2013 Measure Updates and Specifications: Elective Primary Total Hip Arthroplasty (THA) And/Or Total Knee Arthroplasty (TKA) All-Cause Unplanned 30-Day Risk-Standardized Readmission Measure

(Version 2.0)

Submitted By:

Yale New Haven Health Services Corporation/Center for Outcomes Research and Evaluation (YNHHSC/CORE)

Prepared For:

Centers for Medicare & Medicaid Services (CMS)

March 2013

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

YNHHSC/CORE Project Team

Lisa G. Suter, M.D.* – Lead
Jacqueline N. Grady, M.S. – Project Lead
Zhenqiu Lin, Ph.D. – Analytic Director
Craig S. Parzynski, M.S. – Lead Analyst
Jaymie Potteiger, M.P.H. – Research Assistant
Megan Keenan, M.P.H. – Project Coordinator
Kanchana R. Bhat, M.P.H. – Project Manager
Leora I. Horwitz, M.D., M.H.S. – Planned Readmission Lead
Elizabeth E. Drye, M.D., S.M.* – Planned Readmission Director
Harlan M. Krumholz, M.D., S.M.* – Principal Investigator
Susannah M. Bernheim, M.D., M.H.S. – Project Director

*Yale School of Medicine

Acknowledgements

This work is a collaborative effort, and the authors gratefully acknowledge and thank Mai Hubbard, Angela Merrill, Candace Natoli, Sandra Nelson, Bailey Orshan, Eric Schone, and Matthew Sweeney from Mathematica Policy Research; Sharon-Lise Normand from Harvard Medical School, Department of Health Care Policy and Harvard School of Public Health, Department of Biostatistics; Jennifer Mattera, Jinghong Gao, Lori Geary, Elizabeth Eddy, Laura Grosso, Lesli Ott, Alex Liu, Smitha Vellanky, Julia Montague and Mark Volpe from Yale New Haven Health Services Corporation/Center for Outcomes Research and Evaluation; Dima Turkmani from Taybah for Healthcare Consulting, Inc.; and Lein Han and Kate Goodrich at the Centers for Medicare & Medicaid Services for their contributions to this work.

We would also like to acknowledge the very thoughtful and instructive comments on the CMS Planned Readmission Algorithm from stakeholders during the public comment periods and from surgeons nominated by their specialty societies to participate in brief reviews of the procedures considered planned and unplanned in their specialty area.

1. HOW TO USE THIS REPORT

This report describes one of the Centers for Medicare & Medicaid Services (CMS) readmission measures used in the Hospital Inpatient Quality Reporting (IQR) program and publicly reported on Hospital Compare: the hospital-level 30-day risk-standardized readmission rate (RSRR) following elective primary total hip arthroplasty (THA) and/or total knee arthroplasty (TKA) measure.

This report is intended to provide a single source of information about the current measure for a wide range of readers. Within this report we provide an overview of the measure methodology, describe methodology updates to the measure and the national results for 2013 public reporting, and describe our quality assurance processes. The appendices provide further details, including concise tables of measure specifications and a list of the annual updates since the dry run reporting in 2012.

Specifically the reader can find:

- **An overview of the THA/TKA readmission measure (Section 2)**
    - History of the measures
    - Measure Cohort
        - Included and excluded hospitalizations
        - How transfers are handled
    - Outcome
        - What are considered planned readmissions
    - Risk-adjustment specifications
    - Data sources
    - Readmission rate calculation
    - Categorization of hospitals' performance

- **2013 measure updates (Section 3)**
    - The most significant update for 2013 reporting is the addition of an algorithm to identify planned readmissions. Planned readmissions will not be counted in the measures.
        - This algorithm for the THA/TKA readmission measure differs slightly from the AMI, HF, and pneumonia (condition-specific) measures and the hospital-wide readmission measure algorithms.
    - In addition, there were two changes from the original methodology report:
        - Table A3 in Appendix A of this report contains the updated listing of the ICD-9-CM Codes for Femur, Hip, and Pelvic Factures, Revision Procedures, Partial Hip Arthroplasty, Resurfacing Procedures, Mechanical Complications, Removal of Implanted Device, and Malignant Neoplasms that exclude patients from the measure cohort.
        - Section 3.2.3 contains corrected values for the range of RSRRs from the THA/TKA original methodology report.

- **2013 results (Section 4)**
    - Results from the model that are used for the Hospital Inpatient Quality Reporting (IQR) program in 2013.

- **Quality assurance process (Section 5)**

The Appendices contain detailed measure information, including:

- Appendix A: Measure specifications;
- Appendix B: Annual updates to measures since measure development;
- Appendix C: Detailed overview of the Planned Readmission Algorithm;
- Appendix D: Definitions for common terms; and
- Appendix E: RTI's memorandum on updates to the Condition Categories (CC) map.

Additional references, such as the original measure methodology and development technical report, are also available on the claims-based readmission measure page of *QualityNet*:

- Hospital-level 30-day All-Cause Risk-Standardized Readmission Rate Following Elective Primary Total Hip Arthroplasty (THA) And/Or Total Knee Arthroplasty (TKA) Measure Methodology Report.[1]
    - This report is located on *QualityNet* at (www.qualitynet.org) > Hospital-Inpatient > Claims-Based Measures > Readmission Measures > Measure Methodology

2. BACKGROUND AND OVERVIEW OF MEASURE METHODOLOGY

2.1 Background on Readmission Measure

In September 2012, CMS began a dry run for the 30-day RSRRs for THA/TKA for the nation's non-federal* acute care hospitals, including critical access hospitals. This measure complements the elective primary THA/TKA complication measure.[2] The readmission measure results are posted on *Hospital Compare*, and CMS will update the measure annually. Since 2009, CMS has publicly reported the acute myocardial infraction (AMI), heart failure (HF), and pneumonia readmission measures. This year, CMS plans to report an additional readmission measure, the Hospital-Wide All-Cause Unplanned Readmission Measure, along with the THA/TKA readmission measure. The updates and specifications reports for those measures can be found on *QualityNet* at (www.qualitynet.org > Hospital-Inpatient > Claims-Based Measures > Readmission Measures > Measure Methodology).

CMS contracted with Yale New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (YNHHSC/CORE) to update the 30-day THA/TKA readmission measure for 2013 public reporting through a process of measures maintenance. Measures maintenance is an annual process to improve the measures by responding to stakeholder input on the measure and incorporating advances in the science or changes in coding.

2.2 Overview of Measure Methodology

The 2013 risk-adjusted readmission measure uses the National Quality Forum (NQF)-endorsed methodology set forth in the initial measure methodology report with slight refinements to the measure as listed in Appendix B. Below, we provide an overview of the methodology.

2.2.1 Cohort

Index Admissions Included in Measure

An *Index admission* is the hospitalization considered for the readmission outcome.

The THA/TKA readmission measure includes index admissions for patients:

- Who are enrolled in Medicare fee-for-service (FFS);
- Aged 65 years or over;
- Admitted to a non-federal acute care hospital;
- Who have an eligible index admission identified by using the following International Classification of Diseases Ninth Revision (ICD-9) procedure codes in Medicare Part A inpatient claims data:
    - 81.51 Total Hip Arthroplasty
    - 81.54 Total Knee Arthroplasty

* Note: Includes Indian Health Services hospitals

- Medicare FFS beneficiaries with an index admission within a non-federal hospital are included if they have been enrolled in Part A and Part B Medicare for the 12 months prior to and including the date of the index admission to ensure a full year of administrative data for risk adjustment.

Index Admissions Excluded from the Measure[†]

- For the specific ICD-9-CM codes used to define the cohort, refer to Appendix A

The THA/TKA readmission measure excludes index admissions for patients:

- With a femur, hip or pelvic facture coded in the principal discharge diagnosis field;
- Undergoing partial hip arthroplasty (PHA) procedures (with a concurrent THA/TKA);
- Undergoing revision procedures (with a concurrent THA/TKA);
- Undergoing resurfacing procedures (with a concurrent THA/TKA);
- With a mechanical complication coded in the principal discharge diagnosis field;
- With a malignant neoplasm of the pelvis, sacrum, coccyx, lower limbs, or bone/bone marrow or a disseminated malignant neoplasm coded in the principal discharge diagnosis field; or
- With a procedure code for removal of implanted devices/prostheses.

After excluding the above admissions, the measure also excludes admissions for patients:

- Without at least 30 days post-discharge enrollment in Medicare FFS;
- Who were transferred in to the index hospital, as described further below;
- Who were admitted for the index procedure and subsequently transferred to another acute care facility, as described further below;
- Who were discharged against medical advice (AMA), because providers did not have the opportunity to deliver full care and prepare the patient for discharge; or
- With an in-hospital death.

Admissions within 30 days of discharge from an index admission will not be considered index admissions. Thus, no hospitalization will be counted as both a readmission and an index admission within the same measure. However, because the cohorts for the readmission measures are determined independently of each other, a readmission in this measure may qualify as an index admission in other CMS readmission measures.

The number of admissions excluded based on each criterion is shown in Section 4 in Figure 1.

[†] Note: As a part of data processing prior to the measure calculation, records are removed for non-short-term acute care facilities such as psychiatric facilities, rehabilitation facilities, or long-term care hospitals. Additional data cleaning steps include removing: claims with stays longer than one year, claims with overlapping dates, and stays for patients not listed in the Medicare enrollment file as well as records for providers with invalid provider IDs.

Transferred Patients

The THA/TKA readmission measure excludes admissions for patients who are transferred in to the index hospital as they likely do not represent elective THA/TKA procedures.

Patients who were admitted for the index procedure and subsequently transferred to another acute care facility are also excluded as it is difficult to determine to which hospital the readmission outcome should be attributed.

2.2.2 Outcome

All-Cause Unplanned Readmissions

The THA/TKA readmission measure counts all unplanned readmissions. It is designed to capture readmissions that arise from acute clinical events requiring urgent rehospitalization within 30 days of discharge. Planned readmissions, which are generally not a signal of quality of care, are not counted in the measures. For more details about how the planned readmissions are defined see Section 3 and Appendix C.

There are a number of reasons for counting unplanned readmissions for all causes in the CMS readmission measures. First, from a patient perspective, an unplanned readmission for any cause is an adverse event. In addition, it is difficult to make inferences about quality issues and accountability based solely on the documented cause of readmission. For example, a patient might experience a procedure-related complication following his or her THA/TKA, which may go untreated and result in renal failure following discharge. The resulting readmission for renal failure could have been prevented with high quality of care during the admission for the THA/TKA.

30-Day Time Frame

The measure assesses unplanned readmissions within a 30-day period from the date of discharge from an index admission. This standard time period is necessary so that the outcome for each patient is measured uniformly. Outcomes occurring within 30 days of discharge can be influenced by hospital care and the early transition to the outpatient setting. The use of the 30-day timeframe is a clinically meaningful period for hospitals to collaborate with their communities in an effort to reduce readmissions.[3]

Multiple Readmissions

If a patient has more than one unplanned admission within 30 days of discharge from the index admission, only one is counted as a readmission. The measure looks for a dichotomous yes or no readmission outcome of whether each admitted patient has one or more unplanned readmission within 30 days. If the first readmission after discharge is planned, however, then the outcome is considered to be no readmission, regardless of whether a subsequent unplanned readmission takes place, because it would be unfair to attribute the unplanned readmission back to the care received during the index admission.

2.2.3 Risk-Adjustment Specifications

The measure adjusts for variables (i.e. age, sex, comorbid diseases, and indicators of patient frailty) that are clinically relevant and have strong relationships with the outcome. For each patient, risk-adjustment variables are obtained from inpatient, outpatient, and physician Medicare administrative claims extending 12 months prior to, and including, the index admission.

The measure seeks to adjust for case mix differences among hospitals based on the clinical status of the patient at the time of the index admission. Accordingly, only comorbidities that convey information about the patient at that time or in the 12 months prior – and not complications that arise during the course of the hospitalization – are included in the risk adjustment.

The measure does not adjust for the patients' admission source or their discharge disposition (e.g. skilled nursing facility) because these factors are associated with the structure of the health care system, not solely patients' clinical comorbidities. Regional differences in the availability of post-acute care providers and practice patterns might exert an undue influence on model results.

The measure also does not adjust for socioeconomic status (SES) because the association between SES and health outcomes can be due, in part, to differences in the quality of health care received by groups of patients with varying SES. Risk adjusting for patient SES would suggest that hospitals with higher percentages of low SES patients should be held to different standards for patient outcomes than hospitals treating lower percentages of low SES patient populations. It could also mask important disparities and minimize incentives to improve outcomes for vulnerable populations. The intention is for the measure to adjust for patient demographic and clinical characteristics while illuminating important quality differences. This methodology is consistent with guidance from NQF. Additionally, recent analyses have shown that hospitals caring for high proportions of low-SES patients perform similarly on the measures to hospitals caring for low proportions of low-SES patients.[4]

Please refer to Table 2 in Section 4 of this report for the list of risk-adjustment variables.

2.2.4 Data Sources

The data sources for these analyses are Medicare administrative claims data, and enrollment information for patients with hospitalizations that occurred between July 1, 2009 and June 30, 2012. The datasets also contain associated inpatient, outpatient, and physician Medicare administrative claims for the 12 months prior to the index admission and one month subsequent to the index admission for patients admitted this time period. Please see the original methodology report[1] for further descriptions of these data sources and an explanation of the three-year measurement period.

2.2.5 Measure Calculation

The measure estimates hospital-level 30-day all-cause RSRRs following elective primary THA/TKA using a hierarchical logistic regression model (Appendix A). In brief, the approach simultaneously models data at the patient and hospital levels to account for the variance in patient outcomes within and between hospitals.[5] At the patient level, it models the log-odds of hospital readmission within 30 days of discharge using age, sex, selected clinical covariates, and a hospital-specific intercept. At the hospital level, it models the hospital-specific intercepts as arising from a normal distribution. The hospital intercept represents the underlying risk of a readmission at the hospital, after accounting for patient risk. The hospital-specific intercepts are given a distribution in order to account for the clustering (non-independence) of patients within the same hospital.[5] If there were no differences among hospitals, then after adjusting for patient risk, the hospital intercepts should be identical across all hospitals.

The RSRR is calculated as the ratio of the number of "predicted" readmissions to the number of "expected " readmissions at a given hospital, multiplied by the national observed readmission rate. For each hospital, the "numerator" of the ratio is the number of readmissions within 30 days predicted on the basis of the hospital's performance with its observed case mix, and the "denominator" is the number of readmissions expected on the basis of the nation's performance with that hospital's case mix. This approach is analogous to a ratio of "observed" to "expected" used in other types of statistical analyses. It conceptually allows for a comparison of a particular hospital's performance given its case mix to an average hospital's performance with the same case mix. Thus, a lower ratio indicates lower-than-expected readmission rates or better quality, and a higher ratio indicates higher-than-expected readmission rates or worse quality.

The "predicted" number of readmissions (the numerator) is calculated by regressing the risk factors (found in Table 2) and the hospital-specific intercept on the risk of readmission. The estimated regression coefficients are then multiplied by the patient characteristics in the hospital. The results are then transformed and summed over all patients attributed to the hospital to get a value. The "expected" number of readmissions (the denominator) is obtained by regressing the risk factors and a common intercept on the readmission outcome using all hospitals in our sample. The estimated regression coefficients are then multiplied by the patient characteristics in the hospital. The results are then transformed and summed over all patients in the hospital to get a value. To assess hospital performance for each reporting period, we re-estimate the model coefficients using the years of data in that period. This ratio is multiplied by the national rate to calculate the RSRR.

The hierarchical logistic regression models are described fully in the original methodology report.[1]

2.2.6 Categorizing Hospital Performance

To categorize hospital performance, CMS estimates each hospital's RSRR and the corresponding 95% Interval estimate. CMS assigns hospitals to a performance category

by comparing each hospital's RSRR interval estimate to the national observed readmission rate. Comparative performance for hospitals with 25 or more eligible cases is classified as follows:

- "No different than U.S. national rate" if the entire 95% interval estimate surrounding the hospital's rate includes the national observed readmission rate.
- "Worse than U.S. national rate" if the entire 95% interval estimate surrounding the hospital's rate is higher than the national observed readmission rate.
- "Better than U.S. national rate" if the entire 95% interval estimate surrounding the hospital's rate is lower than the national observed readmission rate.

If a hospital has fewer than 25 eligible cases for a measure, CMS assigns the hospital to a separate category: "The number of cases is too small (fewer than 25) to reliably tell how well the hospital is performing." If a hospital has fewer than 25 eligible cases, the hospital's readmission rates and interval estimates will not be publicly reported for the measure.

Section 4 describes the distribution of hospitals by performance category in the U.S. for this 2009-2012 reporting period.

3. UPDATES TO MEASURE FOR 2013 PUBLIC REPORTING

3.1 Rationale for Measure Updates

Measures maintenance ensures that the risk-standardized readmission models are continually assessed and remain valid given possible changes in the data over time and allows for model refinements. As described in this report, for 2013 public reporting, we undertook the following measure maintenance activities:

- Respecified the measures by adding a new planned readmission algorithm to identify and remove planned readmissions from the outcome;
- Incorporated ICD-9-CM coding updates for the Condition Categories and cohort codes;
- Validated the performance of the model and its corresponding risk-adjustment variables in three recent one-year datasets (July 2009-June 2010, July 2010-June 2011, and July 2011-June2012);
- Evaluated and validated model performance in the three-year combined dataset (July 2009-June 2012); and
- Updated the measure SAS pack and documentation.

3.2 Detailed Discussion of Measure Updates

3.2.1 Incorporation of Planned Readmission Algorithm

CMS has worked with experts in the medical community as well as other stakeholders to identify planned readmissions for procedures and treatments and not count them in readmission measures. Specifically, CMS contracted with YNHHSC/CORE to develop a Planned Readmission Algorithm that can be used to identify planned readmissions across its readmission measures, and has applied the algorithm to each of its measures. The algorithm is a set of criteria for classifying readmissions as planned using Medicare claims. The algorithm identifies admissions that are typically planned and may occur within 30 days of discharge from the hospital.

We based the Planned Readmission Algorithm on three principles:

1. A few specific, limited types of care are always considered planned (obstetric delivery, transplant surgery, maintenance chemotherapy/radiotherapy/ immunotherapy, rehabilitation);
2. Otherwise, a planned readmission is defined as a non-acute readmission for a scheduled procedure; and
3. Admissions for acute illness or for complications of care are never planned.

The *Planned Readmission Algorithm Version 2.1 – General Population* is a set of criteria for classifying readmissions as planned among the general Medicare population using Medicare administrative claims data. The algorithm identifies admissions that are typically planned and may occur within 30 days of discharge from the hospital. The details of the *index* admission (diagnosis or procedures) are not considered when determining whether a readmission is planned. For more information on the

development of the algorithm, please refer to the Centers for Medicare & Medicaid Services Planned Readmission Algorithm Version 2.1: General Population report.

CMS has modified its hospital-wide, condition-specific and procedure-specific readmission measures to incorporate Version 2.1 of the algorithm. The algorithm uses a more comprehensive definition of planned readmissions than the definitions of planned readmissions originally used in the development of CMS's readmission measures, several of which had no condition- or procedure-specific planned readmissions as originally specified.

During development of the THA/TKA readmission measure, CMS initially only identified planned procedures and conditions that were considered follow-up care for the specific condition or procedure that was the focus of the measure. For example, the THA/TKA readmission measure originally only considered the following to be a planned readmission: a readmission for a patient undergoing a second elective primary THA/TKA within 30 days of the discharge date for the index admission and in which the readmission has a primary discharge diagnosis of osteoarthritis, rheumatoid arthritis, osteonecrosis, or arthropathy (excluding septic arthropathy). The Planned Readmission Algorithm more generally identifies any likely planned readmission, not solely those related to follow-up care for the index condition or procedure.

In applying the algorithm to condition- and procedure-specific measures, teams of clinical experts reviewed the algorithm in the context of each measure-specific patient cohort and, where clinically indicated, adapted the content of the tables to better reflect the likely clinical experience of each measure's patient cohort. For the THA/TKA readmission measure, CMS used the *Planned Readmission Algorithm Version 2.1 - General Population* with the following changes listed below. Further information on the updated planned readmission algorithm can be found in Appendix C of this report.

The following updates to the algorithm were procedure categories that were removed from the potential planned procedure list for the THA/TKA readmission measure based on the input of clinical experts:

- Procedure CCS 55 (Peripheral vascular bypass): This is performed on the lower extremities and it is not likely that a clinician would perform a THA/TKA procedure on a patient who needed this procedure.
- Procedure CCS 142 (Partial excision of bone): Through clinician review, it was determined that these readmissions were likely due to complications of the THA or TKA surgery and not for planned procedures.
- Procedure CCS 157 (Amputation of Lower Extremities): Amputation of a lower extremity after a THA or TKA procedure would likely be due to a complication of the THA or TKA surgery and not a planned procedure.
- Procedure CCS 993 (Arterectomy of Leg Vessel): This is performed on the lower extremities and it is not likely that a clinician would perform a THA or TKA procedure on a patient needing this procedure.

The following updates to the algorithm were procedure categories that were removed at the request of the NQF Ad Hoc committee meeting on review of the THA/TKA planned readmission algorithm:

- Procedure CCS 47 (Diagnostic Cardiac Catheterization): Clinical experts agreed that such cardiac procedures should be performed prior to elective surgery and their occurrence within 30 days of a THA/TKA procedure likely indicates an unplanned procedure.
- Procedure CCS 48 (Insertion/Revision/Replacement of Cardiac Pacemaker): Clinical experts agreed that such cardiac procedures should be performed prior to elective surgery and their occurrence with 30 days of a THA or TKA procedure likely indicates an unplanned procedure.

The following updates to the algorithm were procedure categories that were added to the list of acute diagnoses that would disqualify a potentially planned procedure from being considered planned in the THA/TKA readmission measure:

- Diagnosis CCS 201 (Infective Arthritis/Osteomyelitis): The most frequent ICD-9-CM codes for patients in the THA/TKA cohort in this category were pyogenic arthritis and acute osteomyelitis, both most likely represent complications of the original procedure.
- Diagnosis CCS 204 (Non-Traumatic Joint Injuries): In the setting of a recent joint surgery, such codes likely represent complications of the original procedure, and thus patients coded with Diagnosis CCS 204 likely represent those with complications from THA or TKA procedures.
- Diagnosis CCS 207 (Pathological Fractures): Patients with bone neoplasms and bone metastases are excluded from the measure cohort, and thus readmitted patients coded with Diagnosis CCS 207 likely represent those with complications and are considered unplanned.
- Diagnosis CCS 231 (Other Fractures): Readmitted patients in the THA/TKA cohort with this diagnosis category were largely coded as such due to acetabular fractures which were likely related to the initial hip surgery.
- Diagnosis CCS 236 (Open Wounds of Extremities): Procedures during readmissions with this primary discharge diagnosis category were reviewed and clinicians determined that readmitted patients in this cohort likely had incision complications and thus these readmission are considered unplanned.

Details of CMS's Planned Readmission Algorithm

The Planned Readmission Algorithm uses a flowchart and four tables of specific procedure categories and discharge diagnosis categories to classify readmissions as planned (Appendix C). As illustrated in the flowchart (Figure PR1), readmissions that include certain procedures (Table PR1) or are for certain diagnoses (Table PR2) are always considered planned. If the readmission does not include a procedure or diagnosis in Table PR1 or Table PR2 that is always considered planned, the algorithm checks if the readmission has at least one procedure that is considered potentially planned (Table PR3). If the readmission has no procedures from Table PR3, the readmission is

considered unplanned. Table PR3 includes 57 Agency for Healthcare Research and Quality (AHRQ) procedure Clinical Classification Software (CCS) categories[‡] from among 231 AHRQ procedure CCS categories, plus 11 individual ICD-9-CM procedure codes. Two examples of potentially planned procedures are total hip replacement (Procedure CCS 153) and hernia repair (Procedure CCS 85).

If the readmission *does* have at least one potentially planned procedure from Table PR3, the algorithm checks for a primary discharge diagnosis that is considered acute (Table PR4). If the readmission has an acute primary discharge diagnosis from Table PR4, the readmission is considered unplanned. Otherwise, it is considered planned. The list of acute primary discharge diagnoses includes 100 diagnosis groups from among 285 AHRQ condition categories, plus 4 groupings of individual ICD-9-CM diagnosis codes that represent cardiac diagnoses that would not be associated with a planned readmission. Two examples of acute primary discharge diagnoses that identify readmissions with potentially planned procedures as unplanned are pneumonia (Diagnosis CCS 122) and cardiac arrest (Diagnosis CCS 107).

Treatment of Unplanned Readmission After a Planned Readmission

Unplanned readmissions within 30 days of discharge from an index admission that occur *after a planned readmission* will not be counted in the outcome. It would be unfair to attribute the unplanned readmission back to the care received during the index admission when there is an intervening planned readmission.

Effect on the Measure for 2013 Reporting Period

The impact of the Planned Readmission Algorithm on the THA/TKA readmission measure is summarized in Table 1 below.

Table 1 – Planned Readmission Effect on the THA/TKA Readmission Measure

	Revised Measure	Original Measure
Number of Admissions	882,887	882,887
Number of Unplanned Readmissions	47,301	48,524
Readmission Rate	5.4%	5.5%
Number of Planned Readmissions	2644	1421
Planned Readmission Rate	0.3%	0.2%
% of Readmissions that are Planned	5.3%	2.8%

[‡] AHRQ CCS codes group thousands of individual procedure and diagnosis ICD-9-CM codes into clinically coherent, mutually exclusive procedure CCS categories and mutually exclusive diagnosis CCS categories.

3.2.2 Updates to the Condition Category (CC) Map and Cohort Codes

RTI International, contracted by CMS to maintain the CC system, assigns new ICD-9-CM codes to the existing CCs based on their clinical expertise and the historical assignment of related ICD-9-CM codes to the CCs. CCs are clinically relevant diagnostic groups of the more than 14,500 ICD-9 codes. The CCs group the ICD-9-CM codes into larger groups that are used in models to predict medical care utilization, spending, mortality, or other related measures.[16] CMS revises the ICD-9-CM CC map annually to reflect changes in ICD-9-CM codes so that the measures will capture all relevant comorbidities coded in patient claims data.

The assignment of new codes and the removal of retired codes had little impact on the model variables since RTI assigned the majority of new codes, which were more specific versions of retired codes, to the same CCs as retired codes. For more details on the CC changes, see Appendix E for RTI's memo to CMS detailing the map changes.

In addition, we added two new FY2012 ICD-9 codes (808.44 "Multiple closed pelvic fractures without disruption of pelvic circle" and 808.54, "Multiple open pelvic fractures without disruption of pelvic circle") to the list of fracture codes that exclude patients from the measure cohort.

3.2.3 Updates and Corrections to Prior Methodology Report

The following updates have been made to the original methodology report during the maintenance period. Please see Appendix A for the corrected table.

Modification: This report contains one correction and one update from the original methodology report:

1. On page 54 of the original THA/TKA methodology report, the mean risk-standardized readmission rate was listed as 6.30% with a range from 3.06% to 50.94% for the 2008 sample.
    a. The report should have shown a mean risk-standardized readmission rate of 5.88 with a range of 3.64%-9.31%
2. Table A3 in Appendix A contains the updated listing of the ICD-9 codes for Femur, Hip, and Pelvic Factures, Revision Procedures, Partial Hip Arthroplasty, Resurfacing Procedures, Mechanical Complications, Removal of Implanted Device, and Malignant Neoplasm table.
    a. FY2012 ICD-9-CM codes 808.44 "Multiple closed pelvic fractures without disruption of pelvic circle" and 808.54, "Multiple open pelvic fractures without disruption of pelvic circle" were added to the list of fracture codes that exclude patients from the measure cohort.

3.2.4 Changes to SAS Analytic Package (SAS Pack)

We revised the measure calculation SAS packs to reflect all changes to the index admission cohorts and models, including ad-hoc patches to address data issues. The primary changes this year were made to incorporate the Planned Readmission Algorithm. The new SAS packs and documentation are available upon request by

emailing cmsreadmissionmeasures@yale.edu. **Do *NOT* submit patient-identifiable information (e.g., Date of Birth, Social Security Number, and Health Insurance Claim Number, etc.) to this address.**

4. RESULTS FOR 2013 PUBLIC REPORTING

4.1 Assessment of Updated Models

The THA/TKA readmission measure estimates hospital-specific 30-day all-cause RSRRs using hierarchical logistic regression models. See Section 2 of this report for a summary of the measure methodology and model risk-adjustment variables. Refer to the prior original technical report[1] for further details.

In this report we evaluate the performance of the model and provide national results using the data for 2013 reporting. This differs from previous reports where we provided national results using calendar year data. We fit the updated model to three single year datasets (July 2009-June 2010, July 2010-June 2011, and July 2011-June 2012) and to a combined three-year (July 2009-June 2012) dataset. We examined trends in the frequency of patient risk factors and the model variable coefficients, and compared the model performance between these datasets.

We assessed logistic regression and hierarchical logistic regression model performance in terms of discriminant ability for each year of data and for the three-year combined period listed above. We computed two summary statistics for assessing model performance: the predictive ability and the area under the receiver operating characteristic (ROC) curve (c-statistic). The c-statistic is an indicator of the model's discriminant ability or ability to correctly classify those who have and have not been readmitted within 30 days of discharge. Potential values range from 0.5 meaning no better than chance to 1.0 meaning perfect discrimination.

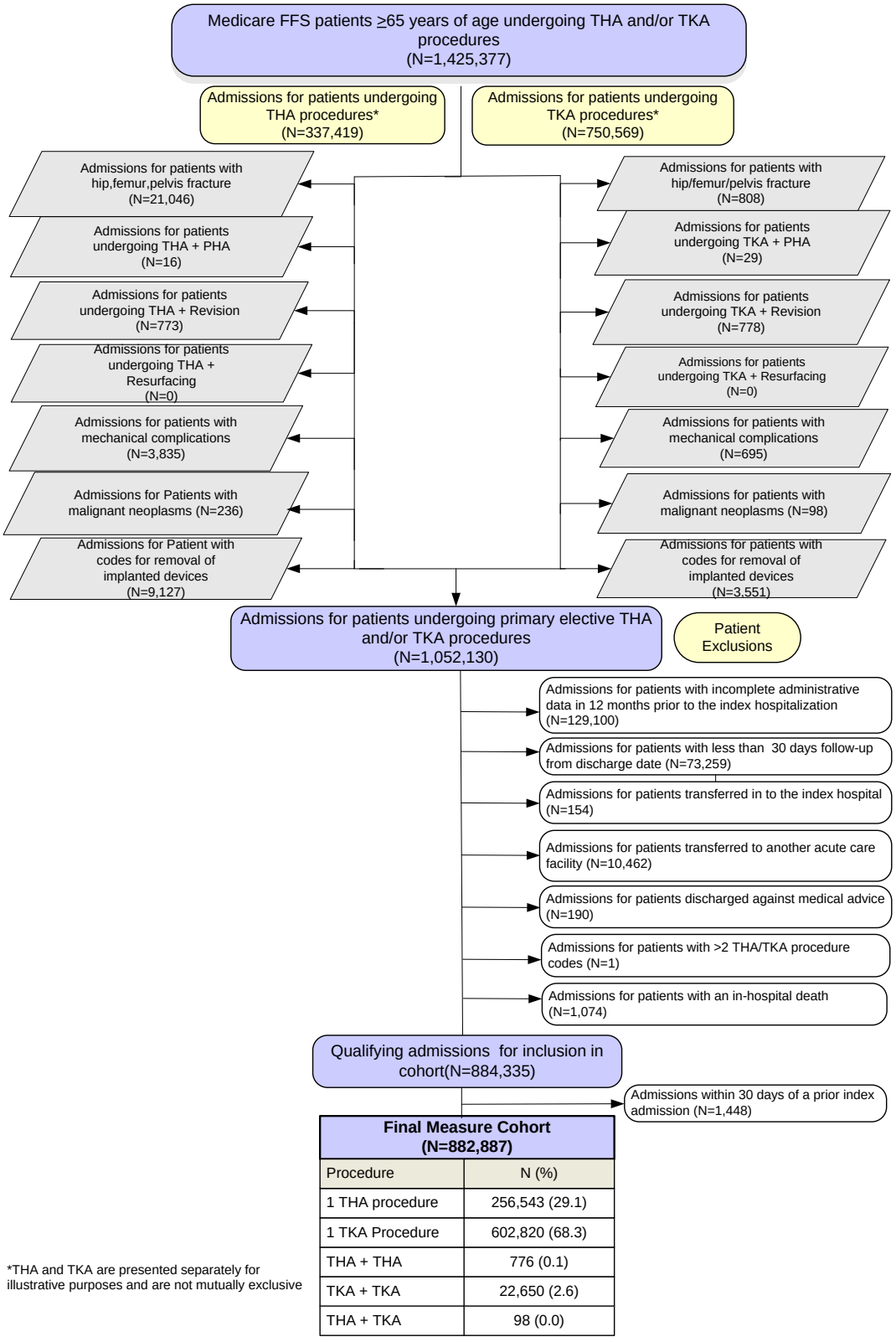
The results of these analyses for the measure are presented below in Sections 4.2.

4.2 THA/TKA Readmission 2013 Model Results

4.2.1 Index Cohort Exclusions

The exclusion criteria for the measures are presented in Section 2. The percentage of THA/TKA patients meeting each exclusion criterion in the July 2009-June 2012 dataset is presented in Figure 1.

Figure 1 – Index Cohort Sample for THA/TKA in the July 2009-June 2012 Dataset



Final Measure Cohort (N=882,887)	
Procedure	N (%)
1 THA procedure	256,543 (29.1)
1 TKA Procedure	602,820 (68.3)
THA + THA	776 (0.1)
TKA + TKA	22,650 (2.6)
THA + TKA	98 (0.0)

*THA and TKA are presented separately for illustrative purposes and are not mutually exclusive

4.2.2 Frequency of THA/TKA Model Variables

We examined the change in both observed readmission rates and frequency of clinical and demographic variables. Between the year July 2009-July 2010 and the year July 2011- June 2012, the observed readmission rate decreased from 5.43% to 5.24%.

The frequency of some model variables increased. The increase may reflect an increased rate of comorbidity in the fee-for-service population, but is also due in part to increased hospital coding of comorbidities. In the 2012 update to the measures, we increased the number of diagnosis codes and procedure codes to align with the Version 5010 format changes required by the Department of Health and Human Services (DHHS). Hospitals could begin to submit up to 25 diagnosis and procedure codes starting in 2010. Over time, more hospitals have submitted increased numbers of codes which translates into increased frequencies for some model variables.

Some notable changes include an increase in the proportion of index admissions with a THA procedure from 28.59% to 30.10%, an increase in Other Injuries (CC162) from 27.10% to 28.30%, an increase in Morbid Obesity (ICD-9 code 287.01) from 4.01% to 5.37%, and an increase in Renal Failure (CC 131) from 7.11% to 8.49%.

4.2.3 THA/TKA Model Parameters and Performance

Table 3 shows the risk-adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for the THA/TKA readmission model by individual year and for the combined three year dataset. Overall, the variable effect sizes were relatively constant across years. Between-hospital variance within the combined dataset was 0.05 (SE: 0.004). If there were no systematic differences between hospitals, the between-hospital variance would be 0. In addition, model performance was stable over the three-year time period; the area under the ROC curve (c-statistic) remained constant at 0.65 (Table 4).

4.2.4 Distribution of Hospital Volumes and RSRRs

Table 5 shows the distribution of hospital volumes, and Table 6 shows the distribution of Hospital RSRRs. These tables show the between-hospital variance by individual year and for the combined three-year dataset. Between July 2009 and June 2012, the mean THA/TKA volume decreased from 92.5 to 82.6 admissions per hospital. The mean RSRR decreased over the three-year period, from 5.45% between July 2009 and June 2010 to 5.26% between July 2011 and June 2012. The median hospital RSRR in the combined three-year dataset was 5.39% (range 3.17% - 10.2%).

Figure 2 shows the overall distribution of the hospital RSRRs for the combined dataset. The odds of all-cause readmission if treated at a hospital one standard deviation above the national rate were 1.57 times higher than the odds of all-cause readmission if treated at a hospital one standard deviation below the national rate. If there were no systematic differences between hospitals, the OR would be 1.0.[5]

4.2.5 Distribution of Hospitals by Performance Category in the Three-Year Dataset

Out of 3,492 number of hospitals in the U.S., 50 performed “better than the U.S. national rate,” 2,740 performed “no different from the U.S. national rate,” and 37 performed “worse than the U.S. national rate.” 665 were classified as “number of cases too small” (fewer than 25) to reliably tell how well the hospital is performing.

Table 2 – Frequency of THA/TKA Model Variables over Different Time Periods

Variable	07/2009-06/2010	07/2010-06/2011	07/2011-06/2012	07/2009-06/2012
Total N	305,897	301,151	275,839	882,887
Observed readmission rate (%)	5.43	5.39	5.24	5.36
Mean age minus 65 (SD)	10.0 (6.0)	10.0 (6.0)	9.9 (6.0)	10.0 (6.0)
Male (%)	36.08	36.33	36.51	36.30
Index admissions with an elective THA procedure	28.59	28.87	30.10	29.16
Number of procedures (two vs. one)	2.89	2.69	2.39	2.66
History of Infection (CC 1, 3-6)	18.02	17.77	17.88	17.89
Metastatic cancer and acute leukemia (CC 7)	0.51	0.55	0.55	0.54
Cancer (CC 8-12)	18.60	18.52	18.74	18.62
Diabetes and DM complications (CC 15-20, 119, 120)	28.17	28.66	28.95	28.58
Protein-calorie malnutrition (CC 21)	0.64	0.71	0.78	0.71
Disorders of fluid/electrolyte/acid-base (CC 22, 23)	12.16	12.51	12.97	12.53
Rheumatoid arthritis and inflammatory connective tissue disease (CC 38)	8.53	8.91	9.19	8.87
Severe hematological disorders (CC 44)	0.73	0.70	0.62	0.68
Dementia and senility (CC 49, 50)	4.22	4.25	4.39	4.28
Major psychiatric disorders (CC 54-56)	3.95	4.32	4.59	4.28
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	1.57	1.63	1.74	1.64
Polyneuropathy (CC 71)	5.89	6.40	6.82	6.35
Congestive heart failure (CC 80)	9.18	9.23	9.16	9.19
Chronic atherosclerosis (CC 83-84)	29.61	29.34	28.74	29.24
Hypertension (CC 89, 91)	82.91	83.49	83.34	83.24
Arrhythmias (CC 92, 93)	22.95	23.44	23.86	23.40
Stroke (CC 95, 96)	2.29	2.20	2.14	2.21
Vascular or circulatory disease (CC 104-106)	22.77	22.91	22.75	22.81
COPD (CC 108)	14.19	14.03	14.18	14.13
Pneumonia (CC 111-113)	4.35	4.21	4.21	4.26
End-stage renal disease or dialysis (CC 129, 130)	0.13	0.15	0.17	0.15
Renal failure (CC 131)	7.11	7.85	8.49	7.79
Decubitus ulcer or chronic skin ulcer (CC 148, 149)	2.63	2.62	2.56	2.61
Cellulitis, local skin infection (CC 152)	7.76	7.71	7.76	7.74
Other injuries (CC162)	27.10	27.55	28.30	27.63
Major symptoms, abnormalities (CC 166)	51.95	52.09	51.99	52.01
Morbid obesity (ICD-9 code 278.01)	4.01	4.63	5.37	4.65
Skeletal deformities (ICD-9 code 755.63)	0.15	0.17	0.17	0.16
Post traumatic osteoarthritis (ICD-9 codes 716.15, 716.16)	0.45	0.42	0.41	0.43

Table 3 – Adjusted OR and 95% CIs for the THA/TKA Hierarchical Logistic Regression Model over Different Time Periods

Variable	07/2009-06/2010 OR (95% CI)	07/2010-06/2011 OR (95% CI)	07/2011-06/2012 OR (95% CI)	07/2009-06/2012 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.0 (1.03-1.04)	1.0 (1.03-1.04)	1.0 (1.03-1.04)	1.0 (1.03-1.04)
Male	1.1 (1.07-1.14)	1.1 (1.09-1.17)	1.2 (1.12-1.20)	1.1 (1.11-1.16)
Index admissions with an elective THA procedure	1.1 (1.08-1.15)	1.1 (1.06-1.14)	1.1 (1.06-1.14)	1.1 (1.08-1.13)
Number of procedures (two vs. one)	1.3 (1.21-1.45)	1.3 (1.21-1.47)	1.4 (1.22-1.51)	1.3 (1.26-1.41)
History of Infection (CC 1, 3-6)	1.1 (1.07-1.15)	1.1 (1.06-1.14)	1.1 (1.10-1.20)	1.1 (1.09-1.14)
Metastatic cancer and acute leukemia (CC 7)	1.1 (0.92-1.35)	1.3 (1.10-1.57)	1.2 (0.98-1.45)	1.2 (1.08-1.35)
Cancer (CC 8-12)	1.0 (0.97-1.05)	1.0 (0.94-1.02)	1.0 (0.93-1.01)	1.0 (0.96-1.01)
Diabetes and DM complications (CC 15-20, 119, 120)	1.1 (1.10-1.18)	1.2 (1.12-1.20)	1.1 (1.09-1.17)	1.1 (1.12-1.16)
Protein-calorie malnutrition (CC 21)	1.4 (1.19-1.58)	1.3 (1.15-1.51)	1.3 (1.10-1.44)	1.3 (1.21-1.42)
Disorders of fluid/electrolyte/acid-base (CC 22, 23)	1.1 (1.09-1.19)	1.1 (1.09-1.19)	1.1 (1.07-1.17)	1.1 (1.10-1.16)
Rheumatoid arthritis and inflammatory connective tissue disease (CC 38)	1.1 (1.09-1.21)	1.2 (1.10-1.22)	1.1 (1.08-1.20)	1.1 (1.11-1.18)
Severe hematological disorders (CC 44)	1.4 (1.19-1.58)	1.4 (1.20-1.59)	1.3 (1.09-1.51)	1.4 (1.24-1.47)
Dementia and senility (CC 49, 50)	1.2 (1.14-1.29)	1.2 (1.11-1.26)	1.2 (1.11-1.27)	1.2 (1.15-1.24)
Major psychiatric disorders (CC 54-56)	1.3 (1.24-1.42)	1.3 (1.26-1.44)	1.2 (1.15-1.32)	1.3 (1.25-1.35)
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	1.1 (0.98-1.21)	1.0 (0.92-1.14)	1.2 (1.04-1.29)	1.1 (1.02-1.16)
Polyneuropathy (CC 71)	1.1 (1.05-1.18)	1.1 (1.09-1.22)	1.1 (1.09-1.22)	1.1 (1.10-1.18)
Congestive heart failure (CC 80)	1.3 (1.22-1.34)	1.3 (1.23-1.35)	1.2 (1.16-1.28)	1.3 (1.23-1.30)
Chronic atherosclerosis (CC 83-84)	1.2 (1.18-1.26)	1.2 (1.19-1.28)	1.2 (1.16-1.25)	1.2 (1.19-1.24)
Hypertension (CC 89, 91)	1.2 (1.15-1.27)	1.2 (1.17-1.29)	1.3 (1.21-1.35)	1.2 (1.20-1.27)
Arrhythmias (CC 92, 93)	1.1 (1.09-1.18)	1.2 (1.11-1.20)	1.2 (1.14-1.23)	1.2 (1.13-1.18)
Stroke (CC 95, 96)	1.1 (1.02-1.21)	1.1 (1.01-1.21)	1.1 (1.00-1.22)	1.1 (1.05-1.17)
Vascular or circulatory disease (CC 104-106)	1.2 (1.11-1.20)	1.1 (1.10-1.18)	1.1 (1.05-1.14)	1.1 (1.11-1.15)
COPD (CC 108)	1.4 (1.31-1.41)	1.3 (1.29-1.40)	1.3 (1.26-1.37)	1.3 (1.31-1.37)
Pneumonia (CC 111-113)	1.2 (1.08-1.23)	1.1 (1.04-1.18)	1.1 (1.06-1.21)	1.1 (1.09-1.18)
End-stage renal disease or dialysis (CC 129, 130)	1.6 (1.19-2.02)	1.7 (1.32-2.17)	2.2 (1.76-2.80)	1.8 (1.57-2.09)
Renal failure (CC 131)	1.3 (1.21-1.34)	1.3 (1.24-1.38)	1.3 (1.20-1.33)	1.3 (1.24-1.32)
Decubitus ulcer or chronic skin ulcer (CC 148, 149)	1.2 (1.14-1.34)	1.2 (1.08-1.27)	1.2 (1.07-1.27)	1.2 (1.14-1.25)
Cellulitis, local skin infection (CC 152)	1.1 (1.00-1.11)	1.1 (1.04-1.16)	1.1 (1.08-1.20)	1.1 (1.06-1.13)
Other injuries (CC162)	1.1 (1.07-1.15)	1.1 (1.07-1.15)	1.1 (1.09-1.17)	1.1 (1.09-1.14)
Major symptoms, abnormalities (CC 166)	1.2 (1.16-1.24)	1.2 (1.16-1.24)	1.2 (1.13-1.22)	1.2 (1.16-1.21)
Morbid obesity (ICD-9 code 278.01)	1.3 (1.23-1.42)	1.3 (1.25-1.43)	1.4 (1.31-1.49)	1.3 (1.30-1.40)
Skeletal deformities (ICD-9 code 755.63)	0.9 (0.57-1.33)	0.7 (0.46-1.14)	0.8 (0.49-1.24)	0.8 (0.61-1.03)
Post traumatic osteoarthritis (ICD-9 codes 716.15, 716.16)	0.9 (0.75-1.19)	1.1 (0.85-1.35)	1.2 (0.93-1.50)	1.1 (0.93-1.22)
Between Hospital Variance (SE)	0.05 (0.01)	0.06 (0.01)	(0.06-0.01)	(0.05-0.004)

Table 4 – THA/TKA Generalized Linear Modeling (Logistic Regression) Performance over Different Time Periods

Characteristic	07/2009-06/2010	07/2010-06/2011	07/2011-06/2012	07/2009-06/2012
Predictive ability, % (lowest decile – highest decile)	(2.3-12.0)	(2.1-12.2)	(2.1-11.6)	(2.1-12.0)
C-statistic	0.65	0.65	0.65	0.65

Table 5 – Distribution of Hospital THA/TKA Volumes over Different Time Periods[§]

Characteristic	07/2009-06/2010	07/2010-06/2011	07/2011-06/2012	07/2009-06/2012
Number of Hospitals	3,307	3,327	3,339	3,492
Mean Number of Admissions (SD)	92.5 (122.6)	90.5 (120.9)	82.6 (113.1)	252.8 (348.6)
Range (min. – max.)	(1-2,071)	(1-2,093)	(1-2,076)	(1-6,240)
25th percentile	16	16	13	38
50th percentile	51	48	43	128
75th percentile	121	122	109	330.5

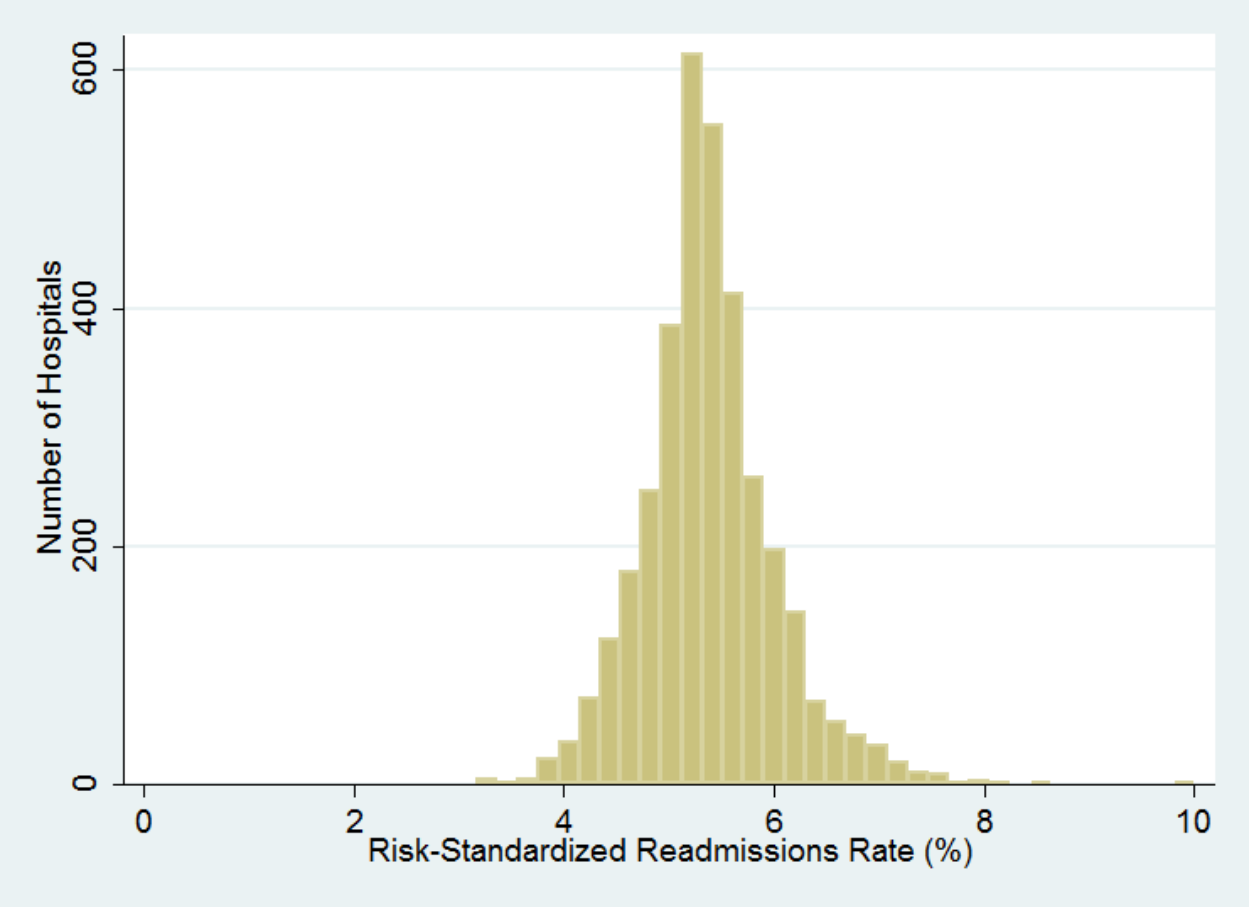
Table 6 – Distribution of Hospital THA/TKA RSRRs over Different Time Periods

Characteristic	07/2009-06/2010	07/2010-06/2011	07/2011-06/2012	07/2009-06/2012
Number of Hospitals	3,307	3,327	3,339	3,492
Mean (SD)	5.45 (0.44)	5.41 (0.51)	5.26 (0.50)	5.39 (0.62)
Range (min. – max.)	(3.68-8.80)	(3.55-8.40)	(3.36-8.19)	(3.17-10.2)
25th percentile	5.22	5.15	5.00	5.04
50th percentile	5.41	5.36	5.21	5.34
75th percentile	5.66	5.65	5.49	5.70

[§] Hospital volumes for third year of reporting (July 2011-2012) are lower in part due to incomplete enrollment data for discharges in June 2012.

Figure 2 – Distribution of Hospital 30-Day THA/TKA RSRRs between July 2009 and June 2012

N= 3,492 hospitals



5. DATA QUALITY ASSURANCE (QA)

We have a two-phase approach to internal QA for the readmission measure maintenance process. These phases are described below. Please refer to Figure 3 for a detailed outline of phase I and Figure 4 for a detailed outline of phase II.

Note that this section represents QA for the subset of the work conducted by YNHHSC/CORE to maintain and report the THA/TKA readmission measure. It does not describe the QA to process data and create the input files, nor does it include the QA for the final processing of production data for public reporting because that work is conducted by another contractor (Mathematica Policy Research Inc.).

5.1 Phase I

The first step in the QA process is to ensure the validity of the input data files. There were no substantial changes to the data input processing, and only one additional year of data was added to our existing datasets. Only one new field was added to support the production of another measure. There was minimal need for targeted quality checks this year, so the automated process we developed previously allowed for a thorough review of the new datasets.

In general, all procedure-specific files for each reporting year are evaluated by comparing them to the prior year's QA results for the same procedure/year. We conduct data validity checks, including crosschecking of readmission information, distributions of ICD-9-CM codes, and frequencies of key variables. We employ both manual scan and descriptive analyses to carry out these tasks. The results are reviewed for accuracy and changes over time compared to prior datasets. Any new variable constructs and other changes in formatting to the input files are also verified as part of this process. We share our QA findings with our data extraction contractor as needed.

To assure accuracy in SAS pack coding, two analysts independently write SAS code for any changes made in calculating the THA/TKA readmission measure: data preparation, sample selection, hierarchical modeling, and calculation of RSRRs. This process highlights any programming errors in syntax or logic. Once the parallel programming process is complete, the analysts cross-check their codes by analyzing datasets in parallel, checking for consistency of output and reconciling any discrepancies.

5.2 Phase II

A third analyst reviews the finalized SAS code and recommends changes to the coding and readability of the SAS pack, where appropriate. The primary analyst receives the suggested changes for possible re-coding or program documentation.

This phase also includes a comparison of prior years' risk-adjustment coefficients and variable frequencies (in this case, those used during the dry run performed in 2012). This enables us to check for potential inconsistencies in the data as well as the impact of any changes to the SAS pack.

Figure 3 – YNHHSC/CORE QA Phase I

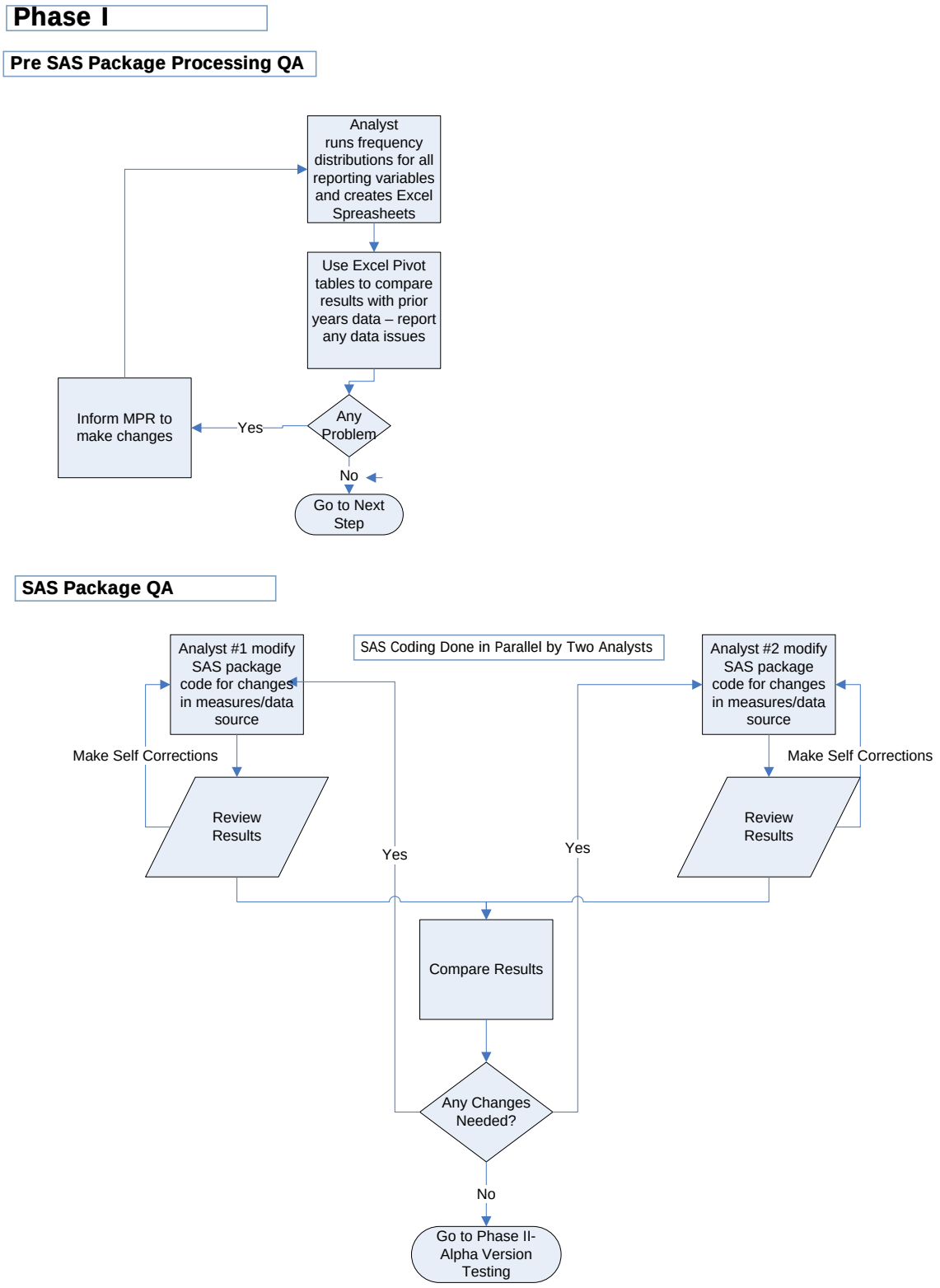
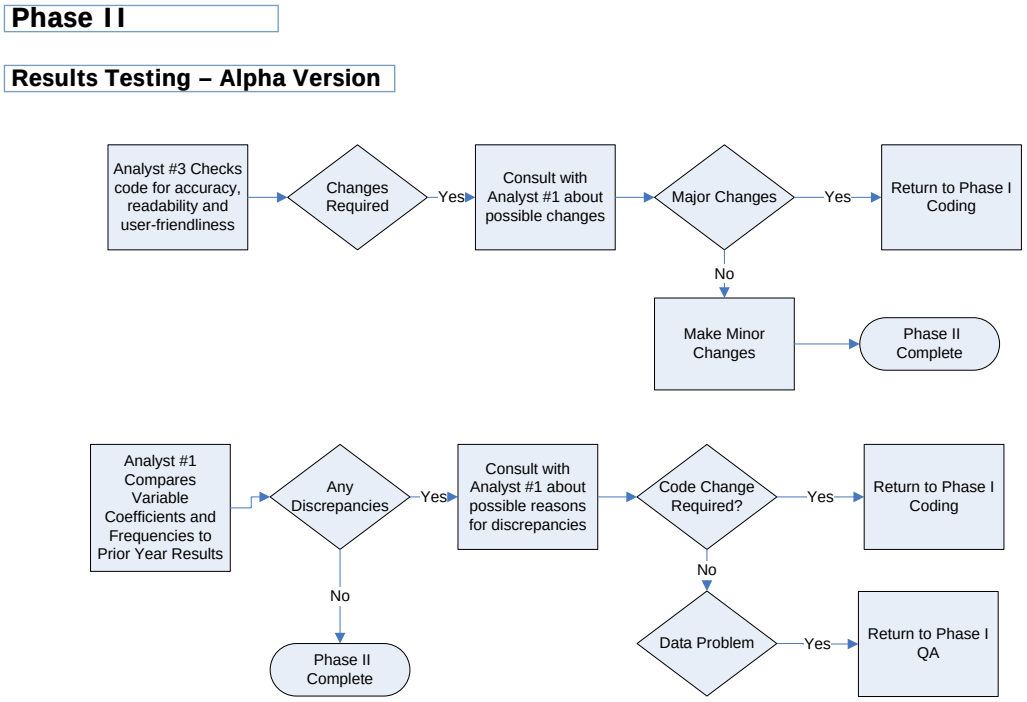


Figure 4 – YNHHSC/CORE QA Phase II



6. REFERENCES

1. Grosso L, Curtis J, Geary L, et al. *Hospital-level 30-Day All-Cause Risk-Standardized Readmission Rate Following Elective Primary Total Hip Arthroplasty (THA)And/Or Total Knee Arthroplasty (TKA) Measure Methodology Report*: Yale New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (YNHHSC/CORE);2012.

2. Grosso L, Curtis J, Geary L, et al. *Hospital-level Risk-Standardized Complication Rate Following Elective Primary Total Hip Arthroplasty (THA) And/Or Total Knee Arthroplasty (TKA) Measure Methodology Report*: Yale New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (YNHHSC/CORE);2012.

3. Drye E, Normand S-L, Wang Y, et al. Comparison of hospital risk-standardized mortlatiy rates calculated by suing in -hospital and 30 day models: an observational study with implications for hospital profiling. *Ann Intern Med.* 2012;156:19-26.

4. *Medicare Hospital Quality Chartbook 2012: Performance Report on Outcome Measures*: Prepared by Yale New Haven Health Services Corporation Center for Outcomes Research and Evaluation for the Centers for Medicare and Medicaid Services;2012.

5. Normand S-L, Shahian D. Development, validation, and results of a measure of 30-day readmission folwoing hosptialization for pneumonia. *Stat Sci.* 2007;22(2):206-226.

7. APPENDICES

Appendix A. Measure Specifications

1. Cohort ICD-9-CM Codes by Measure

THA/TKA Cohort Codes

81.51 Total Hip Arthroplasty
81.54 Total Knee Arthroplasty

2. Outcome Definition Criteria

30-day time frame

Rationale: Outcomes occurring within 30 days of discharge can be strongly influenced by hospital care and the early transition to the outpatient setting. The use of the 30-day timeframe is a clinically meaningful period for hospitals to collaborate with their communities in an effort to reduce readmissions.

All-cause unplanned readmission

Rationale: From a patient perspective, an unplanned readmission for any cause is an adverse event.

Unplanned readmission

Rationale: Planned readmissions are generally not a signal of quality of care. Including planned readmissions in a readmission measure could create a disincentive to provide appropriate care to patients who are scheduled for elective or necessary procedures within 30 days of discharge.

3. Cohort Inclusion Criteria

Principal discharge diagnosis of Total Hip Arthroplasty and/or Total Knee Arthroplasty

Rationale: elective primary total hip or knee arthroplasty is the procedure targeted for measurement in this report.

Enrolled in Part A and Part B Medicare for the 12 months prior to the date of admission, and enrolled in Part A during the index admission

Rationale: The 12 month prior enrollment ensures a full year of administrative data for risk adjustment. Part A is required during the index admission to ensure no Medicare Advantage patients are included in the measures.

Aged 65 or older

Rationale: Medicare patients younger than 65 are not included in the measure because they are considered to be too clinically different from patients 65 and over as they often qualify for Medicare at a younger age because of disabilities.

4. Cohort Exclusion Criteria (Table A3)

Femur, hip, or pelvic fractures coded in the principal discharge diagnosis field

Rationale: Patients with fractures have a higher mortality, complication, and readmission rates and the procedures are not elective.

Partial hip arthroplasty (PHA) procedures (with a concurrent THA/TKA)

Rationale: Partial arthroplasty procedures are primarily done for hip fractures and are typically performed on patients who are older, frailer, and have more comorbid conditions.

Revision procedures (with a concurrent THA/TKA)

Rationale: Revision procedures may be performed at a disproportionately small number of hospitals and are associated with higher mortality, complication, and readmission rates.

Resurfacing procedures (with a concurrent THA/TKA)

Rationale: Resurfacing procedures are a different type of procedure involving only the joint's articular surface. Resurfacing procedures are typically performed on younger, healthier patients.

Mechanical complication coded in the principal discharge

Rationale: A complication coded as the principal discharge diagnosis suggests the procedure was more likely the result of a previous procedure and indicates the complication was present on admission. These patients may require more technically complex arthroplasty procedures and may be at increased risk for complications, particularly mechanical complications.

Malignant neoplasm of the pelvis, sacrum, coccyx, lower limbs, or bone/bone marrow or a disseminated malignant neoplasm coded in the principal discharge diagnosis field

Rationale**:** Patients with these malignant neoplasms are at increased risk for readmission, and the procedure may not be elective.

Removal of implanted devises/prostheses

Rationale: Elective procedures performed in these patients may be more complicated

Without at least 12 months pre-index admission enrollment in Medicare FFS

Rationale: Appropriate risk adjustment requires uniform data availability of pre-operative comorbidity.

Without at least 30 days of post-discharge enrollment in FFS Medicare

Rationale: The 30-day readmission outcome cannot be assessed in this group since claims data are used to determine whether or not a patient was readmitted.

Transfers into the index hospital

Rationale: If the patient is transferred from another acute care facility to the hospital where the index procedure occurs, it is likely that the procedure is not elective or that the admission is associated with an acute condition.

Admitted for the index procedure and subsequently transferred to another acute care facility

Rationale: Attribution of readmission to the index hospital would be difficult in these cases, since the index hospital performed the procedure but another hospital discharged the patient to the non-acute care setting.

Discharged against medical advice (AMA)

Rationale: Providers did not have the opportunity to deliver full care and prepare the patient for discharge.

With more than two THA/TKA procedure codes during the index hospitalization

Rationale: Although clinically possible, it is highly unlikely that patients would receive more than two elective THA/TKA procedures in one hospitalization, and this may reflect a coding error.

In-hospital deaths

Rationale: Patients are not eligible for readmission.

5. Statistical Approach to Risk-Standardized Readmission Rates

We estimate the hospital-specific risk-standardized readmission rates using hierarchical generalized linear models. This strategy accounts for within-hospital correlation of the observed outcome and accommodates the assumption that underlying differences in quality across hospitals lead to systematic differences in outcomes. We model the probability of readmission as a function of patient age, sex, clinically relevant comorbidities with an intercept for the hospital-specific random effect.

We use the following strategy to calculate the hospital-specific readmission rates. We calculate these rates as the ratio of a hospital's "predicted" readmissions to "expected" readmissions multiplied by the national observed readmission rate. The expected number of readmissions for each hospital is estimated using its patient-mix and the average hospital-specific intercept (i.e., the average intercept among all hospitals in the sample). The predicted number of readmissions for each hospital is estimated given the same patient-mix but an estimated hospital-specific intercept. Operationally, the expected number of readmissions for each hospital is obtained by summing the expected probabilities of readmissions for all patients in the hospital. The expected probability of readmission for each patient is calculated via the hierarchical model which applies the estimated regression coefficients to the observed patient characteristics and adds the average of the hospital-specific. The predicted number of readmissions for each hospital is calculated by summing the predicted probabilities for all patients in the hospital. The predicted probability for each patient is calculated through the hierarchical model which applies the estimated regression coefficients to the patient characteristics observed and adding the hospital-specific intercept.

More specifically, we use a hierarchical generalized linear model, in this case, a hierarchical logistic regression, to account for the natural clustering of observations within hospitals. The model employs a logit link function to link the risk factors to the outcome with a hospital-specific random effect as follows:

$$h(Y_{ij}) = \alpha_i + \beta \mathbf{Z}_{ij} \quad (1)$$

$$\alpha_i = \mu + \omega_i; \qquad \omega_i \sim N(0, \tau^2) \quad (2)$$

Where h(.) is a logit link, Y_{ij} is whether the j^{th} patient in the i^{th} hospital was readmitted (1: readmitted, 0 otherwise); α_i represents the hospital-specific intercept, $\mathbf{Z}_{ij} = (Z_{1ij}, Z_{2ij}, \ldots, Z_{pij})$ the patient-specific covariates, μ is the average hospital intercept across all hospitals in the sample, and τ^2 is the between-hospital variance component[**]. This model separates within-hospital variation from between-hospital variation. The hierarchical generalized linear models are estimated using the SAS software system (SAS 9.2 GLIMMIX).

5.1 Hospital performance reporting

Using the selected set of risk factors, we fit the hierarchical generalized linear model defined by Equations (1) - (2) and estimate the parameters, $\hat{\mu}$, $\{\hat{\alpha}_i, \hat{\alpha}_2, \ldots, \hat{\alpha}_I\}$, $\hat{\beta}$, and $\hat{\tau}^2$ where i is the total number of hospitals. We calculate a standardized outcome measure, RSRR, for each hospital by

[**] Daniels M, Gatsonic C. Hierarchical Generalized Linear Models in the Analysis of Variations in Health Care Utilization. *Journal of the American Statistical Association.* 1999;94(445):14

computing the ratio of the predicted number of readmission to the expected number of readmissions, multiplied by the national observed readmission rate, $\bar{y}$. Specifically, we calculate

Predicted $\hat{y}_{ij}(Z_{ij}) = h^{-1}(\hat{\alpha}_i + \hat{\beta}\boldsymbol{Z}_{ij})$ (3)

Expected $\hat{e}_{ij}(Z_{ij}) = h^{-1}(\hat{\mu} + \hat{\beta}\boldsymbol{Z}_{ij})$ (4)

$$\widehat{RSRR}_i = \frac{\sum_{j=1}^{n_i} \hat{y}_{ij}(z_{ij})}{\sum_{j=1}^{n_i} \hat{e}_{ij}(z_{ij})} \times \bar{y} \quad (5)$$

Above, n_i is the number of index hospitalizations for the i^{th} hospital.

If the "predicted" number of readmissions is higher (or lower) than the "expected" number of readmissions for a given hospital, then its $\widehat{RSRR}$ will be higher (or lower) than the national observed readmission rate. For each hospital, we compute an interval estimate of $RSRR_i$ to characterize the level of uncertainty around the point estimate using bootstrapping simulations as described below. The point estimate and interval estimate are used to characterize and compare hospital performance (e.g., higher than expected, as expected, or lower than expected).

5.2 Creating Interval Estimates

Because the statistic described in Equation 5**,** i.e., $\widehat{RSRR}_i$ is a complex function of parameter estimates, we use the re-sampling technique, bootstrapping, to derive an interval estimate. Bootstrapping has the advantage of avoiding unnecessary distributional assumptions.

Algorithm:

Let *I* denote the total number of hospitals in the sample. We repeat steps 1-4 below for B times, where *B* is the number of bootstrap samples desired:

1. Sample *I* hospitals with replacement.
2. Fit the hierarchical generalized linear model using all patients within each sampled hospital. If some hospitals are selected more than once in a bootstrapped sample, we treat them as distinct so that we have *I* random effects to estimate the variance components. At the conclusion of Step 2, we have:
    a. $\hat{\beta}^{(b)}$ (the estimated regression coefficients of the risk factors).
    b. The parameters governing the random effects, hospital adjusted outcomes, distribution, $\hat{\mu}^{(b)}$ and $\hat{\tau}^{2(b)}$.
    c. The set of hospital-specific intercepts and corresponding variances,

    $$\{\hat{\alpha}_i^{(b)}, \widehat{var}(\alpha_i^{(b)}); i = 1,2,\dots,I\}$$
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 $\alpha_i^{(b*)} \sim N(\hat{\alpha}_i^{(b)}, \widehat{var}(\hat{\alpha}_i^{(b)}))$ for the unique set of hospitals sampled in Step 1.

4. Within each unique hospital *i* sampled in Step 1, and for each case *j* in that hospital, we calculate $\hat{y}_{ij}^{(b)}$, $\hat{e}_{ij}^{(b)}$, and $\widehat{RSRR}_i(Z)^{(B)}$ where $\hat{\beta}^{(b)}$ and $\hat{\mu}^{(b)}$ are obtained from Step 2 and $\hat{\alpha}_i^{(b*)}$ is obtained from Step 3.

Ninety-five percent interval estimates (or alternative interval estimates) for the hospital-standardized outcome can be computed by identifying the 2.5th and 97.5th percentiles of the B estimates (or the percentiles corresponding to the alternative desired intervals)[††].

[††] Normand S, Wang Y, Krumholz H. Assessing surrogacy of data sources for institutional comparisons. *Health Services and Outcomes Research Methodology.* 2007;7:79-96.

Table A1. Risk Variables in the THA/TKA Readmission and Complication Measures

Variable	Codes	THA/TKA Readmission Measure	THA/TKA Complications Measure
Age minus 65 (years above 65, continuous)	n/a	x	x
Male	n/a	x	x
Index admissions with an elective THA procedure		x	x
Number of procedures (two vs. one)		x	x
Skeletal deformities	ICD-9 code 755.63	x	x
Post traumatic osteoarthritis	ICD-9 code 716.15, 716.16	x	x
Morbid obesity	ICD-9 code 278.01	x	x
History of infection CC 1, 3-6	CC 1, 3-6	x	
Metastic cancer and acute leukemia	CC 7	x	x
Cancer (CC 8-12)		x	x
Respiratory/Heart/Digestive/Urinary/Other Neoplasms	CC 11-13		x
Diabetes and DM complications	CC 15-20, 119, 120	x	x
Protein-calorie malnutrition	CC 21	x	x
Bone/Joint/Muscle Infections/Necrosis	CC 37		x
Disorders of fluid/electrolyte/acid-base	CC 22, 23	x	
Rheumatoid arthritis and inflammatory connective tissue disease	CC 38	x	x
Osteoporosis of Hip or Knee	CC 40		x
Osteoporosis and Other Bone/Cartilage Disorders	CC 41		x
Sever hematological disorders	CC 44	x	
Dementia and senility	CC 49, 50	x	x
Major psychiatric disorders	CC 54-56	x	x
Hemiplegia, paraplegia, paralysis, functional disability	67-69, 100-102, 177-178	x	x
Cardio-Respiratory Failure and Shock	CC 79		x
Polyneuropathy	CC 71	x	
Congestive heart failure	CC 80	x	
Chronic atherosclerosis	CC 83-84	x	x
Hypertension	CC 89 91	x	
Arrhythmias	CC 92, 93	x	
Stroke	CC 95, 96	x	x
Vascular or circulatory disease	CC 104-106	x	x
COPD	CC 108	x	x
Pneumonia	CC 111-113	x	x

Pleural effusion/pneumothorax	CC 114		x
End-stage renal disease or dialysis	CC 129, 130	x	x
Renal failure	CC 131	x	x
Decubitus ulcer or chronic skin ulcer	CC 148, 149	x	x
Trauma	CC 154-156, 158-161		x
Vertebral Fractures	CC 157	x	x
Cellulitis, local skin infection	CC 152	x	
Other injures	CC 162	x	x
Major symptoms, abnormalities	CC 166	x	
Major Complications of Medicare Care and Trauma	CC 164		x

Table A2. Risk Variables Considered Complications of Care During the Index Admission[‡‡]

CC	Description
2	Septicemia/Shock
6	Other Infectious Diseases
17	Diabetes with Acute Complications
23	Disorders of Fluid/Electrolyte/Acid-Base
24	Other Endocrine/Metabolic/Nutritional Disorders
28	Acute Liver Failure/Disease
31	Intestinal Obstruction/Perforation
34	Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders
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
47	Iron Deficiency and Other/Unspecified Anemias and Blood Disease
48	Delirium and Encephalopathy
51	Drug/Alcohol Psychosis
75	Coma, Brain Compression/Anoxic Damage
76	Mononeuropathy, Other Neurological Conditions/Injuries
77	Respirator Dependence/Tracheostomy Status
78	Respiratory Arrest
79	Cardio-respiratory failure and shock
80	Congestive heart failure
81	Acute myocardial infarction
85	Heart Infection/Inflammation, Except Rheumatic
92	Specified Heart Arrhythmias
93	Other Heart Rhythm and Conduction Disorders
95	Cerebral Hemorrhage
96	Ischemic or Unspecified Stroke
97	Precerebral Arterial Occlusion and Transient Cerebral Ischemia
100	Hemiplegia/Hemiparesis
101	Cerebral Palsy and Other Paralytic Syndromes
102	Speech, Language, Cognitive, Perceptual
104	Vascular Disease with Complications
105	Vascular Disease
106	Other Circulatory Disease
111	Aspiration and Specified Bacterial Pneumonias
112	Pneumococcal Pneumonia, Emphysema, Lung Abscess
113	Viral and Unspecified Pneumonia, Pleurisy
114	Pleural Effusion/Pneumothorax
130	Dialysis Status
131	Renal failure

[‡‡] The selected CC's are considered complications of care and are not risk-adjusted for if they only occur during the index admission.

CC	Description
132	Nephritis
133	Urinary Obstruction and Retention
135	Urinary Tract Infection
148	Decubitus Ulcer of Skin
152	Cellulitis, Local Skin Infection
154	Severe Head Injury
155	Major Head Injury
156	Concussion or Unspecified Head Injury
158	Hip Fracture/Dislocation
159	Major Fracture, Except of Skull, Vertebrae, or Hip
160	Internal Injuries
161	Traumatic Amputation
162	Other Injuries
163	Poisonings and Allergic Reactions
164	Major Complications of Medical Care and Trauma
165	Other Complications of Medical Care
175	Other Organ Transplant/Replacement
177	Amputation Status, Lower Limb/Amputation
178	Amputation Status, Upper Limb

Table A3. ICD-9-CM codes for Hip Fracture, Revision Procedures, Partial Hip Arthroplasty, Resurfacing Procedures, Mechanical Complications, Removal of Implemented Device, and Malignant Neoplasms

Femur, Hip, and Pelvic Fracture Codes	
733.10	Pathological fracture unspecified site
733.14	Pathological fracture of neck of femur
733.15	Pathological fracture of other specified part of femur
733.19	Pathological fracture of other specified site
733.8	Malunion and nonunion of fracture
733.81	Malunion of fracture
733.82	Nonunion of fracture
733.95	Stress fracture of other bone
733.96	Stress fracture of femoral neck
733.97	Stress fracture of shaft of femur
808.0	Closed fracture of acetabulum
808.1	Open fracture of acetabulum
808.2	Closed fracture of pubis
808.3	Open fracture of pubis
808.41	Closed fracture of ilium
808.42	Closed fracture of ischium
808.43	Multiple closed pelvic fractures with disruption of pelvic circle
808.44	Multiple closed pelvic fractures without disruption of pelvic circle
808.49	Closed fracture of other specified part of pelvis
808.50	Open fracture of other specified part of pelvis
808.51	Open fracture of ilium
808.52	Open fracture of ischium
808.53	Multiple open pelvic fractures with disruption of pelvic circle
808.54	Multiple open pelvic fractures without disruption of pelvic circle
808.8	Unspecified closed fracture of pelvis
820	Fracture of neck of femur
820.0	Transcervical fracture closed
820.00	Fracture of unspecified intracapsular section of neck of femur closed
820.01	Fracture of epiphysis (separation) (upper) of neck of femur closed
820.02	Fracture of midcervical section of femur closed
820.03	Fracture of base of neck of femur closed
820.09	Other transcervical fracture of femur closed
820.1	Transcervical fracture open
820.10	Fracture of unspecified intracapsular section of neck of femur open
820.11	Fracture of epiphysis (separation) (upper) of neck of femur open
820.12	Fracture of midcervical section of femur open
820.13	Fracture of base of neck of femur open
820.19	Other transcervical fracture of femur open
820.2	Pertrochanteric fracture of femur closed
820.20	Fracture of unspecified trochanteric section of femur closed
820.21	Fracture of intertrochanteric section of femur closed
820.22	Fracture of subtrochanteric section of femur closed
820.3	Pertrochanteric fracture of femur open

Femur, Hip, and Pelvic Fracture Codes	
820.30	Fracture of unspecified trochanteric section of femur open
820.31	Fracture of intertrochanteric section of femur open
820.32	Fracture of subtrochanteric section of femur open
820.8	Fracture of unspecified part of neck of femur closed
820.9	Fracture of unspecified part of neck of femur open
821	Fracture of other and unspecified parts of femur
821.0	Fracture of shaft or unspecified part of femur closed
821.00	Fracture of unspecified part of femur closed
821.01	Fracture of shaft of femur closed
821.1	Fracture of shaft or unspecified part of femur open
821.10	Fracture of unspecified part of femur open
821.11	Fracture of shaft of femur open
821.2	Fracture of lower end of femur closed
821.20	Fracture of lower end of femur unspecified part closed
821.21	Fracture of femoral condyle closed
821.22	Fracture of lower epiphysis of femur closed
821.23	Supracondylar fracture of femur closed
821.29	Other fracture of lower end of femur closed
821.3	Fracture of lower end of femur open
821.30	Fracture of lower end of femur unspecified part open
821.31	Fracture of femoral condyle open
821.32	Fracture of lower epiphysis of femur open
821.33	Supracondylar fracture of femur open
821.39	Other fracture of lower end of femur open

THA and TKA Revision Codes	
81.53	Revise Hip Replacement, NOS
81.55	Revision of Knee replacement, NOS
81.59	Revision of joint replacement of lower extremity, not elsewhere classified
00.70	REV Hip Repl-acetab/fem
00.71	REV Hip Repl-acetab comp
00.72	REV Hip Repl-fem comp
00.73	REV Hip Repl-liner/head
00.80	Replacement of femoral, tibial, and patellar components (all components)
00.81	Replacement of tibial baseplate and tibial insert (liner)
00.82	Revision of knee replacement, femoral component
00.83	Revision of knee replacement, patellar component
00.84	Revision of total knee replacement, tibial insert (liner)

Partial Hip Replacement	
81.52	Partial Hip Replacement

THA Resurfacing Procedure Codes	
00.85	Resurfacing hip, total, acetabulum and femoral head, hip resurfacing arthroplasty, total
00.86	Resurfacing hip, partial, femoral head, hip resurfacing arthroplasty, NOS, hip resurfacing arthroplasty, partial, femoral head
00.87	Resurfacing hip, partial, acetabulum, hip resurfacing arthroplasty, partial, acetabulum

Mechanical Complications Codes	
996.4	Mechanical complication of internal orthopedic device implant and graft
996.40	Unspecified mechanical complication of internal orthopedic device, implant and graft
996.41	Mechanical loosening of prosthetic joint
996.42	Dislocation of prosthetic joint
996.43	Broken prosthetic joint implant
996.44	Peri prosthetic fracture around prosthetic joint
996.45	Peri prosthetic osteolysis
996.46	Articular bearing surface wear of prosthetic joint
996.47	Other mechanical complication of prosthetic joint implant
996.49	Other mechanical complication of other internal orthopedic device, implant, and graft
996.77	Other complications due to internal joint prosthesis
996.78	Other complications due to other internal orthopedic device implant and graft

Removal of Implanted Devices/Prosthesis Codes	
78.65	Removal of implanted devices from femur
78.66	Removal of implanted devices from bone; patella
78.67	Removal of implanted devices from bone; tibia and fibula
80.05	Arthrotomy for removal of prosthesis - femur
80.06	Arthrotomy for removal of prosthesis without replacement, knee
80.09	Arthrotomy For Removal Of Prosthesis Without Replacement, Other Specified Sites

Malignant Neoplasms Codes	
170.6	Malignant neoplasm of pelvic bones sacrum and coccyx
170.7	Malignant neoplasm of long bones of lower limb
170.9	Malignant neoplasm of bone and articular cartilage site unspecified
195.3	Malignant neoplasm of pelvis
195.5	Malignant neoplasm of lower limb
198.5	Secondary malignant neoplasm of bone and bone marrow
199.0	Disseminated malignant neoplasm

Appendix B. Annual Updates

Prior annual updates for the measures can be found in the annual maintenance reports available on *QualityNet*. For convenience, we have listed all prior updates here under the reporting year and corresponding report. In 2013, CMS began assigning version numbers to its measures. The measure specifications in the original methodology reports are considered Version 1.0 for each measure. The measures receive a new version number for each subsequent year of updates.

2012 Dry Run Technical Report (Version 1.0)

1. **Updates and rationales for the September 2012 dry run**
    a. **Rationale:** The report described the THA/TKA readmission measure and was specified for the dry run period in 2012. It included an Appendix with details on the initial measure development and validation process.

2013 Measures Maintenance Report (Version 2.0)

1. **Respecified the measures by adding a planned readmission algorithm**
    a. **Rationale:** Unplanned readmissions are acute clinical events experienced by a patient that require urgent rehospitalization. In contrast, planned readmissions are generally not a signal of quality of care. Including planned readmissions in a readmission measure could create a disincentive to provide appropriate care to patients who are scheduled for elective or necessary procedures within 30 days of discharge.
2. **Updated CC map**
    a. **Rationale:** The ICD-9-CM CC map is updated annually to capture all relevant comorbidities coded in patient administrative claims data.
3. **Changes from prior methodology report**
    a. **Rationale:** There were two changes from the original methodology report
        i. Table A3 contains the updated listing of the ICD-9-CM Codes for Femur, Hip, and Pelvic Factures, Revision Procedures, Partial Hip Arthroplasty, Resurfacing Procedures, Mechanical Complications, Removal of Implanted Device, and Malignant Neoplasms that exclude patients from the measure cohort.
            1. FY2012 ICD-9-CM codes 808.44 “Multiple closed pelvic fractures without disruption of pelvic circle” and 808.54, “Multiple open pelvic fractures without disruption of pelvic circle” were added to the list of fracture codes that exclude patients from the measure cohort.
        ii. The original THA/TKA methodology report incorrectly listed the mean risk-standardized readmission rate as 6.30% with a range from 3.06% to 50.94% for the 2008 sample on page 54. The report should have shown a mean risk-standardized readmission rate of 5.88% with a range of 3.64%-9.31%.

Appendix C. Planned Readmission Algorithm

Figure PR1: Planned Readmission Algorithm Version 2.1 - Flowchart

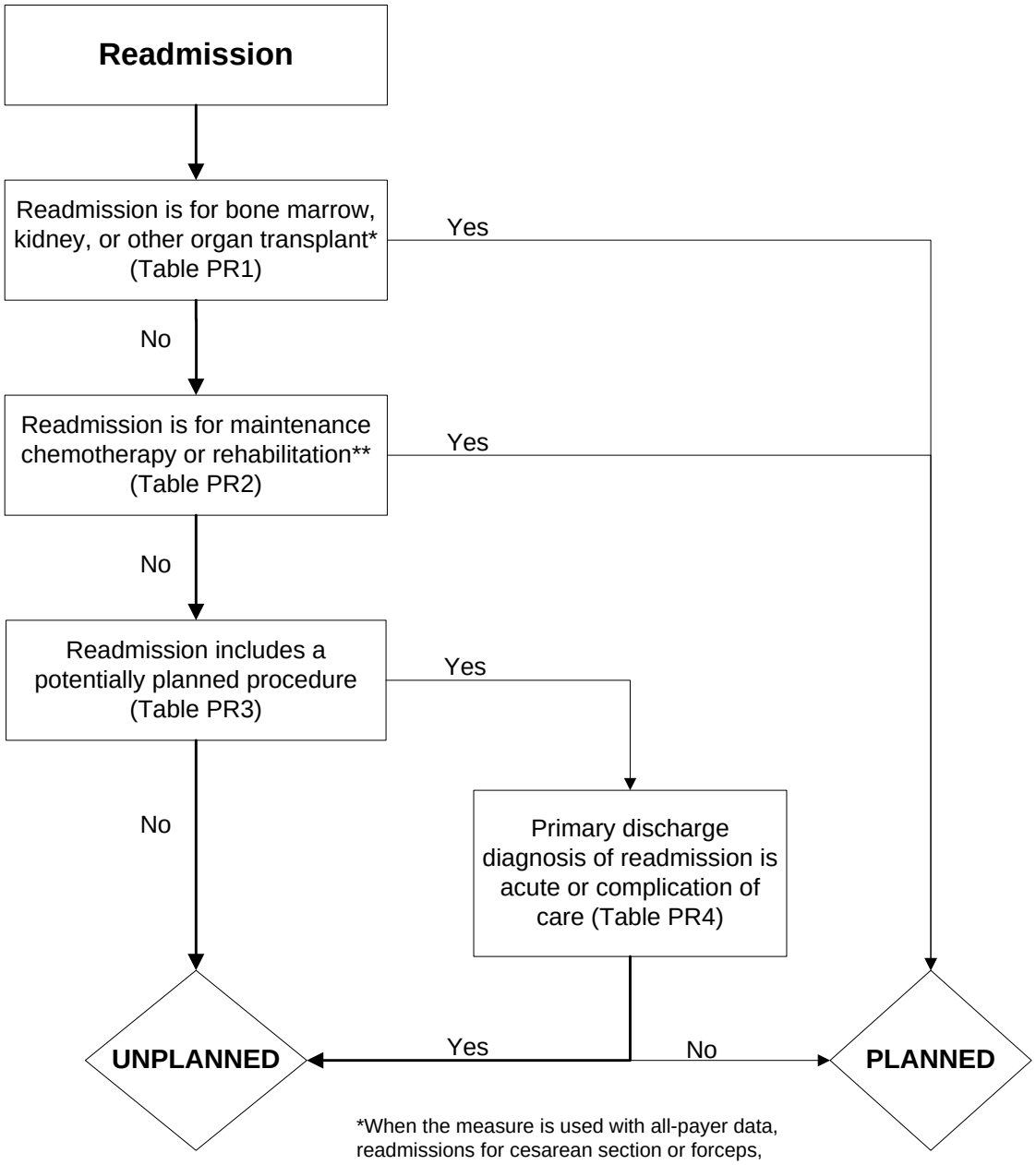


Table PR1: Procedure Categories that are Always Planned (Version 2.1 – THA/TKA population)

Procedure CCS	Description
64	Bone marrow transplant
105	Kidney transplant
134	Cesarean section[§§]
135	Forceps; vacuum; and breech delivery[***]
176	Other organ transplantation

Table PR2. Diagnosis Categories that are Always Planned (Version 2.1 – THA/TKA population)

Diagnosis CCS	Description
45	Maintenance chemotherapy
194	Forceps delivery[†††]
196	Normal pregnancy and/or delivery[‡‡‡]
254	Rehabilitation

[§§] CCS to be included only in all-payer settings, not intended for inclusion in CMS' claims-based readmission measures for Medicare fee-for-service beneficiaries aged 65+ years

[***] CCS to be included only in all-payer settings, not intended for inclusion in CMS' claims-based readmission measures for Medicare fee-for-service beneficiaries aged 65+ years

[†††] CCS to be included only in all-payer settings, not intended for inclusion in CMS' claims-based readmission measures for Medicare fee-for-service beneficiaries aged 65+ years

[‡‡‡] CCS to be included only in all-payer settings, not intended for inclusion in CMS' claims-based readmission measures for Medicare fee-for-service beneficiaries aged 65+ years

Table PR3. Potentially Planned Procedure Categories (Version 2.1 – THA/TKA population)

Procedure CCS	Description
3	Laminectomy; excision intervertebral disc
5	Insertion of catheter or spinal stimulator and injection into spinal
9	Other OR therapeutic nervous system procedures
10	Thyroidectomy; partial or complete
12	Other therapeutic endocrine procedures
33	Other OR therapeutic procedures on nose; mouth and pharynx
36	Lobectomy or pneumonectomy
38	Other diagnostic procedures on lung and bronchus
40	Other diagnostic procedures of respiratory tract and mediastinum
43	Heart valve procedures
44	Coronary artery bypass graft (CABG)
45	Percutaneous transluminal coronary angioplasty (PTCA)
49	Other OR heart procedures
51	Endarterectomy; vessel of head and neck
52	Aortic resection; replacement or anastomosis
53	Varicose vein stripping; lower limb
56	Other vascular bypass and shunt; not heart
59	Other OR procedures on vessels of head and neck
62	Other diagnostic cardiovascular procedures
66	Procedures on spleen
67	Other therapeutic procedures; hemic and lymphatic system
74	Gastrectomy; partial and total
78	Colorectal resection
79	Local excision of large intestine lesion (not endoscopic)
84	Cholecystectomy and common duct exploration
85	Inguinal and femoral hernia repair
86	Other hernia repair
99	Other OR gastrointestinal therapeutic procedures
104	Nephrectomy; partial or complete
106	Genitourinary incontinence procedures
107	Extracorporeal lithotripsy; urinary
109	Procedures on the urethra
112	Other OR therapeutic procedures of urinary tract
113	Transurethral resection of prostate (TURP)
114	Open prostatectomy
119	Oophorectomy; unilateral and bilateral
120	Other operations on ovary
124	Hysterectomy; abdominal and vaginal
129	Repair of cystocele and rectocele; obliteration of vaginal vault

Procedure CCS	Description
132	Other OR therapeutic procedures; female organs
152	Arthroplasty knee
153	Hip replacement; total and partial
154	Arthroplasty other than hip or knee
158	Spinal fusion
159	Other diagnostic procedures on musculoskeletal system
166	Lumpectomy; quadrantectomy of breast
167	Mastectomy
169	Debridement of wound; infection or burn
170	Excision of skin lesion
172	Skin graft
211	Therapeutic radiology for cancer treatment
224	Cancer chemotherapy
ICD-9 Codes	**Description**
30.1, 30.29, 30.3, 30.4, 31.74, 34.6	Laryngectomy, revision of tracheostomy, scarification of pleura (from Proc CCS 42- Other OR Rx procedures on respiratory system and mediastinum)
38.18	Endarterectomy leg vessel (from Proc CCS 60- Embolectomy and endarterectomy of lower limbs)
55.03, 55.04	Percutaneous nephrostomy with and without fragmentation (from Proc CCS 103- Nephrotomy and nephrostomy)
94.26, 94.27	Electroshock therapy (from Proc CCS 218- Psychological and psychiatric evaluation and therapy)

Table PR4. Acute Diagnosis Categories (Version 2.1 – THA/TKA population)

Diagnosis CCS	Description
1	Tuberculosis
2	Septicemia (except in labor)
3	Bacterial infection; unspecified site
4	Mycoses
5	HIV infection
7	Viral infection
8	Other infections; including parasitic
9	Sexually transmitted infections (not HIV or hepatitis)
54	Gout and other crystal arthropathies
55	Fluid and electrolyte disorders
60	Acute posthemorrhagic anemia
61	Sickle cell anemia
63	Diseases of white blood cells
76	Meningitis (except that caused by tuberculosis or sexually transmitted disease)
77	Encephalitis (except that caused by tuberculosis or sexually transmitted disease)
78	Other CNS infection and poliomyelitis
82	Paralysis
83	Epilepsy; convulsions
84	Headache; including migraine
85	Coma; stupor; and brain damage
87	Retinal detachments; defects; vascular occlusion; and retinopathy
89	Blindness and vision defects
90	Inflammation; infection of eye (except that caused by tuberculosis or sexually transmitted disease)
91	Other eye disorders
92	Otitis media and related conditions
93	Conditions associated with dizziness or vertigo
100	Acute myocardial infarction (with the exception of ICD-9 codes 410.x2)
102	Nonspecific chest pain
104	Other and ill-defined heart disease
107	Cardiac arrest and ventricular fibrillation
109	Acute cerebrovascular disease
112	Transient cerebral ischemia
116	Aortic and peripheral arterial embolism or thrombosis
118	Phlebitis; thrombophlebitis and thromboembolism
120	Hemorrhoids
122	Pneumonia (except that caused by TB or sexually transmitted disease)
123	Influenza
124	Acute and chronic tonsillitis
125	Acute bronchitis

Diagnosis CCS	Description
126	Other upper respiratory infections
127	Chronic obstructive pulmonary disease and bronchiectasis
128	Asthma
129	Aspiration pneumonitis; food/vomitus
130	Pleurisy; pneumothorax; pulmonary collapse
131	Respiratory failure; insufficiency; arrest (adult)
135	Intestinal infection
137	Diseases of mouth; excluding dental
139	Gastroduodenal ulcer (except hemorrhage)
140	Gastritis and duodenitis
142	Appendicitis and other appendiceal conditions
145	Intestinal obstruction without hernia
146	Diverticulosis and diverticulitis
148	Peritonitis and intestinal abscess
153	Gastrointestinal hemorrhage
154	Noninfectious gastroenteritis
157	Acute and unspecified renal failure
159	Urinary tract infections
165	Inflammatory conditions of male genital organs
168	Inflammatory diseases of female pelvic organs
172	Ovarian cyst
197	Skin and subcutaneous tissue infections
198	Other inflammatory condition of skin
201	Infective arthritis and osteomyelitis
204	Other non-traumatic joint injuries
207	Pathological Fractures
225	Joint disorders and dislocations; trauma-related
226	Fracture of neck of femur (hip)
227	Spinal cord injury
228	Skull and face fractures
229	Fracture of upper limb
230	Fracture of lower limb
231	Other Fractures
232	Sprains and strains
233	Intracranial injury
234	Crushing injury or internal injury
235	Open wounds of head; neck; and trunk
236	Open wounds of extremities
237	Complication of device; implant or graft
238	Complications of surgical procedures or medical care

Diagnosis CCS	Description
239	Superficial injury; contusion
240	Burns
241	Poisoning by psychotropic agents
242	Poisoning by other medications and drugs
243	Poisoning by nonmedicinal substances
244	Other injuries and conditions due to external causes
245	Syncope
246	Fever of unknown origin
247	Lymphadenitis
249	Shock
250	Nausea and vomiting
251	Abdominal pain
252	Malaise and fatigue
253	Allergic reactions
259	Residual codes; unclassified
650	Adjustment disorders
651	Anxiety disorders
652	Attention-deficit, conduct, and disruptive behavior disorders
653	Delirium, dementia, and amnestic and other cognitive disorders
656	Impluse control disorders, NEC
658	Personality disorders
660	Alcohol-related disorders
661	Substance-related disorders
662	Suicide and intentional self-inflicted injury
663	Screening and history of mental health and substance abuse codes
670	Miscellaneous disorders
ICD-9 codes	**Description**
Acute ICD-9 codes within Dx CCS 97: Peri-; endo-; and myocarditis; cardiomyopathy	
03282	Diphtheritic myocarditis
03640	Meningococcal carditis nos
03641	Meningococcal pericarditis
03642	Meningococcal endocarditis
03643	Meningococcal myocarditis
07420	Coxsackie carditis nos
07421	Coxsackie pericarditis
07422	Coxsackie endocarditis
07423	Coxsackie myocarditis
11281	Candidal endocarditis
11503	Histoplasma capsulatum pericarditis
11504	Histoplasma capssulatum endocarditis
11513	Histoplasma duboisii pericarditis

Diagnosis CCS	Description
11514	Histoplasma duboisii endocarditis
11593	Histoplasmosis pericarditis
11594	Histoplasmosis endocarditis
1303	Toxoplasma myocarditis
3910	Acute rheumatic pericarditis
3911	Acute rheumatic endocarditis
3912	Acute rheumatic myocarditis
3918	Acute rheumatic heart disease nec
3919	Acute rheumatic heart disease nos
3920	Rheumatic chorea w heart involvement
3980	Rheumatic myocarditis
39890	Rheumatic heart disease nos
39899	Rheumatic heart disease nec
4200	Acute pericarditis in other disease
42090	Acute pericarditis nos
42091	Acute idiopath pericarditis
42099	Acute pericarditis nec
4210	Acute/subacute bacterial endocarditis
4211	Acute endocarditis in other diseases
4219	Acute/subacute endocarditis nos
4220	Acute myocarditis in other diseases
42290	Acute myocarditis nos
42291	Idiopathic myocarditis
42292	Septic myocarditis
42293	Toxic myocarditis
42299	Acute myocarditis nec
4230	Hemopericardium
4231	Adhesive pericarditis
4232	Constrictive pericarditis
4233	Cardiac tamponade
4290	Myocarditis nos
Acute ICD-9 codes within Dx CCS 105: Conduction disorders	
4260	Atrioventricular block complete
42610	Atrioventricular block nos
42611	Atrioventricular block-1st degree
42612	Atrioventricular block-mobitz ii
42613	Atrioventricular block-2nd degree nec
4262	Left bundle branch hemiblock
4263	Left bundle branch block nec
4264	Right bundle branch block
42650	Bundle branch block nos

Diagnosis CCS	Description
42651	Right bundle branch block/left posterior fascicular block
42652	Right bundle branch block/left ant fascicular block
42653	Bilateral bundle branch block nec
42654	Trifascicular block
4266	Other heart block
4267	Anomalous atrioventricular excitation
42681	Lown-ganong-levine syndrome
42682	Long qt syndrome
4269	Conduction disorder nos
Acute ICD-9 codes within Dx CCS 106: Dysrhythmia	
4272	Paroxysmal tachycardia nos
7850	Tachycardia nos
42789	Cardiac dysrhythmias nec
4279	Cardiac dysrhythmia nos
42769	Premature beats nec
Acute ICD-9 codes within Dx CCS 108: Congestive heart failure; nonhypertensive	
39891	Rheumatic heart failure
4280	Congestive heart failure
4281	Left heart failure
42820	Unspecified systolic heart failure
42821	Acute systolic heart failure
42823	Acute on chronic systolic heart failure
42830	Unspecified diastolic heart failure
42831	Acute diastolic heart failure
42833	Acute on chronic diastolic heart failure
42840	Unpec combined syst & dias heart failure
42841	Acute combined systolic & diastolic heart failure
42843	Acute on chronic combined systolic & diastolic heart failure
4289	Heart failure nos

Appendix D. Common Terms

Cohort: The index admissions included in the measure after the inclusion and exclusion criteria have been applied.

Complications: Medical conditions that likely occurred as a consequence of care rendered, rather than as an expected outcome of the patient's condition or a condition that the patient had upon presentation to the hospital.

Comorbidities: Medical conditions that the patient had in addition to their primary disease.

Condition Categories (CCs): Groupings of ICD-9-CM diagnosis codes in clinically relevant categories, from the Hierarchical Condition Categories (HCCs) system. CMS uses the grouping but not the hierarchical logic of the system to create risk factor variables. Description of the Condition Categories can be found at http://www.cms.hhs.gov/Reports/downloads/pope_2000_2.pdf.

Expected readmissions: The number of readmissions expected on the basis of average hospital performance with a given hospital's case mix.

Hierarchical model: A widely accepted statistical method that enables fair evaluation of relative hospital performance by taking into account patient risk factors as well as the number of patients that a hospital treats. This statistical model accounts for the structure of the data (patients clustered within hospitals) and calculates: (1) how much variation in hospital readmission rates overall is accounted for by patients' individual risk factors (such as age and other medical conditions); and (2) how much variation is accounted for by hospital contribution to readmission risk.

Hospital-specific intercept: A measure of the hospital quality of care. It is calculated based on the hospital's actual readmission rate relative to hospitals with similar patients – considering how many patients it served, what its patients' risk factors were, and how many died or were readmitted. The hospital-specific effect will be negative for a better-than-average hospital, positive for a worse-than-average hospital, and close to zero for an average hospital. The hospital-specific effect is used in the numerator to calculate "predicted" readmission.

Index admission: Any admission included in the measure calculation as the initial admission for a qualifying elective THA/TKA procedure and evaluated for the outcome.

Interval estimate: Similar to a confidence interval. The interval estimate is a range of probable values for the estimate that characterizes the amount of uncertainty associated with the estimate. For example, a 95% interval estimate for a readmission rate indicates that CMS is 95% confident that the true value of the rate lies between the lower limit and the upper limit of the interval.

Medicare fee-for-service (FFS): Original Medicare plan. Only beneficiaries in Medicare FFS, not in managed care (Medicare Advantage), are included in the measures.

National observed readmission rate: The number of readmissions nationally divided by the number of eligible cases.

Outcome: The result of a broad set of healthcare activities that affect patients' well-being. For the readmission measures, the outcome is readmission within 30 days of discharge.

Planned readmissions: A 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 these measures.

Predicted readmissions: The number of readmissions within 30 days predicted on the basis of the hospital's performance with its observed case mix, also referred to as "adjusted actual" readmissions.

Risk-adjustment variables: Patient demographics and comorbidities that are used to standardize rates for differences in case mix across hospitals.

Unplanned readmissions: Acute clinical events experienced by a patient that require urgent rehospitalization. Unplanned readmissions are counted as outcomes in these measures.

Appendix E. RTI Memorandum

MEMORANDUM

From: RTI International
To: CMS/CCSQ
Date: December 24, 2012

Subject: Overview of update of mappings of ICD-9-CM codes to CC groups for risk adjustment of hospital mortality and readmission models, changes related to FY2012 codes. This is in the context of creating a mapping covering FY2008 – FY2012 to the CC diagnosis clusters.

Overview

Each year the CDC National Center for Health Statistics and the Centers for Medicare & Medicaid Services oversee the changes and modifications to the ICD-9-CM system made through the Coordination and Maintenance Committee. The committee is a joint public-private effort to update and improve the coding system.

RTI has developed and supported a classification system that uses these codes as the basis for risk-adjustment systems. The Hierarchical Condition Category (HCC) system groups the ICD-9-CM codes into larger groups that are used in a model to predict medical care utilization, spending, mortality or other related measures. The condition categories (CCs) may also be used without applying the hierarchies that are used to categorize a person's medical conditions into the highest severity category of a set of related conditions. For this project the full set of 189 CCs in version 12 were updated for FY2012 changes and the changes were documented.

New ICD-9 codes generally become effective October 1 of each year, though there is a round of changes that may be made in an April announcement. Each calendar year of diagnosis data encompasses 2 years of codes. In the new mappings codes valid in FY2008 through FY2012 are all mapped to CCs. This allows the mapping to fully cover data from October 1, 2007 through September 30, 2012. These codes span CY2008 through CY2011 and the first nine months of 2012. The last three months of 2012 fall into FY2013.

Method

Additions and deletions

When the code changes are announced each year there may be both additions, deletions and changes to the descriptions of codes. We map only the valid codes, those of highest specificity, each year. ICD-9-CM codes have a minimum of three characters, mostly digits, and a maximum of five characters. The form is XXX, XXX.X or XXX.XX. [§§§] Code numbers after the decimal point are subclasses of the 3-digit main classes. An addition of new codes may be at any level from a new 3-digit class to new 4 and 5 digit

[§§§] In the Medicare data and our mappings the decimal points are omitted and all codes are left justified to remove ambiguity. The first character of a code may be an E or V as well as a digit.

subclasses. Deletions from ICD-9 may be explicit, the removal of a code from the code book. But deletions from our mapping occur more often because new, more specific, subcodes are introduced. Introduction of a new code of higher specificity than the code it sprang from does not remove the original 3- or 4- digit code from the ICD-9 book, but since coding is supposed to be done to the highest specificity, we remove the more general code from the mapping in the year it is superseded. If the new high specificity code is just an addition to an existing subset of codes of similar specificity, the new code is added but there would be no change in the status of the more general code. That code would have previously been superseded by higher specificity codes.

As an example, in 2012, code 0414, Bacterial infection in conditions classified elsewhere and of unspecified site, Escherichia coli [E.coli] was split into:

ICD-9	Short ICD-9 label
04141	Shiga txn-produce E.coli
04142	Shiga txn prod E.coli NEC
04143	Shiga txn prod E.coli NOS
04149	E.coli infection NEC/NOS

The new 5-digit codes were added to our mapping and were assigned to the same CC that 0414 was assigned to. The old 4-digit code would have been removed, except that 0414 was valid in 2008, 2009, 2010 and 2011. Since our mapping is intended to allow valid codes from those years, 0414 was retained.

In 2012 there were 168 codes added to ICD-9-CM. None were new 3-digit codes. Although there were a few 4-digit codes, the majority were of 5-digit specificity. The new 4-digit code groups were added with 5-digit detail. Among these there were 17 V-codes added but no E-codes. The V codes are for medical encounters but are not actual diagnoses of current conditions. The new 5-digit codes added more specificity within existing diagnostic code groups. In addition to the 0414 changes above another example is the 5 new codes in the ICD-9 code 5128 group, specifying particular types of pneumothorax. These were all mapped to the CC for “Pleural Effusion/Pneumothorax,” where the nonspecific code was mapped previously. A more complicated situation is described in the *Mapping* section, below.

In FY 2012 there were 45 4-digit codes that were no longer at the highest specificity and are invalid starting that year. There was also one 3-digit code removed. However, the 46 codes are retained in our mapping because they were valid in the prior years covered by this mapping.

Mapping

Mapping of the new codes is done by review of the annual changes by RTI staff and clinical consultants. In most cases the codes of higher specificity are mapped to the same CC as the more general code that was split. This does not always occur. For example the ICD-9 code 9980 4-digit group was made invalid by the creation of 5-digit more specific codes. These are:

ICD-9	Short ICD-9 label	New CC	CC label
99800	Postoperative shock, NOS	164	Major Complications of Medical Care and Trauma
99801	Postop shock, cardiogenic	79	Cardio-Respiratory Failure and Shock
99802	Postop shock, septic	2	Septicemia/Shock
99809	Postop shock, other	164	Major Complications of Medical Care and Trauma

The original 4-digit code was assigned to CC 164. The more specific codes are not all assigned to that same CC. There is enough specificity to assign them to more specific CCs.

The general practice in maintaining the mappings for this work has been to maintain the existing structure of the CCs and to map the new codes to the location they would have gone to in prior years. However, sometimes the new specificity makes clear enough distinctions that new related codes do not all logically go to one place. Some new codes require judgment calls to be made. Our decision committee brings together both the people who maintain the integrity of the system and the people who provide the clinical expertise. The changes for FY2012 did not create a need for major changes but there were a few new 5-digit splits that did not all get assigned to the same CC.