2016 Procedure-Specific Measure Updates and Specifications Report Hospital-Level Risk-Standardized Complication Measure

Elective Primary Total Hip Arthroplasty (THA) and/or Total Knee Arthroplasty (TKA) – Version 5.0

Submitted By:

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

Prepared For:

Centers for Medicare & Medicaid Services (CMS)

March 2016

Table of Contents

LIST OF TABLES **3**

LIST OF FIGURES **4**

1. HOW TO USE THIS REPORT **6**

2. BACKGROUND AND OVERVIEW OF MEASURE METHODOLOGY **8**

2.1 Background on the Complication Measure 8
2.2 Overview of Measure Methodology 8
2.2.1 Cohort 8
2.2.2 Outcome 10
2.2.3 Risk-Adjustment Variables 12
2.2.4 Data Sources 12
2.2.5 Measure Calculation 13
2.2.6 Categorizing Hospital Performance 14

3. UPDATES TO THE MEASURE FOR 2016 PUBLIC REPORTING **15**

3.1 Rationale for Measure Updates 15
3.2 Detailed Discussion of Measure Updates 15
3.2.1 Changes to SAS Pack 15

4. RESULTS FOR 2016 PUBLIC REPORTING **16**

4.1 Assessment of Updated Models 16
4.2 THA/TKA Complication 2016 Model Results 17
4.2.1 Index Cohort Exclusions 17
4.2.2 Frequency of THA/TKA Model Variables 18
4.2.3 THA/TKA Model Parameters and Performance 18
4.2.4 Distribution of Hospital Volumes and RSCRs 18
4.2.5 Distribution of Hospitals by Performance Category in the Three-Year Dataset 18

5. GLOSSARY **24**

6. REFERENCES **26**

7. APPENDICES **27**

Appendix A. Statistical Approach to RSCRs for THA/TKA Measure 27
Hospital performance reporting 27
Creating Interval Estimates 28
Appendix B. Data QA 30
Phase I 30
Phase II 30
Appendix C. Annual Updates 33
Appendix D. Measure Specifications 35
Appendix D.1 ..... Hospital-Level RSCR Following Elective Primary THA and/or TKA (NQF #1550) 35

LIST OF TABLES

Table 4.2.1 – Frequency of THA/TKA Model Variables Over Different Time Periods 19
Table 4.2.2 – Hierarchical Regression Model Variable Coefficients for THA/TKA Over Different Time Periods 20
Table 4.2.3 – Adjusted OR and 95% CIs for the THA/TKA Hierarchical Logistic Regression Model Over Different Time Periods 21
Table 4.2.4 – THA/TKA Generalized Linear Modeling (Logistic Regression) Performance Over Different Time Periods 22
Table 4.2.5 – Distribution of Hospital THA/TKA Volumes Over Different Time Periods 22
Table 4.2.6 – Distribution of Hospital THA/TKA RSCRs Over Different Time Periods 22
Table 4.2.7 – Between-Hospital Variance for THA/TKA 22

Table D.1.1 – ICD-9-CM Codes Used to Identify Eligible THA/TKA Procedures 36
Table D.1.2 – ICD-9-CM Codes for Fractures that Disqualify an Admission From Inclusion in the THA/TKA Final Cohort 36
Table D.1.3 – ICD-9-CM Codes for Partial Hip Replacement that Disqualify an Admission From Inclusion in the THA/TKA Final Cohort 38
Table D.1.4 – ICD-9-CM Codes for THA and TKA Revisions that Disqualify an Admission From Inclusion in the THA/TKA Final Cohort 38
Table D.1.5 – ICD-9-CM Codes for Resurfacing Procedures that Disqualify an Admission From Inclusion in the THA/TKA Final Cohort 38
Table D.1.6 – ICD-9-CM Codes for Mechanical Complications that Disqualify an Admission From Inclusion in the THA/TKA Final Cohort 39
Table D.1.7 – ICD-9-CM Codes for Malignant Neoplasms that Disqualify an Admission From Inclusion in the THA/TKA Final Cohort 39
Table D.1.8 – ICD-9-CM Codes for Removal of Devices/Prosthesis that Disqualify an Admission From Inclusion in the THA/TKA Final Cohort 39
Table D.1.9 – Risk Variables for THA/TKA Measure 40
Table D.1.10 – Identification of Complications Following THA/TKA 42

LIST OF FIGURES

Figure 4.2.1 – THA/TKA Cohort Exclusions in the April 2012-March 2015 Dataset 17
Figure 4.2.2 – Distribution of Hospital THA/TKA RSCRs Between April 2012 and March 2015 23
Figure B.1 – CORE QA Phase I 31
Figure B.2 – CORE QA Phase II 32

Center for Outcomes Research & Evaluation Project Team

Karen Dorsey, M.D., Ph.D.* – Reevaluation Team Lead
Jacqueline N. Grady, M.S. – Reevaluation Team Lead Analyst
Lisa G. Suter, M.D.* – Measure and Clinical Expert
Ji Young Kwon, M.P.H. – Measure Reevaluation Analyst
Craig S. Parzynski, M.S. – Measure Development Analyst
Jo DeBuhr, R.N., B.S.N. – Technical Writer
Susannah Bernheim, M.D., M.H.S. – Project Director
Harlan M. Krumholz, M.D., S.M.* – Principal Investigator
*Yale School of Medicine

Measure Reevaluation Team Contributors

Rachel Johnson-DeRycke, M.P.H. – Project Manager
Jaymie Simoes, M.P.H. – Lead Project Coordinator
Chi Ngo, M.P.H. –Supporting Research Associate
Faseeha Altaf, M.P.H. – Supporting Project Coordinator
Elizabeth George, M.P.H. – Supporting Research Associate
Loralee Crowder, B.S. – Supporting Research Associate
Sarah Deacon, B.A. – Supporting Research Associate
Madeline L. Parisi, B.A. – Supporting Research Assistant
Maliha Tariq, B.A. – Supporting Research Assistant
Joanna Ackley, M.P.H. – Supporting Research Associate
Steven Susaña-Castillo, B.A. – Supporting Research Assistant

Acknowledgements

This work is a collaborative effort and the authors gratefully acknowledge Buccaneer Computer Systems and Service, Inc.; Sharon-Lise Normand from Harvard Medical School, Department of Health Care Policy and Harvard School of Public Health, Department of Biostatistics; Kanchana Bhat, Zhenqiu Lin, Jinghong Gao, and Lori Geary from CORE; Taybah for Healthcare Consulting, Inc.; and Lein Han and Pierre Yong at the CMS for their contributions to this work.

1. HOW TO USE THIS REPORT

This report describes the Centers for Medicare & Medicaid Services' (CMS's) procedure-specific complication measure used in the Hospital Inpatient Quality Reporting program and publicly reported on *Hospital Compare*, the hospital-level risk-standardized complication rate (RSCR) following elective primary total hip arthroplasty (THA) and/or total knee arthroplasty (TKA) measure. This report serves as a single source of information about this measure for a wide range of readers. Reports describing THA/TKA readmission and other outcome measures can be found on *QualityNet*.

This report provides an overview of the measure methodology, methodology updates for 2016 public reporting, and the national results for 2016 public reporting. The appendices provide detailed specifications for the measure, including concise tables of the codes used for cohort derivation and risk adjustment, as well as a history of prior annual updates.

Specifically, the report includes:

- **Section 2 - An overview of the THA/TKA complication measure:**
  - Background
  - Cohort inclusions and exclusions
    - included and excluded hospitalizations
    - how transferred patients are handled
    - differences in how the THA/TKA complication measure score will be calculated for the Hospital Inpatient Quality Reporting program and the Hospital Value-Based Purchasing (VBP) program for fiscal year 2019
  - Outcome
  - What is considered a complication
  - Risk-adjustment variables
  - Data sources
  - Complication rate calculation
  - Categorization of hospitals' performance score

  Section 3 - 2016 measure updates

  Section 4 - 2016 measure results

  Section 5 - Glossary

The Appendices contain detailed measure information, including:

- Appendix A: Statistical approach to calculating RSCRs;
- Appendix B: Data quality assurance (QA);
- Appendix C: Annual updates to the measure since measure development; and,
- Appendix D: Measure specifications.

For additional references, the original measure methodology report, as well as prior updates and specifications reports, are available in the Measure Methodology and Archived Resources sections under the claims-based complication measures page of *QualityNet*:

- Hospital-Level Risk-Standardized Complication Rate Following Elective Primary Total Hip Arthroplasty (THA) and/or Total Knee Arthroplasty (TKA): Measure Methodology Report (2012)[1]
- 2013 Measure Updates and Specifications: Elective Primary Total Hip Arthroplasty (THA) and/or Total Knee Arthroplasty (TKA) Risk-Standardized Complication Measure[2]
- 2014 Measure Updates and Specifications: Elective Primary Total Hip Arthroplasty (THA) and/or Total Knee Arthroplasty (TKA) Risk-Standardized Complication Measure[3]
- 2015 Measure Updates and Specifications: Elective Primary Total Hip Arthroplasty (THA) and/or Total Knee Arthroplasty (TKA) Risk-Standardized Complication Measure[4]

2. BACKGROUND AND OVERVIEW OF MEASURE METHODOLOGY

2.1 Background on the Complication Measure

In December 2013, CMS began publicly reporting RSCRs for THA/TKA for the nation's non-federal short-term acute care hospitals (including Indian Health Services hospitals) and critical access hospitals.

Results for the complication measure are posted on *Hospital Compare*, which CMS updates annually.

CMS contracted with the Yale-New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (CORE) to update the THA/TKA complication measure for 2016 public reporting through a process of measure reevaluation. Measures are reevaluated annually in order to improve them by responding to stakeholder input and incorporating advances in science or changes in coding.

2.2 Overview of Measure Methodology

The 2016 risk-adjusted complication measure uses specifications from the initial measure methodology report with refinements to the measure, as listed in Appendix C and described in the prior measure updates and specifications reports.[1-4] An overview of the methodology is provided in this section.

The methodology for the Hospital Inpatient Quality Reporting measure described in this report is the same methodology that will be used to calculate survival rates for the THA/TKA complication measure to be included in the Hospital VBP program for fiscal year 2019, with certain differences in the measure cohorts, as noted in Section 2.2.1. These differences may make an individual hospital's results for the two programs slightly different.

2.2.1 Cohort

Index Admissions Included in the Measure

An index admission is the hospitalization to which the complication outcome is attributed and includes admissions for patients:

- Having a qualifying elective primary THA/TKA procedure during the index admission;
- Enrolled in Medicare fee-for-service (FFS) Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission; and,
- Aged 65 or over.

Elective primary THA/TKA procedures are defined as those THA/TKA procedures *without* any of the following:

  - Femur, hip, or pelvic fractures coded in the principal or secondary discharge diagnosis fields of the index admission;
  - A concurrent partial hip arthroplasty;
  - A concurrent revision procedure;

- A concurrent resurfacing procedure;
- Mechanical complication coded in the principal discharge diagnosis field;
- 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;
- Removal of implanted devices/prostheses; or,
- Transfer from another acute care facility for the THA/TKA.

International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes used to define the cohort are listed in Appendix D, in Tables D.1.1, D.1.2, D.1.3, D.1.4, D.1.5, D.1.6, D.1.7, and D.1.8.

Index Admissions Excluded from the Measure

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

- Without at least 90 days post-discharge enrollment in Medicare FFS;
- Discharged against medical advice (AMA); or,
- With more than two THA/TKA procedure codes during the index admission.

For patients with more than one eligible admission for a THA/TKA procedure in a given year, only one index admission is randomly selected for inclusion in the cohort. The other admissions within that year are excluded.

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 records for providers with invalid provider IDs.

The percentage of admissions excluded based on each criterion is shown in Section 4 in Figure 4.2.1.

Patients Transferred Between Hospitals

The measure considers multiple contiguous hospitalizations as a single acute episode of care. Transfer patients are identified by tracking claims for inpatient short-term acute care hospitalizations over time. To qualify as a transfer, the second inpatient admission must occur on the same day or the next calendar day following discharge from the first inpatient admission at a short-term acute care hospital. Cases that meet this criterion are considered transfers regardless of whether or not the first institution indicates intent to transfer the patient in the discharge disposition code.

The THA/TKA complication measure does not include index admissions for patients who are transferred in to the index hospital from another hospital, as these admissions likely do not represent elective THA/TKA procedures. However, index admissions for patients who were admitted for the THA/TKA and subsequently transferred to another acute care facility are included in the measure, as transfer following THA/TKA is most likely due to a complication of care of the THA/TKA procedure or the peri-operative care the

patient received. In a series of one or more transfers, the complication outcome is always assigned to the hospital that performed the first ("index") THA/TKA procedure, even if it is not the discharge hospital. For example, if a patient is admitted to Hospital A and undergoes a THA/TKA procedure, and then transfers to Hospital B, a complication following the Hospital B admission would be captured in Hospital A's complication outcome.

Hospital Value-Based Purchasing (VBP) Program

The THA/TKA complication measure will be added to the Hospital VBP program for fiscal year 2019.

The Hospital VBP program includes only subsection (d) hospitals and hospitals located in Maryland participating in the All-Payer Model. Critical access hospitals, cancer hospitals, VA hospitals, and hospitals in United States (U.S.) territories will not be included. In addition, the Hospital VBP program excludes hospitals who received a payment reduction under the Hospital Inpatient Quality Reporting program that fiscal year, hospitals cited by the Secretary of Health & Human Services for deficiencies that may cause immediate jeopardy to patients during the Hospital VBP program measurement period, and hospitals lacking the minimum number of measures or cases per measure required to calculate a score. Admissions to such hospitals will not be included as index admissions in the Hospital VBP program.

Note: Subsection (d) hospitals encompass any acute care hospital located in one of the fifty states or the District of Columbia which does not meet any of the following exclusion criteria as defined by the Social Security Act: psychiatric, rehabilitation, children's, or long-term care hospitals, and cancer specialty centers. By definition, all other hospitals are considered subsection (d) hospitals.

The performance periods for the Hospital VBP program differ from the measurement periods used in the Hospital Inpatient Quality Reporting program.

For further information about the Hospital VBP program, please refer to the information posted on the CMS website at: http://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/hospital-value-based-purchasing/index.html.

2.2.2 Outcome

The measure assesses a dichotomous (yes/no) outcome of whether each admitted patient experiences one or more of the complications defined below.

THA/TKA Complications and Time Frame

The measure defines a "complication" as:

- AMI, pneumonia, or sepsis/septicemia/shock during the index admission or within seven days from the date of the index admission;
- Surgical site bleeding, pulmonary embolism, or death during the index admission or within 30 days from the date of the index admission; or,

- Mechanical complication or periprosthetic joint infection/wound infection during the index admission or within 90 days from the date of the index admission.

Examples of how the measure assesses the complication outcome:

- Patient is admitted for THA/TKA on Jan 1, discharged on Jan 6, and a pulmonary embolism occurs on Feb 5. The measure will not capture the pulmonary embolism as a complication (as it falls outside of the 30-day time window).
- Patient is admitted for THA/TKA on May 15, experiences an AMI on May 25, and is discharged on May 27. The measure will capture the AMI as a complication because it occurred during the index admission (regardless of the 7-day time window).

Note that the measure captures all complications occurring during the index admission, regardless of when they occur, with the exception of complications that are coded as present on admission (POA). Not capturing complications coded as POA prevents classifying a condition as a complication of care if it was present at the time the patient was admitted as an inpatient. Clinical experts agree with the approach of capturing complications that occur during the index admission but after the defined time window, as such complications likely represent the quality of care provided during the index admission.

Complications are identified using index admission claims and claims for subsequent hospitalizations at short-term acute care hospitals and critical access hospitals, with the exception of death, which is captured through the Medicare Enrollment database.

See Table D.1.10 for the specific ICD-9-CM codes and other specifications used to define the complication outcome.

The complication-specific follow-up periods are based on the input of clinical experts informed by analyses of 90-day trends in complication rates post procedure:[1]

- The follow-up period for AMI, pneumonia, and sepsis/septicemia/shock complications is seven days from the date of index admission because these conditions are more likely to be attributable to the procedure if they occur within the first week after the procedure. Additionally, analyses indicated a sharp decrease in the rate of these complications after seven days.
- Death, surgical site bleeding, and pulmonary embolism are followed for 30 days following admission because clinical experts agree these complications are still likely attributable to the hospital performing the procedure during this period and rates for these complications remained elevated until roughly 30 days post-admission.
- The measure follow-up period is 90 days after admission for mechanical complications and periprosthetic joint infection/wound infection. Experts agree that mechanical complications and periprosthetic joint infection/wound infections due to the index THA/TKA occur up to 90 days following THA/TKA.

2.2.3 Risk-Adjustment Variables

In order to account for differences in patient mix among hospitals, the measure adjusts for variables (for example, age, comorbid diseases, and indicators of patient frailty) that are clinically relevant and have relationships with the outcome. For each patient, risk-adjustment variables are obtained from inpatient, outpatient, and physician Medicare administrative claims data extending 12 months prior to, and including, the index admission.

The measure adjusts 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 socioeconomic status (SES) because the association between SES and health outcomes can be due, in part, to differences in the quality of health care that groups of patients with varying SES receive. The intent is for the measure to adjust for patient demographic and clinical characteristics while illuminating important quality differences. Additionally, recent analyses have shown that hospitals caring for high proportions of low-SES patients perform similarly on the measure to hospitals caring for low proportions of low-SES patients.[5] Please note that the Office of the Assistant Secretary for Planning and Evaluation (ASPE) is conducting research to examine the impact of SES on quality measures, resource use, and other measures under the Medicare program as directed by the IMPACT Act. ASPE will issue an initial report to Congress by October 2016 and a final report to Congress by October 2019. The findings in these reports will be considered in future reevaluation of this measure. Refer to Table D.1.9 in Appendix D of this report for the list of comorbidity risk-adjustment variables and the list of complications that are excluded from risk adjustment if they occur during the index admission.

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 April 1, 2012, and March 31, 2015. The period for public reporting of this measure differs from the THA/TKA readmission measure, which includes admissions for elective THA/TKA procedures between July 1, 2012, and June 30, 2015, due to the longer period of outcome assessment required to adequately capture complications up to 90 days following admission.

The datasets also contain associated inpatient, outpatient, and physician Medicare administrative claims for the 12 months prior to the index admission and 3 months subsequent to the index admission for patients admitted in this time period. See the original methodology report for further descriptions of these data sources and an explanation of the three-year measurement period.[1]

2.2.5 Measure Calculation

The measure estimates hospital-level all-cause RSCRs following elective primary THA/TKA using hierarchical logistic regression models. 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.[6] At the patient level, it models the log-odds of hospital admission with a complication within 90 days of discharge using age, sex, selected clinical covariates, and a hospital-specific effect. At the hospital level, the approach models the hospital-specific effects as arising from a normal distribution. The hospital effect represents the underlying risk of a complication at the hospital, after accounting for patient risk. The hospital-specific effects are given a distribution to account for the clustering (non-independence) of patients within the same hospital.[6] If there were no differences among hospitals, then after adjusting for patient risk, the hospital effects should be identical across all hospitals.

The RSCR is calculated as the ratio of the number of "predicted" admissions with a complication to the number of "expected" admissions with a complication at a given hospital, multiplied by the national observed complication rate. For each hospital, the numerator of the ratio is the number of admissions with a complication within 90 days predicted based on the hospital's performance with its observed case mix, and the denominator is the number of admissions with a complication expected based on 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 a particular hospital's performance, given its case mix, to be compared to an average hospital's performance with the same case mix. Thus, a lower ratio indicates lower-than-expected complication rates or better quality, while a higher ratio indicates higher-than-expected complication rates or worse quality.

The "predicted" number of admissions with a complication (the numerator) is calculated using the coefficients estimated by regressing the risk factors (Table D.1.9) and the hospital-specific effect on the risk of having an admission with a complication. The estimated hospital-specific effect is added to the sum of the estimated regression coefficients multiplied by the patient characteristics. The results are log transformed and summed over all patients attributed to a hospital to get a predicted value. The "expected" number of admissions with a complication (the denominator) is obtained in the same manner, but a common effect using all hospitals in our sample is added in place of the hospital-specific effect. The results are log transformed and summed over all patients in the hospital to get an expected value. To assess hospital performance for each reporting period, we re-estimate the model coefficients using the years of data in that period.

This calculation transforms the ratio of predicted over expected into a rate that is compared to the national observed complication rate. The hierarchical logistic regression models are described fully in Appendix A and in the original methodology report.[1]

2.2.6 Categorizing Hospital Performance

To categorize hospital performance, CMS estimates each hospital's RSCR and the corresponding 95% interval estimate. CMS assigns hospitals to a performance category by comparing each hospital's RSCR interval estimate to the national observed complication rate. Comparative performance for hospitals with 25 or more eligible cases is classified as follows:

- "No Different than the National Rate" if the 95% interval estimate surrounding the hospital's rate includes the national observed complication rate.
- "Worse than the National Rate" if the entire 95% interval estimate surrounding the hospital's rate is higher than the national observed complication rate.
- "Better than the National Rate" if the entire 95% interval estimate surrounding the hospital's rate is lower than the national observed complication rate.

If a hospital has fewer than 25 eligible cases for a measure, CMS assigns the hospital to a separate category, "Number of Cases Too Small". This category is used when 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 complication rates and interval estimates will not be publicly reported for the measure.

Section 4.2.5 describes the distribution of hospitals by performance category in the U.S. for this reporting period.

3. UPDATES TO THE MEASURE FOR 2016 PUBLIC REPORTING

3.1 Rationale for Measure Updates

Measure reevaluation ensures that the risk-standardized complication model is continually assessed and remains valid, given possible changes in clinical practice and coding standards over time, and allows for model refinements. Modifications made to measure cohorts, risk models, and outcomes are informed by review of the most recent literature related to measure conditions or outcomes, feedback from various stakeholders, and empirical analyses including assessment of coding trends that reveal shifts in clinical practice or billing patterns. In addition, each year we assess measure characteristics and revise the statistical software code used to calculate measure results. As a part of these annual reevaluation activities, we undertook the following activities for 2016 public reporting:

- Validated the performance of the model and its corresponding risk-adjustment variables in three recent one-year datasets (April 2012-March 2013, April 2013-March 2014, and April 2014-March 2015);
- Evaluated and validated model performance in the three-year combined dataset (April 2012-March 2015); and,
- Updated the measure's SAS analytic package (SAS pack) and documentation.

No methodological changes to the measure were made for 2016 public reporting.

Although hospitals are using International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) coding for discharges effective on or after October 1, 2015, ICD-10 codes for use in defining the cohort and complications, and ICD-10-based Condition Category (CC) Groups for use in risk adjustment were not incorporated into the measure specifications this year, as the measurement period for 2016 public reporting does not include claims data after March 31, 2015.

3.2 Detailed Discussion of Measure Updates

3.2.1 Changes to SAS Pack

We made minor refinements to the measure calculation SAS pack. The new SAS pack and documentation are available upon request by emailing cmscomplicationmeasures@yale.edu. **Do *NOT* submit patient-identifiable information (for example, date of birth, Social Security number, health insurance claim number) to this address.**

The SAS pack describes the data files and data elements that feed the model software. Please be aware that CMS does not provide training or technical support for the software. CMS has made the SAS pack available to be completely transparent regarding the measure calculation methodology. However, note that even with the SAS pack it is not possible to replicate the RSCR calculation without the data files which contain longitudinal patient data from the entire national sample of acute care hospitals to estimate the individual hospital-specific effects, the average hospital-specific effect, and the risk-adjustment coefficients used in the equations.

4. RESULTS FOR 2016 PUBLIC REPORTING

4.1 Assessment of Updated Models

The THA/TKA complication measure estimates hospital-specific RSCRs using hierarchical logistic regression models. See Section 2 for a summary of the measure methodology and model risk-adjustment variables. Refer to prior methodology and technical reports for further details.[1-4]

We evaluated the performance of the model, using the April 2012-March 2015 data for 2016 reporting. We examined differences in the frequency of patient risk factors and the model variable coefficients.

We assessed logistic regression model performance in terms of discriminant ability for each year of data and for the three-year combined period. 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 had a complication following a THA/TKA procedure. Potential values range from 0.5, meaning no better than chance, to 1.0, an indication of perfect prediction. Perfect prediction implies patients' outcomes can be predicted completely by their risk factors, and physicians and hospitals play no role in patients' outcomes.

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

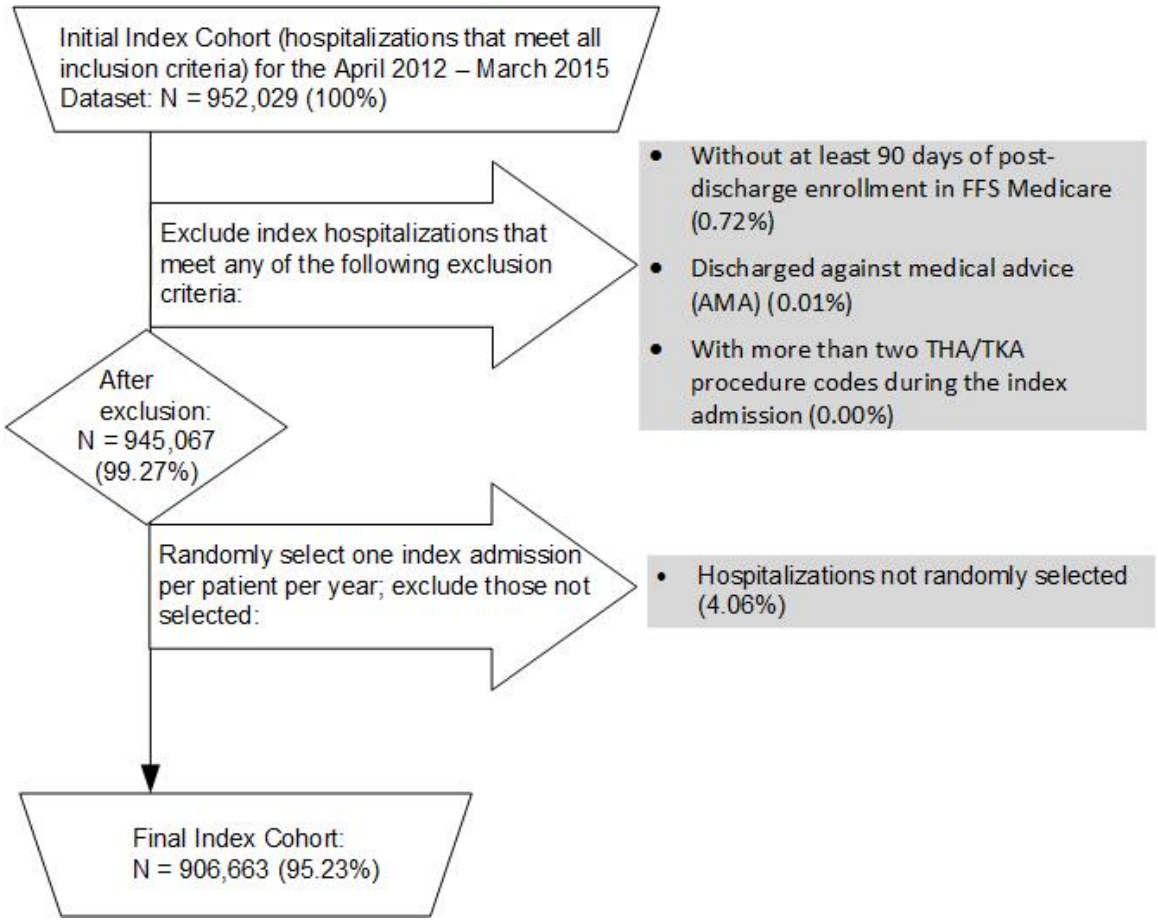
4.2 THA/TKA Complication 2016 Model Results

4.2.1 Index Cohort Exclusions

The exclusion criteria for the measure are presented in Section 2.2.1. The percentage of THA/TKA admissions meeting each exclusion criterion in the April 2012-March 2015 dataset is presented in Figure 4.2.1.

Admissions may have been counted in more than one exclusion category because they are not mutually exclusive. The index cohort includes short-term acute care hospitalizations for Medicare patients aged 65 or over with a qualifying elective primary THA/TKA procedure; and enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission.

Figure 4.2.1 – THA/TKA Cohort Exclusions in the April 2012-March 2015 Dataset



4.2.2 Frequency of THA/TKA Model Variables

We examined the change in both observed complication rates and frequency of clinical and demographic variables. Between April 2012-March 2013 and April 2014-March 2015, the observed complication rate decreased from 3.1% to 2.9%. Notable changes in the frequencies for model variables include:

- Decreases in Osteoporosis and other bone/cartilage disorders (24.8% to 23.8%) and Coronary atherosclerosis or angina (27.7% to 25.8%)
- Increases in Morbid obesity (5.6% to 6.4%) and Renal failure (8.6% to 9.3%)

Refer to Table 4.2.1 for more detail.

4.2.3 THA/TKA Model Parameters and Performance

Table 4.2.2 shows hierarchical regression model coefficients by individual year and for the combined three-year dataset. Table 4.2.3 shows the risk-adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for the THA/TKA complication model by individual year and for the combined three-year dataset. Overall, the variable effect sizes were relatively constant across years. In addition, model performance was stable over the three-year time period; the c-statistic remained constant at 0.65 (Table 4.2.4).

4.2.4 Distribution of Hospital Volumes and RSCRs

Table 4.2.5 shows the distribution of hospital admission volumes and Table 4.2.6 shows the distribution of hospital RSCRs. The mean RSCR decreased over the three-year period, from 3.2% between April 2012 and March 2013 to 3.0% between April 2014 and March 2015. The median hospital RSCR in the combined three-year dataset was 3.0% (Interquartile Range [IQR] 2.8% - 3.3%). Table 4.2.7 shows the between-hospital variance by individual year and for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.096 (Standard Error [SE]: 0.006). If there were no systematic differences between hospitals, the between-hospital variance would be 0.

Figure 4.2.2 shows the overall distribution of the hospital RSCRs for the combined dataset. The odds of complication if treated at a hospital one standard deviation (SD) above the national rate were 1.86 times higher than the odds of complication if treated at a hospital one SD below the national rate. If there were no systematic differences between hospitals, the OR would be 1.0.[6]

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

Of 3,483 hospitals in the study cohort, 62 performed “Better than the National Rate,” 2,693 performed “No Different than the National Rate,” and 49 performed “Worse than the National Rate.” 679 were classified as “Number of Cases Too Small” (fewer than 25) to reliably tell how well the hospital is performing.

Table 4.2.1 – Frequency of THA/TKA Model Variables Over Different Time Periods

Variable	04/2012-03/2013	04/2013-03/2014	04/2014-03/2015	04/2012-03/2015
Total N	295,387	306,429	304,847	906,663
Observed complication rate (%)	3.1	3.0	2.9	3.0
Mean age minus 65 (SD)	9.8 (6.0)	9.6 (6.0)	9.5 (6.0)	9.6 (6.0)
Male (%)	36.6	37.1	37.2	37.0
Index admissions with an elective THA procedure	30.6	30.8	32.1	31.2
Number of procedures (two vs. one)	2.4	2.3	2.2	2.3
Morbid obesity (ICD-9 diagnosis code 278.01)	5.6	6.0	6.4	6.0
Other congenital deformity of hip (joint) (ICD-9 diagnosis code 755.63)	0.2	0.2	0.2	0.2
Post traumatic osteoarthritis (ICD-9 diagnosis codes 716.15, 716.16)	0.4	0.4	0.4	0.4
Metastatic cancer or acute leukemia (CC 7)	0.6	0.6	0.6	0.6
Other major cancers; lung, upper digestive tract, and other severe cancers (CC 8-10)	13.0	12.9	12.9	12.9
Respiratory/heart/digestive/urinary/other neoplasms (CC 11-13)	17.8	17.8	18.0	17.9
Diabetes mellitus (DM) or DM complications (CC 15-19, 119-120)	28.8	28.3	28.2	28.4
Protein-calorie malnutrition (CC 21)	0.8	0.7	0.7	0.7
Bone/joint/muscle infections/necrosis (CC 37)	2.7	2.7	2.7	2.7
Rheumatoid arthritis and inflammatory connective tissue disease (CC 38)	9.2	9.2	9.3	9.2
Osteoarthritis of hip or knee (CC 40)	96.3	96.2	96.2	96.2
Osteoporosis and other bone/cartilage disorders (CC 41)	24.8	23.9	23.8	24.2
Dementia or other specified brain disorders (CC 49-50)	4.3	4.2	4.1	4.2
Major psychiatric disorders (CC 54-56)	4.6	4.6	4.8	4.7
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	1.7	1.6	1.6	1.6
Cardio-respiratory failure and shock (CC 79)	2.3	2.5	2.4	2.4
Coronary atherosclerosis or angina (CC 83-84)	27.7	26.7	25.8	26.7
Stroke (CC 95-96)	2.1	2.1	2.1	2.1
Vascular or circulatory disease (CC 104-106)	22.2	21.8	21.7	21.9
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	13.6	13.1	12.8	13.1
Pneumonia (CC 111-113)	4.0	4.1	3.8	4.0
Pleural effusion/pneumothorax (CC 114)	1.5	1.5	1.4	1.4
Dialysis status (CC 130)	0.2	0.2	0.2	0.2
Renal failure (CC 131)	8.6	9.0	9.3	9.0
Decubitus ulcer or chronic skin ulcer (CC 148-149)	2.4	2.4	2.4	2.4
Trauma (CC 154-156, 158-161)	4.7	4.7	4.8	4.7
Vertebral fractures (CC 157)	1.2	1.2	1.2	1.2
Other injuries (CC 162)	28.1	27.8	28.0	28.0
Major complications of medical care and trauma (CC 164)	3.5	3.5	3.4	3.5

Table 4.2.2 – Hierarchical Regression Model Variable Coefficients for THA/TKA Over Different Time Periods

Variable	04/2012-03/2013	04/2013-03/2014	04/2014-03/2015	04/2012-03/2015
Intercept	-4.250	-4.315	-4.225	-4.244
Age minus 65 (years above 65, continuous)	0.027	0.027	0.029	0.028
Male	0.161	0.111	0.101	0.126
Index admissions with an elective THA procedure	0.334	0.315	0.370	0.341
Number of procedures (two vs. one)	0.564	0.425	0.602	0.544
Morbid obesity (ICD-9 diagnosis code 278.01)	0.469	0.458	0.485	0.468
Other congenital deformity of hip (joint) (ICD-9 diagnosis code 755.63)	0.098	-0.043	-0.026	0.006
Post traumatic osteoarthritis (ICD-9 diagnosis codes 716.15, 716.16)	-0.089	0.200	0.247	0.129
Metastatic cancer or acute leukemia (CC 7)	0.008	0.120	0.194	0.112
Other major cancers; lung, upper digestive tract, and other severe cancers (CC 8-10)	-0.024	-0.042	0.007	-0.018
Respiratory/heart/digestive/urinary/other neoplasms (CC 11-13)	-0.104	-0.046	-0.049	-0.063
Diabetes mellitus (DM) or DM complications (CC 15-19, 119-120)	0.181	0.089	0.124	0.128
Protein-calorie malnutrition (CC 21)	1.060	0.927	0.834	0.938
Bone/joint/muscle infections/necrosis (CC 37)	0.093	0.185	0.171	0.150
Rheumatoid arthritis and inflammatory connective tissue disease (CC 38)	0.152	0.109	0.139	0.134
Osteoarthritis of hip or knee (CC 40)	-0.085	0.024	-0.139	-0.065
Osteoporosis and other bone/cartilage disorders (CC 41)	0.074	-0.001	0.012	0.030
Dementia or other specified brain disorders (CC 49-50)	0.119	0.182	0.207	0.166
Major psychiatric disorders (CC 54-56)	0.302	0.289	0.290	0.293
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	0.060	0.245	0.072	0.129
Cardio-respiratory failure and shock (CC 79)	0.199	0.124	0.219	0.177
Coronary atherosclerosis or angina (CC 83-84)	0.322	0.258	0.283	0.289
Stroke (CC 95-96)	0.178	0.060	-0.083	0.057
Vascular or circulatory disease (CC 104-106)	0.155	0.153	0.116	0.142
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	0.382	0.440	0.419	0.409
Pneumonia (CC 111-113)	0.173	0.256	0.207	0.211
Pleural effusion/pneumothorax (CC 114)	-0.138	-0.132	-0.030	-0.098
Dialysis status (CC 130)	0.258	0.264	0.427	0.329
Renal failure (CC 131)	0.161	0.242	0.162	0.185
Decubitus ulcer or chronic skin ulcer (CC 148-149)	0.213	0.282	0.280	0.257
Trauma (CC 154-156, 158-161)	0.143	0.278	0.148	0.189
Vertebral fractures (CC 157)	0.036	0.074	0.148	0.087
Other injuries (CC 162)	0.098	0.032	0.058	0.063
Major complications of medical care and trauma (CC 164)	0.215	0.230	0.181	0.210

Table 4.2.3 – Adjusted OR and 95% CIs for the THA/TKA Hierarchical Logistic Regression Model Over Different Time Periods

Variable	04/2012-03/2013 OR (95% CI)	04/2013-03/2014 OR (95% CI)	04/2014-03/2015 OR (95% CI)	04/2012-03/2015 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.00 (1.02-1.03)	1.00 (1.02-1.03)	1.00 (1.03-1.03)	1.00 (1.03-1.03)
Male	1.20 (1.12-1.23)	1.10 (1.07-1.17)	1.10 (1.06-1.16)	1.10 (1.10-1.16)
Index admissions with an elective THA procedure	1.40 (1.34-1.46)	1.40 (1.31-1.43)	1.40 (1.38-1.51)	1.40 (1.37-1.44)
Number of procedures (two vs. one)	1.80 (1.56-1.98)	1.50 (1.34-1.74)	1.80 (1.61-2.07)	1.70 (1.60-1.85)
Morbid obesity (ICD-9 diagnosis code 278.01)	1.60 (1.48-1.73)	1.60 (1.47-1.70)	1.60 (1.51-1.75)	1.60 (1.53-1.67)
Other congenital deformity of hip (joint) (ICD-9 diagnosis code 755.63)	1.10 (0.71-1.70)	1.00 (0.61-1.51)	1.00 (0.63-1.50)	1.00 (0.78-1.30)
Post traumatic osteoarthritis (ICD-9 diagnosis codes 716.15, 716.16)	0.90 (0.66-1.27)	1.20 (0.91-1.64)	1.30 (0.95-1.72)	1.10 (0.95-1.36)
Metastatic cancer or acute leukemia (CC 7)	1.00 (0.78-1.31)	1.10 (0.88-1.45)	1.20 (0.96-1.54)	1.10 (0.97-1.29)
Other major cancers; lung, upper digestive tract, and other severe cancers (CC 8-10)	1.00 (0.92-1.04)	1.00 (0.90-1.02)	1.00 (0.95-1.07)	1.00 (0.95-1.02)
Respiratory/heart/digestive/urinary/other neoplasms (CC 11-13)	0.90 (0.85-0.95)	1.00 (0.90-1.01)	1.00 (0.90-1.01)	0.90 (0.91-0.97)
Diabetes mellitus (DM) or DM complications (CC 15-19, 119-120)	1.20 (1.15-1.25)	1.10 (1.04-1.14)	1.10 (1.08-1.19)	1.10 (1.11-1.17)
Protein-calorie malnutrition (CC 21)	2.90 (2.53-3.29)	2.50 (2.20-2.90)	2.30 (1.98-2.68)	2.60 (2.36-2.77)
Bone/joint/muscle infections/necrosis (CC 37)	1.10 (0.99-1.22)	1.20 (1.08-1.34)	1.20 (1.07-1.32)	1.20 (1.09-1.23)
Rheumatoid arthritis and inflammatory connective tissue disease (CC 38)	1.20 (1.09-1.25)	1.10 (1.04-1.19)	1.10 (1.07-1.23)	1.10 (1.10-1.19)
Osteoarthritis of hip or knee (CC 40)	0.90 (0.82-1.02)	1.00 (0.91-1.15)	0.90 (0.78-0.97)	0.90 (0.88-1.00)
Osteoporosis and other bone/cartilage disorders (CC 41)	1.10 (1.02-1.13)	1.00 (0.95-1.05)	1.00 (0.96-1.07)	1.00 (1.00-1.06)
Dementia or other specified brain disorders (CC 49-50)	1.10 (1.03-1.23)	1.20 (1.10-1.31)	1.20 (1.12-1.34)	1.20 (1.12-1.24)
Major psychiatric disorders (CC 54-56)	1.40 (1.24-1.47)	1.30 (1.23-1.45)	1.30 (1.23-1.45)	1.30 (1.28-1.41)
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	1.10 (0.92-1.22)	1.30 (1.12-1.46)	1.10 (0.93-1.25)	1.10 (1.05-1.23)
Cardio-respiratory failure and shock (CC 79)	1.20 (1.09-1.36)	1.10 (1.02-1.26)	1.20 (1.12-1.39)	1.20 (1.12-1.27)
Coronary atherosclerosis or angina (CC 83-84)	1.40 (1.32-1.44)	1.30 (1.23-1.36)	1.30 (1.27-1.39)	1.30 (1.30-1.37)
Stroke (CC 95-96)	1.20 (1.06-1.35)	1.10 (0.94-1.20)	0.90 (0.80-1.05)	1.10 (0.98-1.14)
Vascular or circulatory disease (CC 104-106)	1.20 (1.11-1.23)	1.20 (1.11-1.22)	1.10 (1.07-1.18)	1.20 (1.12-1.19)
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	1.50 (1.39-1.54)	1.60 (1.47-1.64)	1.50 (1.44-1.61)	1.50 (1.46-1.55)
Pneumonia (CC 111-113)	1.20 (1.09-1.30)	1.30 (1.18-1.41)	1.20 (1.12-1.35)	1.20 (1.17-1.30)
Pleural effusion/pneumothorax (CC 114)	0.90 (0.76-1.01)	0.90 (0.76-1.01)	1.00 (0.84-1.12)	0.90 (0.84-0.98)
Dialysis status (CC 130)	1.30 (0.94-1.79)	1.30 (0.95-1.79)	1.50 (1.14-2.07)	1.40 (1.16-1.66)

Variable	04/2012-03/2013 OR (95% CI)	04/2013-03/2014 OR (95% CI)	04/2014-03/2015 OR (95% CI)	04/2012-03/2015 OR (95% CI)
Renal failure (CC 131)	1.20 (1.10-1.25)	1.30 (1.19-1.36)	1.20 (1.10-1.25)	1.20 (1.16-1.25)
Decubitus ulcer or chronic skin ulcer (CC 148-149)	1.20 (1.11-1.38)	1.30 (1.19-1.47)	1.30 (1.19-1.47)	1.30 (1.22-1.37)
Trauma (CC 154-156, 158-161)	1.20 (1.06-1.26)	1.30 (1.21-1.44)	1.20 (1.06-1.27)	1.20 (1.15-1.27)
Vertebral fractures (CC 157)	1.00 (0.88-1.22)	1.10 (0.92-1.26)	1.20 (0.99-1.36)	1.10 (0.99-1.20)
Other injuries (CC 162)	1.10 (1.05-1.16)	1.00 (0.98-1.08)	1.10 (1.01-1.11)	1.10 (1.04-1.10)
Major complications of medical care and trauma (CC 164)	1.20 (1.13-1.36)	1.30 (1.15-1.38)	1.20 (1.09-1.32)	1.20 (1.17-1.30)

Table 4.2.4 – THA/TKA Generalized Linear Modeling (Logistic Regression) Performance Over Different Time Periods

Characteristic	04/2012-03/2013	04/2013-03/2014	04/2014-03/2015	04/2012-03/2015
Predictive ability, % (lowest decile – highest decile)	1.5 - 7.3	1.3 - 7.1	1.1 - 6.7	1.3 - 7.1
c-statistic	0.65	0.65	0.65	0.65

Table 4.2.5 – Distribution of Hospital THA/TKA Volumes Over Different Time Periods

Characteristic	04/2012-03/2013	04/2013-03/2014	04/2014-03/2015	04/2012-03/2015
Number of hospitals	3,339	3,315	3,302	3,483
Mean number of admissions (SD)	88.5 (125.4)	92.4 (130.5)	92.3 (131.7)	260.3 (378.4)
Range (min. – max.)	1 - 2,922	1 - 2,903	1 - 2,913	1 - 8,738
25th percentile	15	15	15	38
50th percentile	47	48	47	128
75th percentile	117	123	122	346

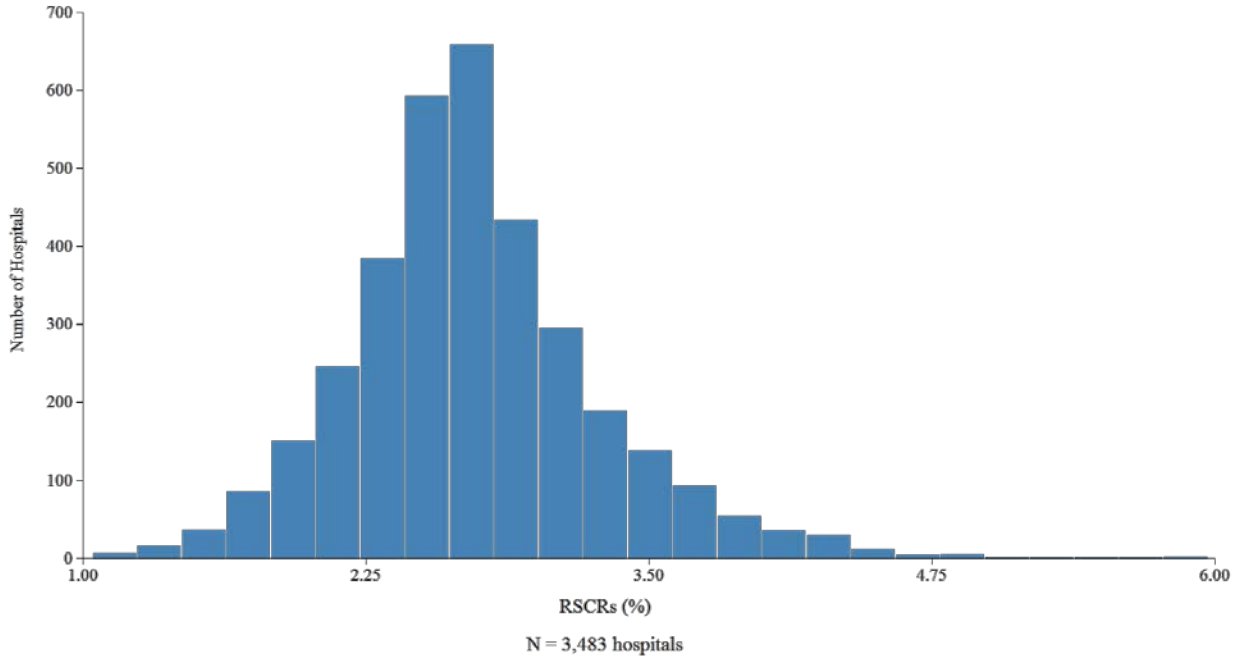
Table 4.2.6 – Distribution of Hospital THA/TKA RSCRs Over Different Time Periods

Characteristic	04/2012-03/2013	04/2013-03/2014	04/2014-03/2015	04/2012-03/2015
Number of hospitals	3,339	3,315	3,302	3,483
Mean (SD)	3.2 (0.4)	3.0 (0.4)	3.0 (0.4)	3.1 (0.5)
Range (min. – max.)	1.8 - 5.4	1.6 - 5.5	1.7 - 5.3	1.5 - 6.0
25th percentile	3.0	2.8	2.7	2.8
50th percentile	3.1	2.9	2.9	3.0
75th percentile	3.3	3.2	3.1	3.3

Table 4.2.7 – Between-Hospital Variance for THA/TKA

	04/2012-03/2013	04/2013-03/2014	04/2014-03/2015	04/2012-03/2015
Between-hospital variance (SE)	0.089 (0.011)	0.106 (0.012)	0.105 (0.012)	0.096 (0.006)

Figure 4.2.2 – Distribution of Hospital THA/TKA RSCRs Between April 2012 and March 2015



5. GLOSSARY

Case mix: The particular illness severity and age characteristics of patients with index admissions at a given hospital.

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

Comorbidities: Medical conditions that the patient had in addition to his/her primary reason for admission to the hospital.

Complications: Medical conditions that may have occurred as a consequence of care rendered during hospitalization.

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.

Confidence interval (CI): A CI is a range of values that describes the uncertainty surrounding an estimate. It is indicated by its endpoints; for example, a 95% CI for the OR associated with protein-calorie malnutrition noted as "1.09 – 1.15" would indicate that there is 95% confidence that the OR lies between 1.09 and 1.15.

Expected number of admissions with a complication: The number of admissions with a complication expected based on 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 accounting for patient risk factors and 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 complication 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 complication risk.

Hospital-specific effect: A measure of the hospital quality of care that is calculated through hierarchical logistic regression, taking into consideration how many patients were eligible for the cohort, these patients' risk factors, and how many had THA/TKA complications. The hospital-specific effect is the calculated random effect intercept for each hospital. The hospital-specific intercept 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 intercept is used in the numerator to calculate "predicted" complications.

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 CI. The interval estimate is a range of probable values for the estimate that characterizes the amount of uncertainty. For example, a 95% interval estimate for a complication rate indicates that CMS is 95% confident that the true value of the rate lies between the lower and the upper limit of the interval.

Medicare fee-for-service (FFS): Original Medicare plan in which providers receive a fee or payment for each individual service provided directly from Medicare. Only beneficiaries in Medicare FFS, not in managed care (Medicare Advantage), are included in the measures.

National observed complication rate: All included hospitalizations with the outcome divided by all included hospitalizations.

Odds ratio (OR): The ORs express the relative odds of the outcome for each of the predictor variables. For example, the OR for Protein-calorie malnutrition (CC 21) represents the odds of the outcome for patients with that risk variable present relative to those without the risk variable present. The model coefficient for each risk variable is the log (odds) for that variable.

Outcome: The result of a broad set of healthcare activities that affect patients' well-being. For the complication measure, the outcome is any one of the specified complications occurring during the index admission or during a readmission, except for death, which can occur anywhere as long as it is within 30 days of the index admission.

Predicted number of admissions with a complication: The number of admissions with a complication predicted based on the hospital's performance with its observed case mix.

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

6. REFERENCES

1. Grosso L, Curtis J, Lin Z, et al. Hospital-level Risk-Standardized Complication Rate Following Elective Primary Total Hip Arthroplasty (THA) And/Or Total Knee Arthroplasty (TKA) Measure Methodology Report 2012; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier3&cid=1228774719413. Accessed March 1, 2016.
2. Suter L, Parzynski C, Grady J, et al. 2013 Measures Update and Specifications: Elective Primary Total Hip Arthroplasty (THA) and/or Total Knee Arthroplasty (TKA) Risk-Standardized Complication Measure (Version 2.0). 2013; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier4&cid=1228772782693. Accessed March 1, 2016.
3. Suter L, Parzynski C, Searfoss R, et al. 2014 Procedure-Specific Complication Measure Updates and Specifications Report: Elective Primary Total Hip Arthroplasty (THA) and/or Total Knee Arthroplasty (TKA) – Version 3.0 2014; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier4&cid=1228772782693. Accessed March 1, 2016.
4. Suter L, Zhang W, Parzynski C, DeBuhr J, Bernheim S, Krumholz H. 2015 Procedure-Specific Complication Measure Updates and Specifications Report: Elective Primary Total Hip Arthroplasty (THA) and/or Total Knee Arthroplasty (TKA) – Version 4.0. 2015; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier4&cid=1228772782693. Accessed Available as of April 22, 2016.
5. 2015 Medicare Hospital Quality Chartbook. Prepared by Yale New Haven Health Services Corporation Center for Outcomes Research and Evaluation for the Centers for Medicare and Medicaid Services 2015; https://www.cms.gov/medicare/quality-initiatives-patient-assessment-instruments/hospitalqualityinits/outcomemeasures.html. Accessed March 1, 2016.
6. Normand S-L, Shahian D. Statistical and clinical aspects of hospital outcomes profiling. *Statistical Science.* 2007;22(2):206-226.
7. Daniels M, Gatsonis C. Hierarchical Generalized Linear Models in the Analysis of Variations in Health Care Utilization. *Journal of the American Statistical Association.* 1999/03/01 1999;94(445):29-42.
8. Normand S-L, Wang Y, Krumholz H. Assessing surrogacy of data sources for institutional comparisons. *Health Serv Outcomes Res Method.* 2007/06/01 2007;7(1-2):79-96.

7. APPENDICES

Appendix A. Statistical Approach to RSCRs for THA/TKA Measure

We estimate the hospital-specific RSCRs 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 complication as a function of patient age, sex, and clinically relevant comorbidities with an intercept for the hospital-specific random effect.

We use the following strategy to calculate the hospital-specific RSCRs, which we calculate as the ratio of a hospital's "predicted" complications to "expected" complications multiplied by the national observed complication rate. The expected number of admissions with a complication for each hospital is estimated using its patient mix and the average hospital-specific effect (that is, the average effect among all hospitals in the sample). The predicted number of admissions with a complication for each hospital is estimated given the same patient mix but an estimated hospital-specific effect. Operationally, the expected number of admissions with a complication for each hospital is obtained by summing the expected probabilities of complications for all patients in the hospital. The expected probability of complication 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 effect. The predicted number of admissions with a complication 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 adds the hospital-specific effect.

More specifically, we use a hierarchical logistic regression model 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:

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

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

Where h(.) is a logit link, Y_{ij} is whether the j^{th} patient in the i^{th} hospital had a complication (equal to 1 if complication, zero 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 adjusted average hospital intercept across all hospitals in the sample, and τ^2 is the between-hospital variance component.[7] This model separates within-hospital variation from between-hospital variation. The hierarchical logistic regression models are estimated using the SAS software system (SAS 9.3 GLIMMIX).

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, RSCR, for each hospital by computing the ratio of the predicted number of admissions with a complication to the expected number

of admissions with a complication, multiplied by the national observed complication rate, $\bar{y}$. Specifically, we calculate

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

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

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

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

If the "predicted" number of admissions with a complication is higher (or lower) than the "expected" number of admissions with a complication for a given hospital, its $\widehat{RSCR}_i$ will be higher (or lower) than the national observed complication rate. For each hospital, we compute an interval estimate of *RSCR*$_i$ to characterize the level of uncertainty around the point estimate using bootstrapping simulations, as described in the next section. The point and interval estimates are used to characterize and compare hospital performance (for example, higher than expected, as expected, or lower than expected).

Creating Interval Estimates

Because the statistic described in Equation 5, that is, $\widehat{RSCR}_i$, 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, $\{\hat{\alpha}_i^{(b)}, \widehat{var}(\hat{\alpha}_i^{(b)}); i = 1,2,\ldots,I\}$

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 $\hat{\alpha}_i^{(b*)} \sim N\left(\hat{\alpha}_i^{(b)}, \widehat{var}\left(\hat{\alpha}_i^{(b)}\right)\right)$ 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 $\hat{y}_{ij}^{(b)}$, $\hat{e}_{ij}^{(b)}$, $\widehat{RSCR}_i(Z)^{(B)}$ 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).[8]

Appendix B. Data QA

We use a two-phase approach to internal QA for the complication measure reevaluation process. Refer to Figure B.1 for a detailed outline of phase I and Figure B.2 for a detailed outline of phase II.

This section represents QA for the subset of the work CORE conducted to maintain and report the THA/TKA complication 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.

Phase I

The first step in the QA process is to ensure the validity of the input data files. No new variables that impacted the measures were added to the input files; thus, our main task was to ensure that variable frequencies and distributions in the newly created input data files were consistent with data from the prior time period.

In general, we use both manual scan and descriptive analyses to conduct data validity checks, including cross-checking of complication information, distributions of ICD-9-CM codes, and frequencies of key variables. The results are reviewed for accuracy and changes compared to data from prior data sources. Any new variable constructs and other changes in formatting to the input files are also verified. 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 complication measure: data preparation, sample selection, hierarchical modeling, and calculation of RSCRs. 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.

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 compares prior years' risk-adjustment coefficients and variable frequencies, to enable us to check for potential inconsistencies in the data and the impact of any changes to the SAS pack.

Figure B.1 – CORE QA Phase I

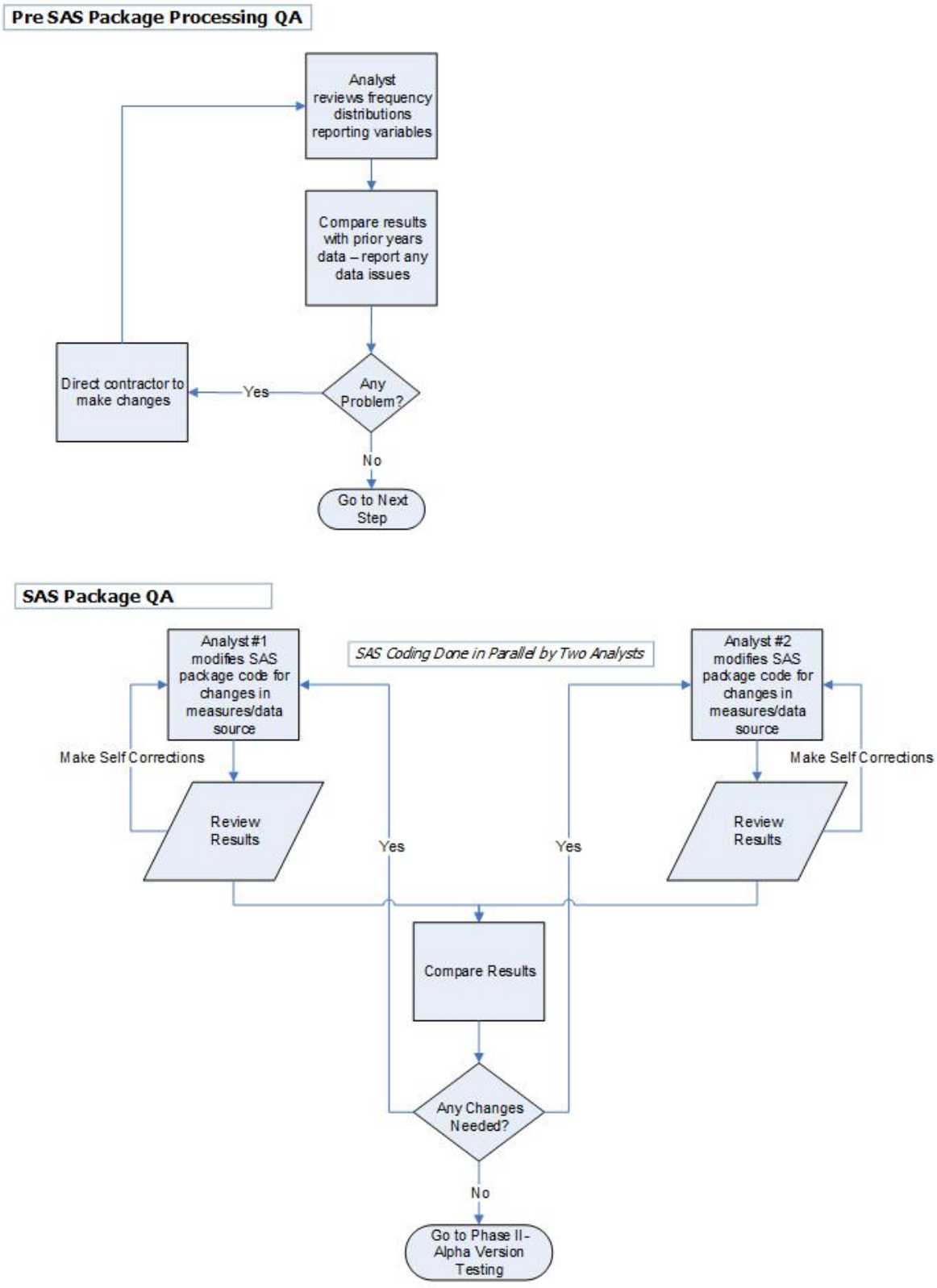
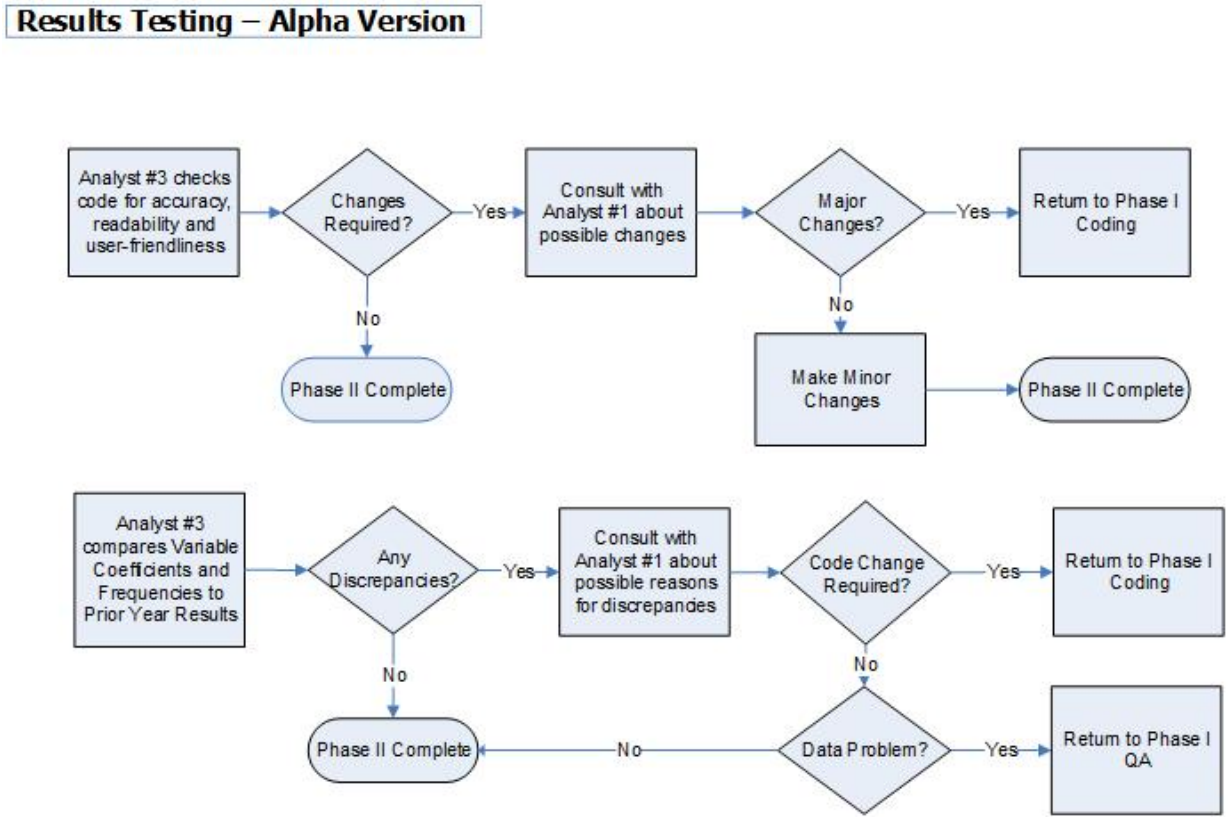


Figure B.2 – CORE QA Phase II



Appendix C. Annual Updates

Prior annual updates for the measure can be found in the annual updates and specifications reports 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 dry run report are considered Version 1.0 for a measure. The measure receives a new version number for each subsequent year of public reporting.

2016

2016 Measures Updates and Specifications Report THA/TKA Complication (Version 5.0)

No updates were made to the specifications of the THA/TKA complication measure for 2016 public reporting.

2015

2015 Measures Updates and Specifications Report THA/TKA Complication (Version 4.0)

1. Updated cohort to exclude patients without at least 90 days post-discharge enrollment in Medicare FFS.
    - Rationale: Removing index admissions for patients who withdrew from the Medicare FFS program within 90 days after discharge improves the accuracy of the measure by removing patients for whom there is no available outcome data and makes the measure consistent with the methodologies used in the THA/TKA 30-day readmission measure and other publicly reported condition-specific readmission measures for AMI, HF, pneumonia, COPD, and stroke admissions.

2014

2014 Measures Updates and Specifications Report THA/TKA Complication (Version 3.0)

1. Updated measure specifications to not include all patients with a secondary diagnosis of fracture during index admission in the measure cohort.
    - Rationale: These procedures are presumably not elective THA/TKA procedures and the cohort aims to include only elective THA/TKA procedures.
2. Updated measure specifications to exclude complications coded as POA during index admission from measure outcome.
    - Rationale: These complications are presumably not related to the index procedure and/or peri-operative care provided and the measure aims to assess quality of hospital care.

2013

2013 Measures Updates and Specifications Report THA/TKA Complication (Version 2.0)

1. Updated CC map.
    - Rationale: Prior to 2014, the ICD-9-CM CC map was updated annually to capture all relevant comorbidities coded in patient administrative claims data.
2. Updated complication and fracture exclusion codes.
    - Rationale: New ICD-9-CM codes identified and added to the THA/TKA complication measure.
        i. Updated ICD-9-CM codes defining the pneumonia, sepsis/septicemia, and pulmonary embolism complications to reflect changes to the ICD-9-CM coding (no change to the clinical meaning of the complications).

ii. Updated ICD-9-CM codes defining the femur, hip, or pelvic fracture exclusions to the measure cohort to reflect relevant new ICD-9-CM codes.

3. Changes from prior methodology report.
   - Rationale: Two tables were corrected from the original methodology report and the combined dataset was shortened from 36 to 33 months due to the timing of public reporting and the longer period of outcome assessment required to adequately capture complications up to 90 days following admission.
     i. Table A.3 in Appendix A contains the updated list of CCs not risk adjusted for during the index admission, to reflect the measure specifications in the SAS pack.
        - CC 82 (Unstable Angina and Other Acute Ischemic Heart Disease) was added.
        - CC 85 (Heart Infection/Inflammation, Except Rheumatic) was removed.
     ii. Table A.4 in Appendix A contains the labeling correction for the list of ICD-9-CM THA Resurfacing Procedure codes.

Appendix D. Measure Specifications

Appendix D.1 Hospital-Level RSCR Following Elective Primary THA and/or TKA (NQF #1550)

Cohort

Inclusion Criteria for THA/TKA Measure

1. **Enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission**
   Rationale: Claims data are consistently available only for Medicare FFS beneficiaries. The 12-month prior enrollment criterion ensures that patients remain Medicare FFS beneficiaries and that their comorbidities are captured from claims for risk adjustment. Medicare Part A is required at the time of admission to ensure that no Medicare Advantage patients are included in the measure.
2. **Aged 65 or over**
   Rationale: Medicare patients younger than 65 usually qualify for the program due to severe disability. They are not included in the measure because they are considered to be too clinically distinct from Medicare patients 65 and over.
3. **Having a qualifying elective primary THA/TKA procedure during the index admission**
   Rationale: Elective primary THA or TKA is the procedure targeted for measurement (Table D.1.1).
   Elective primary THA/TKA procedures are defined as those THA/TKA procedures *without* any of the following:
   - **Femur, hip, or pelvic fractures coded in the principal or secondary discharge diagnosis fields of the index admission**
     Rationale: Patients with fractures have higher mortality, complication, and readmission rates and the procedures are not elective (Table D.1.2).
   - **A concurrent partial hip arthroplasty procedure**
     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 (Table D.1.3). Partial knee arthroplasty procedures are not distinguished by ICD-9-CM codes and are therefore currently captured by the THA/TKA complication measure.
   - **A concurrent revision procedure**
     Rationale: Revision procedures may be performed at a disproportionately small number of hospitals and are associated with higher mortality, complication, and readmission rates (Table D.1.4).
   - **A concurrent resurfacing procedure**
     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 (Table D.1.5).
   - **Mechanical complication coded in the principal discharge diagnosis field of the index admission**
     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 (Table D.1.6).

- **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 complication, and the procedure may not be elective (Table D.1.7).
- **Removal of implanted devices/prostheses**
  Rationale: Elective procedures performed in these patients may be more complicated (Table D.1.8).
- **Transfer from another acute care facility for the THA/TKA**
  Rationale: The THA/TKA complication measure does not include admissions for patients transferred in to the index hospital, as they likely do not represent elective THA/TKA procedures.

Exclusion Criteria for THA/TKA Measure

1. **Without at least 90 days of post-discharge enrollment in Medicare FFS**
   Rationale: The 90-day complication outcome cannot be assessed in this group since claims data are used to determine whether a complication of care occurred.
2. **Discharged against medical advice (AMA)**
   Rationale: Providers did not have the opportunity to deliver full care and prepare the patient for discharge.
3. **With more than two THA/TKA procedure codes during the index admission**
   Rationale: Although clinically possible, it is highly unlikely that patients would receive more than two elective THA/TKA procedures in one hospitalization, which may reflect a coding error.

   After exclusions #1-3 are applied, the measure randomly selects one index admission per patient per year for inclusion in the cohort so that each episode of care is mutually independent with the same probability of the outcome. Additional admissions within that year are excluded.

Table D.1.1 – ICD-9-CM Codes Used to Identify Eligible THA/TKA Procedures

ICD-9-CM Procedure Codes	Description
81.51	Total hip replacement
81.54	Total knee replacement

Table D.1.2 – ICD-9-CM Codes for Fractures that Disqualify an Admission From Inclusion in the THA/TKA Final Cohort

ICD-9-CM Diagnosis Codes	Description
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
733.81	Malunion of fracture
733.82	Nonunion of fracture

ICD-9-CM Diagnosis Codes	Description
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
808.51	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
808.59	Open fracture of other specified part of pelvis
808.8	Closed unspecified fracture of pelvis
808.9	Open unspecified fracture of pelvis
820.00	Closed fracture of intracapsular section of neck of femur, unspecified
820.01	Closed fracture of epiphysis (separation) (upper) of neck of femur
820.02	Closed fracture of midcervical section of neck of femur
820.03	Closed fracture of base of neck of femur
820.09	Other closed transcervical fracture of neck of femur
820.10	Open fracture of intracapsular section of neck of femur, unspecified
820.11	Open fracture of epiphysis (separation) (upper) of neck of femur
820.12	Open fracture of midcervical section of neck of femur
820.13	Open fracture of base of neck of femur
820.19	Other open transcervical fracture of neck of femur
820.20	Closed fracture of trochanteric section of neck of femur
820.21	Closed fracture of intertrochanteric section of neck of femur
820.22	Closed fracture of subtrochanteric section of neck of femur
820.30	Open fracture of trochanteric section of neck of femur, unspecified
820.31	Open fracture of intertrochanteric section of neck of femur
820.32	Open fracture of subtrochanteric section of neck of femur
820.8	Closed fracture of unspecified part of neck of femur
820.9	Open fracture of unspecified part of neck of femur
821.00	Closed fracture of unspecified part of femur
821.01	Closed fracture of shaft of femur
821.10	Open fracture of unspecified part of femur

ICD-9-CM Diagnosis Codes	Description
821.11	Open fracture of shaft of femur
821.20	Closed fracture of lower end of femur, unspecified part
821.21	Closed fracture of condyle, femoral
821.22	Closed fracture of epiphysis, lower (separation) of femur
821.23	Closed supracondylar fracture of femur
821.29	Other closed fracture of lower end of femur
821.30	Open fracture of lower end of femur, unspecified part
821.31	Open fracture of condyle, femoral
821.32	Open fracture of epiphysis, lower (separation) of femur
821.33	Open supracondylar fracture of femur
821.39	Other open fracture of lower end of femur

Table D.1.3 – ICD-9-CM Codes for Partial Hip Replacement that Disqualify an Admission From Inclusion in the THA/TKA Final Cohort

ICD-9-CM Procedure Codes	Description
81.52	Partial hip replacement

Table D.1.4 – ICD-9-CM Codes for THA and TKA Revisions that Disqualify an Admission From Inclusion in the THA/TKA Final Cohort

ICD-9-CM Procedure Codes	Description
81.53	Revision of hip replacement, not otherwise specified
81.55	Revision of knee replacement, not otherwise specified
81.59	Revision of joint replacement of lower extremity, not elsewhere classified
00.70	Revision of hip replacement, both acetabular and femoral components
00.71	Revision of hip replacement, acetabular component
00.72	Revision of hip replacement, femoral component
00.73	Revision of hip replacement, acetabular liner and/or femoral head only
00.80	Replacement of knee replacement, total (all components)
00.81	Replacement of knee replacement, tibial component
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)

Table D.1.5 – ICD-9-CM Codes for Resurfacing Procedures that Disqualify an Admission From Inclusion in the THA/TKA Final Cohort

ICD-9-CM Procedure Codes	Description
00.85	Resurfacing hip, total, acetabulum and femoral head
00.86	Resurfacing hip, partial, femoral head
00.87	Resurfacing hip, partial, acetabulum

Table D.1.6 – ICD-9-CM Codes for Mechanical Complications that Disqualify an Admission From Inclusion in the THA/TKA Final Cohort

ICD-9-CM Diagnosis Codes	Description
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

Table D.1.7 – ICD-9-CM Codes for Malignant Neoplasms that Disqualify an Admission From Inclusion in the THA/TKA Final Cohort

ICD-9-CM Diagnosis Codes	Description
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 without specification of site

Table D.1.8 – ICD-9-CM Codes for Removal of Devices/Prosthesis that Disqualify an Admission From Inclusion in the THA/TKA Final Cohort

ICD-9-CM Procedure Codes	Description
78.65	Removal of implanted devices from bone, 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 without replacement, hip
80.06	Arthrotomy for removal of prosthesis without replacement, knee
80.09	Arthrotomy for removal of prosthesis without replacement, other specified sites

Risk Adjustment

Table D.1.9 – Risk Variables for THA/TKA Measure

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
Age minus 65 (years above 65, continuous)	n/a	
Male	n/a	
Index admissions with an elective THA procedure	n/a	
Number of procedures (two vs. one)	n/a	
Other congenital deformity of hip (joint)	ICD-9 diagnosis code 755.63	
Post traumatic osteoarthritis	ICD-9 diagnosis codes 716.15, 716.16	
Morbid obesity	ICD-9 diagnosis code 278.01	
Metastatic cancer or acute leukemia	CC 7 Metastatic cancer or acute leukemia	
Other major cancers; lung, upper digestive tract, and other severe cancers	CC 8 Lung, upper digestive tract, and other severe cancers	
	CC 9 Lymphatic, head and neck, brain, and other major cancers	
	CC 10 Breast, prostate, colorectal and other cancers and tumors	
Respiratory/heart/digestive/urinary/other neoplasms	CC 11 Other respiratory and heart neoplasms	
	CC 12 Other digestive and urinary neoplasms	
	CC 13 Other neoplasms	
Diabetes mellitus (DM) or DM complications	CC 15 Diabetes with renal manifestation	
	CC 16 Diabetes with neurologic or peripheral circulatory manifestation	
	CC 17 Diabetes with acute complications	X
	CC 18 Diabetes with ophthalmologic manifestation	
	CC 19 Diabetes with no or unspecified complications	
	CC 119 Proliferative diabetic retinopathy and vitreous hemorrhage	
	CC 120 Diabetic and other vascular retinopathies	
Protein-calorie malnutrition	CC 21 Protein-calorie malnutrition	
Bone/joint/muscle infections/necrosis	CC 37 Bone/joint/muscle infections/necrosis	X
Rheumatoid arthritis and inflammatory connective tissue disease	CC 38 Rheumatoid arthritis and inflammatory connective tissue disease	
Osteoarthritis of hip or knee	CC 40 Osteoarthritis of hip or knee	
Osteoporosis and other bone/cartilage disorders	CC 41 Osteoporosis and other bone/cartilage disorders	
Dementia or other specified brain disorders	CC 49 Dementia	
	CC 50 Senility, nonpsychotic organic brain syndromes/conditions	
Major psychiatric disorders	CC 54 Schizophrenia	

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
	CC 55 Major depressive, bipolar, and paranoid disorders	
	CC 56 Reactive and unspecified psychosis	
Hemiplegia, paraplegia, paralysis, functional disability	CC 67 Quadriplegia, other extensive paralysis	
	CC 68 Paraplegia	
	CC 69 Spinal cord disorders/injuries	
	CC 100 Hemiplegia/hemiparesis	X
	CC 101 Diplegia (upper), monoplegia, and other paralytic syndromes	X
	CC 102 Speech, language, cognitive, perceptual deficits	X
	CC 177 Amputation status, lower limb/amputation complications	X
	CC 178 Amputation status, upper limb	X
Cardio-respiratory failure and shock	CC 79 Cardio-respiratory failure and shock	X
Coronary atherosclerosis or angina	CC 83 Angina pectoris/old myocardial infarction	
	CC 84 Coronary atherosclerosis/other chronic ischemic heart disease	
Stroke	CC 95 Cerebral hemorrhage	X
	CC 96 Ischemic or unspecified stroke	X
Vascular or circulatory disease	CC 104 Vascular disease with complications	X
	CC 105 Vascular disease	X
	CC 106 Other circulatory disease	X
Chronic Obstructive Pulmonary Disease (COPD)	CC 108 Chronic Obstructive Pulmonary Disease (COPD)	
Pneumonia	CC 111 Aspiration and specified bacterial pneumonias	X
	CC 112 Pneumococcal pneumonia, emphysema, lung abscess	X
	CC 113 Viral and unspecified pneumonia, pleurisy	X
Pleural effusion/pneumothorax	CC 114 Pleural effusion/pneumothorax	X
Dialysis status	CC 130 Dialysis status	X
Renal failure	CC 131 Renal failure	X
Decubitus ulcer or chronic skin ulcer	CC 148 Decubitus ulcer of skin	X
	CC 149 Chronic ulcer of skin, except decubitus	
Trauma	CC 154 Severe head injury	X
	CC 155 Major head injury	X
	CC 156 Concussion or unspecified head injury	X
	CC 158 Hip fracture/dislocation	X
	CC 159 Major fracture, except of skull, vertebrae, or hip	X
	CC 160 Internal injuries	X
	CC 161 Traumatic amputation	X
Vertebral fractures	CC 157 Vertebral fractures	

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
Other injuries	CC 162 Other injuries	X
Major complications of medical care and trauma	CC 164 Major complications of medical care and trauma	X

Outcome

Outcome Criteria for the THA/TKA Complication Measure

Complication within the specified time frame

Rationale: The goal is to identify medical and surgical complications that could be attributable to the care provided during and after an elective THA or TKA procedure. The outcome for this measure is any one of the specified complications occurring during the index admission or during a readmission except for deaths, which can occur anywhere as long as it is within 30 days of the index admission. Therefore, if a patient experiences one or more complications in the applicable time period, the outcome variable is coded as a "yes." If an otherwise qualifying complication is coded as POA during index admission, the complication is excluded from the measure outcome. Applicable time period recommendations specific to each complication were established through clinical input and examining 90-day trends in complication rates.

Table D.1.10 – Identification of Complications Following THA/TKA

Complication	Follow-up Period in Days	ICD-9 Codes Defining Complication	Required Coding Placement
Acute myocardial infarction	During index admission or within 7 days of admission date	410.00 Acute myocardial infarction of anterolateral wall, episode of care unspecified 410.01 Acute myocardial infarction of anterolateral wall, initial episode of care 410.10 Acute myocardial infarction of other anterior wall, episode of care unspecified 410.11 Acute myocardial infarction of other anterior wall, initial episode of care 410.20 Acute myocardial infarction of inferolateral wall, episode of care unspecified 410.21 Acute myocardial infarction of inferolateral wall, initial episode of care 410.30 Acute myocardial infarction of inferoposterior wall, episode of care unspecified 410.31 Acute myocardial infarction of inferoposterior wall, initial episode of care 410.40 Acute myocardial infarction of other inferior wall, episode of care unspecified 410.41 Acute myocardial infarction of other inferior wall, initial episode of care	• Index admission – secondary discharge diagnosis fields only AND not coded as POA • Readmissions – principal discharge diagnosis field only

Complication	Follow-up Period in Days	ICD-9 Codes Defining Complication	Required Coding Placement
		410.50 Acute myocardial infarction of other lateral wall, episode of care unspecified 410.51 Acute myocardial infarction of other lateral wall, initial episode of care 410.60 True posterior wall infarction, episode of care unspecified 410.61 True posterior wall infarction, initial episode of care 410.70 Subendocardial infarction, episode of care unspecified 410.71 Subendocardial infarction, initial episode of care 410.80 Acute myocardial infarction of other specified sites, episode of care unspecified 410.81 Acute myocardial infarction of other specified sites, initial episode of care 410.90 Acute myocardial infarction of unspecified site, episode of care unspecified 410.91 Acute myocardial infarction of unspecified site, initial episode of care	

Complication	Follow-up Period in Days	ICD-9 Codes Defining Complication	Required Coding Placement
Pneumonia	During index admission or within 7 days of admission date	480.0 Pneumonia due to adenovirus 480.1 Pneumonia due to respiratory syncytial virus 480.2 Pneumonia due to parainfluenza virus 480.3 Pneumonia due to SARS-associated coronavirus 480.8 Pneumonia due to other virus not elsewhere classified 480.9 Viral pneumonia, unspecified 481 Pneumococcal pneumonia (Streptococcus pneumoniae pneumonia) 482.0 Pneumonia due to Klebsiella pneumoniae 482.1 Pneumonia due to Pseudomonas 482.2 Pneumonia due to *Hemophilus influenzae* (*H. influenzae*) 482.30 Pneumonia due to Streptococcus, unspecified 482.31 Pneumonia due to Streptococcus, group A 482.32 Pneumonia due to Streptococcus, group B 482.39 Pneumonia due to other Streptococcus 482.40 Pneumonia due to Staphylococcus, unspecified 482.41 Methicillin susceptible pneumonia due to *Staphylococcus aureus* 482.42 Methicillin resistant pneumonia due to *Staphylococcus aureus* 482.49 Other Staphylococcus pneumonia 482.81 Pneumonia due to anaerobes 482.82 Pneumonia due to *Escherichia coli* [*E. coli*] 482.83 Pneumonia due to other gram-negative bacteria 482.84 Pneumonia due to Legionnaires' disease 482.89 Pneumonia due to other specified bacteria 482.9 Bacterial pneumonia, unspecified 483.0 Pneumonia due to m*ycoplasma pneumoniae* 483.1 Pneumonia due to chlamydia 483.8 Pneumonia due to other specified organism 485 Bronchopneumonia, organism unspecified 486 Pneumonia, organism unspecified 487.0 Influenza with pneumonia 488.11 Influenza due to identified 2009 H1N1 influenza virus with pneumonia 507.0 Pneumonitis due to inhalation of food or vomitus 997.32 Postprocedural aspiration pneumonia	• Index admission – secondary discharge diagnosis fields only AND not coded as POA • Readmissions – principal discharge diagnosis field only

Complication	Follow-up Period in Days	ICD-9 Codes Defining Complication	Required Coding Placement
Sepsis/ septicemia/ shock	During index admission or within 7 days of admission date	038.0 Streptococcal septicemia 038.10 Staphylococcal septicemia, unspecified 038.11 Methicillin susceptible Staphylococcus aureus septicemia 038.12 Methicillin resistant Staphylococcus aureus septicemia 038.19 Other staphylococcal septicemia 038.2 Pneumococcal septicemia [Streptococcus pneumoniae septicemia] 038.3 Septicemia due to anaerobes 038.40 Septicemia due to gram negative organism, unspecified 038.41 Septicemia due to hemophilus influenzae [H. influenzae] 038.42 Septicemia due to escherichia coli [E. coli] 038.43 Septicemia due to pseudomonas 038.44 Septicemia due to serratia 038.49 Other septicemia due to gram-negative organisms 038.8 Other specified septicemias 038.9 Unspecified septicemia 785.52 Septic shock 785.59 Other shock without trauma 790.7 Bacteremia 995.91 Sepsis 995.92 Severe sepsis 998.0 Postoperative shock, not elsewhere classified 998.00 Postoperative shock, unspecified 998.01 Postoperative shock, cardiogenic 998.02 Postoperative shock, septic 998.09 Postoperative shock, other	• Index admission – secondary discharge diagnosis fields only AND not coded as POA • Readmissions – principal discharge diagnosis field only

Complication	Follow-up Period in Days	ICD-9 Codes Defining Complication	Required Coding Placement
Surgical site bleeding	During index admission or within 30 days of admission date	One of the following diagnosis codes: 719.10 Hemarthrosis, site unspecified 719.16 Hemarthrosis, lower leg 719.17 Hemarthrosis, ankle and foot 998.11 Hemorrhage complicating a procedure 998.12 Hematoma complicating a procedure 998.13 Seroma complicating a procedure AND One of the following procedure codes: 39.98 Control of hemorrhage, not otherwise specified 86.04 Other incision with drainage of skin and subcutaneous tissue	• Index admission o Diagnosis code in secondary discharge diagnosis fields only AND not coded as POA o Procedure code in secondary procedure fields only • Readmissions o Diagnosis code in principal or secondary discharge diagnosis fields o Procedure code in principal or secondary procedure fields
Pulmonary embolism	During index admission or within 30 days of admission date	415.11 Iatrogenic pulmonary embolism and infarction 415.13 Saddle embolus of pulmonary artery 415.19 Other pulmonary embolism and infarction	• Index admission – secondary discharge diagnosis fields only AND not coded as POA • Readmissions – principal or secondary discharge diagnosis fields
Death	During index admission or within 30 days of admission date	N/A	N/A

Complication	Follow-up Period in Days	ICD-9 Codes Defining Complication	Required Coding Placement
Mechanical complications	During index admission or within 90 days of admission date	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 996.44 Peri prosthetic fracture around prosthetic joint 996.47 Other mechanical complication of prosthetic joint implant 996.49 Other mechanical complication of other internal orthopedic device, implant, and graft	• Index admission – secondary discharge diagnosis fields only AND not coded as POA • Readmissions – principal or secondary discharge diagnosis fields
Periprosthetic Joint Infection / Wound Infection	During index admission or within 90 days of admission date	One of the following diagnosis codes: 996.66 Infection and inflammatory reaction due to internal joint prosthesis 996.67 Infection and inflammatory reaction due to other internal orthopedic device, implant, and graft 998.30 Disruption of wound, unspecified 998.31 Disruption of internal operation (surgical) wound 998.32 Disruption of external operation (surgical) wound 998.33 Disruption of traumatic injury wound repair 998.51 Infected postoperative seroma 998.59 Other postoperative infection 998.6 Persistent postoperative fistula 998.83 Non-healing surgical wound AND One of the following procedure codes: 00.70 Revision of hip replacement, both acetabular and femoral components 00.71 Revision of hip replacement, acetabular component 00.72 Revision of hip replacement, femoral component 00.73 Revision of hip replacement, acetabular liner and/or femoral head only 00.80 Replacement knee replacement, total (all components) 00.81 Replacement of knee replacement, tibial component 00.82 Revision of knee replacement, femoral component 00.83 Revision of knee replacement, patellar component	• Index admission o Diagnosis code in secondary discharge diagnosis fields only AND not coded as POA o Procedure code in secondary procedure fields only • Readmissions o Diagnosis code in principal or secondary discharge diagnosis fields o Procedure code in principal or secondary procedure fields

Complication	Follow-up Period in Days	ICD-9 Codes Defining Complication	Required Coding Placement
		00.84 Revision of total knee replacement, tibial insert (liner) 78.65 Removal of implanted devices from bone, 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 without replacement, hip 80.06 Arthrotomy for removal of prosthesis without replacement, knee 80.09 Arthrotomy for removal of prosthesis without replacement, other specified sites 81.53 Revision of hip replacement, not otherwise specified 81.55 Revision of knee replacement, not otherwise specified 81.59 Revision of joint replacement of lower extremity, not elsewhere classified 86.04 Other incision with drainage of skin and subcutaneous tissue 86.22 Excisional debridement of wound, infection, or burn 86.28 Non-excisional debridement of wound, infection or burn	