.15, 1.16)</b>
Septicemia/shock	6.02	1.10 (1.09, 1.12)	5.99	1.10 (1.09, 1.11)
CHF	20.18	1.22 (1.21, 1.23)	20.19	1.23 (1.22, 1.24)
Coronary atherosclerosis or angina, cerebrovascular disease	48.71	1.10 (1.09, 1.11)	48.67	1.09 (1.08, 1.10)
Specified arrhythmias	20.00	1.12 (1.11, 1.13)	20.00	1.11 (1.11, 1.12)
Cardiorespiratory failure or cardiorespiratory shock	7.34	1.08 (1.07, 1.10)	7.35	1.10 (1.09, 1.11)
Coronary obstructive pulmonary disease	23.28	<b>1.16 (1.15, 1.17)</b>	23.30	<b>1.17 (1.17, 1.18)</b>
Fibrosis of lung or other chronic lung disorders	2.88	1.10 (1.09, 1.12)	2.86	1.09 (1.08, 1.11)
Protein-calorie malnutrition	8.27	1.17 (1.16, 1.18)	8.30	1.17 (1.16, 1.19)
Disorders of fluid, electrolyte, acid-base	27.56	1.20 (1.19, 1.21)	27.53	1.18 (1.18, 1.19)
Rheumatoid arthritis and inflammatory connective tissue disease	4.19	1.10 (1.09, 1.12)	4.20	1.11 (1.09, 1.12)
Diabetes mellitus	31.10	1.09 (1.08, 1.10)	31.07	1.09 (1.08, 1.10)
Ulcers	6.72	1.18 (1.17, 1.20)	6.73	1.18 (1.17, 1.20)
Hemiplegia, paraplegia, paralysis, functional disability	4.56	1.13 (1.12, 1.15)	4.55	1.13 (1.12, 1.15)
Seizure disorders and convulsions	4.10	1.11 (1.10, 1.13)	4.10	1.11 (1.09, 1.13)

<sup>1</sup> Mean (standard deviation)

		2007-2008 Development Sample N= 3,085,962		2007-2008 Validation Sample N=3,082,357	
Risk variable		% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
Respirator dependence/tracheostomy status		0.34	1.24 (1.19, 1.29)	0.34	1.23 (1.18, 1.29)
Drug and alcohol disorders		2.94	1.10 (1.08, 1.12)	2.92	1.10 (1.08, 1.12)
Psychiatric comorbidity		18.11	1.08 (1.07, 1.09)	18.13	1.08 (1.07, 1.09)
Hip fracture/dislocation		2.90	0.93 (0.92, 0.95)	2.90	0.95 (0.93, 0.96)
<b>Condition indicator (AHRQ CCS)</b>					
93	Conditions associated with dizziness or vertigo	1.06	Reference Group	1.05	Reference Group
159	Urinary tract infections	7.39	2.12 (2.03, 2.21)	7.41	2.04 (1.96, 2.13)
2	Septicemia (except in labor)	7.27	2.28 (2.18, 2.38)	7.29	2.23 (2.13, 2.32)
55	Fluid and electrolyte disorders	5.97	2.20 (2.11, 2.30)	5.96	2.13 (2.04, 2.22)
157	Acute and unspecified renal failure	5.25	2.50 (2.40, 2.61)	5.26	2.44 (2.34, 2.54)
153	Gastrointestinal hemorrhage	4.44	1.91 (1.83, 1.99)	4.43	1.83 (1.75, 1.91)
197	Skin and subcutaneous tissue infections	3.62	1.80 (1.72, 1.88)	3.60	1.78 (1.70, 1.86)
245	Syncope	3.56	1.42 (1.35, 1.48)	3.55	1.36 (1.30, 1.43)
146	Diverticulosis and diverticulitis	2.87	1.80 (1.72, 1.88)	2.88	1.73 (1.66, 1.81)
145	Intestinal obstruction without hernia	2.84	2.08 (1.99, 2.17)	2.85	2.06 (1.97, 2.16)
129	Aspiration pneumonitis; food/vomitus	2.81	2.35 (2.25, 2.46)	2.82	2.32 (2.22, 2.43)
238	Complications of surgical procedures or medical care	2.68	2.09 (2.00, 2.18)	2.66	1.99 (1.90, 2.08)
237	Complication of device; implant or graft	2.61	2.32 (2.22, 2.43)	2.60	2.29 (2.19, 2.40)
59	Deficiency and other anemia	2.51	2.45 (2.35, 2.57)	2.53	2.37 (2.26, 2.47)
50	Diabetes mellitus with complications	2.48	2.08 (1.98, 2.17)	2.46	2.08 (1.99, 2.17)
135	Intestinal infection	2.28	2.59 (2.48, 2.71)	2.30	2.56 (2.45, 2.68)
231	Other fractures	2.21	1.96 (1.87, 2.05)	2.22	1.92 (1.83, 2.01)
99	Hypertension with complications and secondary hypertension	2.20	2.44 (2.33, 2.55)	2.22	2.36 (2.26, 2.47)
205	Spondylosis; intervertebral disc disorders; other back problems	1.59	2.15 (2.05, 2.25)	1.59	2.10 (2.00, 2.20)
118	Phlebitis; thrombophlebitis and thromboembolism	1.54	1.74 (1.65, 1.82)	1.54	1.68 (1.60, 1.76)
155	Other gastrointestinal disorders	1.47	2.32 (2.21, 2.43)	1.47	2.27 (2.17, 2.38)
653	Delirium, dementia, and amnesic and other cognitive disorders	1.45	1.97 (1.88, 2.07)	1.45	1.90 (1.81, 2.00)
133	Other lower respiratory disease	1.21	2.04 (1.94, 2.14)	1.20	2.01 (1.91, 2.11)

		2007-2008 Development Sample N= 3,085,962		2007-2008 Validation Sample N=3,082,357	
Risk variable		% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
154	Noninfectious gastroenteritis	1.15	1.82 (1.73, 1.91)	1.15	1.77 (1.69, 1.87)
152	Pancreatic disorders (not diabetes)	1.14	1.92 (1.82, 2.02)	1.14	1.91 (1.81, 2.00)
138	Esophageal disorders	1.12	1.65 (1.56, 1.73)	1.13	1.70 (1.62, 1.79)
149	Biliary tract disease	1.11	2.04 (1.94, 2.15)	1.10	1.97 (1.87, 2.07)
259	Residual codes; unclassified	1.06	2.07 (1.97, 2.18)	1.04	2.00 (1.90, 2.10)
140	Gastritis and duodenitis	1.02	2.02 (1.92, 2.12)	1.02	1.94 (1.85, 2.04)
130	Pleurisy; pneumothorax; pulmonary collapse	0.94	2.98 (2.84, 3.13)	0.94	2.87 (2.73, 3.02)
251	Abdominal pain	0.93	2.03 (1.92, 2.14)	0.94	1.98 (1.88, 2.09)
211	Other connective tissue disease	0.91	1.88 (1.78, 1.98)	0.90	1.84 (1.75, 1.94)
244	Other injuries and conditions due to external causes	0.69	1.75 (1.65, 1.85)	0.69	1.73 (1.63, 1.83)
151	Other liver diseases	0.68	3.23 (3.06, 3.40)	0.68	3.03 (2.87, 3.19)
98	Essential hypertension	0.63	1.63 (1.54, 1.73)	0.63	1.61 (1.52, 1.71)
207	Pathological fracture	0.62	2.76 (2.62, 2.92)	0.62	2.73 (2.58, 2.88)
239	Superficial injury; contusion	0.59	1.93 (1.82, 2.05)	0.60	1.83 (1.73, 1.94)
141	Other disorders of stomach and duodenum	0.57	2.26 (2.14, 2.39)	0.57	2.28 (2.15, 2.40)
199	Chronic ulcer of skin	0.55	2.25 (2.13, 2.38)	0.55	2.17 (2.05, 2.29)
N/A	Low frequency CCS combined	0.54	2.05 (1.94, 2.17)	0.55	2.00 (1.89, 2.12)
58	Other nutritional; endocrine; and metabolic disorders	0.53	2.38 (2.24, 2.51)	0.54	2.31 (2.18, 2.44)
51	Other endocrine disorders	0.53	2.27 (2.14, 2.40)	0.52	2.25 (2.13, 2.39)
229	Fracture of upper limb	0.51	2.21 (2.08, 2.35)	0.51	2.13 (2.00, 2.26)
252	Malaise and fatigue	0.46	1.97 (1.86, 2.10)	0.45	1.91 (1.80, 2.03)
63	Diseases of white blood cells	0.45	2.41 (2.27, 2.55)	0.45	2.35 (2.22, 2.49)
230	Fracture of lower limb	0.44	1.97 (1.85, 2.10)	0.44	1.92 (1.80, 2.04)
246	Fever of unknown origin	0.44	1.98 (1.86, 2.10)	0.44	1.92 (1.81, 2.04)
7	Viral infection	0.44	1.98 (1.86, 2.10)	0.43	1.95 (1.83, 2.07)
160	Calculus of urinary tract	0.41	1.83 (1.71, 1.95)	0.41	1.84 (1.72, 1.96)
242	Poisoning by other medications and drugs	0.40	1.79 (1.68, 1.91)	0.40	1.71 (1.61, 1.83)
250	Nausea and vomiting	0.37	2.27 (2.14, 2.42)	0.37	2.32 (2.18, 2.47)
204	Other non-traumatic joint disorders	0.37	1.80 (1.68, 1.93)	0.37	1.69 (1.58, 1.81)
163	Genitourinary symptoms and ill-defined conditions	0.36	2.15 (2.02, 2.29)	0.36	2.11 (1.97, 2.25)
661	Substance-related disorders	0.35	2.11 (1.98, 2.25)	0.35	1.97 (1.84, 2.10)

		2007-2008 Development Sample N= 3,085,962		2007-2008 Validation Sample N=3,082,357	
Risk variable		% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
120	Hemorrhoids	0.34	1.70 (1.59, 1.82)	0.34	1.73 (1.62, 1.85)
62	Coagulation and hemorrhagic disorders	0.32	2.95 (2.77, 3.13)	0.33	2.87 (2.70, 3.05)
134	Other upper respiratory disease	0.30	1.99 (1.86, 2.13)	0.30	1.93 (1.80, 2.06)
123	Influenza	0.28	1.51 (1.40, 1.63)	0.29	1.42 (1.31, 1.53)
660	Alcohol-related disorders	0.28	1.78 (1.66, 1.92)	0.28	1.73 (1.60, 1.86)
234	Crushing injury or internal injury	0.27	2.01 (1.87, 2.16)	0.28	1.78 (1.65, 1.92)
201	Infective arthritis and osteomyelitis (except that caused by TB/STD)	0.27	2.31 (2.16, 2.47)	0.27	2.25 (2.10, 2.41)
203	Osteoarthritis	0.26	1.66 (1.54, 1.80)	0.27	1.76 (1.64, 1.90)
144	Regional enteritis and ulcerative colitis	0.26	2.67 (2.49, 2.86)	0.26	2.60 (2.43, 2.79)
139	Gastroduodenal ulcer (except hemorrhage)	0.25	1.88 (1.75, 2.03)	0.24	1.94 (1.80, 2.09)
47	Other and unspecified benign neoplasm	0.25	2.30 (2.14, 2.47)	0.24	2.33 (2.16, 2.50)
161	Other diseases of kidney and ureters	0.25	2.18 (2.03, 2.35)	0.24	2.19 (2.04, 2.36)
4	Mycoses	0.24	2.79 (2.61, 2.98)	0.24	2.82 (2.64, 3.01)
143	Abdominal hernia	0.24	2.63 (2.45, 2.83)	0.24	2.54 (2.36, 2.73)
126	Other upper respiratory infections	0.23	<b>2.22 (1.94, 2.55)</b>	0.23	<b>1.44 (1.33, 1.56)</b>
121	Other diseases of veins and lymphatics	0.23	<b>1.60 (1.47, 1.73)</b>	0.23	<b>1.97 (1.83, 2.12)</b>
232	Sprains and strains	0.22	<b>2.11 (1.96, 2.27)</b>	0.22	<b>1.78 (1.64, 1.93)</b>
60	Acute posthemorrhagic anemia	0.21	<b>1.70 (1.57, 1.84)</b>	0.22	<b>2.24 (2.08, 2.41)</b>
54	Gout and other crystal arthropathies	0.21	<b>2.17 (2.01, 2.34)</b>	0.21	<b>1.82 (1.69, 1.97)</b>
84	Headache; including migraine	0.20	<b>1.92 (1.77, 2.07)</b>	0.19	<b>1.61 (1.48, 1.76)</b>
147	Anal and rectal conditions	0.18	<b>1.51 (1.38, 1.65)</b>	0.17	<b>2.25 (2.08, 2.44)</b>
158	Chronic renal failure	0.17	2.31 (2.13, 2.50)	0.17	2.24 (2.07, 2.42)
212	Other bone disease and musculoskeletal deformities	0.16	<b>2.25 (2.08, 2.43)</b>	0.16	<b>1.68 (1.53, 1.84)</b>
663	Screening and history of mental health and substance abuse codes	0.15	<b>1.93 (1.76, 2.10)</b>	0.15	<b>2.73 (2.52, 2.96)</b>
228	Skull and face fractures	0.14	<b>2.84 (2.62, 3.07)</b>	0.15	<b>1.57 (1.42, 1.73)</b>
165	Inflammatory conditions of male genital organs	0.14	1.65 (1.49, 1.82)	0.14	1.47 (1.32, 1.63)
52	Nutritional deficiencies	0.14	<b>1.37 (1.23, 1.52)</b>	0.13	<b>2.68 (2.46, 2.92)</b>
253	Allergic reactions	0.13	<b>2.82 (2.60, 3.07)</b>	0.13	<b>1.84 (1.67, 2.03)</b>

		2007-2008 Development Sample N= 3,085,962		2007-2008 Validation Sample N=3,082,357	
Risk variable		% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
162	Other diseases or bladder and urethra	0.12	<b>1.82 (1.65, 2.01)</b>	0.13	<b>2.26 (2.06, 2.48)</b>
164	Hyperplasia of prostate	0.12	2.39 (2.18, 2.62)	0.12	2.18 (1.98, 2.39)
48	Thyroid disorders	0.12	2.37 (2.16, 2.60)	0.12	2.30 (2.09, 2.53)
235	Open wounds of head; neck; and trunk	0.12	<b>2.34 (2.13, 2.57)</b>	0.12	<b>1.50 (1.34, 1.66)</b>
148	Peritonitis and intestinal abscess	0.12	<b>1.61 (1.45, 1.79)</b>	0.12	<b>2.71 (2.49, 2.96)</b>
137	Diseases of mouth; excluding dental	0.12	<b>2.75 (2.52, 3.00)</b>	0.12	<b>1.76 (1.59, 1.94)</b>
241	Poisoning by psychotropic agents	0.10	<b>1.89 (1.71, 2.08)</b>	0.10	<b>1.52 (1.35, 1.70)</b>
202	Rheumatoid arthritis and related disease	0.10	<b>1.57 (1.40, 1.76)</b>	0.09	<b>2.06 (1.86, 2.29)</b>
6	Hepatitis	0.09	<b>2.19 (1.98, 2.43)</b>	0.09	<b>2.75 (2.50, 3.04)</b>
236	Open wounds of extremities	0.08	<b>2.84 (2.57, 3.14)</b>	0.08	<b>2.07 (1.84, 2.32)</b>
8	Other infections' including parasitic	0.07	1.92 (1.70, 2.17)	0.08	1.59 (1.40, 1.80)
49	Diabetes mellitus without complication	0.07	1.36 (1.18, 1.56)	0.07	1.73 (1.53, 1.96)
248	Gangrene	0.07	1.82 (1.60, 2.06)	0.07	2.18 (1.95, 2.45)
90	Inflammation' infection of eye (except that caused by TB/STD)	0.07	<b>2.28 (2.05, 2.55)</b>	0.07	<b>1.57 (1.37, 1.80)</b>
198	Other inflammatory condition of skin	0.06	<b>1.75 (1.53, 2.01)</b>	0.07	<b>2.42 (2.15, 2.73)</b>
76	Meningitis (except that caused by TB/STD)	0.06	2.73 (2.43, 3.06)	0.06	2.35 (2.08, 2.66)
132	Lung disease due to external agents	0.06	2.25 (1.99, 2.56)	0.06	2.27 (2.01, 2.56)
136	Disorders of teeth and jaw	0.05	<b>2.36 (2.10, 2.66)</b>	0.05	<b>1.32 (1.12, 1.56)</b>
243	Poisoning by nonmedicinal substances	0.05	1.46 (1.25, 1.71)	0.05	1.24 (1.04, 1.49)
89	Blindness and vision defects	0.05	<b>0.85 (0.70, 1.05)</b>	0.05	<b>1.44 (1.23, 1.70)</b>
210	Systemic lupus erythematosus and connective tissue disorders	0.05	<b>1.35 (1.14, 1.60)</b>	0.05	<b>2.96 (2.61, 3.37)</b>
3	Bacterial infection; unspecified site	0.05	<b>3.00 (2.64, 3.41)</b>	0.05	<b>2.04 (1.76, 2.36)</b>
240	Burns	0.05	2.18 (1.88, 2.53)	0.04	2.09 (1.80, 2.43)
77	Encephalitis (except that caused by TB/STD)	0.05	2.26 (1.96, 2.62)	0.04	2.74 (2.38, 3.15)
91	Other eye disorders	0.04	1.40 (1.17, 1.67)	0.04	1.37 (1.14, 1.64)
175	Other female genital disorders	0.04	2.32 (1.99, 2.70)	0.04	2.04 (1.75, 2.39)
225	Joint disorders and dislocations; trauma-related	0.04	1.56 (1.30, 1.88)	0.04	1.59 (1.33, 1.89)
94	Other ear & sense organ disorders	0.03	1.74 (1.44, 2.11)	0.03	1.41 (1.15, 1.73)



Table 10 – Surgery/gynecology model, risk variable frequencies, and odds ratios by sample datasets

	2007-2008 Development Sample N= 2,208,753		2007-2008 Validation Sample N= 2,208,482	
Risk variable	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
Age, years	75.8 (7.2) <sup>1</sup>	1.02 (1.02, 1.02)	75.8 (7.2) <sup>1</sup>	1.02 (1.02, 1.02)
Metastatic cancer/acute leukemia	3.83	1.30 (1.27, 1.33)	3.83	1.29 (1.26, 1.31)
Severe Cancer	3.13	1.20 (1.17, 1.22)	3.14	1.21 (1.18, 1.23)
Other major cancers	5.58	1.05 (1.03, 1.07)	5.59	1.04 (1.03, 1.06)
Other hematological disorders	0.90	1.36 (1.31, 1.41)	0.90	1.29 (1.24, 1.33)
Coagulation defects and other specified hematological disorders	2.04	1.04 (1.02, 1.07)	2.02	1.07 (1.04, 1.09)
Iron deficiency	29.88	1.16 (1.15, 1.17)	29.87	1.16 (1.15, 1.18)
End-stage liver disease	0.68	1.42 (1.36, 1.48)	0.68	1.40 (1.35, 1.46)
Pancreatic disease	1.56	1.15 (1.12, 1.19)	1.57	1.16 (1.12, 1.19)
Dialysis status	1.06	1.49 (1.44, 1.53)	1.05	1.44 (1.40, 1.49)
Acute renal failure	8.75	1.23 (1.21, 1.25)	8.74	1.22 (1.21, 1.24)
Transplants	0.27	1.56 (1.47, 1.66)	0.27	1.65 (1.55, 1.75)
Severe Infection	0.78	1.20 (1.16, 1.25)	0.76	1.19 (1.15, 1.24)
Other infectious disease & pneumonias	10.72	1.19 (1.17, 1.20)	10.72	1.20 (1.18, 1.21)
Septicemia/shock	2.28	1.01 (0.99, 1.04)	2.29	1.03 (1.01, 1.05)
CHF	10.04	1.23 (1.21, 1.24)	10.06	1.25 (1.23, 1.27)
Coronary atherosclerosis or angina, cerebrovascular disease	41.85	1.10 (1.09, 1.11)	41.81	1.11 (1.10, 1.12)
Specified arrhythmias	12.31	1.12 (1.10, 1.13)	12.29	1.11 (1.10, 1.13)
Cardiorespiratory failure or cardiorespiratory shock	3.64	1.02 (1.00, 1.04)	3.63	1.03 (1.01, 1.05)
Coronary obstructive pulmonary disease	17.73	1.25 (1.24, 1.27)	17.74	1.25 (1.24, 1.26)
Fibrosis of lung or other chronic lung disorders	1.78	1.09 (1.06, 1.12)	1.78	1.12 (1.09, 1.15)
Protein-calorie malnutrition	4.05	1.26 (1.23, 1.28)	4.02	1.23 (1.21, 1.26)
Disorders of fluid, electrolyte, acid-base	13.44	1.11 (1.10, 1.13)	13.41	1.11 (1.10, 1.13)
Rheumatoid arthritis and inflammatory connective tissue disease	3.40	1.15 (1.12, 1.17)	3.43	1.13 (1.11, 1.16)
Diabetes mellitus	25.64	1.13 (1.12, 1.14)	25.63	1.15 (1.14, 1.16)
Ulcers	3.96	<b>1.14 (1.12, 1.16)</b>	3.97	<b>1.10 (1.08, 1.12)</b>
Hemiplegia, paraplegia, paralysis, functional disability	2.37	1.15 (1.13, 1.18)	2.37	1.14 (1.12, 1.17)

<sup>1</sup> Mean (standard deviation)

		2007-2008 Development Sample N= 2,208,753		2007-2008 Validation Sample N= 2,208,482	
Risk variable		% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
Seizure disorders and convulsions		2.00	1.17 (1.14, 1.20)	1.99	1.15 (1.13, 1.18)
Respirator dependence/tracheostomy status		0.11	1.11 (1.01, 1.22)	0.11	1.15 (1.05, 1.26)
Drug and alcohol disorders		1.93	1.19 (1.16, 1.22)	1.94	1.17 (1.14, 1.20)
Psychiatric comorbidity		11.71	1.11 (1.09, 1.12)	11.71	1.10 (1.08, 1.11)
Hip fracture/dislocation		2.02	0.95 (0.93, 0.97)	2.01	0.98 (0.96, 1.01)
<b>Condition indicator (AHRQ CCS)</b>					
170	Prolapse of female genital organs	1.55	Reference Group	1.57	Reference Group
203	Osteoarthritis	14.35	1.50 (1.41, 1.59)	14.40	1.46 (1.38, 1.55)
101	Coronary atherosclerosis and other heart disease	8.60	3.11 (2.92, 3.30)	8.55	2.92 (2.76, 3.10)
226	Fracture of neck or femur (hip)	8.00	3.11 (2.92, 3.30)	7.98	2.99 (2.82, 3.17)
237	Complication of device; implant or graft	4.97	3.51 (3.30, 3.73)	4.97	3.35 (3.16, 3.56)
205	Spondylosis; intervertebral disc disorders; other back problems	4.69	2.11 (1.98, 2.25)	4.70	2.01 (1.89, 2.14)
100	Acute myocardial infarction	3.70	4.31 (4.05, 4.59)	3.70	3.98 (3.74, 4.23)
149	Biliary tract disease	3.06	2.76 (2.59, 2.94)	3.07	2.61 (2.45, 2.78)
110	Occlusion or stenosis of precerebral arteries	2.81	1.79 (1.67, 1.91)	2.80	1.65 (1.54, 1.76)
114	Peripheral and visceral atherosclerosis	2.59	3.54 (3.32, 3.77)	2.60	3.41 (3.20, 3.63)
143	Abdominal hernia	2.05	2.66 (2.49, 2.84)	2.02	2.57 (2.41, 2.74)
230	Fracture of lower limb	1.71	3.12 (2.92, 3.33)	1.72	2.86 (2.68, 3.05)
14	Cancer of colon	1.66	3.08 (2.88, 3.29)	1.69	2.85 (2.67, 3.04)
238	Complications of surgical procedures or medical care	1.55	3.90 (3.65, 4.16)	1.57	3.69 (3.46, 3.93)
115	Aortic; peripheral; and visceral artery aneurysms	1.51	3.36 (3.14, 3.59)	1.50	3.22 (3.02, 3.44)
164	Hyperplasia of prostate	1.42	1.85 (1.72, 1.99)	1.43	1.74 (1.62, 1.87)
96	Heart valve disorders	1.40	5.59 (5.24, 5.97)	1.38	5.34 (5.01, 5.69)
N/A	Low frequency CCS combined	1.36	4.00 (3.74, 4.27)	1.36	3.90 (3.65, 4.16)
47	Other and unspecified benign neoplasm	1.30	2.68 (2.50, 2.88)	1.29	2.55 (2.38, 2.74)
229	Fracture of upper limb	1.24	2.50 (2.33, 2.68)	1.24	2.30 (2.14, 2.47)
207	Pathological fracture	1.22	3.87 (3.62, 4.14)	1.21	3.62 (3.39, 3.86)
106	Cardiac dysrhythmias	1.17	3.62 (3.38, 3.88)	1.17	3.44 (3.22, 3.68)

		2007-2008 Development Sample N= 2,208,753		2007-2008 Validation Sample N= 2,208,482	
Risk variable		% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
145	Intestinal obstruction without hernia	1.17	3.77 (3.52, 4.03)	1.17	3.64 (3.41, 3.90)
29	Cancer of prostate	1.00	1.65 (1.52, 1.80)	1.01	1.64 (1.51, 1.78)
24	Cancer of breast	0.98	1.48 (1.37, 1.61)	0.97	1.40 (1.29, 1.52)
19	Cancer of bronchus; lung	0.96	3.22 (3.00, 3.46)	0.96	3.16 (2.95, 3.39)
2	Septicemia (except in labor)	0.91	5.27 (4.93, 5.64)	0.91	4.98 (4.66, 5.33)
50	Diabetes mellitus with complications	0.90	4.07 (3.80, 4.37)	0.90	3.97 (3.71, 4.26)
42	Secondary malignancies	0.88	3.85 (3.58, 4.13)	0.89	3.89 (3.63, 4.17)
231	Other fractures	0.87	3.55 (3.31, 3.81)	0.88	3.40 (3.17, 3.65)
146	Diverticulosis and diverticulitis	0.79	3.82 (3.56, 4.11)	0.80	3.65 (3.40, 3.92)
32	Cancer of bladder	0.77	4.55 (4.24, 4.88)	0.75	4.32 (4.03, 4.64)
155	Other gastrointestinal disorders	0.69	3.74 (3.48, 4.02)	0.69	3.42 (3.18, 3.67)
109	Acute cerebrovascular disease	0.65	5.02 (4.67, 5.40)	0.65	4.51 (4.20, 4.85)
248	Gangrene	0.65	4.46 (4.16, 4.79)	0.64	4.59 (4.28, 4.93)
142	Appendicitis and other appendiceal conditions	0.65	2.42 (2.23, 2.63)	0.64	2.27 (2.09, 2.47)
108	Congestive heart failure; nonhypertensive	0.56	5.87 (5.47, 6.31)	0.56	5.29 (4.93, 5.67)
212	Other bone disease and musculoskeletal deformities	0.53	2.36 (2.17, 2.57)	0.53	2.28 (2.10, 2.48)
33	Cancer of kidney and renal pelvis	0.52	2.47 (2.27, 2.69)	0.53	2.38 (2.19, 2.59)
209	Other acquired deformities	0.51	2.46 (2.25, 2.68)	0.53	2.30 (2.11, 2.51)
118	Phlebitis; thrombophlebitis and thromboembolism	0.51	4.05 (3.75, 4.37)	0.50	3.94 (3.66, 4.24)
160	Calculus of urinary tract	0.50	3.14 (2.89, 3.41)	0.50	3.08 (2.84, 3.34)
15	Cancer of rectum and anus	0.49	4.41 (4.08, 4.76)	0.48	4.23 (3.92, 4.57)
211	Other connective tissue disease	0.47	1.90 (1.73, 2.09)	0.47	1.90 (1.73, 2.08)
25	Cancer of uterus	0.42	2.84 (2.60, 3.11)	0.43	2.66 (2.43, 2.91)
116	Aortic and peripheral arterial embolism or thrombosis	0.41	4.31 (3.98, 4.66)	0.42	4.25 (3.94, 4.60)
233	Intracranial injury	0.41	4.82 (4.45, 5.21)	0.42	4.60 (4.26, 4.97)
201	Infective arthritis and osteomyelitis (except that caused by TB/STD)	0.41	3.62 (3.34, 3.92)	0.42	3.30 (3.05, 3.58)
152	Pancreatic disorders (not diabetes)	0.39	3.18 (2.92, 3.47)	0.38	3.08 (2.83, 3.35)
103	Pulmonary heart disease	0.37	4.69 (4.33, 5.08)	0.38	4.49 (4.16, 4.86)

		2007-2008 Development Sample N= 2,208,753		2007-2008 Validation Sample N= 2,208,482	
Risk variable		% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
159	Urinary tract infections	0.29	4.82 (4.43, 5.25)	0.28	4.61 (4.24, 5.01)
175	Other female genital disorders	0.28	2.00 (1.79, 2.24)	0.28	1.65 (1.47, 1.86)
147	Anal and rectal conditions	0.27	2.88 (2.61, 3.17)	0.27	2.60 (2.36, 2.87)
81	Other hereditary and degenerative nervous system conditions	0.26	4.26 (3.89, 4.68)	0.26	4.06 (3.70, 4.44)
122	Pneumonia (except caused by TB/STD)	0.26	4.93 (4.53, 5.37)	0.26	4.45 (4.09, 4.85)
157	Acute and unspecified renal failure	0.26	5.66 (5.20, 6.16)	0.26	5.53 (5.09, 6.01)
162	Other diseases of bladder and urethra	0.26	3.15 (2.85, 3.47)	0.25	3.16 (2.87, 3.48)
199	Chronic ulcer of skin	0.24	3.61 (3.30, 3.95)	0.24	3.68 (3.36, 4.03)
117	Other circulatory disease	0.24	3.68 (3.35, 4.04)	0.24	3.55 (3.24, 3.90)
44	Neoplasms of unspecified nature or uncertain behavior	0.24	3.33 (3.01, 3.69)	0.23	3.12 (2.82, 3.45)
197	Skin and subcutaneous tissue infections	0.24	3.33 (3.02, 3.66)	0.23	3.28 (2.99, 3.60)
11	Cancer of head and neck	0.23	3.46 (3.13, 3.81)	0.23	3.43 (3.11, 3.78)
48	Thyroid disorders	0.22	1.05 (0.90, 1.23)	0.23	1.17 (1.01, 1.35)
153	Gastrointestinal hemorrhage	0.22	4.85 (4.43, 5.30)	0.22	4.70 (4.30, 5.14)
204	Other non-traumatic joint disorders	0.21	1.53 (1.34, 1.76)	0.21	1.63 (1.43, 1.86)
130	Pleurisy; pneumothorax; pulmonary collapse	0.20	3.91 (3.55, 4.30)	0.20	3.66 (3.33, 4.02)
38	Non-Hodgkin's lymphoma	0.20	7.18 (6.55, 7.86)	0.19	6.65 (6.08, 7.28)
232	Sprains and strains	0.19	1.49 (1.29, 1.72)	0.19	1.27 (1.10, 1.48)
225	Joint disorders and dislocations; trauma-related	0.19	2.55 (2.27, 2.87)	0.18	2.52 (2.25, 2.83)
27	Cancer of ovary	0.18	3.97 (3.58, 4.41)	0.18	4.44 (4.02, 4.90)
99	Hypertension with complications and secondary hypertension	0.18	5.48 (4.98, 6.02)	0.17	5.01 (4.56, 5.52)
95	Other nervous system disorders	0.18	3.54 (3.18, 3.95)	0.17	3.47 (3.10, 3.87)
17	Cancer of pancreas	0.17	5.44 (4.94, 6.00)	0.17	5.20 (4.72, 5.73)
163	Genitourinary symptoms and ill- defined conditions	0.17	3.41 (3.06, 3.79)	0.17	3.39 (3.05, 3.78)
18	Cancer of other GI organs; peritoneum	0.17	4.64 (4.19, 5.13)	0.17	4.20 (3.80, 4.65)

		2007-2008 Development Sample N= 2,208,753		2007-2008 Validation Sample N= 2,208,482	
Risk variable		% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
13	Cancer of stomach	0.17	4.90 (4.43, 5.41)	0.17	4.60 (4.16, 5.08)
131	Respiratory failure; insufficiency; arrest (adult)	0.17	4.79 (4.34, 5.28)	0.16	4.91 (4.46, 5.40)
97	Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by TB/STD)	0.16	5.11 (4.62, 5.64)	0.16	4.80 (4.35, 5.30)
138	Esophageal disorders	0.16	2.95 (2.62, 3.33)	0.16	2.82 (2.50, 3.17)
133	Other lower respiratory disease	0.16	3.10 (2.76, 3.49)	0.16	2.99 (2.66, 3.35)
161	Other diseases of kidney and ureters	0.15	3.60 (3.22, 4.03)	0.16	3.50 (3.14, 3.91)
58	Other nutritional; endocrine; and metabolic disorders	0.15	2.76 (2.42, 3.14)	0.15	2.56 (2.25, 2.92)
127	Chronic obstructive pulmonary disease and bronchiectasis	0.14	6.20 (5.61, 6.85)	0.14	5.79 (5.24, 6.39)
217	Other congenital anomalies	0.14	2.19 (1.89, 2.53)	0.14	2.05 (1.77, 2.37)
139	Gastroduodenal ulcer (except hemorrhage)	0.13	4.77 (4.27, 5.33)	0.13	4.27 (3.82, 4.77)
35	Cancer of brain and nervous system	0.13	5.34 (4.77, 5.97)	0.13	5.10 (4.56, 5.70)
55	Fluid and electrolyte disorders	0.13	4.61 (4.15, 5.13)	0.13	4.54 (4.08, 5.05)
36	Cancer of thyroid	0.13	1.61 (1.37, 1.90)	0.12	1.62 (1.38, 1.91)
202	Rheumatoid arthritis and related disease	0.10	1.83 (1.53, 2.18)	0.10	1.64 (1.37, 1.97)
23	Other non-epithelial cancer of skin	0.10	2.79 (2.42, 3.21)	0.10	2.32 (2.01, 2.69)
234	Crushing injury or internal injury	0.10	4.43 (3.90, 5.03)	0.10	4.38 (3.87, 4.95)
21	Cancer of bone and connective tissue	0.10	3.74 (3.27, 4.27)	0.10	3.46 (3.03, 3.94)
51	Other endocrine disorders	0.09	2.39 (2.04, 2.81)	0.10	2.19 (1.87, 2.57)
111	Other and ill-defined cerebrovascular disease	0.09	3.02 (2.59, 3.53)	0.09	3.39 (2.93, 3.92)
236	Open wounds or extremities	0.09	2.82 (2.42, 3.29)	0.08	2.31 (1.96, 2.72)
166	Other male genital disorders	0.08	2.37 (2.00, 2.80)	0.08	2.58 (2.20, 3.03)
245	Syncope	0.08	3.07 (2.65, 3.56)	0.08	3.68 (3.21, 4.22)
28	Cancer of other female genital organs	0.08	3.37 (2.90, 3.91)	0.08	3.13 (2.70, 3.63)
172	Ovarian cyst	0.08	1.95 (1.60, 2.38)	0.07	1.45 (1.16, 1.81)
46	Benign neoplasm of uterus	0.07	1.31 (1.02, 1.67)	0.07	1.38 (1.09, 1.75)

		2007-2008 Development Sample N= 2,208,753		2007-2008 Validation Sample N= 2,208,482	
Risk variable		% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
129	Aspiration pneumonitis; food/vomit	0.07	5.82 (5.13, 6.59)	0.07	5.27 (4.65, 5.98)
141	Other disorders of stomach and duodenum	0.07	4.46 (3.89, 5.13)	0.07	4.80 (4.21, 5.47)
134	Other upper respiratory disease	0.07	3.43 (2.93, 4.01)	0.07	2.99 (2.56, 3.49)
59	Deficiency and other anemia	0.07	4.78 (4.17, 5.48)	0.07	4.29 (3.73, 4.93)
228	Skull and face fractures	0.06	2.40 (2.00, 2.89)	0.06	2.35 (1.96, 2.83)
213	Cardiac and circulatory congenital anomalies	0.06	3.90 (3.32, 4.59)	0.06	3.08 (2.59, 3.67)
34	Cancer of other urinary organs	0.06	3.10 (2.62, 3.66)	0.06	3.02 (2.56, 3.56)
144	Regional enteritis and ulcerative colitis	0.06	5.88 (5.09, 6.79)	0.06	5.77 (5.02, 6.64)
121	Other diseases of veins and lymphatics	0.06	3.81 (3.28, 4.42)	0.06	3.22 (2.76, 3.76)
135	Intestinal infection	0.06	6.05 (5.29, 6.92)	0.06	5.62 (4.92, 6.42)
151	Other liver diseases	0.06	6.30 (5.48, 7.25)	0.06	5.90 (5.12, 6.80)
208	Acquired foot deformities	0.06	1.44 (1.12, 1.86)	0.06	1.21 (0.93, 1.58)
244	Other injuries and conditions due to external causes	0.06	3.51 (2.97, 4.16)	0.06	4.16 (3.57, 4.86)
112	Transient cerebral ischemia	0.05	3.82 (3.23, 4.51)	0.06	3.17 (2.67, 3.77)
16	Cancer of liver and intrahepatic bile duct	0.05	4.89 (4.18, 5.71)	0.05	4.21 (3.61, 4.91)
102	Nonspecific chest pain	0.05	3.96 (3.36, 4.67)	0.05	3.14 (2.65, 3.73)
12	Cancer of esophagus	0.05	6.43 (5.54, 7.47)	0.05	5.75 (4.95, 6.68)
173	Menopausal disorders	0.05	1.60 (1.23, 2.08)	0.05	1.53 (1.18, 2.00)
259	Residual codes; unclassified	0.05	3.07 (2.53, 3.72)	0.05	2.60 (2.14, 3.15)
105	Conduction disorders	0.05	3.71 (3.10, 4.45)	0.05	3.55 (2.97, 4.23)
235	Open wounds of head; neck; and trunk	0.04	2.64 (2.15, 3.25)	0.05	2.73 (2.25, 3.32)

Table 11 – Cardiorespiratory model, risk variable frequencies, and odds ratios by sample datasets

Risk variable	2007-2008 Development Sample N= 1,396,562		2007-2008 Validation Sample N= 1,396,855	
	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
Age, years	78.8 (7.9) <sup>1</sup>	1.00 (1.00, 1.00)	78.8 (8.0) <sup>1</sup>	1.00 (1.00, 1.00)
Metastatic cancer/acute leukemia	2.26	1.20 (1.17, 1.24)	2.25	1.21 (1.18, 1.25)
Severe Cancer	5.06	<b>1.21 (1.19, 1.23)</b>	5.11	<b>1.26 (1.23, 1.28)</b>
Other major cancers	4.73	1.04 (1.02, 1.06)	4.73	1.05 (1.03, 1.07)
Other hematological disorders	1.99	1.19 (1.16, 1.23)	1.99	1.17 (1.14, 1.20)
Coagulation defects and other specified hematological disorders	3.99	1.07 (1.05, 1.09)	4.00	1.09 (1.07, 1.11)
Iron deficiency	31.70	1.13 (1.12, 1.14)	31.68	1.12 (1.11, 1.13)
End-stage liver disease	0.95	1.17 (1.12, 1.21)	0.95	1.17 (1.12, 1.22)
Pancreatic disease	2.56	1.14 (1.11, 1.17)	2.55	1.14 (1.11, 1.17)
Dialysis status	1.43	1.29 (1.25, 1.33)	1.43	1.34 (1.30, 1.39)
Acute renal failure	20.15	<b>1.22 (1.20, 1.23)</b>	20.17	<b>1.19 (1.17, 1.20)</b>
Transplants	0.27	1.16 (1.08, 1.25)	0.28	1.16 (1.08, 1.25)
Severe Infection	1.40	1.18 (1.15, 1.22)	1.39	1.20 (1.16, 1.24)
Other infectious disease & pneumonias	33.65	1.10 (1.09, 1.11)	33.70	1.11 (1.10, 1.12)
Septicemia/shock	4.36	1.07 (1.05, 1.09)	4.36	1.06 (1.04, 1.08)
CHF	35.06	1.24 (1.23, 1.26)	35.17	1.25 (1.23, 1.26)
Coronary atherosclerosis or angina, cerebrovascular disease	56.86	1.08 (1.07, 1.10)	56.95	1.10 (1.09, 1.11)
Specified arrhythmias	27.71	1.11 (1.10, 1.12)	27.75	1.12 (1.11, 1.13)
Cardiorespiratory failure or cardiorespiratory shock	15.19	<b>1.17 (1.16, 1.19)</b>	15.22	<b>1.15 (1.14, 1.16)</b>
Coronary obstructive pulmonary disease	47.03	1.22 (1.21, 1.23)	47.09	1.22 (1.20, 1.23)
Fibrosis of lung or other chronic lung disorders	6.95	1.09 (1.07, 1.10)	6.95	1.09 (1.08, 1.11)
Protein-calorie malnutrition	6.60	1.15 (1.13, 1.16)	6.62	1.13 (1.12, 1.15)
Disorders of fluid, electrolyte, acid-base	27.51	1.16 (1.14, 1.17)	27.52	1.16 (1.15, 1.18)
Rheumatoid arthritis and inflammatory connective tissue disease	3.84	1.07 (1.05, 1.09)	3.86	1.08 (1.05, 1.10)
Diabetes mellitus	33.44	1.08 (1.07, 1.09)	33.43	1.09 (1.08, 1.10)
Ulcers	4.78	1.18 (1.16, 1.21)	4.79	1.17 (1.15, 1.19)
Hemiplegia, paraplegia, paralysis, functional disability	3.23	1.11 (1.09, 1.14)	3.26	1.11 (1.09, 1.14)

<sup>1</sup> Mean (standard deviation)

		2007-2008 Development Sample N= 1,396,562		2007-2008 Validation Sample N= 1,396,855	
Risk variable		% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
Seizure disorders and convulsions		3.20	1.14 (1.11, 1.16)	3.19	1.09 (1.07, 1.12)
Respirator dependence/tracheostomy status		0.45	1.25 (1.19, 1.32)	0.46	1.32 (1.25, 1.39)
Drug and alcohol disorders		2.33	1.15 (1.12, 1.18)	2.31	1.12 (1.09, 1.15)
Psychiatric comorbidity		19.41	1.12 (1.10, 1.13)	19.37	1.13 (1.11, 1.14)
Hip fracture/dislocation		2.38	0.90 (0.88, 0.93)	2.38	0.94 (0.91, 0.96)
<b>Condition indicator (AHRQ CCS)</b>					
125	Acute bronchitis	1.71	Reference Group	1.69	Reference Group
108	Congestive heart failure; non-hypertensive	33.28	1.62 (1.55, 1.68)	33.28	1.62 (1.56, 1.69)
122	Pneumonia	29.71	1.24 (1.19, 1.29)	29.64	1.24 (1.19, 1.29)
127	Chronic obstructive pulmonary disease and bronchiectasis	19.67	1.53 (1.47, 1.59)	19.73	1.53 (1.47, 1.59)
131	Respiratory failure; insufficiency; arrest (adult)	8.16	1.50 (1.44, 1.57)	8.17	1.50 (1.44, 1.57)
128	Asthma	4.20	1.34 (1.28, 1.40)	4.19	1.32 (1.26, 1.38)
103	Pulmonary heart disease	3.27	1.21 (1.15, 1.26)	3.29	1.21 (1.15, 1.26)



Table 12 – Cardiovascular model, risk variable frequencies, and odds ratios by sample datasets

	2007-2008 Development Sample N= 860,485		2007-2008 Validation Sample N= 861,925	
Risk variable	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
Age, years	78.2 (7.7) <sup>1</sup>	1.02 (1.01, 1.02)	78.2 (7.7) <sup>1</sup>	1.02 (1.01, 1.02)
Metastatic cancer/acute leukemia	1.44	1.33 (1.27, 1.39)	1.44	1.31 (1.25, 1.37)
Severe Cancer	2.88	1.34 (1.29, 1.38)	2.91	1.36 (1.31, 1.40)
Other major cancers	4.19	1.06 (1.03, 1.10)	4.17	1.06 (1.03, 1.09)
Other hematological disorders	1.29	1.27 (1.21, 1.33)	1.32	1.29 (1.24, 1.35)
Coagulation defects and other specified hematological disorders	2.72	1.06 (1.02, 1.09)	2.74	1.08 (1.05, 1.12)
Iron deficiency	22.09	1.18 (1.16, 1.19)	22.18	1.18 (1.16, 1.19)
End-stage liver disease	0.62	1.36 (1.27, 1.45)	0.62	1.29 (1.21, 1.38)
Pancreatic disease	1.33	1.20 (1.15, 1.25)	1.35	1.18 (1.13, 1.24)
Dialysis status	1.29	1.54 (1.48, 1.61)	1.28	1.59 (1.53, 1.66)
Acute renal failure	13.11	<b>1.21 (1.19, 1.23)</b>	13.03	<b>1.25 (1.23, 1.27)</b>
Transplants	0.23	1.45 (1.30, 1.61)	0.23	1.26 (1.13, 1.41)
Severe Infection	0.64	1.28 (1.21, 1.37)	0.63	1.17 (1.10, 1.25)
Other infectious disease & pneumonias	14.50	1.17 (1.15, 1.19)	14.53	1.17 (1.15, 1.19)
Septicemia/shock	2.31	1.05 (1.01, 1.08)	2.29	1.03 (1.00, 1.07)
CHF	20.41	1.32 (1.30, 1.34)	20.42	1.31 (1.28, 1.33)
Coronary atherosclerosis or angina, cerebrovascular disease	60.31	1.11 (1.09, 1.12)	60.23	1.08 (1.07, 1.10)
Specified arrhythmias	25.46	1.16 (1.14, 1.18)	25.50	1.16 (1.14, 1.18)
Cardiorespiratory failure or cardiorespiratory shock	5.29	1.11 (1.08, 1.14)	5.33	1.08 (1.06, 1.11)
Coronary obstructive pulmonary disease	22.52	1.27 (1.26, 1.29)	22.57	1.28 (1.26, 1.30)
Fibrosis of lung or other chronic lung disorders	2.62	1.15 (1.11, 1.19)	2.61	1.12 (1.08, 1.16)
Protein-calorie malnutrition	2.94	1.16 (1.13, 1.20)	2.98	1.16 (1.12, 1.19)
Disorders of fluid, electrolyte, acid-base	17.67	1.19 (1.17, 1.21)	17.68	1.18 (1.16, 1.20)
Rheumatoid arthritis and inflammatory connective tissue disease	3.46	1.15 (1.12, 1.19)	3.43	1.17 (1.13, 1.20)
Diabetes mellitus	29.87	1.15 (1.14, 1.17)	29.72	1.15 (1.14, 1.17)
Ulcers	2.81	1.22 (1.18, 1.25)	2.83	1.25 (1.21, 1.29)
Hemiplegia, paraplegia, paralysis, functional disability	2.59	1.19 (1.15, 1.23)	2.57	1.20 (1.16, 1.24)

<sup>1</sup> Mean (standard deviation)

		2007-2008 Development Sample N= 860,485		2007-2008 Validation Sample N= 861,925	
Risk variable		% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
Seizure disorders and convulsions		2.45	1.16 (1.12, 1.20)	2.46	1.17 (1.13, 1.21)
Respirator dependence/tracheostomy status		0.10	1.14 (0.98, 1.33)	0.10	1.01 (0.87, 1.18)
Drug and alcohol disorders		1.57	1.25 (1.20, 1.30)	1.55	1.21 (1.16, 1.27)
Psychiatric comorbidity		14.87	1.14 (1.12, 1.16)	14.89	1.15 (1.14, 1.17)
Hip fracture/dislocation		1.51	0.90 (0.86, 0.94)	1.54	0.91 (0.87, 0.95)
<b>Condition indicator (AHRQ CCS)</b>					
102	Nonspecific chest pain	17.80	Reference Group	17.83	Reference Group
106	Cardiac dysrhythmias	36.39	1.53 (1.50, 1.56)	36.37	1.51 (1.48, 1.54)
101	Coronary atherosclerosis and other heart disease	14.47	1.25 (1.22, 1.27)	14.48	1.23 (1.20, 1.26)
100	Acute myocardial infarction	13.56	2.00 (1.95, 2.04)	13.52	1.94 (1.90, 1.99)
117	Other circulatory disease	6.37	1.38 (1.35, 1.42)	6.40	1.37 (1.33, 1.41)
105	Conduction disorders	4.06	1.09 (1.05, 1.13)	4.02	1.06 (1.02, 1.10)
114	Peripheral and visceral atherosclerosis	3.15	1.43 (1.38, 1.49)	3.19	1.39 (1.34, 1.44)
97	Peri-, endo-, and myocarditis; cardiomyopathy (except caused by TB/STD)	1.62	1.94 (1.85, 2.03)	1.61	1.87 (1.79, 1.96)
96	Heart valve disorders	1.13	1.58 (1.50, 1.67)	1.14	1.65 (1.56, 1.74)
115	Aortic; peripheral; and visceral artery aneurysms	0.61	1.48 (1.37, 1.60)	0.61	1.53 (1.42, 1.65)
116	Aortic and peripheral arterial embolism or thrombosis	0.32	1.60 (1.45, 1.77)	0.32	1.49 (1.35, 1.65)
107	Cardiac arrest and ventricular fibrillation	0.24	1.55 (1.38, 1.74)	0.25	1.65 (1.47, 1.84)
104	Other and ill-defined heart disease	0.19	1.44 (1.25, 1.66)	0.19	1.30 (1.12, 1.50)
213	Cardiac and circulatory congenital anomalies	0.08	1.51 (1.22, 1.85)	0.07	1.80 (1.47, 2.19)

Table 13 – Neurology model, risk variable frequencies, and odds ratios by sample datasets

	2007-2008 Development Sample N= 461,225		2007-2008 Validation Sample N= 461,262	
Risk variable	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
Age, years	79.1 (7.8) <sup>1</sup>	1.01 (1.01, 1.01)	79.1 (7.8) <sup>1</sup>	1.01 (1.01, 1.01)
Metastatic cancer/acute leukemia	2.15	1.27 (1.20, 1.34)	2.15	1.25 (1.19, 1.32)
Severe Cancer	3.11	1.31 (1.25, 1.37)	3.05	1.28 (1.22, 1.34)
Other major cancers	4.85	1.11 (1.07, 1.15)	4.87	1.08 (1.04, 1.12)
Other hematological disorders	1.22	1.30 (1.22, 1.38)	1.21	1.30 (1.22, 1.38)
Coagulation defects and other specified hematological disorders	2.53	1.13 (1.08, 1.18)	2.54	1.07 (1.02, 1.12)
Iron deficiency	20.12	1.15 (1.13, 1.18)	20.21	1.18 (1.15, 1.20)
End-stage liver disease	0.72	1.52 (1.40, 1.65)	0.72	1.44 (1.32, 1.56)
Pancreatic disease	1.21	1.10 (1.03, 1.18)	1.19	1.16 (1.09, 1.24)
Dialysis status	1.02	1.51 (1.42, 1.62)	1.02	1.48 (1.38, 1.58)
Acute renal failure	10.44	1.21 (1.18, 1.24)	10.45	1.19 (1.15, 1.22)
Transplants	0.21	1.32 (1.14, 1.53)	0.21	1.37 (1.18, 1.59)
Severe Infection	0.90	1.16 (1.07, 1.25)	0.90	1.15 (1.06, 1.24)
Other infectious disease & pneumonias	13.97	1.16 (1.13, 1.19)	13.94	1.15 (1.12, 1.17)
Septicemia/shock	2.58	1.04 (1.00, 1.09)	2.60	1.08 (1.03, 1.13)
CHF	13.24	1.23 (1.19, 1.26)	13.27	1.23 (1.20, 1.26)
Coronary atherosclerosis or angina, cerebrovascular disease	44.9	1.11 (1.09, 1.13)	44.88	1.10 (1.08, 1.12)
Specified arrhythmias	16.65	1.10 (1.08, 1.13)	16.73	1.11 (1.08, 1.14)
Cardiorespiratory failure or cardiorespiratory shock	4.23	1.04 (1.00, 1.08)	4.29	1.02 (0.98, 1.06)
Coronary obstructive pulmonary disease	16.63	1.16 (1.14, 1.19)	16.68	1.18 (1.15, 1.20)
Fibrosis of lung or other chronic lung disorders	1.79	1.12 (1.05, 1.18)	1.77	1.01 (0.95, 1.07)
Protein-calorie malnutrition	4.52	1.23 (1.19, 1.28)	4.47	1.27 (1.23, 1.32)
Disorders of fluid, electrolyte, acid-base	18.66	1.16 (1.13, 1.18)	18.66	1.14 (1.12, 1.17)
Rheumatoid arthritis and inflammatory connective tissue disease	3.11	1.10 (1.05, 1.15)	3.15	1.10 (1.05, 1.15)
Diabetes mellitus	28.35	1.13 (1.11, 1.16)	28.29	1.14 (1.12, 1.16)
Ulcers	2.72	1.17 (1.12, 1.23)	2.68	1.18 (1.13, 1.23)

<sup>1</sup> Mean (standard deviation)

		2007-2008 Development Sample N= 461,225		2007-2008 Validation Sample N= 461,262	
Risk variable		% of hospitalizations with this risk variable	OR estimate (95% confidence limits)	% of hospitalizations with this risk variable	OR estimate (95% confidence limits)
Hemiplegia, paraplegia, paralysis, functional disability		6.53	1.09 (1.06, 1.12)	6.45	1.14 (1.11, 1.18)
Seizure disorders and convulsions		8.81	1.15 (1.12, 1.19)	8.86	1.12 (1.09, 1.15)
Respirator dependence/tracheostomy status		0.13	1.15 (0.96, 1.39)	0.13	1.25 (1.04, 1.50)
Drug and alcohol disorders		2.58	1.00 (0.95, 1.05)	2.63	1.09 (1.04, 1.14)
Psychiatric comorbidity		17.81	1.05 (1.03, 1.07)	17.83	1.05 (1.03, 1.07)
Hip fracture/dislocation		2.11	0.87 (0.82, 0.92)	2.08	0.89 (0.84, 0.94)
<b>Condition indicator (AHRQ CCS)</b>					
112	Transient cerebral ischemia	18.39	Reference Group	18.41	Reference Group
109	Acute cerebrovascular disease	43.40	1.32 (1.29, 1.35)	43.29	1.34 (1.31, 1.38)
95	Other nervous system disorders	12.06	1.42 (1.38, 1.47)	12.18	1.45 (1.41, 1.50)
83	Epilepsy; convulsions	8.29	1.27 (1.22, 1.31)	8.30	1.24 (1.20, 1.29)
233	Intracranial injury	7.41	1.57 (1.52, 1.63)	7.47	1.51 (1.46, 1.57)
81	Other hereditary and degenerative nervous system conditions	2.19	1.53 (1.45, 1.62)	2.21	1.53 (1.45, 1.62)
110	Occlusion or stenosis of precerebral arteries	1.97	1.23 (1.16, 1.31)	1.98	1.25 (1.18, 1.33)
79	Parkinson's disease	1.47	1.29 (1.20, 1.39)	1.48	1.33 (1.24, 1.43)
113	Late effects of cerebrovascular disease	1.41	1.27 (1.18, 1.36)	1.40	1.28 (1.19, 1.37)
85	Coma; stupor; and brain damage	1.40	1.27 (1.19, 1.37)	1.35	1.26 (1.18, 1.36)
111	Other and ill-defined cerebrovascular disease	1.21	1.04 (0.95, 1.13)	1.18	1.05 (0.97, 1.15)
N/A	Low frequency CCS combined	0.57	1.33 (1.20, 1.49)	0.54	1.57 (1.41, 1.74)
80	Multiple sclerosis	0.22	1.67 (1.41, 1.97)	0.22	1.49 (1.25, 1.78)

### 3.2 Assessment of Risk Adjustment

Table 14 to Table 18 summarize each model's performance. For assessment of risk adjustment, we used two validation samples: one from the split-sample 2007-2008 data as described in Section 3.1, and a second validation sample using data from 2009. The latter dataset allows us to determine how reliable our models are year to year. For each logistic regression model, we computed five summary statistics to assess model performance: calibration (a measure of over-fitting),<sup>6</sup> discrimination in terms of predictive ability, discrimination in terms of c statistic (equivalent to area under the receiver operating curve [ROC]), distribution of residuals, and model chi-square.

Over-fitting refers to the phenomenon in which a model describes the relationship between predictive variables and outcome well in the development dataset, but fails to provide valid predictions in new patients. Since the  $\gamma_0$  in the validation sample is close to zero and the  $\gamma_1$  is close to one in each of the models, there is little evidence of over-fitting.

Discrimination in predictive ability measures the ability to distinguish high-risk subjects from low-risk subjects. Therefore, we would hope to see a wide range between the lowest decile and highest decile, which these models show.

The c statistic is a measure of how accurately a statistical model is able to distinguish between a patient with and without an outcome. For binary outcomes the c statistic is identical to the ROC. A c statistic of 0.50 indicates random prediction, implying all patient risk factors are useless. A c statistic of 1.0 indicates perfect prediction, implying patients' outcomes can be predicted completely by their risk factors, and physicians and hospitals play no role in patients' outcomes. While higher c statistic is desirable, we do not want to maximize it by adjusting for factors that should not be adjusted for. For example, we do not want to include in-hospital complications as a risk factor. The range of c statistic results is 0.613 to 0.675 which is in line with results we have seen for other 30-day readmission measures.

Table 14 – Medicine model performance (logistic regression)

Indices	2007-2008 Development Sample	2007-2008 Validation Sample	2009 Validation Sample
Number of hospital stays	3,085,962	3,082,357	3,032,518
Number of hospitals	4,954	4,946	4,908
Unadjusted readmission rate	18.0%	18.0%	18.1%
Calibration ( $\gamma_0$ , $\gamma_1$ )	(0, 1)	(0.011, 1.006)	(0.132, 1.118)
Discrimination -Predictive Ability (lowest decile %, highest decile %)	9 – 34	9 – 34	7 – 36
Discrimination – c statistic	0.640	0.641	0.663

<sup>6</sup> Over-Fitting Indices ( $\gamma_0$ ,  $\gamma_1$ ) provide evidence of over-fitting and require several steps to calculate. Let  $b$  denote the *estimated vector* of regression coefficients. *Predicted Probabilities* ( $\hat{p}$ ) =  $1/(1+\exp\{-Xb\})$ , and  $Z = Xb$  (e.g., the linear predictor that is a scalar value for everyone). A new logistic regression model that includes only an intercept and a slope by regressing the logits on  $Z$  is fitted in the validation sample; e.g.,  $\text{Logit}(P(Y=1|Z)) = \gamma_0 + \gamma_1 Z$ . Estimated values of  $\gamma_0$  far from 0 and estimated values of  $\gamma_1$  far from 1 provide evidence of over-fitting.

Distribution of residuals (Pearson Residual Fall %)			
<-2	0	0	0
-2 to <0	82.0	82.0	81.8
0 to <2	8.3	8.4	9.2
≥2	9.7	9.7	8.9
Model $\chi^2$ (DF)	111236 (141)	112790 (141)	143908 (141)

Table 15 – Surgical model performance (logistic regression)

Indices	2007-2008 Development Sample	2007-2008 Validation Sample	2009 Validation Sample
Number of hospital stays	2,208,753	2,208,482	2,109,292
Number of hospitals	4,354	4,353	4,232
Unadjusted readmission rate	12.6%	12.6%	12.6%
Calibration ( $\gamma_0$ , $\gamma_1$ )	(0, 1)	(-0.012, 0.995)	(0.104, 1.076)
Discrimination -Predictive Ability (lowest decile %, highest decile %)	4 – 27	4 – 27	3 – 30
Discrimination – c statistic	0.675	0.675	0.699
Distribution of residuals (Pearson Residual Fall %)			
<-2	0	0	0
-2 to <0	87.4	87.4	87.4
0 to <2	3.4	3.3	4.1
≥2	9.3	9.3	8.5
Model $\chi^2$ (DF)	89386 (152)	88937 (152)	109867 (153)

Table 16 – Cardiorespiratory model performance (logistic regression)

Indices	2007-2008 Development Sample	2007-2008 Validation Sample	2009 Validation Sample
Number of hospital stays	1,396,562	1,396,855	1,331,539
Number of hospitals	4,810	4,806	4,718
Unadjusted readmission rate	21.1%	21.2%	21.4%
Calibration ( $\gamma_0$ , $\gamma_1$ )	(0, 1)	(0.010, 1.006)	(0.193, 1.184)
Discrimination -Predictive Ability (lowest decile %, highest decile %)	11 – 37	11 – 37	9 – 40
Discrimination – c statistic	0.630	0.631	0.657
Distribution of residuals (Pearson Residual Fall %)			
<-2	0	0	0
-2 to <0	78.9	78.8	78.6

0 to <2	12.9	13.1	14.0
≥2	8.2	8.1	7.4
Model $\chi^2$ (DF)	48535 (38)	49296 (38)	65048 (38)

Table 17 – Cardiovascular model performance (logistic regression)

Indices	2007-2008 Development Sample	2007-2008 Validation Sample	2009 Validation Sample
Number of hospital stays	860,485	861,925	809,520
Number of hospitals	4,702	4,703	4,641
Unadjusted readmission rate	15.2%	15.2%	15.4%
Calibration ( $\gamma_0$ , $\gamma_1$ )	(0, 1)	(-0.019, 0.993)	(0.145, 1.109)
Discrimination -Predictive Ability (lowest decile %, highest decile %)	5 – 31	6 – 30	5 – 33
Discrimination – c statistic	0.657	0.656	0.680
Distribution of residuals (Pearson Residual Fall %)			
<-2	0	0	0
-2 to <0	84.8	84.8	84.5
0 to <2	5.3	5.2	6.4
≥2	9.9	9.9	9.0
Model $\chi^2$ (DF)	33509 (45)	33155 (45)	41079 (45)

Table 18 – Neurology model performance (logistic regression)

Indices	2007-2008 Development Sample	2007-2008 Validation Sample	2009 Validation Sample
Number of hospital stays	461,225	461,262	452,743
Number of hospitals	4,699	4,686	4,609
Unadjusted readmission rate	14.7%	14.7%	14.6%
Calibration ( $\gamma_0$ , $\gamma_1$ )	(0, 1)	(-0.036, 0.982)	(0.201, 1.163)
Discrimination -Predictive Ability (lowest decile %, highest decile %)	8 – 27	8 – 26	6 – 29
Discrimination – c statistic	0.614	0.613	0.646
Distribution of residuals (Pearson Residual Fall %)			
<-2	0	0	0
-2 to <0	85.3	85.3	85.4
0 to <2	3.4	3.3	4.5
≥2	11.3	11.3	10.1
Model $\chi^2$ (DF)	10248 (44)		15311 (44)

### 3.3 Composite Measure Testing

#### 3.3.1 Number of models per hospital

The HWR measure is a composite score derived from the results of five separate specialty cohort models; however, hospitals need not have index admissions in every specialty cohort to have a composite score (see Section 2.6.2). The SRR for a specialty cohort is not included in the composite score for a hospital if that hospital has no patients in that specialty cohort. In Table 19 we categorize hospitals by the number of cohorts to which they contribute index admissions in the 2007-8 development data. For example, in this dataset, 83.4% of hospitals had at least one index admission in all five specialty cohorts while 1.4% of hospitals had index admissions in only one specialty cohort.

Table 19 – Number of specialty cohorts for which hospitals have at least one index admission

Number of Models for which the Hospital has at Least One Included Patient	Number of Hospitals	Percentage of Hospitals	Cumulative %
5	4,147	83.4%	83.4%
4	493	9.9%	93.2%
3	143	2.9%	96.1%
2	123	2.5%	98.6%
1	72	1.4%	100.0%

#### 3.3.2 Internal consistency of overall composite score

To assess how well the specialty cohort SRRs fit together, we calculated the weighted correlation among the specialty cohort SRRs. If these condition SRRs are relatively homogeneous, measuring a similar underlying factor, the correlation among these SRRs should be high. Our results showed correlation coefficients ranging from 0.35 (neurology and cardiovascular) to 0.65 (medicine and cardiorespiratory), with correlation coefficients among the three largest specialty cohorts all above 0.5. This provided good evidence that there is a consistent underlying factor for readmission risk across all these cohorts. We do not expect perfect correlation since we expect there to be specialty-specific factors contributing to readmission risk.

Table 20 – Weighted correlation among the SRRs for each specialty cohort

Pearson Correlation Coefficients, N = 4147 Prob >  r  under H0: Rho=0					
	Medicine	Surgery/ gynecology	Cardiovascular	Cardiorespiratory	Neurology
Medicine	1.00000	0.60886 <.0001	0.51418 <.0001	0.64592 <.0001	0.52491 <.0001



<b>Pearson Correlation Coefficients, N = 4147</b> <b>Prob &gt;  r  under H0: Rho=0</b>					
	Medicine	Surgery/ gynecology	Cardiovascular	Cardiorespiratory	Neurology
Surgery/ gynecology	0.60886 <.0001	1.00000	0.44109 <.0001	0.53653 <.0001	0.47020 <.0001
Cardiovascular	0.51418 <.0001	0.44109 <.0001	1.00000	0.48269 <.0001	0.34635 <.0001
Cardiorespiratory	0.64592 <.0001	0.53653 <.0001	0.48269 <.0001	1.00000	0.43456 <.0001
Neurology	0.52491 <.0001	0.47020 <.0001	0.34635 <.0001	0.43456 <.0001	1.00000

To assess the overall internal consistency of the specialty cohort SRRs, we calculated Cronbach's coefficient  $\alpha$ . This coefficient reflects the proportion of total variance in the summated scale composite score that is accounted for by a common source among the condition measures. Theoretically  $\alpha$  varies from 0 to 1, since it is the ratio of two variances. Cronbach's  $\alpha$  generally increases as the intercorrelations among components increase, although it is also affected by factors such as the number of contributing items. Therefore, higher values of  $\alpha$  are more desirable. The composite score we derived is a geometric mean, not an arithmetic mean. We used Cronbach's  $\alpha$  as an approximate measure of internal consistency.

Using data from the 4,147 hospitals with index admissions in every specialty cohort, we calculated Cronbach's  $\alpha$  for the global measure to be 0.83, indicating good internal consistency of the condition SRRs.<sup>45</sup>

In addition, we also calculated the correlation between each specialty cohort SRR with the composite SRR (Table 21). In all cases, the correlation of each specialty cohort with the overall score was greater than 0.59.

Table 21 – Correlation of condition SRRs with composite SRRs

<b>Model</b>	<b>Correlation with overall composite score</b>
Medicine	0.914
Surgery	0.818
Cardiorespiratory	0.776
Cardiovascular	0.616
Neurology	0.593

### 3.4 Final Model Results

#### 3.4.1 Distribution of standardized risk ratios

We estimated a separate hierarchical logistic regression model for each specialty cohort, using the development sample, and calculated the SRR as described in Section 2.6.2. Figure 3 shows the distribution of the overall SRR derived from the volume-weighted pooled results of the five specialty cohorts, as well as the distribution of SRRs for each one of the specialty cohorts. These results are also summarized in Table 22.

Figure 3 – Distributions of the overall (pooled) SRR and the SRRs derived from each of the five models

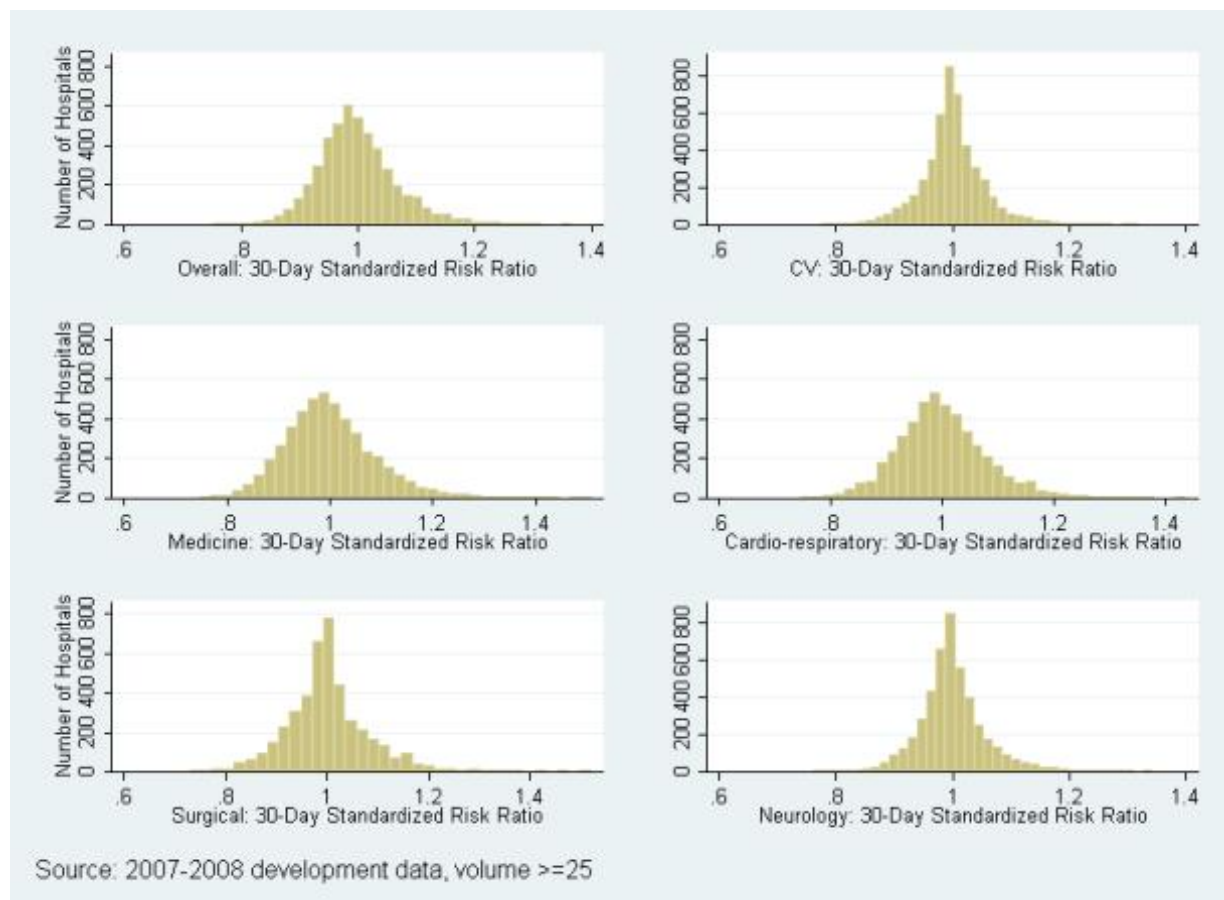


Table 22 – Distribution of standardized risk ratios: hierarchical logistic regression results for the 2007-2008 development sample

	Mean	SD	Min	10 <sup>th</sup> Pctl	Lower Quartile	Median	Upper Quartile	90 <sup>th</sup> Pctl	Max
SRR Combined	1.00	0.07	0.75	0.92	0.96	0.99	1.04	1.09	1.36
SRR Medicine	1.00	0.09	0.75	0.90	0.94	0.99	1.05	1.12	1.51
SRR Surgery	1.00	0.08	0.73	0.91	0.96	1.00	1.04	1.10	1.52
SRR Cardiorespiratory	1.00	0.08	0.75	0.90	0.95	1.00	1.05	1.11	1.44
SRR Cardiovascular	1.00	0.05	0.78	0.94	0.97	1.00	1.03	1.06	1.32

SRR Neurology	1.00	0.06	0.76	0.94	0.97	1.00	1.03	1.07	1.34
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### 3.4.2 Distribution of unadjusted and adjusted readmission rate

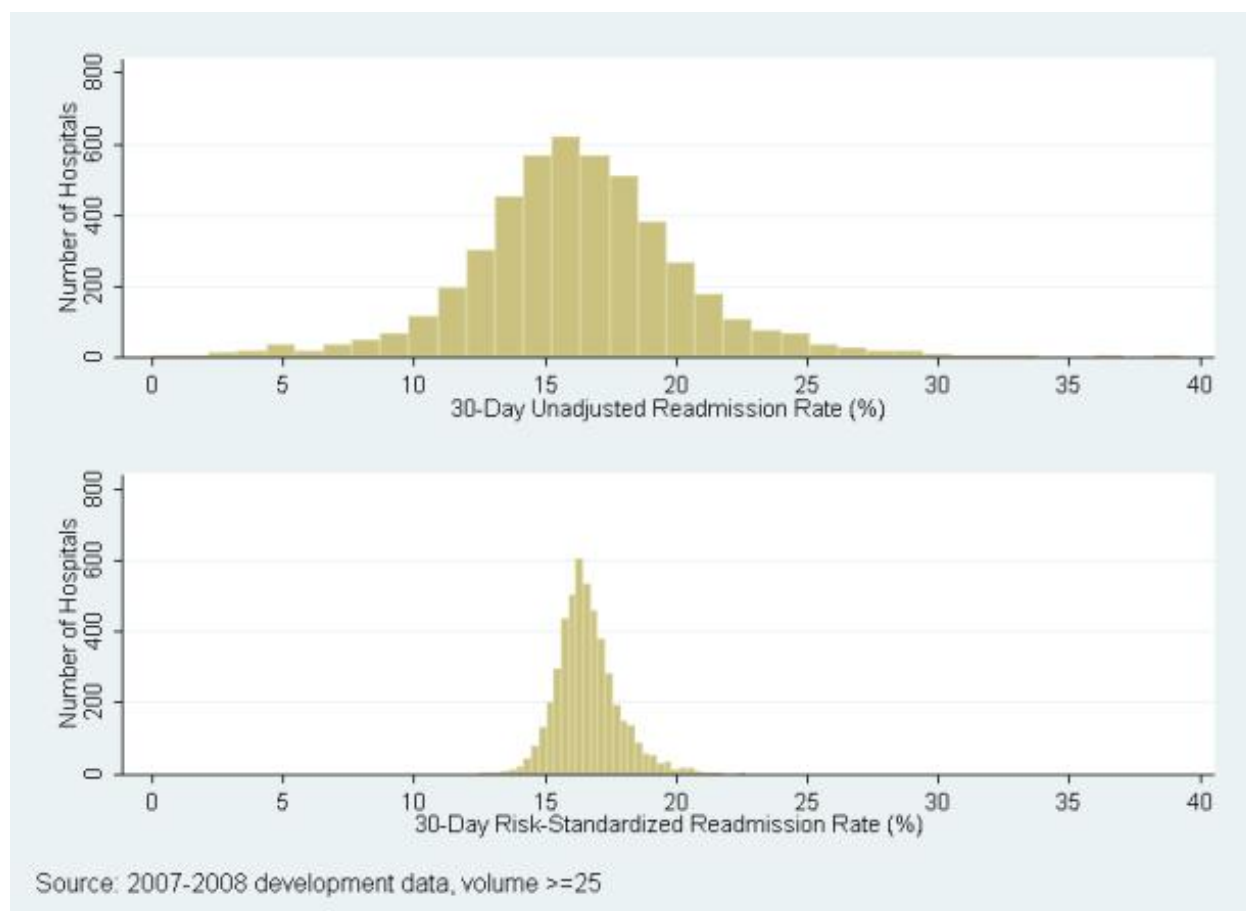
We calculated the frequency distributions of the unadjusted and risk-standardized hospital-level, 30-day readmission rates across the 4742 hospitals with at least 25 index admissions, using the development dataset. We excluded hospitals with fewer than 25 cases total across the five models, since estimates for hospitals with fewer cases are less reliable, and CMS' past approach to public reporting has been not to report these results.

Table 23 and Figure 4 show the distribution of overall unadjusted and RSRRs. The unadjusted readmission rates ranged from 0% to 36.56%, with a median of 16.26% and an interquartile range of 14.01-18.64. The mean  $\pm$  SD hospital unadjusted readmission rate was 16.35%  $\pm$  4.20. The RSRRs had a much narrower range, from 12.58% to 22.76%, with a median of 16.58% and an interquartile range of 15.96-17.30. The mean  $\pm$  SD hospital RSRR was 16.69%  $\pm$  1.15%.

Table 23 – Distribution of unadjusted and adjusted readmission rate, results for the 2007-2008 development sample

Composite readmission rate	Mean	SD	Min	10th Pctl	Lower Quartile	Median	Upper Quartile	90th Pctl	Max
Unadjusted	16.35	4.20	0.00	11.66	14.01	16.26	18.64	21.21	36.56
Risk-standardized	16.69	1.15	12.58	15.39	15.96	16.58	17.30	18.20	22.76

Figure 4 – Distribution of 30-day hospital-wide unadjusted and adjusted readmission rates



### 3.4.3 Test-retest reliability of RSRR

To determine the extent to which assessments of a hospital using different but randomly selected subsets of patients produces similar measures of hospital performance, we calculated the RSRR using each half of the split-sample 2007-2008 data. Thus, we obtain two RSRRs for each hospital, using an entirely distinct set of patients from the same time period. To the extent that the calculated measures of these two subsets agree, we have evidence that the measure is assessing an attribute of the hospital, not of the patients. As a metric of agreement we calculated the intra-class correlation as defined by ICC (2,1) by Shrout and Fleiss (1979).<sup>46</sup> The agreement between the two independent assessments of each hospital was 0.881, which according to the conventional interpretation is “almost perfect.”<sup>47</sup>

## 3.5 Validity testing

### 3.5.1 Validity of risk adjustment approach

Our team has demonstrated for a number of prior measures the validity of claims-based measures for profiling hospitals by comparing either the measure results or individual data elements against the corresponding results and elements from medical records. CMS validated the six NQF-endorsed measures currently in public reporting (AMI, heart failure,

and pneumonia mortality and readmission) with models that used chart-abstracted data for risk-adjustment. Specifically, claims model validation was conducted by building comparable models using abstracted medical chart data for risk adjustment for AMI patients (Cooperative Cardiovascular Project data),<sup>4</sup> heart failure patients (National Heart Failure data),<sup>5,48</sup> and pneumonia patients (National Pneumonia Project dataset).<sup>6</sup> When both models were applied to the same patient population, the hospital risk-standardized rates estimated using the claims-based risk adjustment models had a high level of agreement with the results based on the medical record model, thus supporting the use of the claims-based models for public reporting.

We have also completed two national, multi-site validation efforts for two procedure-based complications measures (for primary elective hip/knee arthroplasty and implantable cardioverter defibrillator [ICD]). Both projects demonstrated strong agreement between complications coded in claims and abstracted medical chart data. These validation efforts suggest that such claims data variables are valid across a variety of conditions.

### 3.5.2 Validity of development process

We developed this measure in consultation with national guidelines for publicly reported outcomes measures, with outside experts, and with the public. The measure is consistent with the technical approach to outcomes measurement set forth in National Quality Forum (NQF) guidance for outcomes measures,<sup>36</sup> CMS Measure Management System guidance, and the guidance articulated in the American Heart Association scientific statement, “Standards for Statistical Models Used for Public Reporting of Health Outcomes.”<sup>3</sup>

### 3.5.3 Construct validity

In order to test the construct validity of the HWR measure, we examined whether hospitals considered “top performers” according to other measures and ranking systems had lower hospital-wide risk-standardized readmission rates than remaining hospitals. This type of validity testing is more relevant than face validity and tests the assumption that hospitals considered top performers have developed an organizational culture of excellence that will manifest itself in better outcomes including lower hospital-wide readmission rates.

However, there are multiple challenges associated with this approach:

1. There are many measures and ranking systems available, using a variety of criteria in order to define and select top performers, including: adherence to core processes of care, complications and safety indexes, resource utilization, outcomes, patient satisfaction, and even reputation. “Top performers” on one measure are not the same as “top performers” on another. Moreover, most of these measures are not themselves validated.
2. In many cases, the methodology for identifying “top performers” is proprietary and not transparent.
3. The starting set of hospitals from which different ranking systems select the top performers usually includes only a subset of all acute care hospitals included in the HWR measure; in most cases it is not possible to replicate this starting set exactly.
4. We have not found a ranking system which specifically measures factors most relevant to readmission risk, such as medication reconciliation, patient education, post-discharge follow up, or communication with outpatient clinicians.

After reviewing ranking systems, we selected the following three to use for construct validity testing, because they are widely used and their methodology is available to the public:

1. HCAHPS survey score (<http://www.hcahpsonline.org/home.aspx>)
2. Thomson Reuters 100 top hospitals (<http://www.100tophospitals.com/top-national-hospitals/>)
3. Joint Commission list of Top Performers on Key Quality Measures ([http://www.jointcommission.org/assets/1/18/Top\\_Performers\\_2010\\_list\\_9\\_13\\_11.pdf](http://www.jointcommission.org/assets/1/18/Top_Performers_2010_list_9_13_11.pdf))

### **Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS)**

From the 27 questions in the HCAHPS survey, we selected seven that we felt were most likely to be correlated with readmission rates, based on clinical judgment and on previously reported results by others.<sup>49</sup> Based on previous results we expected to see that patient satisfaction is significantly correlated with hospital readmission rates. For this analysis, we compared 2009 HCAHPS results to 2009 RSRRs. Table 24 shows the Pearson correlation coefficient between RSRR and the proportion of patients who responded in that given manner to the question. The analysis includes the 3,723 hospitals that publicly report HCAHPS results. The results indicate that all the negative answers were significantly correlated with readmission rates - that is, that lower patient satisfaction is associated with higher RSRR, as expected.

Table 24 – Correlation between RSRR and HCAHPS response (N=3,723 hospitals)

<b>HCAHPS Question</b>	<b>Correlation*</b>
Pain was 'sometimes' or 'never' well controlled	0.34
Patients 'sometimes' or 'never' received help as soon as they wanted	0.34
Nurses 'sometimes' or 'never' communicated well	0.33
'NO' patients would not recommend the hospital	0.32
Patients were 'sometimes' or 'never' given information about what to do during their recovery at home	0.32
Patients who gave a rating of '6' or lower	0.31
Doctors 'sometimes' or 'never' communicated well	0.23

\*p<0.001 for all correlations

### **Thomson Reuters Top 100 Hospitals**

Thomson Reuters annually names 100 Top Hospitals based on facility-wide performance among short-term, acute-care, nonfederal U.S. hospitals. Hospitals do not apply and winners do not pay to market this honor. Critical access hospitals are excluded. Data sources include the MedPAR dataset, the Medicare Cost Report, HCAHPS survey data, core measures from CMS Hospital Compare dataset, the American Medical Association, and the American Osteopathic Association (AOA). The top performers are selected based on a set of measures including:

- Risk-adjusted mortality index
- Risk-adjusted complications index

- Risk-adjusted patient safety index
- Core measures score
- 30-day mortality rate
- 30-day risk-adjusted readmission rate
- Severity-adjusted average length of stay
- Case mix- and wage-adjusted inpatient expense per adjusted discharge
- Profitability (operating profit margin)
- HCAHPS score (patient rating of overall hospital performance)

They also incorporate the direction of performance change over time. Given that this measure includes several elements theoretically related to readmission risk, including complications, patient safety, readmissions, and HCAHPS, we felt this measure was a reasonable candidate for construct validity testing. However, since the measure also contains other components such as core measures, expenses and profitability that would not be expected to correlate with readmission, we expected the analysis to show at best small improvements in readmission performance among top performers. Table 25 shows the RSRRs distribution for the top performers in comparison to the rest of hospitals. The mean RSRR for the top performers is lower than the mean RSRR for hospitals not on the list (16.19 versus 16.65). The magnitude of difference is approximately 0.5%, as we had expected, and in the right direction.

Table 25 – Distribution of RSRR for the Thomson Reuters Top 100 Hospitals versus Others

Top 100 list	N Obs	Mean	Std Dev	Minimum	Lower Quartile	Median	Upper Quartile	Maximum
No	3,017	16.65	1.28	12.51	15.79	16.51	17.35	22.69
Yes	100	16.19	1.39	13.77	15.05	16.06	16.99	19.81

### The Joint Commission's Top Performers on Key Quality Measures program

The Top Performers on Key Quality Measures program recognizes accredited hospitals and critical access hospitals that have consistently superior performance (>95%) on clinical process measures for heart attack, heart failure, pneumonia, surgical care and children's asthma. In 2011, 405 hospitals were recognized, which represent the top 14 percent of Joint Commission accredited hospitals reporting data. Of the Joint Commission's top performers list, we selected only those 158 hospitals with superior performance in *all four* adult measure sets (HWR is for patients 18 years and older), on the assumption that these hospitals demonstrated hospital-wide performance excellence. We calculated their hospital-wide readmission rates and compared them to those of other hospitals.

Numerous studies have shown that there is little relationship between performance on core process measures and outcomes including mortality and readmission rates.<sup>50-55</sup> Therefore we expected the Joint Commission's top performers to have similar risk-standardized readmission rates as other hospitals. The table below shows the distribution of risk-standardized readmission rates of the 158 top performers compared to others. Of the Joint Commission's list of 405 top performers, we selected only those 158 hospitals with superior performance in *all four* adult measure sets (HWR is for patients 18 years and older), on the assumption that these hospitals demonstrated hospital-wide performance excellence. We calculated their hospital-wide readmission rates and compared them to those of other hospitals. See results in Table 26. The mean RSRR for Joint Commission top performing

hospitals was 16.66 versus 16.61 for the remaining hospitals in our measure cohort. The absence of difference was consistent with our *a priori* expectation based on published studies.

Table 26 - Distribution of RSRR for The Joint Commission's Top Performers versus Others

Top Performers List	N Obs	Mean	Std Dev	Minimum	Lower Quartile	Median	Upper Quartile	Maximum
Not in List	4,630	16.61	1.16	12.51	15.87	16.49	17.21	22.69
In List	158	16.66	0.99	14.18	16.01	16.64	17.17	19.91

In summary, these three construct validity analyses demonstrated results consistent with our expectations. There is a significant correlation between patient satisfaction and RSRR as measured by HWR measure. “Top performers” as defined by Thomson Reuters have lower RSRRs as measured by HWR measure. On the other hand, hospitals identified by The Joint Commission as having superior performance on all four categories of clinical process measures have identical performance as those with lower performance, consistent with published studies.



## 4. SUMMARY

In this measure methodology report, we present a measure for 30-day all-cause readmission following hospitalization for any condition that is based on administrative claims data for FFS Medicare beneficiaries 65 years and older. Admissions for medical cancer treatment and for conditions not typically cared for in acute care hospitals are excluded. The measure excludes planned readmissions as an outcome, since they are not a signal of care quality.

The measure is comprised of five hierarchical logistic regression models, each of which includes a specialty cohort consisting of a clinically coherent group of admissions. The measure includes adjustment for case mix (patient comorbidity) and service mix (types of conditions and procedures cared for by the hospital). We excluded covariates that are not appropriate for inclusion in a quality measure such as race, socioeconomic status, and hospital-level factors (e.g., hospital bed size or teaching status). Our approach to model development and risk adjustment is consistent with quality measure methods recommendations for publicly reported outcomes measures from NQF, CMS, and the American Heart Association scientific statement. The hierarchical modeling accounts for hospital case mix and service mix; the clustering of patients within hospitals; and differences in sample size across hospitals, thereby making the measure suitable for public reporting. The measure will also be tested with all-payer data and modified as necessary to apply to the full spectrum of adult hospitalized patients.

This measure includes 93.1% of admissions to acute care non-federal hospitals of Medicare FFS patients over age 65 who are discharged alive to the non-acute care setting. The measure captures 92.1% of readmissions following eligible admissions. A total of 83% of hospitals have admissions in every specialty cohort, and c statistics for performance of each model are consistent with those of models for other publicly reported measures. The overall raw readmission rate is 16.4% (range 0% to 36.6%); our risk-standardized measure has a similar mean of 16.7% but narrows the range to 12.6%-22.8%, indicating adjustment for case mix and service mix. We have tested the measure across multiple years of data and found the results to be consistent. The measure has external validity as demonstrated by correlation with other measures of hospital quality. These characteristics make the measure suitable for public reporting.

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## 6. APPENDIX – TABLES

Appendix A – Top 10 primary discharge diagnoses for each planned procedure

AHRQ CCS (Proc)	AHRQ CCS Procedure Description	AHRQ CCS (Diag)	AHRQ CCS Diagnosis Description	30-Day Readmits	Total Admits	Obs 30-Day Rate
2	Insertion; replacement; or removal of extracranial ventricular shunt		<b>Total</b>	<b>1,203</b>	<b>6,697</b>	<b>18.0%</b>
		81	Other hereditary and degenerative nervous system conditions	629	4,205	15.0%
		237	Complication of device; implant or graft	198	984	20.1%
		109	Acute cerebrovascular disease	173	734	23.6%
		233	Intracranial injury	45	167	26.9%
		42	Secondary malignancies	25	75	33.3%
		47	Other and unspecified benign neoplasm	21	71	29.6%
		238	Complications of surgical procedures or medical care	18	59	30.5%
		95	Other nervous system disorders	12	77	15.6%
		35	Cancer of brain and nervous system	9	43	20.9%
		2	Septicemia (except in labor)	8	24	33.3%
3	Laminectomy; excision intervertebral disc		<b>Total</b>	<b>8,904</b>	<b>103,340</b>	<b>8.6%</b>
		205	Spondylosis; intervertebral disc disorders; other back problems	6,535	85,978	7.6%
		209	Other acquired deformities	462	5,354	8.6%
		217	Other congenital anomalies	130	1,524	8.5%
		237	Complication of device; implant or graft	186	1,308	14.2%
		238	Complications of surgical procedures or medical care	228	1,157	19.7%
		231	Other fractures	129	768	16.8%
		212	Other bone disease and musculoskeletal deformities	109	766	14.2%
		207	Pathological fracture	125	647	19.3%
		81	Other hereditary and degenerative nervous system conditions	149	634	23.5%
		42	Secondary malignancies	131	463	28.3%
10	Thyroidectomy ; partial or complete		<b>Total</b>	<b>802</b>	<b>11,084</b>	<b>7.2%</b>
		48	Thyroid disorders	241	5,121	4.7%
		36	Cancer of thyroid	292	2,848	10.3%
		47	Other and unspecified benign neoplasm	74	1,739	4.3%
		51	Other endocrine disorders	31	354	8.8%
		11	Cancer of head and neck	25	123	20.3%
		42	Secondary malignancies	15	82	18.3%
		38	Non-Hodgkin`s lymphoma	14	66	21.2%
		131	Respiratory failure; insufficiency; arrest (adult)	10	56	17.9%
		2	Septicemia (except in labor)	7	43	16.3%
		101	Coronary atherosclerosis and other heart disease	8	32	25.0%
36	Lobectomy or pneumonectomy		<b>Total</b>	<b>3,883</b>	<b>28,904</b>	<b>13.4%</b>
		19	Cancer of bronchus; lung	2,679	19,827	13.5%
		133	Other lower respiratory disease	274	2,793	9.8%
		42	Secondary malignancies	216	2,075	10.4%
		130	Pleurisy; pneumothorax; pulmonary collapse	154	1,019	15.1%
		122	Pneumonia (except that caused by tuberculosis or sexually transmitted disease)	94	545	17.2%



AHRQ CCS (Proc)	AHRQ CCS Procedure Description	AHRQ CCS (Diag)	AHRQ CCS Diagnosis Description	30-Day Readmits	Total Admits	Obs 30-Day Rate
43	Heart valve procedures	127	Chronic obstructive pulmonary disease and bronchiectasis	64	362	17.7%
		101	Coronary atherosclerosis and other heart disease	36	172	20.9%
		238	Complications of surgical procedures or medical care	30	172	17.4%
		38	Non-Hodgkin's lymphoma	21	148	14.2%
		4	Mycoses	20	131	15.3%
			<b>Total</b>	<b>9,348</b>	<b>41,913</b>	<b>22.3%</b>
		96	Heart valve disorders	6,610	30,925	21.4%
		101	Coronary atherosclerosis and other heart disease	1,018	4,257	23.9%
		100	Acute myocardial infarction	449	1,672	26.9%
		108	Congestive heart failure; nonhypertensive	375	1,313	28.6%
		237	Complication of device; implant or graft	305	1,260	24.2%
		115	Aortic; peripheral; and visceral artery aneurysms	197	813	24.2%
		97	Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transm	120	460	26.1%
		213	Cardiac and circulatory congenital anomalies	60	394	15.2%
		106	Cardiac dysrhythmias	66	246	26.8%
		99	Hypertension with complications and secondary hypertension	22	64	34.4%
44	Coronary artery bypass graft (CABG)		<b>Total</b>	<b>17,449</b>	<b>93,852</b>	<b>18.6%</b>
		101	Coronary atherosclerosis and other heart disease	9,754	58,416	16.7%
		100	Acute myocardial infarction	3,639	17,656	20.6%
		96	Heart valve disorders	2,655	11,993	22.1%
		237	Complication of device; implant or graft	334	1,717	19.5%
		108	Congestive heart failure; nonhypertensive	379	1,247	30.4%
		106	Cardiac dysrhythmias	126	505	25.0%
		115	Aortic; peripheral; and visceral artery aneurysms	121	469	25.8%
		97	Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transm	49	176	27.8%
		238	Complications of surgical procedures or medical care	32	131	24.4%
		114	Peripheral and visceral atherosclerosis	27	80	33.8%
45	Percutaneous transluminal coronary angioplasty (PTCA)		<b>Total</b>	<b>36,600</b>	<b>239,412</b>	<b>15.3%</b>
		101	Coronary atherosclerosis and other heart disease	17,349	133,645	13.0%
		100	Acute myocardial infarction	12,841	72,027	17.8%
		237	Complication of device; implant or graft	2,382	17,465	13.6%
		108	Congestive heart failure; nonhypertensive	1,138	4,091	27.8%
		106	Cardiac dysrhythmias	568	2,775	20.5%
		131	Respiratory failure; insufficiency; arrest (adult)	216	764	28.3%
		2	Septicemia (except in labor)	140	528	26.5%
		127	Chronic obstructive pulmonary disease and bronchiectasis	148	469	31.6%
		122	Pneumonia (except that caused by tuberculosis or sexually transmitted disease)	131	468	28.0%
		99	Hypertension with complications and secondary hypertension	110	468	23.5%

AHRQ CCS (Proc)	AHRQ CCS Procedure Description	AHRQ CCS (Diag)	AHRQ CCS Diagnosis Description	30-Day Readmits	Total Admits	Obs 30-Day Rate
48	Insertion; revision; replacement; removal of cardiac pacemaker or cardioverter/defibrillator		<b>Total</b>	<b>27,971</b>	<b>185,737</b>	<b>15.1%</b>
		106	Cardiac dysrhythmias	10,102	74,614	13.5%
		105	Conduction disorders	3,663	31,993	11.4%
		108	Congestive heart failure; nonhypertensive	3,957	21,542	18.4%
		237	Complication of device; implant or graft	2,012	14,114	14.3%
		101	Coronary atherosclerosis and other heart disease	1,585	11,237	14.1%
		100	Acute myocardial infarction	1,270	5,389	23.6%
		97	Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transm	381	2,954	12.9%
		96	Heart valve disorders	609	2,624	23.2%
		245	Syncope	287	2,174	13.2%
		109	Acute cerebrovascular disease	265	1,466	18.1%
51	Endarterectomy; vessel of head and neck		<b>Total</b>	<b>6,017</b>	<b>59,461</b>	<b>10.1%</b>
		110	Occlusion or stenosis of precerebral arteries	4,940	53,549	9.2%
		109	Acute cerebrovascular disease	326	2,471	13.2%
		101	Coronary atherosclerosis and other heart disease	257	1,212	21.2%
		100	Acute myocardial infarction	65	276	23.6%
		112	Transient cerebral ischemia	30	201	14.9%
		96	Heart valve disorders	54	185	29.2%
		106	Cardiac dysrhythmias	32	148	21.6%
		114	Peripheral and visceral atherosclerosis	25	111	22.5%
		237	Complication of device; implant or graft	15	109	13.8%
		108	Congestive heart failure; nonhypertensive	38	90	42.2%
52	Aortic resection; replacement or anastomosis		<b>Total</b>	<b>3,705</b>	<b>27,182</b>	<b>13.6%</b>
		115	Aortic; peripheral; and visceral artery aneurysms	3,345	25,354	13.2%
		237	Complication of device; implant or graft	137	893	15.3%
		96	Heart valve disorders	36	154	23.4%
		114	Peripheral and visceral atherosclerosis	20	103	19.4%
		101	Coronary atherosclerosis and other heart disease	23	88	26.1%
		238	Complications of surgical procedures or medical care	15	44	34.1%
		100	Acute myocardial infarction	10	39	25.6%
		108	Congestive heart failure; nonhypertensive	10	32	31.3%
		106	Cardiac dysrhythmias	6	25	24.0%
		2	Septicemia (except in labor)	6	23	26.1%
55	Peripheral vascular bypass		<b>Total</b>	<b>6,468</b>	<b>29,739</b>	<b>21.7%</b>
		114	Peripheral and visceral atherosclerosis	2,735	15,179	18.0%
		115	Aortic; peripheral; and visceral artery aneurysms	556	3,117	17.8%
		248	Gangrene	1,042	3,017	34.5%
		237	Complication of device; implant or graft	631	2,647	23.8%
		116	Aortic and peripheral arterial embolism or thrombosis	415	2,144	19.4%
		50	Diabetes mellitus with complications	510	1,614	31.6%
		117	Other circulatory disease	95	425	22.4%
		238	Complications of surgical procedures or medical care	81	314	25.8%
		2	Septicemia (except in labor)	42	125	33.6%
		201	Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted di	28	86	32.6%



AHRQ CCS (Proc)	AHRQ CCS Procedure Description	AHRQ CCS (Diag)	AHRQ CCS Diagnosis Description	30-Day Readmits	Total Admits	Obs 30-Day Rate
60	Embolectomy and endarterectomy of lower limbs		<b>Total</b>	<b>4,229</b>	<b>18,918</b>	<b>22.4%</b>
		114	Peripheral and visceral atherosclerosis	1,447	7,997	18.1%
		116	Aortic and peripheral arterial embolism or thrombosis	796	3,349	23.8%
		237	Complication of device; implant or graft	448	1,854	24.2%
		115	Aortic; peripheral; and visceral artery aneurysms	333	1,848	18.0%
		248	Gangrene	422	1,182	35.7%
		50	Diabetes mellitus with complications	167	522	32.0%
		238	Complications of surgical procedures or medical care	82	405	20.2%
		117	Other circulatory disease	42	200	21.0%
		101	Coronary atherosclerosis and other heart disease	53	198	26.8%
		100	Acute myocardial infarction	54	182	29.7%
64	Bone marrow transplant		<b>Total</b>	<b>268</b>	<b>1,102</b>	<b>24.3%</b>
		40	Multiple myeloma	83	466	17.8%
		38	Non-Hodgkin's lymphoma	85	316	26.9%
		39	Leukemias	58	168	34.5%
		45	Maintenance chemotherapy; radiotherapy	12	37	32.4%
		37	Hodgkin's disease	4	28	14.3%
		44	Neoplasms of unspecified nature or uncertain behavior	13	25	52.0%
		58	Other nutritional; endocrine; and metabolic disorders	4	18	22.2%
		237	Complication of device; implant or graft	2	7	28.6%
		250	Nausea and vomiting	2	2	100.0%
		106	Cardiac dysrhythmias	1	2	50.0%
74	Gastrectomy; partial and total		<b>Total</b>	<b>1,294</b>	<b>6,355</b>	<b>20.4%</b>
		13	Cancer of stomach	590	2,925	20.2%
		12	Cancer of esophagus	93	430	21.6%
		139	Gastroduodenal ulcer (except hemorrhage)	91	413	22.0%
		153	Gastrointestinal hemorrhage	89	338	26.3%
		44	Neoplasms of unspecified nature or uncertain behavior	25	337	7.4%
		141	Other disorders of stomach and duodenum	62	296	20.9%
		47	Other and unspecified benign neoplasm	42	280	15.0%
		238	Complications of surgical procedures or medical care	37	142	26.1%
		17	Cancer of pancreas	34	135	25.2%
		143	Abdominal hernia	24	112	21.4%
75	Small bowel resection		<b>Total</b>	<b>4,697</b>	<b>24,425</b>	<b>19.2%</b>
		145	Intestinal obstruction without hernia	1,212	6,861	17.7%
		143	Abdominal hernia	635	3,722	17.1%
		155	Other gastrointestinal disorders	404	2,074	19.5%
		114	Peripheral and visceral atherosclerosis	327	1,459	22.4%
		14	Cancer of colon	228	1,195	19.1%
		42	Secondary malignancies	256	1,040	24.6%
		146	Diverticulosis and diverticulitis	161	1,038	15.5%
		238	Complications of surgical procedures or medical care	187	829	22.6%
		2	Septicemia (except in labor)	178	635	28.0%
		237	Complication of device; implant or graft	141	603	23.4%
78	Colorectal resection		<b>Total</b>	<b>16,436</b>	<b>102,473</b>	<b>16.0%</b>
		14	Cancer of colon	5,035	36,222	13.9%

AHRQ CCS (Proc)	AHRQ CCS Procedure Description	AHRQ CCS (Diag)	AHRQ CCS Diagnosis Description	30-Day Readmits	Total Admits	Obs 30-Day Rate
		146	Diverticulosis and diverticulitis	2,230	15,600	14.3%
		47	Other and unspecified benign neoplasm	1,075	10,139	10.6%
		15	Cancer of rectum and anus	1,691	9,298	18.2%
		145	Intestinal obstruction without hernia	943	4,634	20.4%
		155	Other gastrointestinal disorders	862	4,629	18.6%
		147	Anal and rectal conditions	313	2,374	13.2%
		114	Peripheral and visceral atherosclerosis	570	2,249	25.3%
		2	Septicemia (except in labor)	500	1,912	26.2%
		238	Complications of surgical procedures or medical care	326	1,677	19.4%
80	Appendectomy		<b>Total</b>	<b>2,894</b>	<b>24,117</b>	<b>12.0%</b>
		142	Appendicitis and other appendiceal conditions	1,285	14,041	9.2%
		145	Intestinal obstruction without hernia	155	1,145	13.5%
		14	Cancer of colon	159	1,113	14.3%
		146	Diverticulosis and diverticulitis	133	1,016	13.1%
		27	Cancer of ovary	122	694	17.6%
		47	Other and unspecified benign neoplasm	69	667	10.3%
		155	Other gastrointestinal disorders	96	592	16.2%
		2	Septicemia (except in labor)	104	520	20.0%
		32	Cancer of bladder	136	511	26.6%
		15	Cancer of rectum and anus	83	484	17.1%
84	Cholecystectomy and common duct exploration		<b>Total</b>	<b>12,476</b>	<b>95,087</b>	<b>13.1%</b>
		149	Biliary tract disease	7,825	67,494	11.6%
		152	Pancreatic disorders (not diabetes)	861	7,090	12.1%
		2	Septicemia (except in labor)	633	3,590	17.6%
		14	Cancer of colon	259	1,876	13.8%
		17	Cancer of pancreas	326	1,436	22.7%
		18	Cancer of other GI organs; peritoneum	252	1,124	22.4%
		42	Secondary malignancies	140	915	15.3%
		145	Intestinal obstruction without hernia	134	843	15.9%
		143	Abdominal hernia	122	762	16.0%
		47	Other and unspecified benign neoplasm	133	722	18.4%
85	Inguinal and femoral hernia repair		<b>Total</b>	<b>2,193</b>	<b>17,933</b>	<b>12.2%</b>
		143	Abdominal hernia	1,588	13,922	11.4%
		238	Complications of surgical procedures or medical care	53	399	13.3%
		29	Cancer of prostate	21	388	5.4%
		145	Intestinal obstruction without hernia	57	290	19.7%
		14	Cancer of colon	23	183	12.6%
		149	Biliary tract disease	22	174	12.6%
		2	Septicemia (except in labor)	31	124	25.0%
		237	Complication of device; implant or graft	20	100	20.0%
		114	Peripheral and visceral atherosclerosis	21	91	23.1%
		32	Cancer of bladder	26	84	31.0%
103	Nephrotomy and nephrostomy		<b>Total</b>	<b>3,089</b>	<b>11,493</b>	<b>26.9%</b>
		160	Calculus of urinary tract	491	2,989	16.4%
		2	Septicemia (except in labor)	421	1,474	28.6%
		157	Acute and unspecified renal failure	438	1,363	32.1%
		161	Other diseases of kidney and ureters	270	1,068	25.3%
		32	Cancer of bladder	301	900	33.4%
		159	Urinary tract infections	168	545	30.8%
		237	Complication of device; implant or graft	127	412	30.8%
		42	Secondary malignancies	118	404	29.2%
		238	Complications of surgical procedures or medical care	108	380	28.4%

AHRQ CCS (Proc)	AHRQ CCS Procedure Description	AHRQ CCS (Diag)	AHRQ CCS Diagnosis Description	30-Day Readmits	Total Admits	Obs 30-Day Rate
104	Nephrectomy; partial or complete	29	Cancer of prostate	60	216	27.8%
			<b>Total</b>	<b>1,766</b>	<b>16,132</b>	<b>10.9%</b>
		33	Cancer of kidney and renal pelvis	1,130	11,079	10.2%
		161	Other diseases of kidney and ureters	98	1,097	8.9%
		47	Other and unspecified benign neoplasm	77	1,060	7.3%
		34	Cancer of other urinary organs	91	826	11.0%
		32	Cancer of bladder	45	208	21.6%
		159	Urinary tract infections	34	179	19.0%
		42	Secondary malignancies	22	158	13.9%
		215	Genitourinary congenital anomalies	19	136	14.0%
105	Kidney transplant	99	Hypertension with complications and secondary hypertension	24	127	18.9%
			<b>Total</b>	<b>551</b>	<b>1,811</b>	<b>30.4%</b>
		237	Complication of device; implant or graft	26	88	29.5%
		99	Hypertension with complications and secondary hypertension	316	1,038	30.4%
		50	Diabetes mellitus with complications	144	445	32.4%
		158	Chronic renal failure	58	200	29.0%
		237	Complication of device; implant or graft	14	49	28.6%
		215	Genitourinary congenital anomalies	7	23	30.4%
		156	Nephritis; nephrosis; renal sclerosis	6	19	31.6%
		151	Other liver diseases	2	8	25.0%
113	Transurethral resection of prostate (TURP)	115	Aortic; peripheral; and visceral artery aneurysms	1	6	16.7%
		117	Other circulatory disease	1	4	25.0%
		157	Acute and unspecified renal failure	1	3	33.3%
			<b>Total</b>	<b>4,237</b>	<b>41,835</b>	<b>10.1%</b>
		164	Hyperplasia of prostate	2,319	28,747	8.1%
		29	Cancer of prostate	440	4,073	10.8%
		32	Cancer of bladder	175	1,362	12.8%
		162	Other diseases of bladder and urethra	93	1,065	8.7%
		160	Calculus of urinary tract	69	846	8.2%
		163	Genitourinary symptoms and ill-defined conditions	131	797	16.4%
114	Open prostatectomy	159	Urinary tract infections	127	583	21.8%
		238	Complications of surgical procedures or medical care	72	548	13.1%
		157	Acute and unspecified renal failure	110	507	21.7%
		2	Septicemia (except in labor)	95	362	26.2%
			<b>Total</b>	<b>1,010</b>	<b>20,783</b>	<b>4.9%</b>
		29	Cancer of prostate	771	18,482	4.2%
		164	Hyperplasia of prostate	137	1,763	7.8%
		32	Cancer of bladder	35	165	21.2%
		162	Other diseases of bladder and urethra	4	36	11.1%
		238	Complications of surgical procedures or medical care	5	31	16.1%
119	Oophorectomy ; unilateral and	160	Calculus of urinary tract	5	29	17.2%
		165	Inflammatory conditions of male genital organs	6	23	26.1%
		163	Genitourinary symptoms and ill-defined conditions	4	18	22.2%
		166	Other male genital disorders	4	18	22.2%
		15	Cancer of rectum and anus	4	15	26.7%
			<b>Total</b>	<b>3,530</b>	<b>35,902</b>	<b>9.8%</b>
		25	Cancer of uterus	940	9,228	10.2%

AHRQ CCS (Proc)	AHRQ CCS Procedure Description	AHRQ CCS (Diag)	AHRQ CCS Diagnosis Description	30-Day Readmits	Total Admits	Obs 30-Day Rate
124	bilateral	170	Prolapse of female genital organs	218	5,648	3.9%
		47	Other and unspecified benign neoplasm	302	4,165	7.3%
		27	Cancer of ovary	697	3,766	18.5%
		175	Other female genital disorders	117	2,009	5.8%
		172	Ovarian cyst	99	1,574	6.3%
		14	Cancer of colon	131	976	13.4%
		146	Diverticulosis and diverticulitis	92	659	14.0%
		18	Cancer of other GI organs; peritoneum	106	495	21.4%
		42	Secondary malignancies	102	491	20.8%
			<b>Total</b>	<b>2,732</b>	<b>35,432</b>	<b>7.7%</b>
	Hysterectomy; abdominal and vaginal	170	Prolapse of female genital organs	430	12,633	3.4%
		25	Cancer of uterus	965	9,479	10.2%
		27	Cancer of ovary	427	2,429	17.6%
		47	Other and unspecified benign neoplasm	137	2,008	6.8%
		175	Other female genital disorders	97	1,960	4.9%
		46	Benign neoplasm of uterus	86	1,660	5.2%
		26	Cancer of cervix	61	699	8.7%
		18	Cancer of other GI organs; peritoneum	67	319	21.0%
		42	Secondary malignancies	52	274	19.0%
		32	Cancer of bladder	56	195	28.7%
145	Treatment; fracture or dislocation of radius and ulna		<b>Total</b>	<b>2,048</b>	<b>18,197</b>	<b>11.3%</b>
		229	Fracture of upper limb	1,146	12,208	9.4%
		226	Fracture of neck of femur (hip)	369	2,325	15.9%
		230	Fracture of lower limb	51	435	11.7%
		231	Other fractures	49	373	13.1%
		233	Intracranial injury	68	367	18.5%
		237	Complication of device; implant or graft	43	326	13.2%
		212	Other bone disease and musculoskeletal deformities	19	206	9.2%
		245	Syncope	29	191	15.2%
		106	Cardiac dysrhythmias	22	119	18.5%
		238	Complications of surgical procedures or medical care	19	98	19.4%
147	Treatment; fracture or dislocation of lower extremity (other than hip or femur)		<b>Total</b>	<b>4,361</b>	<b>34,131</b>	<b>12.8%</b>
		230	Fracture of lower limb	3,223	26,133	12.3%
		237	Complication of device; implant or graft	345	2,302	15.0%
		203	Osteoarthritis	67	953	7.0%
		212	Other bone disease and musculoskeletal deformities	76	766	9.9%
		238	Complications of surgical procedures or medical care	70	426	16.4%
		225	Joint disorders and dislocations; trauma-related	41	351	11.7%
		229	Fracture of upper limb	32	279	11.5%
		207	Pathological fracture	50	277	18.1%
		226	Fracture of neck of femur (hip)	30	231	13.0%
		233	Intracranial injury	26	136	19.1%
148	Other fracture and dislocation procedure		<b>Total</b>	<b>4,064</b>	<b>31,991</b>	<b>12.7%</b>
		229	Fracture of upper limb	1,421	12,285	11.6%
		205	Spondylosis; intervertebral disc disorders; other back problems	448	4,687	9.6%
		237	Complication of device; implant or graft	503	3,957	12.7%
		231	Other fractures	194	1,252	15.5%
		225	Joint disorders and dislocations; trauma-related	152	1,237	12.3%

AHRQ CCS (Proc)	AHRQ CCS Procedure Description	AHRQ CCS (Diag)	AHRQ CCS Diagnosis Description	30-Day Readmits	Total Admits	Obs 30-Day Rate
152	Arthroplasty knee	212	Other bone disease and musculoskeletal deformities	127	1,222	10.4%
		226	Fracture of neck of femur (hip)	207	1,154	17.9%
		207	Pathological fracture	166	809	20.5%
		230	Fracture of lower limb	91	470	19.4%
		238	Complications of surgical procedures or medical care	77	450	17.1%
			<b>Total</b>	<b>15,063</b>	<b>250,228</b>	<b>6.0%</b>
		203	Osteoarthritis	12,785	226,600	5.6%
		237	Complication of device; implant or graft	1,588	16,662	9.5%
		204	Other non-traumatic joint disorders	94	1,749	5.4%
		209	Other acquired deformities	141	1,171	12.0%
		202	Rheumatoid arthritis and related disease	71	982	7.2%
		225	Joint disorders and dislocations; trauma-related	54	666	8.1%
		212	Other bone disease and musculoskeletal deformities	42	603	7.0%
		230	Fracture of lower limb	91	534	17.0%
		238	Complications of surgical procedures or medical care	37	230	16.1%
153	Hip replacement; total and partial	201	Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted di	31	180	17.2%
			<b>Total</b>	<b>20,643</b>	<b>184,630</b>	<b>11.2%</b>
		203	Osteoarthritis	5,349	86,059	6.2%
		226	Fracture of neck of femur (hip)	10,996	68,890	16.0%
		237	Complication of device; implant or graft	2,601	18,074	14.4%
		212	Other bone disease and musculoskeletal deformities	568	5,086	11.2%
		207	Pathological fracture	308	1,838	16.8%
		204	Other non-traumatic joint disorders	57	607	9.4%
		209	Other acquired deformities	62	440	14.1%
		230	Fracture of lower limb	50	285	17.5%
		229	Fracture of upper limb	39	255	15.3%
		231	Other fractures	51	217	23.5%
154	Arthroplasty other than hip or knee		<b>Total</b>	<b>1,669</b>	<b>30,007</b>	<b>5.6%</b>
		203	Osteoarthritis	622	15,818	3.9%
		229	Fracture of upper limb	406	4,817	8.4%
		211	Other connective tissue disease	103	2,093	4.9%
		237	Complication of device; implant or graft	153	1,983	7.7%
		204	Other non-traumatic joint disorders	75	1,491	5.0%
		212	Other bone disease and musculoskeletal deformities	79	914	8.6%
		232	Sprains and strains	35	792	4.4%
		225	Joint disorders and dislocations; trauma-related	34	541	6.3%
		202	Rheumatoid arthritis and related disease	16	381	4.2%
		230	Fracture of lower limb	29	232	12.5%
157	Amputation of lower extremity		<b>Total</b>	<b>10,822</b>	<b>39,698</b>	<b>27.3%</b>
		50	Diabetes mellitus with complications	3,243	12,591	25.8%
		248	Gangrene	3,065	10,053	30.5%
		201	Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted di	515	2,938	17.5%
		114	Peripheral and visceral atherosclerosis	810	2,937	27.6%
		2	Septicemia (except in labor)	621	2,056	30.2%

AHRQ CCS (Proc)	AHRQ CCS Procedure Description	AHRQ CCS (Diag)	AHRQ CCS Diagnosis Description	30-Day Readmits	Total Admits	Obs 30-Day Rate
158	Spinal fusion	238	Complications of surgical procedures or medical care	554	2,052	27.0%
		237	Complication of device; implant or graft	462	1,581	29.2%
		199	Chronic ulcer of skin	177	749	23.6%
		116	Aortic and peripheral arterial embolism or thrombosis	216	642	33.6%
		117	Other circulatory disease	132	387	34.1%
			<b>Total</b>	<b>7,495</b>	<b>74,484</b>	<b>10.1%</b>
		205	Spondylosis; intervertebral disc disorders; other back problems	4,782	52,912	9.0%
		209	Other acquired deformities	853	8,999	9.5%
		217	Other congenital anomalies	224	2,710	8.3%
		237	Complication of device; implant or graft	303	2,413	12.6%
		231	Other fractures	344	2,086	16.5%
		212	Other bone disease and musculoskeletal deformities	206	1,573	13.1%
		207	Pathological fracture	201	919	21.9%
		227	Spinal cord injury	128	660	19.4%
		42	Secondary malignancies	136	536	25.4%
166	Lumpectomy; quadrantectomy of breast	201	Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted diseases)	56	252	22.2%
			<b>Total</b>	<b>483</b>	<b>4,422</b>	<b>10.9%</b>
		24	Cancer of breast	278	3,199	8.7%
		167	Nonmalignant breast conditions	31	207	15.0%
		238	Complications of surgical procedures or medical care	18	181	9.9%
		42	Secondary malignancies	12	61	19.7%
		106	Cardiac dysrhythmias	10	38	26.3%
		108	Congestive heart failure; nonhypertensive	7	26	26.9%
		2	Septicemia (except in labor)	9	18	50.0%
		122	Pneumonia (except that caused by tuberculosis or sexually transmitted disease)	6	17	35.3%
		127	Chronic obstructive pulmonary disease and bronchiectasis	5	17	29.4%
		131	Respiratory failure; insufficiency; arrest (adult)	6	11	54.5%
167	Mastectomy		<b>Total</b>	<b>1,265</b>	<b>19,789</b>	<b>6.4%</b>
		24	Cancer of breast	1,154	18,854	6.1%
		167	Nonmalignant breast conditions	10	178	5.6%
		259	Residual codes; unclassified	6	113	5.3%
		238	Complications of surgical procedures or medical care	10	97	10.3%
		42	Secondary malignancies	11	73	15.1%
		106	Cardiac dysrhythmias	4	20	20.0%
		55	Fluid and electrolyte disorders	4	18	22.2%
		157	Acute and unspecified renal failure	4	7	57.1%
		109	Acute cerebrovascular disease	4	6	66.7%
		103	Pulmonary heart disease	3	5	60.0%
176	Other organ transplantation		<b>Total</b>	<b>232</b>	<b>677</b>	<b>34.3%</b>
		151	Other liver diseases	62	184	33.7%
		133	Other lower respiratory disease	35	101	34.7%
		108	Congestive heart failure; nonhypertensive	18	76	23.7%
		16	Cancer of liver and intrahepatic bile duct	16	64	25.0%
		127	Chronic obstructive pulmonary disease and bronchiectasis	31	56	55.4%



AHRQ CCS (Proc)	AHRQ CCS Procedure Description	AHRQ CCS (Diag)	AHRQ CCS Diagnosis Description	30-Day Readmits	Total Admits	Obs 30-Day Rate
		663	Screening and history of mental health and substance abuse codes	19	48	39.6%
		6	Hepatitis	9	28	32.1%
		101	Coronary atherosclerosis and other heart disease	8	28	28.6%
		237	Complication of device; implant or graft	5	17	29.4%
		149	Biliary tract disease	7	9	77.8%
211	Therapeutic radiology for cancer treatment		<b>Total</b>	<b>7,089</b>	<b>22,957</b>	<b>30.9%</b>
		42	Secondary malignancies	1,572	5,271	29.8%
		19	Cancer of bronchus; lung	798	2,662	30.0%
		45	Maintenance chemotherapy; radiotherapy	743	1,456	51.0%
		29	Cancer of prostate	171	877	19.5%
		55	Fluid and electrolyte disorders	225	631	35.7%
		122	Pneumonia (except that caused by tuberculosis or sexually transmitted disease)	200	598	33.4%
		38	Non-Hodgkin's lymphoma	175	496	35.3%
		95	Other nervous system disorders	145	453	32.0%
		40	Multiple myeloma	144	407	35.4%
		2	Septicemia (except in labor)	143	387	37.0%

**Appendix B – Procedure categories defining the surgery/gynecology cohort (2008 data)**

<b>AHRQ CCS</b>	<b>Description</b>	<b>Number of procedures*</b>	<b>Number of readmissions with this procedure*</b>	<b>Readmission Rate</b>
1	Incision and excision of CNS	28,261	5,753	20.4%
2	Insertion; replacement; or removal of extracranial ventricular shunt	7,270	1,304	17.9%
3	Laminectomy; excision intervertebral disc	79,631	6,619	8.3%
9	Other OR therapeutic nervous system procedures	16,275	2,817	17.3%
10	Thyroidectomy; partial or complete	12,989	862	6.6%
12	Other therapeutic endocrine procedures	10,415	1,340	12.9%
13	Corneal transplant	157	16	10.2%
14	Glaucoma procedures	130	18	13.8%
15	Lens and cataract procedures	633	97	15.3%
16	Repair of retinal tear; detachment	292	33	11.3%
17	Destruction of lesion of retina and choroid	127	9	7.1%
20	Other intraocular therapeutic procedures	1,107	138	12.5%
21	Other extraocular muscle and orbit therapeutic procedures	1,163	150	12.9%
22	Tympanoplasty	140	14	10.0%
23	Myringotomy	450	99	22.0%
24	Mastoidectomy	273	29	10.6%
26	Other therapeutic ear procedures	2,002	263	13.1%
28	Plastic procedures on nose	1,790	213	11.9%
30	Tonsillectomy and/or adenoidectomy	333	43	12.9%
33	Other OR therapeutic procedures on nose; mouth and pharynx	8,040	913	11.4%
36	Lobectomy or pneumonectomy	32,065	4,350	13.6%
42	Other OR Rx procedures on respiratory system and mediastinum	16,452	3,453	21.0%
43	Heart valve procedures	45,477	10,398	22.9%
44	Coronary artery bypass graft (CABG)	82,527	14,548	17.6%
49	Other OR heart procedures	41,585	8,125	19.5%
51	Endarterectomy; vessel of head and neck	63,024	6,288	10.0%
52	Aortic resection; replacement or anastomosis	27,967	3,765	13.5%
53	Varicose vein stripping; lower limb	245	33	13.5%
55	Peripheral vascular bypass	28,972	6,163	21.3%
56	Other vascular bypass and shunt; not heart	2,387	763	32.0%
59	Other OR procedures on vessels of head and neck	14,335	1,771	12.4%
60	Embolectomy and endarterectomy of lower limbs	9,770	2,292	23.5%
61	Other OR procedures on vessels other than head and neck	178,209	37,411	21.0%
66	Procedures on spleen	2,903	548	18.9%



AHRQ CCS	Description	Number of procedures*	Number of readmissions with this procedure*	Readmission Rate
67	Other therapeutic procedures; hemic and lymphatic system	42,288	5,557	13.1%
72	Colostomy; temporary and permanent	10,365	1,970	19.0%
73	Ileostomy and other enterostomy	5,592	1,805	32.3%
74	Gastrectomy; partial and total	6,507	1,305	20.1%
75	Small bowel resection	21,833	4,255	19.5%
78	Colorectal resection	105,467	16,702	15.8%
79	Local excision of large intestine lesion (not endoscopic)	368	50	13.6%
80	Appendectomy	19,326	1,851	9.6%
84	Cholecystectomy and common duct exploration	102,698	13,143	12.8%
85	Inguinal and femoral hernia repair	14,656	1,683	11.5%
86	Other hernia repair	33,253	3,887	11.7%
89	Exploratory laparotomy	2,981	611	20.5%
90	Excision; lysis peritoneal adhesions	36,415	6,278	17.2%
94	Other OR upper GI therapeutic procedures	31,731	4,334	13.7%
96	Other OR lower GI therapeutic procedures	33,387	5,846	17.5%
99	Other OR gastrointestinal therapeutic procedures	29,873	6,478	21.7%
101	Transurethral excision; drainage; or removal urinary obstruction	33,225	6,075	18.3%
103	Nephrotomy and nephrostomy	13,530	3,649	27.0%
104	Nephrectomy; partial or complete	19,504	2,338	12.0%
105	Kidney transplant	10,873	3,175	29.2%
106	Genitourinary incontinence procedures	8,819	351	4.0%
112	Other OR therapeutic procedures of urinary tract	17,650	3,688	20.9%
113	Transurethral resection of prostate (TURP)	42,523	4,259	10.0%
114	Open prostatectomy	23,965	1,158	4.8%
118	Other OR therapeutic procedures; male genital	6,005	835	13.9%
142	Partial excision bone	37,930	5,070	13.4%
143	Bunionectomy or repair of toe deformities	931	84	9.0%
144	Treatment; facial fracture or dislocation	1,968	204	10.4%
145	Treatment; fracture or dislocation of radius and ulna	14,471	1,466	10.1%
146	Treatment; fracture or dislocation of hip and femur	149,336	22,795	15.3%
147	Treatment; fracture or dislocation of lower extremity (other than hip or femur)	39,901	5,000	12.5%
148	Other fracture and dislocation procedure	23,019	2,900	12.6%
150	Division of joint capsule; ligament or cartilage	3,002	230	7.7%
151	Excision of semilunar cartilage of knee	1,381	181	13.1%
152	Arthroplasty knee	292,149	17,995	6.2%
153	Hip replacement; total and partial	207,011	23,096	11.2%
154	Arthroplasty other than hip or knee	32,597	1,772	5.4%

AHRQ CCS	Description	Number of procedures*	Number of readmissions with this procedure*	Readmission Rate
157	Amputation of lower extremity	51,213	13,548	26.5%
158	Spinal fusion	106,703	10,307	9.7%
160	Other therapeutic procedures on muscles and tendons	32,254	4,998	15.5%
161	Other OR therapeutic procedures on bone	29,314	5,611	19.1%
162	Other OR therapeutic procedures on joints	25,661	4,125	16.1%
164	Other OR therapeutic procedures on musculoskeletal system	5,963	1,346	22.6%
166	Lumpectomy; quadrantectomy of breast	2,994	311	10.4%
167	Mastectomy	16,333	1,102	6.7%
172	Skin graft	13,987	2,508	17.9%
175	Other OR therapeutic procedures on skin and breast	6,626	879	13.3%
176	Other organ transplantation	2,483	855	34.4%
119	Oophorectomy; unilateral and bilateral	33,667	2,856	8.5%
120	Other operations on ovary	906	111	12.3%
121	Ligation or occlusion of fallopian tubes	228	13	5.7%
122	Removal of ectopic pregnancy	143	6	4.2%
123	Other operations on fallopian tubes	937	82	8.8%
124	Hysterectomy; abdominal and vaginal	48,236	3,515	7.3%
125	Other excision of cervix and uterus	1,062	131	12.3%
126	Abortion (termination of pregnancy)	39	10	25.6%
127	Dilatation and curettage (D&C); aspiration after delivery or abortion	298	26	8.7%
129	Repair of cystocele and rectocele; obliteration of vaginal vault	14,446	476	3.3%
131	Other non-OR therapeutic procedures; female organs	509	115	22.6%
132	Other OR therapeutic procedures; female organs	13,796	996	7.2%
133	Episiotomy	372	7	1.9%
134	Cesarean section	6,226	280	4.5%
135	Forceps; vacuum; and breech delivery	535	15	2.8%
136	Artificial rupture of membranes to assist delivery	1,510	37	2.5%
137	Other procedures to assist delivery	5,131	162	3.2%
139	Fetal monitoring	1,488	179	12.0%
140	Repair of current obstetric laceration	1,387	38	2.7%
141	Other therapeutic obstetrical procedures	166	10	6.0%

\*Full Medicare data including those <65 years. Not mutually exclusive; multiple procedures may be performed during a single admission

**Appendix C – Condition categories assigned to the specialty cohorts (2008 Data- All inclusion and exclusion criteria applied)**

Model Group	AHRQ CCS	Description	Admits	30 Day Unplanned Readmits	30-Day Unplanned Readm Rate
Medicine	2	Septicemia (except in labor)	236,993	50,554	21.30%
Medicine	159	Urinary tract infections	232,590	41,421	17.80%
Medicine	55	Fluid and electrolyte disorders	178,808	32,670	18.30%
Medicine	157	Acute and unspecified renal failure	163,356	36,226	22.20%
Medicine	153	Gastrointestinal hemorrhage	135,891	22,873	16.80%
Medicine	197	Skin and subcutaneous tissue infections	111,669	17,020	15.20%
Medicine	245	Syncope	107,933	10,924	10.10%
Medicine	129	Aspiration pneumonitis; food/vomitus	88,296	19,311	21.90%
Medicine	145	Intestinal obstruction without hernia	88,193	14,712	16.70%
Medicine	146	Diverticulosis and diverticulitis	85,920	11,864	13.80%
Medicine	237	Complication of device; implant or graft	81,549	18,771	23.00%
Medicine	238	Complications of surgical procedures or medical care	81,398	14,856	18.30%
Medicine	59	Deficiency and other anemia	79,516	17,683	22.20%
Medicine	50	Diabetes mellitus with complications	74,976	14,274	19.00%
Medicine	135	Intestinal infection	70,077	16,192	23.10%
Medicine	231	Other fractures	69,105	10,186	14.70%
Medicine	99	Hypertension with complications and secondary hypertension	67,337	14,808	22.00%
Medicine	118	Phlebitis; thrombophlebitis and thromboembolism	48,254	7,038	14.60%
Medicine	205	Spondylosis; intervertebral disc disorders; other back problems	46,916	7,395	15.80%
Medicine	653	Delirium, dementia, and amnestic and other cognitive disorders	44,266	6,489	14.70%
Medicine	155	Other gastrointestinal disorders	44,151	8,915	20.20%
Medicine	133	Other lower respiratory disease	36,203	6,414	17.70%
Medicine	152	Pancreatic disorders (not diabetes)	34,779	5,378	15.50%
Medicine	149	Biliary tract disease	33,718	5,443	16.10%
Medicine	138	Esophageal disorders	33,354	4,733	14.20%
Medicine	154	Noninfectious gastroenteritis	33,236	4,721	14.20%
Medicine	259	Residual codes; unclassified	32,960	5,853	17.80%
Medicine	93	Conditions associated with dizziness or vertigo	30,934	2,296	7.40%
Medicine	130	Pleurisy; pneumothorax; pulmonary collapse	29,482	7,463	25.30%
Medicine	140	Gastritis and duodenitis	29,329	4,953	16.90%
Medicine	211	Other connective tissue disease	28,565	4,106	14.40%
Medicine	251	Abdominal pain	27,091	4,425	16.30%
Medicine	151	Other liver diseases	20,612	6,282	30.50%
Medicine	244	Other injuries and conditions due to external causes	20,470	3,071	15.00%
Medicine	98	Essential hypertension	18,409	2,104	11.40%
Medicine	207	Pathological fracture	18,040	3,800	21.10%
Medicine	239	Superficial injury; contusion	17,651	2,670	15.10%
Medicine	141	Other disorders of stomach and duodenum	17,168	3,586	20.90%
Medicine	58	Other nutritional; endocrine; and metabolic disorders	16,379	3,394	20.70%

Medicine	199	Chronic ulcer of skin	16,350	3,408	20.80%
Medicine	51	Other endocrine disorders	16,343	3,160	19.30%
Medicine	229	Fracture of upper limb	15,309	2,477	16.20%
Medicine	252	Malaise and fatigue	14,677	2,414	16.40%
Medicine	63	Diseases of white blood cells	14,138	3,387	24.00%
Medicine	123	Influenza	14,096	1,672	11.90%
Medicine	7	Viral infection	13,805	2,178	15.80%
Medicine	230	Fracture of lower limb	13,448	2,039	15.20%
Medicine	246	Fever of unknown origin	13,079	2,304	17.60%
Medicine	242	Poisoning by other medications and drugs	12,394	1,915	15.50%
Medicine	160	Calculus of urinary tract	12,195	1,562	12.80%
Medicine	163	Genitourinary symptoms and ill-defined conditions	11,122	1,933	17.40%
Medicine	661	Substance-related disorders	11,050	1,924	17.40%
Medicine	204	Other non-traumatic joint disorders	10,891	1,556	14.30%
Medicine	250	Nausea and vomiting	10,795	2,148	19.90%
Medicine	120	Hemorrhoids	10,365	1,616	15.60%
Medicine	62	Coagulation and hemorrhagic disorders	9,534	2,477	26.00%
Medicine	134	Other upper respiratory disease	9,068	1,569	17.30%
Medicine	226	Fracture of neck of femur (hip)	8,585	1,303	15.20%
Medicine	660	Alcohol-related disorders	8,578	1,257	14.70%
Medicine	234	Crushing injury or internal injury	8,329	1,216	14.60%
Medicine	201	Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted di	8,105	1,683	20.80%
Medicine	203	Osteoarthritis	7,984	1,049	13.10%
Medicine	144	Regional enteritis and ulcerative colitis	7,954	1,586	19.90%
Medicine	60	Acute posthemorrhagic anemia	7,768	1,577	20.30%
Medicine	4	Mycoses	7,739	2,135	27.60%
Medicine	126	Other upper respiratory infections	7,663	961	12.50%
Medicine	143	Abdominal hernia	7,410	1,397	18.90%
Medicine	139	Gastroduodenal ulcer (except hemorrhage)	7,378	1,105	15.00%
Medicine	47	Other and unspecified benign neoplasm	7,123	1,104	15.50%
Medicine	161	Other diseases of kidney and ureters	7,057	1,299	18.40%
Medicine	121	Other diseases of veins and lymphatics	6,969	1,249	17.90%
Medicine	232	Sprains and strains	6,531	885	13.60%
Medicine	54	Gout and other crystal arthropathies	6,150	995	16.20%
Medicine	84	Headache; including migraine	5,839	677	11.60%
Medicine	147	Anal and rectal conditions	5,116	1,002	19.60%
Medicine	212	Other bone disease and musculoskeletal deformities	4,926	744	15.10%
Medicine	158	Chronic renal failure	4,886	1,186	24.30%
Medicine	228	Skull and face fractures	4,632	587	12.70%
Medicine	663	Screening and history of mental health and substance abuse codes	4,482	1,134	25.30%
Medicine	165	Inflammatory conditions of male genital organs	4,222	465	11.00%
Medicine	52	Nutritional deficiencies	4,003	972	24.30%
Medicine	253	Allergic reactions	3,885	565	14.50%
Medicine	162	Other diseases of bladder and urethra	3,850	698	18.10%
Medicine	137	Diseases of mouth; excluding dental	3,821	609	15.90%
Medicine	164	Hyperplasia of prostate	3,734	675	18.10%
Medicine	148	Peritonitis and intestinal abscess	3,663	896	24.50%

Medicine	48	Thyroid disorders	3,634	663	18.20%
Medicine	235	Open wounds of head; neck; and trunk	3,631	453	12.50%
Medicine	241	Poisoning by psychotropic agents	3,191	406	12.70%
Medicine	6	Hepatitis	3,042	827	27.20%
Medicine	202	Rheumatoid arthritis and related disease	2,806	480	17.10%
Medicine	8	Other infections; including parasitic	2,381	293	12.30%
Medicine	236	Open wounds of extremities	2,253	353	15.70%
Medicine	49	Diabetes mellitus without complication	2,198	308	14.00%
Medicine	198	Other inflammatory condition of skin	2,028	418	20.60%
Medicine	76	Meningitis (except that caused by tuberculosis or sexually transmitted disease)	2,003	332	16.60%
Medicine	248	Gangrene	1,996	435	21.80%
Medicine	90	Inflammation; infection of eye (except that caused by tuberculosis or sexually transmitted disease)	1,994	272	13.60%
Medicine	132	Lung disease due to external agents	1,866	376	20.20%
Medicine	136	Disorders of teeth and jaw	1,602	192	12.00%
Medicine	89	Blindness and vision defects	1,550	163	10.50%
Medicine	210	Systemic lupus erythematosus and connective tissue disorders	1,466	351	23.90%
Medicine	243	Poisoning by nonmedicinal substances	1,424	112	7.90%
Medicine	3	Bacterial infection; unspecified site	1,386	260	18.80%
Medicine	240	Burns	1,373	222	16.20%
Medicine	77	Encephalitis (except that caused by tuberculosis or sexually transmitted disease)	1,361	242	17.80%
Medicine	91	Other eye disorders	1,344	144	10.70%
Medicine	175	Other female genital disorders	1,119	203	18.10%
Medicine	225	Joint disorders and dislocations; trauma-related	1,104	129	11.70%
Medicine	94	Other ear and sense organ disorders	1,005	117	11.60%
Medicine	119	Varicose veins of lower extremity	991	138	13.90%
Medicine	200	Other skin disorders	985	148	15.00%
Medicine	167	Nonmalignant breast conditions	977	123	12.60%
Medicine	257	Other aftercare	894	141	15.80%
Medicine	168	Inflammatory diseases of female pelvic organs	852	137	16.10%
Medicine	87	Retinal detachments; defects; vascular occlusion; and retinopathy	852	83	9.70%
Medicine	142	Appendicitis and other appendiceal conditions	803	98	12.20%
Medicine	209	Other acquired deformities	760	108	14.20%
Medicine	156	Nephritis; nephrosis; renal sclerosis	756	200	26.50%
Medicine	173	Menopausal disorders	748	116	15.50%
Medicine	1	Tuberculosis	735	135	18.40%
Medicine	64	Other hematologic conditions	730	146	20.00%
Medicine	92	Otitis media and related conditions	724	104	14.40%
Medicine	166	Other male genital disorders	714	149	20.90%
Medicine	5	HIV infection	611	175	28.60%
Medicine	247	Lymphadenitis	456	87	19.10%
Medicine	249	Shock	451	109	24.20%
Medicine	9	Sexually transmitted infections (not HIV or hepatitis)	366	55	15.00%
Medicine	258	Other screening for suspected conditions (not mental disorders or infectious disease)	328	41	12.50%

Medicine	217	Other congenital anomalies	312	58	18.60%
Medicine	214	Digestive congenital anomalies	305	49	16.10%
Medicine	170	Prolapse of female genital organs	257	52	20.20%
Medicine	215	Genitourinary congenital anomalies	239	42	17.60%
Medicine	124	Acute and chronic tonsillitis	221	10	4.50%
Medicine	61	Sickle cell anemia	203	49	24.10%
Medicine	57	Immunity disorders	158	54	34.20%
Medicine	206	Osteoporosis	148	22	14.90%
Medicine	10	Immunizations and screening for infectious disease	127	16	12.60%
Medicine	88	Glaucoma	124	20	16.10%
Medicine	172	Ovarian cyst	114	14	12.30%
Medicine	208	Acquired foot deformities	103	17	16.50%
Medicine	46	Benign neoplasm of uterus	102	15	14.70%
Medicine	53	Disorders of lipid metabolism	98	16	16.30%
Medicine	171	Menstrual disorders	68	11	16.20%
Medicine	86	Cataract	37	6	16.20%
Medicine	256	Medical examination/evaluation	30	5	0.00%
Medicine	255	Administrative/social admission	14	2	0.00%
Medicine	56	Cystic fibrosis	14	3	0.00%
Medicine	169	Endometriosis	13	2	0.00%
<b>Medicine</b>		<b>Total</b>	<b>3,086,792</b>	<b>556,131</b>	<b>18.00%</b>
Surgery/gynecology	203	Osteoarthritis	316,437	17,171	5.40%
Surgery/gynecology	101	Coronary atherosclerosis and other heart disease	176,014	20,772	11.80%
Surgery/gynecology	226	Fracture of neck of femur (hip)	174,221	25,570	14.70%
Surgery/gynecology	237	Complication of device; implant or graft	108,171	17,096	15.80%
Surgery/gynecology	205	Spondylosis; intervertebral disc disorders; other back problems	103,542	7,693	7.40%
Surgery/gynecology	100	Acute myocardial infarction	80,208	13,197	16.50%
Surgery/gynecology	149	Biliary tract disease	66,034	7,444	11.30%
Surgery/gynecology	110	Occlusion or stenosis of precerebral arteries	59,540	4,223	7.10%
Surgery/gynecology	114	Peripheral and visceral atherosclerosis	54,232	8,629	15.90%
Surgery/gynecology	143	Abdominal hernia	44,379	4,918	11.10%
Surgery/gynecology	230	Fracture of lower limb	37,222	4,754	12.80%
Surgery/gynecology	14	Cancer of colon	35,852	4,847	13.50%
Surgery/gynecology	238	Complications of surgical procedures or medical care	34,110	6,328	18.60%
Surgery/gynecology	170	Prolapse of female genital organs	32,935	1,085	3.30%
Surgery/gynecology	115	Aortic; peripheral; and visceral artery aneurysms	32,714	4,300	13.10%
Surgery/gynecology	96	Heart valve disorders	31,286	6,631	21.20%
Surgery/gynecology	164	Hyperplasia of prostate	30,171	2,245	7.40%
Surgery/gynecology	47	Other and unspecified benign neoplasm	27,845	2,704	9.70%
Surgery/gynecology	229	Fracture of upper limb	27,214	2,687	9.90%
Surgery/gynecology	106	Cardiac dysrhythmias	26,198	4,055	15.50%
Surgery/gynecology	145	Intestinal obstruction without hernia	25,829	4,152	16.10%
Surgery/gynecology	207	Pathological fracture	25,176	4,305	17.10%
Surgery/gynecology	19	Cancer of bronchus; lung	21,281	2,981	14.00%
Surgery/gynecology	2	Septicemia (except in labor)	21,158	5,327	25.20%
Surgery/gynecology	29	Cancer of prostate	21,069	1,207	5.70%
Surgery/gynecology	24	Cancer of breast	20,936	1,224	5.80%
Surgery/gynecology	50	Diabetes mellitus with complications	19,556	4,311	22.00%
Surgery/gynecology	42	Secondary malignancies	19,132	3,352	17.50%
Surgery/gynecology	231	Other fractures	18,928	2,983	15.80%



Surgery/gynecology	146	Diverticulosis and diverticulitis	17,044	2,475	14.50%
Surgery/gynecology	32	Cancer of bladder	16,392	3,142	19.20%
Surgery/gynecology	155	Other gastrointestinal disorders	15,109	2,489	16.50%
Surgery/gynecology	109	Acute cerebrovascular disease	14,296	2,688	18.80%
Surgery/gynecology	142	Appendicitis and other appendiceal conditions	13,863	1,194	8.60%
Surgery/gynecology	248	Gangrene	13,724	3,593	26.20%
Surgery/gynecology	209	Other acquired deformities	11,837	1,093	9.20%
Surgery/gynecology	108	Congestive heart failure; nonhypertensive	11,641	3,294	28.30%
Surgery/gynecology	33	Cancer of kidney and renal pelvis	11,385	1,125	9.90%
Surgery/gynecology	212	Other bone disease and musculoskeletal deformities	11,331	1,155	10.20%
Surgery/gynecology	118	Phlebitis; thrombophlebitis and thromboembolism	11,273	2,297	20.40%
Surgery/gynecology	160	Calculus of urinary tract	11,052	1,334	12.10%
Surgery/gynecology	15	Cancer of rectum and anus	10,360	1,794	17.30%
Surgery/gynecology	211	Other connective tissue disease	9,959	805	8.10%
Surgery/gynecology	233	Intracranial injury	9,148	1,762	19.30%
Surgery/gynecology	25	Cancer of uterus	9,129	903	9.90%
Surgery/gynecology	201	Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted di	9,080	1,624	17.90%
Surgery/gynecology	116	Aortic and peripheral arterial embolism or thrombosis	8,582	1,701	19.80%
Surgery/gynecology	103	Pulmonary heart disease	8,316	1,832	22.00%
Surgery/gynecology	152	Pancreatic disorders (not diabetes)	7,891	1,051	13.30%
Surgery/gynecology	159	Urinary tract infections	6,278	1,441	23.00%
Surgery/gynecology	147	Anal and rectal conditions	5,848	726	12.40%
Surgery/gynecology	175	Other female genital disorders	5,700	422	7.40%
Surgery/gynecology	122	Pneumonia (except that caused by tuberculosis or sexually transmitted disease)	5,684	1,367	24.00%
Surgery/gynecology	81	Other hereditary and degenerative nervous system conditions	5,624	892	15.90%
Surgery/gynecology	162	Other diseases of bladder and urethra	5,449	726	13.30%
Surgery/gynecology	157	Acute and unspecified renal failure	5,364	1,469	27.40%
Surgery/gynecology	197	Skin and subcutaneous tissue infections	5,359	897	16.70%
Surgery/gynecology	44	Neoplasms of unspecified nature or uncertain behavior	5,159	654	12.70%
Surgery/gynecology	199	Chronic ulcer of skin	5,144	1,099	21.40%
Surgery/gynecology	11	Cancer of head and neck	5,027	765	15.20%
Surgery/gynecology	48	Thyroid disorders	4,948	203	4.10%
Surgery/gynecology	153	Gastrointestinal hemorrhage	4,871	1,199	24.60%
Surgery/gynecology	204	Other non-traumatic joint disorders	4,804	296	6.20%
Surgery/gynecology	130	Pleurisy; pneumothorax; pulmonary collapse	4,383	849	19.40%
Surgery/gynecology	38	Non-Hodgkin's lymphoma	4,182	1,080	25.80%
Surgery/gynecology	117	Other circulatory disease	4,155	721	17.40%
Surgery/gynecology	27	Cancer of ovary	4,080	738	18.10%
Surgery/gynecology	225	Joint disorders and dislocations; trauma-related	4,040	409	10.10%
Surgery/gynecology	232	Sprains and strains	3,980	210	5.30%
Surgery/gynecology	95	Other nervous system disorders	3,945	562	14.20%
Surgery/gynecology	58	Other nutritional; endocrine; and metabolic disorders	3,856	349	9.10%
Surgery/gynecology	17	Cancer of pancreas	3,808	876	23.00%

Surgery/gynecology	131	Respiratory failure; insufficiency; arrest (adult)	3,739	966	25.80%
Surgery/gynecology	18	Cancer of other GI organs; peritoneum	3,727	716	19.20%
Surgery/gynecology	13	Cancer of stomach	3,673	757	20.60%
Surgery/gynecology	163	Genitourinary symptoms and ill-defined conditions	3,654	543	14.90%
Surgery/gynecology	99	Hypertension with complications and secondary hypertension	3,624	931	25.70%
Surgery/gynecology	133	Other lower respiratory disease	3,611	434	12.00%
Surgery/gynecology	97	Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transm	3,551	788	22.20%
Surgery/gynecology	161	Other diseases of kidney and ureters	3,518	519	14.80%
Surgery/gynecology	138	Esophageal disorders	3,387	405	12.00%
Surgery/gynecology	127	Chronic obstructive pulmonary disease and bronchiectasis	3,321	968	29.10%
Surgery/gynecology	217	Other congenital anomalies	3,148	241	7.70%
Surgery/gynecology	139	Gastroduodenal ulcer (except hemorrhage)	2,879	532	18.50%
Surgery/gynecology	35	Cancer of brain and nervous system	2,834	494	17.40%
Surgery/gynecology	55	Fluid and electrolyte disorders	2,723	643	23.60%
Surgery/gynecology	36	Cancer of thyroid	2,704	170	6.30%
Surgery/gynecology	234	Crushing injury or internal injury	2,179	389	17.90%
Surgery/gynecology	21	Cancer of bone and connective tissue	2,110	319	15.10%
Surgery/gynecology	51	Other endocrine disorders	2,093	185	8.80%
Surgery/gynecology	202	Rheumatoid arthritis and related disease	2,070	139	6.70%
Surgery/gynecology	111	Other and ill-defined cerebrovascular disease	2,067	225	10.90%
Surgery/gynecology	23	Other non-epithelial cancer of skin	2,029	235	11.60%
Surgery/gynecology	236	Open wounds of extremities	1,819	187	10.30%
Surgery/gynecology	28	Cancer of other female genital organs	1,816	246	13.50%
Surgery/gynecology	166	Other male genital disorders	1,797	167	9.30%
Surgery/gynecology	245	Syncope	1,779	257	14.40%
Surgery/gynecology	129	Aspiration pneumonitis; food/vomit	1,612	464	28.80%
Surgery/gynecology	172	Ovarian cyst	1,562	92	5.90%
Surgery/gynecology	46	Benign neoplasm of uterus	1,558	75	4.80%
Surgery/gynecology	141	Other disorders of stomach and duodenum	1,557	332	21.30%
Surgery/gynecology	134	Other upper respiratory disease	1,514	223	14.70%
Surgery/gynecology	59	Deficiency and other anemia	1,460	363	24.90%
Surgery/gynecology	34	Cancer of other urinary organs	1,412	184	13.00%
Surgery/gynecology	228	Skull and face fractures	1,387	127	9.20%
Surgery/gynecology	144	Regional enteritis and ulcerative colitis	1,378	309	22.40%
Surgery/gynecology	213	Cardiac and circulatory congenital anomalies	1,358	155	11.40%
Surgery/gynecology	121	Other diseases of veins and lymphatics	1,305	260	19.90%
Surgery/gynecology	135	Intestinal infection	1,294	408	31.50%
Surgery/gynecology	151	Other liver diseases	1,244	372	29.90%
Surgery/gynecology	244	Other injuries and conditions due to external causes	1,229	214	17.40%
Surgery/gynecology	208	Acquired foot deformities	1,223	50	4.10%
Surgery/gynecology	16	Cancer of liver and intrahepatic bile duct	1,170	220	18.80%
Surgery/gynecology	102	Nonspecific chest pain	1,144	176	15.40%
Surgery/gynecology	12	Cancer of esophagus	1,143	266	23.30%
Surgery/gynecology	112	Transient cerebral ischemia	1,124	162	14.40%



Surgery/gynecology	173	Menopausal disorders	1,099	68	6.20%
Surgery/gynecology	259	Residual codes; unclassified	1,089	128	11.80%
Surgery/gynecology	105	Conduction disorders	1,023	156	15.20%
Surgery/gynecology	235	Open wounds of head; neck; and trunk	1,000	117	11.70%
Surgery/gynecology	148	Peritonitis and intestinal abscess	999	178	17.80%
Surgery/gynecology	79	Parkinson`s disease	969	200	20.60%
Surgery/gynecology	227	Spinal cord injury	943	190	20.10%
Surgery/gynecology	22	Melanomas of skin	940	109	11.60%
Surgery/gynecology	240	Burns	912	164	18.00%
Surgery/gynecology	26	Cancer of cervix	841	86	10.20%
Surgery/gynecology	168	Inflammatory diseases of female pelvic organs	775	81	10.50%
Surgery/gynecology	41	Cancer; other and unspecified primary	723	92	12.70%
Surgery/gynecology	62	Coagulation and hemorrhagic disorders	649	144	22.20%
Surgery/gynecology	165	Inflammatory conditions of male genital organs	643	100	15.60%
Surgery/gynecology	239	Superficial injury; contusion	629	120	19.10%
Surgery/gynecology	167	Nonmalignant breast conditions	614	53	8.60%
Surgery/gynecology	137	Diseases of mouth; excluding dental	602	65	10.80%
Surgery/gynecology	247	Lymphadenitis	590	90	15.30%
Surgery/gynecology	78	Other CNS infection and poliomyelitis	579	112	19.30%
Surgery/gynecology	83	Epilepsy; convulsions	579	97	16.80%
Surgery/gynecology	128	Asthma	566	146	25.80%
Surgery/gynecology	140	Gastritis and duodenitis	559	125	22.40%
Surgery/gynecology	257	Other aftercare	519	65	12.50%
Surgery/gynecology	158	Chronic renal failure	488	121	24.80%
Surgery/gynecology	251	Abdominal pain	478	79	16.50%
Surgery/gynecology	4	Mycoses	476	105	22.10%
Surgery/gynecology	40	Multiple myeloma	469	123	26.20%
Surgery/gynecology	98	Essential hypertension	456	50	11.00%
Surgery/gynecology	136	Disorders of teeth and jaw	441	39	8.80%
Surgery/gynecology	126	Other upper respiratory infections	424	51	12.00%
Surgery/gynecology	54	Gout and other crystal arthropathies	416	72	17.30%
Surgery/gynecology	154	Noninfectious gastroenteritis	381	74	19.40%
Surgery/gynecology	39	Leukemias	73	123	33.00%
Surgery/gynecology	653	Delirium, dementia, and amnestic and other cognitive disorders	372	65	17.50%
Surgery/gynecology	87	Retinal detachments; defects; vascular occlusion; and retinopathy	352	20	5.70%
Surgery/gynecology	60	Acute posthemorrhagic anemia	337	69	20.50%
Surgery/gynecology	20	Cancer; other respiratory and intrathoracic	334	56	16.80%
Surgery/gynecology	91	Other eye disorders	328	42	12.80%
Surgery/gynecology	200	Other skin disorders	317	41	12.90%
Surgery/gynecology	93	Conditions associated with dizziness or vertigo	315	34	10.80%
Surgery/gynecology	120	Hemorrhoids	312	64	20.50%
Surgery/gynecology	215	Genitourinary congenital anomalies	301	32	10.60%
Surgery/gynecology	94	Other ear and sense organ disorders	294	20	6.80%
Surgery/gynecology	250	Nausea and vomiting	283	46	16.30%
Surgery/gynecology	214	Digestive congenital anomalies	282	33	11.70%
Surgery/gynecology	64	Other hematologic conditions	282	57	20.20%
Surgery/gynecology	104	Other and ill-defined heart disease	274	39	14.20%
Surgery/gynecology	90	Inflammation; infection of eye (except that caused by tuberculosis or sexually transmitted disease)	273	39	14.30%

Surgery/gynecology	43	Malignant neoplasm without specification of site	269	52	19.30%
Surgery/gynecology	31	Cancer of other male genital organs	263	20	7.60%
Surgery/gynecology	661	Substance-related disorders	262	55	21.00%
Surgery/gynecology	45	Maintenance chemotherapy; radiotherapy	257	71	27.60%
Surgery/gynecology	119	Varicose veins of lower extremity	247	31	12.60%
Surgery/gynecology	52	Nutritional deficiencies	237	74	31.20%
Surgery/gynecology	107	Cardiac arrest and ventricular fibrillation	227	43	18.90%
Surgery/gynecology	37	Hodgkin's disease	211	62	29.40%
Surgery/gynecology	242	Poisoning by other medications and drugs	206	33	16.00%
Surgery/gynecology	92	Otitis media and related conditions	198	35	17.70%
Surgery/gynecology	8	Other infections; including parasitic	197	24	12.20%
Surgery/gynecology	663	Screening and history of mental health and substance abuse codes	196	64	32.70%
Surgery/gynecology	169	Endometriosis	183	11	6.00%
Surgery/gynecology	246	Fever of unknown origin	180	49	27.20%
Surgery/gynecology	113	Late effects of cerebrovascular disease	169	39	23.10%
Surgery/gynecology	7	Viral infection	168	42	25.00%
Surgery/gynecology	124	Acute and chronic tonsillitis	154	7	4.50%
Surgery/gynecology	3	Bacterial infection; unspecified site	152	34	22.40%
Surgery/gynecology	125	Acute bronchitis	144	34	23.60%
Surgery/gynecology	63	Diseases of white blood cells	144	39	27.10%
Surgery/gynecology	82	Paralysis	131	25	19.10%
Surgery/gynecology	1	Tuberculosis	125	23	18.40%
Surgery/gynecology	76	Meningitis (except that caused by tuberculosis or sexually transmitted disease)	118	22	18.60%
Surgery/gynecology	9	Sexually transmitted infections (not HIV or hepatitis)	117	17	14.50%
Surgery/gynecology	216	Nervous system congenital anomalies	114	20	17.50%
Surgery/gynecology	132	Lung disease due to external agents	113	15	13.30%
Surgery/gynecology	660	Alcohol-related disorders	110	7	6.40%
Surgery/gynecology	88	Glaucoma	108	8	7.40%
Surgery/gynecology	123	Influenza	107	27	25.20%
Surgery/gynecology	252	Malaise and fatigue	106	25	23.60%
Surgery/gynecology	206	Osteoporosis	103	22	21.40%
Surgery/gynecology	6	Hepatitis	88	34	38.60%
Surgery/gynecology	253	Allergic reactions	83	16	19.30%
Surgery/gynecology	85	Coma; stupor; and brain damage	82	17	20.70%
Surgery/gynecology	156	Nephritis; nephrosis; renal sclerosis	81	20	24.70%
Surgery/gynecology	198	Other inflammatory condition of skin	79	12	15.20%
Surgery/gynecology	86	Cataract	76	8	10.50%
Surgery/gynecology	210	Systemic lupus erythematosus and connective tissue disorders	74	18	24.30%
Surgery/gynecology	49	Diabetes mellitus without complication	59	10	16.90%
Surgery/gynecology	171	Menstrual disorders	53	2	3.80%
Surgery/gynecology	77	Encephalitis (except that caused by tuberculosis or sexually transmitted disease)	53	12	22.60%
Surgery/gynecology	84	Headache; including migraine	47	8	17.00%
Surgery/gynecology	80	Multiple sclerosis	42	10	23.80%
Surgery/gynecology	249	Shock	35	10	28.60%
Surgery/gynecology	243	Poisoning by nonmedicinal substances	34	3	8.80%
Surgery/gynecology	5	HIV infection	31	12	38.70%

Surgery/gynecology	241	Poisoning by psychotropic agents	29	12	41.40%
Surgery/gynecology	53	Disorders of lipid metabolism	27	3	11.10%
Surgery/gynecology	89	Blindness and vision defects	24	5	20.80%
Surgery/gynecology	30	Cancer of testis	18	3	16.70%
Surgery/gynecology	256	Medical examination/evaluation	16	5	31.30%
Surgery/gynecology	258	Other screening for suspected conditions (not mental disorders or infectious disease)	9	-	0.00%
Surgery/gynecology	61	Sickle cell anemia	3	-	0.00%
Surgery/gynecology	10	Immunizations and screening for infectious disease	1	-	0.00%
Surgery/gynecology	193	OB-related trauma to perineum and vulva	1	-	0.00%
Surgery/gynecology	56	Cystic fibrosis	1	-	0.00%
Surgery/gynecology	57	Immunity disorders	1	-	0.00%
<b>Surgery/gynecology</b>		<b>Total</b>	<b>2,163,279</b>	<b>272,830</b>	<b>12.60%</b>
Cardiorespiratory	108	Congestive heart failure; nonhypertensive	453,340	111,720	24.60%
Cardiorespiratory	122	Pneumonia (except that caused by tuberculosis or sexually transmitted disease)	403,972	71,538	17.70%
Cardiorespiratory	127	Chronic obstructive pulmonary disease and bronchiectasis	297,735	64,132	21.50%
Cardiorespiratory	131	Respiratory failure; insufficiency; arrest (adult)	117,569	28,597	24.30%
Cardiorespiratory	128	Asthma	61,696	11,066	17.90%
Cardiorespiratory	103	Pulmonary heart disease	45,122	7,432	16.50%
Cardiorespiratory	125	Acute bronchitis	25,833	3,264	12.60%
<b>Cardiorespiratory</b>		<b>Total</b>	<b>1,405,267</b>	<b>297,749</b>	<b>21.20%</b>
Cardiovascular	106	Cardiac dysrhythmias	315,298	49,471	15.70%
Cardiovascular	102	Nonspecific chest pain	142,883	15,241	10.70%
Cardiovascular	100	Acute myocardial infarction	116,810	25,035	21.40%
Cardiovascular	101	Coronary atherosclerosis and other heart disease	116,147	15,040	12.90%
Cardiovascular	117	Other circulatory disease	56,016	8,998	16.10%
Cardiovascular	105	Conduction disorders	33,899	3,704	10.90%
Cardiovascular	114	Peripheral and visceral atherosclerosis	27,169	4,262	15.70%
Cardiovascular	97	Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transm	13,241	2,735	20.70%
Cardiovascular	96	Heart valve disorders	9,920	1,803	18.20%
Cardiovascular	115	Aortic; peripheral; and visceral artery aneurysms	5,010	767	15.30%
Cardiovascular	116	Aortic and peripheral arterial embolism or thrombosis	2,570	444	17.30%
Cardiovascular	107	Cardiac arrest and ventricular fibrillation	2,009	360	17.90%
Cardiovascular	104	Other and ill-defined heart disease	1,749	247	14.10%
Cardiovascular	213	Cardiac and circulatory congenital anomalies	652	117	17.90%
<b>Cardiovascular</b>		<b>Total</b>	<b>843,373</b>	<b>128,224</b>	<b>15.20%</b>
Neurology	109	Acute cerebrovascular disease	197,598	28,620	14.50%
Neurology	112	Transient cerebral ischemia	82,499	9,073	11.00%
Neurology	95	Other nervous system disorders	58,486	10,172	17.40%
Neurology	83	Epilepsy; convulsions	38,034	6,013	15.80%
Neurology	233	Intracranial injury	35,366	5,890	16.70%

Neurology	81	Other hereditary and degenerative nervous system conditions	10,075	1,760	17.50%
Neurology	110	Occlusion or stenosis of precerebral arteries	9,091	1,273	14.00%
Neurology	79	Parkinson`s disease	6,651	907	13.60%
Neurology	113	Late effects of cerebrovascular disease	6,396	1,044	16.30%
Neurology	85	Coma; stupor; and brain damage	6,092	975	16.00%
Neurology	111	Other and ill-defined cerebrovascular disease	5,316	621	11.70%
Neurology	80	Multiple sclerosis	1,036	147	14.20%
Neurology	82	Paralysis	883	131	14.80%
Neurology	227	Spinal cord injury	832	144	17.30%
Neurology	78	Other CNS infection and poliomyelitis	786	135	17.20%
Neurology	216	Nervous system congenital anomalies	48	12	25.00%
<b>Neurology</b>		<b>Total</b>	<b>459,189</b>	<b>66,917</b>	<b>14.60%</b>
<b>All Cohorts</b>		<b>Grand Total</b>	<b>7,957,901</b>	<b>1,321,851</b>	<b>16.60%</b>

**Appendix D – Conditions that are treated as complications if occurring during index admission**

<b>CMS-CC<sup>40</sup></b>	<b>Label</b>	<b>Potential Complications</b>
2	Septicemia/Shock	x
6	Other Infectious Diseases	x
17	Diabetes with Acute Complications	x
23	Disorders of Fluid/Electrolyte/Acid-Base	x
24	Other Endocrine/Metabolic/ Nutritional Disorders	
28	Acute Liver Failure/Disease	x
31	Intestinal Obstruction/Perforation	x
34	Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders	x
36	Other Gastrointestinal Disorders	
37	Bone/Joint/Muscle Infections/Necrosis	
43	Other Musculoskeletal and Connective Tissue Disorders	
46	Coagulation Defects and Other Specified Hematological Disorders	x
47	Iron Deficiency and Other/ Unspecified Anemias and Blood Disease	
48	Delirium and Encephalopathy	x
51	Drug/Alcohol Psychosis	
75	Coma, Brain Compression/Anoxic Damage	x
76	Mononeuropathy, Other Neurological Conditions/Injuries	
77	Respirator Dependence/Tracheostomy Status	x
78	Respiratory Arrest	x
79	Cardio-Respiratory Failure and Shock	x
80	Congestive Heart Failure	x
81	Acute Myocardial Infarction	x
82	Unstable Angina and Other Acute Ischemic Heart Disease	x
85	Heart Infection/Inflammation, Except Rheumatic	
92	Specified Heart Arrhythmias	x
93	Other Heart Rhythm and Conduction Disorders	x
95	Cerebral Hemorrhage	x
96	Ischemic or Unspecified Stroke	x
97	Precerebral Arterial Occlusion and Transient Cerebral Ischemia	x
100	Hemiplegia/Hemiparesis	x
101	Diplegia (Upper), Monoplegia, and Other Paralytic Syndromes	x
102	Speech, Language, Cognitive, Perceptual	x
104	Vascular Disease with Complications	x
105	Vascular Disease	x
106	Other Circulatory Disease	x
111	Aspiration and Specified Bacterial Pneumonias	x
112	Pneumococcal Pneumonia, Emphysema, Lung Abscess	x
114	Pleural Effusion/Pneumothorax	x
124	Other Eye Disorders	
129	End Stage Renal Disease	x
130	Dialysis Status	x
131	Renal Failure	x

<b>CMS-CC<sup>40</sup></b>	<b>Label</b>	<b>Potential Complications</b>
132	Nephritis	x
133	Urinary Obstruction and Retention	x
135	Urinary Tract Infection	x
148	Decubitus Ulcer of Skin	x
152	Cellulitis, Local Skin Infection	x
154	Severe Head Injury	x
155	Major Head Injury	x
156	Concussion or Unspecified Head Injury	x
157	Vertebral Fractures	
158	Hip Fracture/Dislocation	x
159	Major Fracture, Except of Skull, Vertebrae, or Hip	x
160	Internal Injuries	
161	Traumatic Amputation	
162	Other Injuries	
163	Poisonings and Allergic Reactions	x
164	Major Complications of Medical Care and Trauma	x
165	Other Complications of Medical Care	x
166	Major Symptoms, Abnormalities	
174	Major Organ Transplant Status	x
175	Other Organ Transplant/Replacement	x
176	Artificial Openings for Feeding or Elimination	x
177	Amputation Status, Lower Limb/Amputation	x
178	Amputation Status, Upper Limb	x
179	Post-Surgical States/Aftercare/Elective	x

## Appendix E –Candidate comorbid risk variables

Risk variable group label	CMS-CCs <sup>40</sup>	Description
rv1	1, 3-5	History of Infection
rv2	6	Other infectious disease
rv3	7	Metastatic cancer/acute leukemia
rv4	8	Lung or other severe cancers
rv5	9	Other major cancers
rv6	10	Other major cancers
rv7	11	Cancer
rv8	12	Cancer
rv9	15,16,18-20, 119, 120	Diabetes mellitus or DM complications
rv10	21	Protein-calorie malnutrition
rv11	25, 26	Liver or biliary disease
rv12	44	Other hematological disorders
rv13	49, 50	Dementia or other specified brain disorders
rv14	52, 53	Drug/alcohol abuse/dependence/psychosis
rv15	54-56	Major psychiatric disorders
rv16	58	Depression
rv17	60	Other psychiatric disorders
rv18	67-69, 100-102, 177, 178	Hemiplegia, paraplegia, paralysis, functional disability
rv19	74	Seizure disorders and convulsions
rv20	80	CHF
rv21	83, 84	Coronary atherosclerosis or angina
rv22	86	Valvular or rheumatic heart disease
rv23	90	Hypertensive heart failure
rv24	92, 93	Specified arrhythmias
rv25	98, 99, 103	Cerebrovascular disease
rv26	108	COPD
rv27	109	Fibrosis of lung or other chronic lung disorders
rv28	110	Asthma
rv29	129, 130	End stage renal disease
rv30	149	Decubitus ulcer or chronic skin ulcer
rv31	2	Septicemia/Shock
rv32	22, 23	Disorders of fluid, electrolyte, acid-base
rv33	47	Iron deficiency
rv34	79	Cardio-respiratory failure or shock
rv35	81, 82	Acute coronary syndrome
rv36	95, 96	Stroke
rv37	104, 105, 106	Circulatory or vascular disease
rv38	111, 112, 113	Pneumonia
rv39	131	Renal failure
rv40	136	Other urinary tract disorders
rv41	148	Decubitus ulcer

## Appendix F – Final comorbid risk variables

Risk variable group label	CMS-CCs <sup>40</sup>	Description	Not adjusted for if only present on index admission (complication)
Age	n/a	Age (-65)	
Cond. Ind.	n/a	Condition indicator (AHRQ CCS)	
rv1	1, 3-5	Severe infection	
	1	HIV/AIDS	
	3	Central nervous system infection	
	4	Tuberculosis	
	5	Opportunistic infections	
rv2	6, 111-113	Other infectious disease & pneumonias	
	6	Other infectious disease	x
	111	Aspiration and specified bacterial pneumonias	x
	112	Pneumococcal pneumonia, emphysema, lung abscess	x
	113	Viral and unspecified pneumonia, pleurisy	x
rv3	7	Metastatic cancer/acute leukemia	
rv4	8, 9	Severe cancer	
	8	Lung, upper digestive tract, and other severe cancers	
	9	Other major cancers	
rv6	10, 11, 12	Other major cancers	
	10	Breast, prostate, colorectal and other cancers and tumors	
	11	Other respiratory and heart neoplasms	
	12	Other digestive and urinary neoplasms	
rv9	15-20, 119, 120	Diabetes mellitus	
	15	Diabetes with renal manifestation	
	16	Diabetes with neurologic or peripheral circulatory manifestation	
	17	Diabetes with acute complications	x
	18	Diabetes with ophthalmologic manifestation	
	19	Diabetes with no or unspecified complications	
	20	Type I diabetes mellitus	
	119	Proliferative diabetic retinopathy and vitreous hemorrhage	
	120	Diabetic and other vascular retinopathies	
rv10	21	Protein-calorie malnutrition	
rv11	25, 26	End-Stage liver disease	
	25	End-Stage Liver Disease	
	26	Cirrhosis of Liver	
rv12	44	Other hematological disorders	
rv14	51-52	Drug and Alcohol disorders	
	51	Drug/alcohol psychosis	
	52	Drug/alcohol dependence	



Risk variable group label	CMS-CCs <sup>40</sup>	Description	Not adjusted for if only present on index admission (complication)
rv15	54-56, 58, 60	<b>Psychiatric comorbidity</b>	
	54	Schizophrenia	
	55	Major depressive, bipolar, and paranoid disorders	
	56	Reactive and unspecified psychosis	
	58	Depression	
	60	Other psychiatric disorders	
rv18	67-69, 100-102, 177, 178	<b>Hemiplegia, paraplegia, paralysis, functional disability</b>	
	67	Quadriplegia, other extensive paralysis	
	68	Paraplegia	
	69	Spinal Cord Disorders/Injuries	
	100	Hemiplegia/hemiparesis	
	101	Diplegia (upper), monoplegia, and other paralytic syndromes	
	102	Speech, language, cognitive, perceptual	
	177	Amputation status, lower limb/amputation	
	178	Amputation status, upper limb	
rv19	74	<b>Seizure disorders and convulsions</b>	
rv20	80	<b>CHF</b>	x
rv21	81-84, 89, 98, 99, 103-106	<b>Coronary atherosclerosis or angina, cerebrovascular disease</b>	
	81	Acute myocardial infarction	x
	82	Unstable angina and other acute ischemic heart disease	x
	83	Angina pectoris/old myocardial infarction	
	84	Coronary atherosclerosis/other chronic ischemic heart disease	
	89	Hypertensive heart and renal disease or encephalopathy	
	98	Cerebral atherosclerosis and aneurysm	
	99	Cerebrovascular disease, unspecified	
	103	Cerebrovascular disease late effects, unspecified	
	104	Vascular disease with complications	x
	105	Vascular disease	x
	106	Other circulatory disease	x
rv24	92, 93	<b>Specified arrhythmias</b>	
	92	Specified heart arrhythmias	
	93	Other heart rhythm and conduction disorders	
rv26	108	<b>Chronic obstructive pulmonary disease</b>	
rv27	109	<b>Fibrosis of lung or other chronic lung disorders</b>	
rv29	130	<b>Dialysis Status</b>	x
rv30	148-149	<b>Ulcers</b>	
	148	Decubitus ulcer	x
	149	Decubitus ulcer or chronic skin ulcer	

Risk variable group label	CMS-CCs <sup>40</sup>	Description	Not adjusted for if only present on index admission (complication)
rv31	2	Septicemia/shock	x
rv32	22-23	Disorders of fluid, electrolyte, acid-base	
	22	Other significant endocrine and metabolic disorders	x
	23	Disorders of fluid/electrolyte/acid-base	x
rv33	47	Iron deficiency	x
rv34	79	Cardio-respiratory failure or cardio-respiratory shock	x
rv39	131	Acute Renal failure	x
rv40	32	Pancreatic disease	
rv41	38	Rheumatoid arthritis and inflammatory connective tissue disease	
rv42	77	Respirator dependence/tracheostomy status	
rv43	128, 174	Transplants	
	128	Kidney transplant status	
	174	Major organ transplant status	
rv44	46	Coagulation defects and other specified hematological disorders	
rv45	158	Hip fracture/dislocation	