2024 Condition- and Procedure-Specific Mortality/Complication Measures Supplemental Methodology Report

Stroke
Elective Primary Total Hip Arthroplasty (THA) and/or Total Knee Arthroplasty (TKA)

Submitted By:

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NOTE: This supplemental methodology report is not meant to replace the original measure methodology reports, but to provide additional information and results based on the addition of Medicare Advantage (MA) admissions to the cohorts and the modification of the risk adjustment models. The original methodology reports for the measures are available on QualityNet here.

1. EXECUTIVE SUMMARY

In this supplemental methodology report, we present the rationale and testing results of updates to the hospital-level 30-day risk-standardized mortality rates (RSMRs) following stroke and the hospital-level 30-day risk-standardized complication rates (RSCRs) following elective total hip arthroplasty and/or total knee arthroplasty (THA/TKA) admissions. The updates include: 1) integrating Medicare Advantage (MA) beneficiaries into the cohorts and, 2) the reselection of risk adjustment variables. All other specifications remain the same.

For testing purposes, the cohorts include hospital admissions with discharge dates from January 1 to December 30, 2022. Inpatient, outpatient, professional, and DME claims for Medicare Fee-For-Service (FFS) and MA beneficiaries were extracted from the Centers for Medicare & Medicaid Services (CMS) Integrated Data Repository (IDR). The MA claims data comprise Medicare Advantage Organization (MAO)-submitted encounter data (Encounter Data Records and Chart Review Records for all settings) and hospital-submitted inpatient MA claims.[1]

The addition of MA admissions into these measures approximately doubled the admissions in the cohorts and led to improved measure reliability and more hospitals and beneficiaries included for measure calculation. Unadjusted 30-day mortality rate was slightly lower for MA versus FFS admissions for stroke mortality measure and unadjusted 30-day complication rate was slightly higher for MA for THA/TKA complication measure. The prevalence of comorbidities was generally higher in the MA cohort as compared to FFS.

A new approach to variable reselection was implemented to leverage the specificity of individual International Classification of Diseases (ICD)-10 codes in place of Condition Categories (CCs) to improve performance of the risk adjustment models. With this new variable selection approach, the discriminative performance of the models as measured by c-statistics, was significantly better for stroke mortality and remained the same for THA/TKA complications. Calibration performance also proved to be satisfactory using the new approach. After the two measure updates, we observed meaningful shifts in hospital performance.

2. BACKGROUND AND OBJECTIVES

2.1. Importance of Including MA Beneficiaries in Hospital Outcome Measures

Including MA beneficiaries in CMS hospital outcome measures helps ensure that hospital quality is measured across all Medicare beneficiaries and not just the FFS population. MA beneficiary enrollment has been rapidly expanding as a share of Medicare beneficiaries. In 2023, nearly 51% of the eligible Medicare beneficiaries — or 30.8 million people — were covered by MA plans.[2] The Congressional Budget Office projects that by 2030, 62% of beneficiaries will be covered by MA plans.[3] Consequently, using FFS-only beneficiaries may exclude a large segment of the focus population for CMS quality measures, which are intended to measure the quality of care of all Medicare beneficiaries.

Inclusion of MA beneficiaries has several important benefits for the reliability and validity of the hospital outcome measures. The addition of MA beneficiaries to FFS significantly increases the size of the measure's cohort, which enhances the reliability of the measure scores, leads to more hospitals receiving results, and increases the chance of identifying meaningful differences in quality for some low-volume hospitals. Moreover, this update addresses stakeholder concerns about differences in quality for MA and FFS beneficiaries.[4,5] The addition of MA inpatient admissions also allows for inclusion in the measure of beneficiaries who switch between FFS and MA. CMS's current claims-based measures require enrollment in FFS Part A and Part B for the 12 months prior to the date of admission and Part A during the index admission.

2.2. Importance of Risk Adjustment Model Changes

The goal of risk-adjustment models is to adjust for case-mix differences across the hospitals. Risk adjustment supports fair and accurate comparison of outcomes across measured entities by including an adjustment for factors such as age, comorbid diseases, and indicators of patient frailty, which are clinically relevant and have relationships with the outcome.

The original process for clinical risk adjustment for the current measures involved reviewing CCs for clinical relevance and evaluating the CCs for statistical association with the outcome. The CCs are part of CMS's Hierarchical Condition Categories (HCC), and the HCC system groups the ICD-10 diagnosis codes into larger clinically relevant diagnostic categories.[6,7] Mappings which show the assignment of ICD-10 codes to the CCs are available on *QualityNet*. In pursuing an approach that best leverages the data and analytical advancements since initial measure development, we developed and evaluated a framework to use individual ICD-10 codes for risk adjustment. The main advantage of leveraging ICD-10 codes in place of CCs is the ability to address the clinical heterogeneity found in the broadly defined CCs. Our previous research indicates that the model performance of the mortality measures is significantly improved by using individual codes instead of CCs.[8] Therefore, this new approach has been applied to both measures in this report.

2.3. Objectives

We had two main objectives: 1) To assess the impact of incorporating MA inpatient admissions into the claims-based stroke mortality and THA/TKA complication measure, and 2) To improve the performance of risk adjustment models for these measures by leveraging the individual ICD-10 codes rather than CCs.

3. METHODS

3.1. Data Sources

For testing of these measure updates, we extracted all claims and beneficiary data for FFS and MA beneficiaries as well as Medicare provider data from the CMS IDR. The condition- and procedure-specific mortality/complication measures use inpatient claims and enrollment data for cohort construction and outcome derivation and use inpatient and outpatient facility, professional, and durable medical equipment (DME) claims data for risk adjustment. We downloaded claims data for index admissions with the claim discharge date from January 1 to December 30, 2022 (calendar year [CY] 2022) as well as historical claims up to 12 months prior to the index admission based on the claim types in Table 3.1. We also downloaded beneficiary information such as birth date, date of death, and enrollment information needed for cohort inclusion and exclusion criteria. We downloaded provider history data that details the association between the CMS Certification Number (CCN) and National Provider Identifier (NPI).

Most MA beneficiary inpatient admissions had two claim submission sources: MAO-submitted encounter claims and hospital-submitted claims. MAO-submitted encounter claims are information-only (i.e., not billing) claims for items and services provided under the plan that are required to be submitted by MAOs to CMS.[1] Hospitals that receive disproportionate-share hospital or medical education payments from Medicare are also required to submit information-only claims for inpatient stays for MA beneficiaries.

To create the combined FFS+MA cohort, we included both MAO-submitted and hospital-submitted MA admission claims. While most hospitals submit MA inpatient claims, not all hospitals are required to submit claims for MA beneficiaries (i.e., those that do not receive disproportionate-share hospital or medical education payments from Medicare), so MAO-submitted claims capture additional admissions not found in the hospital-submitted claims. However, there are benefits in including the hospital-submitted claims. Hospital-submitted claims are timelier than MAO-submitted claims, which is advantageous for reporting deadlines for CMS hospital outcome measures. In addition, a small proportion of admissions were only found in the hospital-submitted claims. Further, unlike MAO-submitted claims which are associated with NPI, hospital-submitted claims are already associated with a CCN used to identify hospitals in the CMS outcome measures. Therefore, if an admission was found in both datasets, we used the claim found in the hospital-submitted data. For a small portion of admissions with only MAO-submitted claims, we obtained the CCN using the IDR provider history data through NPI, claim discharge date, provider history begin (effective) date, and provider history end (obsolete) date. Admissions with only MAO-submitted claims not associated with a CCN were excluded from analyses (<5% of all admissions).

Hospital measures used for public reporting are limited to short-term acute care hospitals and critical access hospitals. In a last step, we used the CCN taxonomy to restrict the claims to those filed by acute care hospitals (3rd and 4th digit as '01') and critical access hospitals (3rd and 4th digit as '13').

Table 3.1: Claim Type Codes

Type of Claim	FFS	Hospital-submitted MA	MAO-submitted (encounter) MA
Inpatient	60	62, 63, 64	4011, 4041
Outpatient Facility	40	-	4012 – 4014, 4022, 4023, 4034, 4043, 4071 – 4077, 4079, 4083, 4085, 4089
Professional	71, 72	-	4700
DME	81, 82	-	4800

3.2. Cohort and Outcomes

The cohorts included hospital admissions with discharge dates from January 1 to December 30, 2022 (CY 2022). The risk adjustment data were derived from both FFS and MA inpatient and outpatient claims one year prior to and during the index claims. We followed the methodology for the current FFS-only mortality/complication measures for cohort inclusion/exclusion criteria, risk factor derivations from inpatient, outpatient, DME, and professional claims diagnoses/procedures during the 12 months prior to admission or present on admission (POA) at the index hospitalization, outcome definitions, and measure score calculation. After adding the MA beneficiaries, the enrollment requirement was updated to include patients with 12 months FFS or MA enrollment prior to the index admission. Information on the FFS-only measures, including measure specifications and calculation methodology, is available on *QualityNet* at:

- 2023 Condition-Specific Mortality Measure Updates and Specifications Report: https://qualitynet.cms.gov/inpatient/measures > Mortality Measures > Methodology
- 2023 Procedure-Specific Complication Measure Updates and Specifications Report: https://qualitynet.cms.gov/inpatient/measures > Complication Measure > Methodology

3.3. Risk Model Reselection

For candidate risk variables, we included all secondary ICD-10 codes documented as POA during the index admission (with the exception of the palliative care code of Z51.5 which effective October 1, 2021, was considered POA-exempt) and both principal and secondary ICD-10 codes in the 12 months prior to admission from any inpatient, outpatient, professional, and DME provider claims. For procedure-specific measures, we additionally considered the principal discharge diagnosis code for the index admission. We also considered age, frailty, sex, an indicator for whether the admission was MA vs. FFS, and other non-individual-ICD variables in the existing publicly reported CMS mortality measures. The variable selection of individual ICD codes mainly relied on data-driven methodologies involving three key steps: 1) pre-processing, 2) evaluating association with outcome, and 3) consideration of associations between other non-individual-code variables, including frailty, with the outcome.

In pre-processing, we screened and included index and history (pre-index) codes if their prevalence exceeded 0.5% and 2.5%, respectively. Further, pairs of index and pre-index codes that had a correlation larger than 0.8 were combined into one risk variable. Specific ICD-10 codes for social risk factors were removed from the candidate list to be consistent with how the measures currently address social risk. For the stroke mortality measure, we additionally excluded ICD-10 codes that begin with R297 since they are components of the National Institutes of Health Stroke Scale (NIHSS) variable included in the

risk adjustment model for the measure as a numeric variable in a later stage. Finally, pairs of index and pre-index ICD-10 codes where the difference in association with the outcome, measured by Odds Ratio (OR), was less than 0.2 were merged.

In the second step, we included the remaining candidate variables with age in a multivariable logistic regression model and underwent variable selection through 1,000 iterations of bootstrapping. We selected variables which were statistically significantly associated with outcome ($p<0.05$) greater than a certain cutoff value of frequency over the bootstrapped samples. The cutoff value was chosen for each measure based on empirical evaluation of the model performance. We forced age into the model if it was not selected into the model through the bootstrapping process.

Lastly, based on literature evidence, specific suggestions and guidance from the consensus-based entity for measure endorsement, the Assistant Secretary for Planning and Evaluation, other stakeholders, as well as prior testing results, we included a claims-based indicator of frailty that was developed for CMS' Multiple Chronic Conditions measure[9] in the final model for all measures. We generally did not include sex as a variable since sex can be considered a socio-demographic variable. There were other non-individual-ICD variables currently included in the publicly reported CMS mortality/complication measures that may contain additional predictive information. Such variables were included in the final models if their regression coefficients were statistically significant when added to the models. We also added into the model for all measures the history of coronavirus disease 2019 (COVID-19) variable to be consistent with current CMS policy. For the stroke mortality measure only, we added into the model the NIHSS score variable derived from ICD-10 codes R29701–R29742 corresponding to NIHSS score 1–42. For patients with no R297 codes, we imputed the NIHSS score as 0.[10]

For the combined MA and FFS cohort, the risk adjustment model was updated to include an MA indicator (versus FFS) as a main effect. This was to adjust for the generally higher prevalence of comorbidities in the MA cohort, especially among the pre-index variables that were derived from services in the outpatient setting (e.g., physician visits). For the stroke mortality measure, the NIHSS variable was also included in the final model as specified in the current measure.

3.4. Statistical Analyses

We first compared between MA and FFS admissions the number of admissions and observed (unadjusted) mortality rates for stroke and observed complication rates for THA/TKA. We then examined risk variable prevalence in MA and FFS admissions for both the CC-based (original) and ICD-10-based (reselected) risk variables. For MA+FFS admissions with reselected ICD-10-based variables, we calculated the adjusted OR and 95% confidence intervals (CIs) for the hierarchical logistic regression model.

To evaluate the impact of adding MA admissions and risk variable reselection on model performance metrics, we compared c-statistics and predictive ability for three different combinations of cohorts and risk models: 1) FFS-only admissions with the original CC-based risk model, 2) FFS+MA admissions with the original CC-based risk model, and 3) FFS+MA admissions with reselected ICD-10-based variables. Calibration performance was also assessed by calibration slope and intercept and visually by calibration plots, both in the overall cohort and in subgroups stratified by sex, MA indicator, and hospital volume.

We used hierarchical logistic models with a random effect for hospitals to calculate hospital risk-standardized mortality ratios and rates (SMRs and RSMRs) for stroke, and RSCRs following THA/TKA

admissions and compared these and the number of hospitals using the three different combinations of cohort and risk model variables listed above. We show the distribution of measure scores among all hospitals and among reporting hospitals with at least 25 admissions. We also calculated and compared signal-to-noise reliability (STNR) for hospitals with at least 25 admissions based on between hospital variance and hospital volume. The volume threshold of 25 admissions used here was to align with the public reporting volume cutoff.

To assess the overall impact of adding MA data to hospital measure scores, using original CC-based risk variables we examined shifts in hospital RSMR/RSCR quintiles in the FFS-only cohort versus the combined FFS+MA cohort among hospitals with at least 25 FFS admissions. To examine the associations between hospital characteristics and the addition of MA admissions, we examined quintile shifts in hospital RSMR/RSCR by quintiles of the proportion of hospital MA admissions and by quintiles of overall hospital volume. We then repeated these analyses to assess the impact of adding both MA and updated risk model variables, examining hospital performance shifts in the FFS-only cohort with the original CC-based variables and the FFS+MA cohort with the reselected ICD-10-based variables.

4. RESULTS

4.1. Stroke Mortality Results

Stroke Admission Volume and Observed Mortality Rate

As presented in Table 4.1.1, the FFS+MA cohort included 280,536 unique admissions from January 1 – December 30, 2022 (140,035 FFS and 140,501 MA)). The observed (unadjusted) 30-day mortality rate for the FFS+MA cohort for Stroke was 12.9%. The observed mortality rate was 13.5% among FFS beneficiaries compared to 12.2% among MA beneficiaries (difference 1.3%).

Table 4.2.1: Number of Admissions and Observed 30-Day Mortality Rate for Stroke, FFS versus MA Admissions, CY 2022

Stroke	MA + FFS	FFS	MA	Difference FFS – MA
N	280,536	140,035	140,501	NA
Mortality Rate (%)	12.9	13.5	12.2	1.3

Frequency of Stroke Risk Variables

We examined the frequencies of variables used for risk adjustment in FFS and MA admissions. The variables from the original CC-based risk model are presented in Table 4.1.2, and the reselected ICD-10-based variables in Table 4.1.3. Frequencies of model variables were generally higher in MA than FFS admissions for both the CC- and ICD-10-based variables. The median difference in risk variable prevalence between FFS and MA (%FFS – %MA) was -0.9% for CC-based variables with a range from -7.7% to 2.6%. The risk variable prevalence differences between FFS and MA for ICD-10-based variables ranged from -8.3% to 3.1% with no difference at the median, however for ICD-10 codes in the 12 months prior to admission (pre-index codes), the differences were more pronounced. Table 4.1.3 also presents adjusted OR and 95% CIs for the hierarchical logistic regression model using FFS+MA admissions.

Table 4.3.2: Frequency of CC-Based Risk Variables in the Stroke Cohort, FFS versus MA Admissions, CY 2022

Variable (% unless otherwise indicated)	MA + FFS (N= 280,536)	FFS (N= 140,035)	MA (N= 140,501)	FFS - MA
Age, mean (SD)	78.7 (8.2)	79.5 (8.3)	78.0 (8.0)	1.5
NIH stroke scale/score, mean (SD)	4.3 (6.7)	4.3 (6.7)	4.3 (6.6)	0.1
Transfer from another Emergency Department (ED)	11.0	12.0	10.0	2.0
Metastatic cancer and acute leukemia and other major cancers (CC 8, 9)	5.6	5.8	5.4	0.4
Protein-calorie malnutrition (CC 21)	9.1	8.9	9.3	-0.4
Other significant endocrine and metabolic disorders (CC 22 – 26)	93.2	92.2	94.3	-2.1
Other gastrointestinal disorders (CC 38)	55.0	53.1	56.9	-3.8
Disorders of the vertebrae and spinal discs (CC 41)	25.0	24.0	26.0	-2.0
Osteoarthritis of hip or knee (CC 42)	15.4	15.0	15.7	-0.7
Other musculoskeletal and connective tissue disorders (CC 45)	66.5	64.9	68.0	-3.2
Iron deficiency and other/unspecified anemia and blood disease (CC 49)	38.5	38.0	39.1	-1.1
Dementia or senility (CC 51 – 53)	35.1	32.7	37.4	-4.7
Multiple sclerosis (CC 77, 81)	22.7	21.4	23.9	-2.5
Seizure disorders and convulsions (CC 79)	8.0	7.6	8.5	-0.9
Congestive heart failure (CC 85)	34.0	32.3	35.6	-3.4
Congenital cardiac/circulatory defects (CC 92,93)	3.0	2.9	3.0	-0.1
Specified heart arrhythmias (CC 96)	39.6	40.9	38.3	2.6
Cerebral atherosclerosis and aneurysm (CC 102)	28.7	24.8	32.5	-7.7
Pneumonia (CC 114 – 116)	15.3	14.8	15.8	-0.9
Renal failure (CC 135 – 140)	42.6	39.5	45.7	-6.2
History of COVID-19	13.5	13.7	13.3	0.4

Table 4.4.3: Frequency of ICD-10-Based Risk Variables in the Stroke Cohort, FFS versus MA Admissions, and Adjusted OR and 95% Confidence Intervals for the Stroke Hierarchical Logistic Regression Model Using FFS+MA Admissions, CY 2022

Variable	Description	MA + FFS (%) (N= 280,536)	FFS (%) (N= 140,035)	MA (%) (N= 140,501)	FFS – MA (%)	FFS + MA OR (95% CI)
AGE	Age, mean (SD)	78.7 (8.2)	79.5 (8.3)	78.0 (8.0)	1.5	1.04 (1.04, 1.04)
ICD-10 codes during the index admission						
A419	Sepsis, unspecified organism	1.0	1.0	1.0	0.0	1.70 (1.52, 1.89)
C1	End stage renal disease or Dependence on renal dialysis	1.7	1.7	1.6	0.1	1.70 (1.53, 1.90)
C787	Secondary malignant neoplasm of liver and intrahepatic bile duct	0.7	0.7	0.6	0.1	5.96 (5.25, 6.76)
C7951	Secondary malignant neoplasm of bone	0.7	0.8	0.7	0.1	2.23 (1.95, 2.54)
D631	Anemia in chronic kidney disease	3.1	3.1	3.1	-0.1	0.84 (0.77, 0.92)
E041	Nontoxic single thyroid nodule	1.3	1.2	1.3	-0.1	0.56 (0.47, 0.67)
E538	Deficiency of other specified B group vitamins	2.1	2.1	2.1	0.0	0.70 (0.62, 0.79)
E785	Hyperlipidemia, unspecified	55.7	55.2	56.3	-1.2	0.86 (0.83, 0.88)
E870	Hyperosmolality and hypernatremia	1.7	1.6	1.7	-0.1	1.59 (1.46, 1.73)
E872	Acidosis	2.9	2.8	2.9	-0.1	1.47 (1.37, 1.58)
G43909	Migraine, unspecified, not intractable, without status migrainosus	1.2	1.2	1.2	0.0	0.55 (0.44, 0.68)
G8101	Flaccid hemiplegia affecting right dominant side	0.8	0.8	0.8	0.0	1.96 (1.73, 2.22)
G8104	Flaccid hemiplegia affecting left nondominant side	0.8	0.7	0.8	-0.1	1.76 (1.53, 2.01)
G8191	Hemiplegia, unspecified affecting right dominant side	18.8	18.5	19.1	-0.6	1.24 (1.18, 1.29)
G9340	Encephalopathy, unspecified	3.9	3.8	3.9	-0.1	1.50 (1.40, 1.59)
G9341	Metabolic encephalopathy	6.9	7.0	6.8	0.2	1.36 (1.29, 1.43)
G9349	Other encephalopathy	3.5	3.5	3.6	-0.1	1.43 (1.34, 1.53)
G935	Compression of brain	1.2	1.1	1.2	-0.1	2.02 (1.81, 2.26)
G936	Cerebral edema	4.4	6.4	4.4	0.0	1.80 (1.69, 1.91)
H518	Other specified disorders of binocular movement	0.8	0.8	0.9	-0.1	1.17 (1.03, 1.34)
I10	Essential (primary) hypertension	54.3	54.4	54.1	0.3	0.84 (0.82, 0.87)
I214	Non-ST elevation (NSTEMI) myocardial infarction	1.4	1.4	1.5	-0.1	1.94 (1.76, 2.13)
I21A1	Myocardial infarction type 2	2.3	2.3	2.3	0.0	1.30 (1.20, 1.41)
I2699	Other pulmonary embolism without acute cor pulmonale	0.7	0.7	0.7	0.0	1.61 (1.40, 1.86)
I440	Atrioventricular block, first degree	1.9	2.0	1.9	0.1	0.72 (0.64, 0.82)

Variable	Description	MA + FFS (%) (N= 280,536)	FFS (%) (N= 140,035)	MA (%) (N= 140,501)	FFS – MA (%)	FFS + MA OR (95% CI)
I480	Paroxysmal atrial fibrillation	12.1	13.0	11.3	1.7	0.87 (0.83, 0.91)
I4821	Permanent atrial fibrillation	1.6	1.7	1.4	0.3	0.84 (0.75, 0.93)
I4892	Unspecified atrial flutter	2.3	2.4	2.2	0.2	0.83 (0.75, 0.91)
I5022	Chronic systolic (congestive) heart failure	4.1	4.0	4.2	-0.2	0.98 (0.91, 1.05)
I5032	Chronic diastolic (congestive) heart failure	6.1	6.3	5.9	0.4	0.89 (0.84, 0.95)
I609	Nontraumatic subarachnoid hemorrhage, unspecified	0.5	0.5	0.5	0.0	1.86 (1.59, 2.17)
I671	Cerebral aneurysm, nonruptured	1.8	1.8	1.9	-0.2	0.82 (0.72, 0.92)
I951	Orthostatic hypotension	1.1	1.1	1.0	0.1	0.71 (0.60, 0.85)
J189	Pneumonia, unspecified organism	1.9	1.9	1.8	0.1	1.56 (1.43, 1.70)
J690	Pneumonitis due to inhalation of food and vomit	2.3	2.4	2.2	0.2	1.76 (1.63, 1.89)
J90	Pleural effusion, not elsewhere classified	1.0	1.1	0.9	0.2	1.40 (1.25, 1.56)
J9600	Acute respiratory failure, unspecified whether with hypoxia or hypercapnia	0.7	0.7	0.8	-0.1	3.44 (3.04, 3.89)
J9601	Acute respiratory failure with hypoxia	3.9	3.8	4.0	-0.2	2.35 (2.21, 2.49)
K7460	Unspecified cirrhosis of liver	0.6	0.5	0.6	0.0	1.62 (1.37, 1.92)
N170	Acute kidney failure with tubular necrosis	0.7	0.6	0.7	-0.1	1.79 (1.56, 2.06)
Q211	Atrial septal defect	2.0	2.0	2.0	0.0	0.72 (0.64, 0.83)
R1310	Dysphagia, unspecified	10.0	10.1	9.9	0.2	1.23 (1.18, 1.29)
R260	Ataxic gait	0.8	0.9	0.8	0.1	0.53 (0.40, 0.70)
R2681	Unsteadiness on feet	1.2	1.2	1.1	0.1	0.70 (0.57, 0.86)
R2689	Other abnormalities of gait and mobility	1.2	1.2	1.2	0.1	0.69 (0.57, 0.83)
R270	Ataxia, unspecified	3.8	3.7	3.9	-0.2	0.70 (0.62, 0.78)
R413	Other amnesia	0.5	0.5	0.5	0.1	0.49 (0.36, 0.67)
R4189	Other symptoms and signs involving cognitive functions and awareness	0.8	0.8	0.8	0.1	0.64 (0.53, 0.77)
R42	Dizziness and giddiness	1.7	1.7	1.7	0.0	0.57 (0.47, 0.69)
R4701	Aphasia	25.2	25.6	24.9	0.8	1.07 (1.03, 1.12)
R627	Adult failure to thrive	1.3	1.3	1.3	0.0	1.44 (1.31, 1.59)
R64	Cachexia	1.0	1.0	1.0	0.1	1.51 (1.35, 1.69)
R7303	Prediabetes	3.1	2.9	3.3	-0.4	0.62 (0.56, 0.70)
R778	Other specified abnormalities of plasma proteins	2.3	2.3	2.2	0.1	1.24 (1.13, 1.36)
R911	Solitary pulmonary nodule	1.0	1.0	1.0	0.0	0.74 (0.63, 0.89)

Variable	Description	MA + FFS (%) (N= 280,536)	FFS (%) (N= 140,035)	MA (%) (N= 140,501)	FFS – MA (%)	FFS + MA OR (95% CI)
Z20822	Contact with and (suspected) exposure to COVID-19	50.9	51.3	50.6	0.7	0.75 (0.73, 0.78)
Z515	Encounter for palliative care	9.4	10.1	8.8	1.3	21.75 (20.94, 22.59)
Z66	Do not resuscitate	15.8	147.4	14.3	3.1	1.89 (1.82, 1.96)
Z7401	Bed confinement status	1.1	1.1	1.1	0.0	1.25 (1.12, 1.39)
Z751	Person awaiting admission to adequate facility elsewhere	0.5	0.4	0.7	-0.3	0.33 (0.25, 0.44)
Z7901	Long term (current) use of anticoagulants	16.2	17.0	15.5	1.5	0.93 (0.89, 0.97)
Z7902	Long term (current) use of antithrombotics/antiplatelets	13.0	12.7	13.4	-0.7	0.83 (0.78, 0.87)
Z7982	Long term (current) use of aspirin	33.9	33.9	33.9	0.0	0.75 (0.73, 0.78)
Z7984	Long term (current) use of oral hypoglycemic drugs	13.3	12.0	14.6	-2.6	0.86 (0.81, 0.91)
Z79890	Hormone replacement therapy	6.3	6.8	5.7	1.1	0.81 (0.76, 0.88)
Z79899	Other long term (current) drug therapy	29.2	29.9	28.5	1.4	0.85 (0.81, 0.88)
Z8673	Personal history of transient ischemic attack (TIA), and cerebral infarction without residual deficits	16.6	16.6	16.6	0.0	0.89 (0.85, 0.93)
Z87891	Personal history of nicotine dependence	22.4	23.1	21.8	1.3	0.93 (0.90, 0.97)
ICD-10 codes in the 12 months prior to admission						
G459	Transient cerebral ischemic attack, unspecified	16.0	15.5	16.4	-0.9	0.78 (0.75, 0.82)
I63511	Cerebral infarction due to unspecified occlusion or stenosis of right middle cerebral artery	6.6	6.2	7.0	-0.8	1.23 (1.16, 1.30)
I63512	Cerebral infarction due to unspecified occlusion or stenosis of left middle cerebral artery	7.4	7.0	7.8	-0.8	1.26 (1.20, 1.33)
I6381	Other cerebral infarction due to occlusion or stenosis of small artery	6.3	5.7	6.8	-1.1	0.78 (0.72, 0.84)
I6521	Occlusion and stenosis of right carotid artery	6.2	5.5	6.8	-1.2	1.13 (1.07, 1.21)
J90	Pleural effusion, not elsewhere classified	8.2	7.8	8.7	-0.8	1.26 (1.20, 1.32)
M1711	Unilateral primary osteoarthritis, right knee	4.7	4.7	4.7	-0.1	0.81 (0.75, 0.88)
R202	Paresthesia of skin	4.8	3.6	6.0	-2.4	0.85 (0.77, 0.94)
R29818	Other symptoms and signs involving the nervous system	23.1	21.4	24.7	-3.2	0.88 (0.85, 0.92)
R4182	Altered mental status, unspecified	24.9	23.6	26.2	-2.5	1.21 (1.17, 1.25)
R4701	Aphasia	10.4	8.9	11.9	-3.1	0.87 (0.83, 0.92)
R634	Abnormal weight loss	3.8	3.3	4.3	-1.0	1.30 (1.22, 1.40)
R778	Other specified abnormalities of plasma proteins	5.3	3.7	6.9	-3.1	1.26 (1.19, 1.34)

Variable	Description	MA + FFS (%) (N= 280,536)	FFS (%) (N= 140,035)	MA (%) (N= 140,501)	FFS – MA (%)	FFS + MA OR (95% CI)
Z1231	Encounter for screening mammogram for malignant neoplasm of breast	11.9	11.5	12.2	-0.7	0.75 (0.71, 0.79)
Z4682	Encounter for fitting and adjustment of non-vascular catheter	3.7	3.4	3.9	-0.5	1.33 (1.24, 1.42)
Z66	Do not resuscitate	6.4	7.1	5.8	1.4	1.16 (1.10, 1.23)
ICD-10 codes either during the index admission or 12 months prior to admission						
D696	Thrombocytopenia, unspecified	6.0	5.9	6.2	-0.3	1.30 (1.22, 1.40)
D72829	Elevated white blood cell count, unspecified	8.4	7.8	9.1	-1.3	1.26 (1.19, 1.34)
E119	Type 2 diabetes mellitus without complications	36.1	32.0	40.3	-8.3	0.75 (0.71, 0.79)
F0390	Unspecified dementia without behavioral disturbance	14.6	14.5	14.8	-0.3	1.33 (1.24, 1.42)
G8194	Hemiplegia, unspecified affecting left nondominant side	21.8	21.3	22.3	-1.0	1.16 (1.10, 1.23)
I4891	Unspecified atrial fibrillation	26.9	26.9	26.9	0.1	1.30 (1.22, 1.40)
R000	Tachycardia, unspecified	6.6	6.0	7.1	-1.1	1.14 (1.08, 1.21)
R200	Anesthesia of skin	7.4	6.1	8.7	-2.6	0.69 (0.63, 0.75)
R471	Dysarthria and anarthria	21.5	20.5	22.6	-2.1	0.89 (0.85, 0.92)
R4781	Slurred speech	17.9	16.8	18.9	-2.0	0.89 (0.85, 0.93)
Other risk variables						
MCCFI	Multiple Chronic Conditions Frailty Index	26.0	25.5	26.5	-1.0	1.28 (1.23, 1.32)
NIHSS	NIHSS mean (SD)	4.3 (6.7)	4.3 (6.6)	4.3 (6.7)	0.3	1.04 (1.04, 1.04)
HX_COVID	History of COVID-19	13.5	13.7	13.3	0.4	0.89 (0.85, 0.93)
MA	MA (versus FFS)	50.1	NA	NA	NA	0.95 (0.92, 0.98)

Stroke Model Performance

Table 4.1.4 presents model performance for the Stroke measure across three scenarios: the FFS-only cohort with CC-based risk variables, the FFS+MA cohort with CC-based risk variables, and the FFS+MA cohort with ICD-10-based risk variables. Predictive ability and c-statistics were similar between the FFS-only and FFS+MA cohorts using the original CC-based variables. For the MA+FFS cohort, the model using reselected ICD-10-based risk variables had a higher c-statistic compared to the original CC-based model and wider predictive ability. Calibration performance was generally acceptable across all modeling approaches in the overall cohort and in subgroups, including male versus female, MA versus FFS, and quartiles of hospital volume (figures not shown).

Table 4.5.4: Stroke Mortality: Predictive Ability and C-Statistics Comparing FFS-only and FFS+MA Cohorts with CC-Based and ICD-10-Based Risk Variables, CY 2022

Value	FFS-only cohort with CC-based risk variables	FFS+MA cohort with CC-based risk variables	FFS+MA cohort with ICD-10-based risk variables
Predictive Ability, % (lowest decile – highest decile)	1.8 – 47.8	1.7 – 45.8	0.5 – 75.2
c-statistic	0.79	0.79	0.91

Note: These statistics were calculated using the patient-level logistic model.

Risk-Standardized Mortality Rates for Stroke

Tables 4.1.5 and 4.1.6 present distribution of hospital volume, SMR, and RSMR for all hospitals (Table 4.1.5) and for hospitals with 25 or more eligible admissions (Table 4.1.6). Numbers of hospitals and admissions were higher in the combined FFS+MA data compared to the FFS-only data. With the addition of MA data, 147 additional hospitals were included in the measure (3,830 versus 3,683) and 491 additional hospitals met the 25 or more admissions cutoff for public reporting (2,033 versus 1,542). For all hospitals, the mean RSMR was 13.6% for the FFS-only cohort with CC-based risk variables, 12.9% for the FFS+MA cohort with CC-based risk variables, and 13.2% for the FFS+MA cohort with reselected ICD-10-based risk variables. Among hospitals with 25 or more admissions, mean RSMRs were 13.5%, 12.8%, and 13.0%, respectively.

Table 4.6.5: Stroke Mortality: Hospital Volume, Standardized Mortality Ratio (SMR), and Risk-Standardized Mortality Rate (RSMR) Comparing FFS-only and FFS+MA Cohorts with CC-Based and ICD-10-Based Risk Variables, CY 2022, for All Hospitals

Value	FFS-Only cohort with CC-based risk variables (N= 3,683 hospitals)		FFS+MA cohort with CC-based risk variables (N= 3,830 hospitals)		FFS+MA cohort with ICD-10-based risk variables (N= 3,830 hospitals)	
	Mean (SD)	Median (25% Q1, 75% Q3)	Mean (SD)	Median (25% Q1, 75% Q3)	Mean (SD)	Median (25% Q1, 75% Q3)
Hospital Volume	38.0 (52.6)	16 (4, 51)	73.2 (102.2)	30 (6, 101)	73.25 (102.2)	30 (6, 101)
SMR	1.00 (0.08)	1.00 (0.96, 1.05)	1.01 (0.10)	1.00 (0.96, 1.06)	1.03 (0.16)	0.99 (0.94, 1.09)
RSMR (%)	13.6 (1.1)	13.5 (13.1, 14.1)	12.9 (1.3)	12.8 (12.3, 13.6)	13.2 (2.1)	12.8 (12.1, 14.1)

Table 4.7.6: Stroke Mortality: Hospital Volume, Standardized Mortality Ratio (SMR), and Risk-Standardized Mortality Rate (RSMR) Comparing FFS-only and FFS+MA Cohorts with CC-Based and ICD-10-Based Risk Variables, CY 2022, for Hospitals with 25 or More Admissions

Value	FFS-Only cohort with CC-based risk variables (N= 1,542 hospitals)		FFS+MA cohort with CC-based risk variables (N= 2,033 hospitals)		FFS+MA cohort with ICD-10-based risk variables (N= 2,033 hospitals)	
	Mean (SD)	Median (25% Q1, 75% Q3)	Mean (SD)	Median (25% Q1, 75% Q3)	Mean (SD)	Median (25% Q1, 75% Q3)
Hospital Volume	80.6 (58.4)	61 (39, 105)	131.3 (111.5)	95 (54, 174)	131.3 (111.5)	95 (54, 174)
SMR	1.00 (0.11)	0.99 (0.92, 1.06)	1.00 (0.13)	0.99 (0.91, 1.07)	1.01 (0.18)	0.98 (0.90, 1.08)
RSMR (%)	13.5 (1.4)	13.4 (12.5, 14.3)	12.8 (1.6)	12.7 (11.7, 13.7)	13.0 (2.3)	12.6 (11.5, 13.9)

Measure Reliability for Stroke

Between hospital variance and STNR for the measure score comparing the addition of MA admissions to the FFS-only cohort and reselected ICD-10-based variables to the CC-based variables in the FFS+MA cohort are noted in Table 4.1.7. Median STNR, calculated based on between hospital variance and hospital volume, was 0.570 for the FFS-only cohort with CC-based risk variables, 0.684 for the FFS+MA cohort with CC-based risk variables, and 0.852 for the FFS+MA cohort with reselected ICD-10-based risk variables.

Table 4.8.7: Stroke Mortality: Between Hospital Variance and Signal-to-Noise Reliability (STNR) Comparing FFS-only and FFS+MA Cohorts with CC-Based and ICD-10-Based Risk Variables, CY 2022, for Hospitals with 25 or More Admissions

Value	FFS-only cohort with CC-based risk variables	FFS+MA cohort with CC-based risk variables	FFS+MA cohort with ICD-10-based risk variables
Number of Hospitals	1,542	2,033	2,033
Between Hospital Variance	0.071	0.075	0.199
STNR: Median (Q1, Q3)	0.570 (0.458, 0.695)	0.684 (0.552, 0.799)	0.852 (0.766, 0.913)

Change in Hospital Performance for Stroke

Table 4.1.8 shows the quintile shifts in RSMR across hospitals with at least 25 FFS admissions for the Stroke measure in the combined FFS+MA cohort as compared to the FFS-only cohort in hospitals for the model with the original CC-based variables. After adding MA admissions to the FFS-only cohort, about half (49.6%) of hospitals remained in the same performance quintile, and 88.5% remained within +/- 1 quintile. Correlation between hospital RSMRs was 0.82. As hospitals' proportion of MA admissions increased, fewer hospitals remained in the same performance quintile (58.1% among hospitals in the lowest quintile of percent MA admissions; 41.6% of hospitals in the highest quintile of percent of MA admissions). As hospital volume increased, there was not a notable trend in RSMR shifts.

Table 4.1.9 shows the quintile shifts in RSMR across hospitals with at least 25 FFS admissions for the Stroke measure after both measure updates, comparing the combined FFS+MA cohort using the reselected ICD-10-based risk variables to the FFS-only cohort using the CC-based variables. With the addition of the MA admissions and the ICD-10-based risk variables, 34.4% of hospitals remained in the same performance quintile and 71.7% remained within +/- 1 quintile. Correlation between hospital RSMRs was 0.52. There was not a notable trend by proportion of MA admissions or admission volume.

Table 4.9.8: Shifts in RSMR Hospital Performance Quintile Rankings for Stroke, Overall and Based on Hospitals' Percentages of MA Admissions and Total Admission Volume, Comparing FFS-Only Cohort to the FFS+MA Cohort, CC-Based Variables, CY 2022

Description	Same quintile (%)	±1 quintile (%)	Correlation
Overall	49.6	88.5	0.82
By Percent of MA Admissions			
Q1: 0.0% – 34.2%	58.1	97.1	0.92
Q2: 34.2% – 43.6%	52.8	90.0	0.87
Q3: 43.7% – 51.0%	49.7	89.3	0.83
Q4: 51.1% – 58.9%	46.0	87.4	0.79
Q5: 58.9% – 89.0%	41.6	78.9	0.68
By MA+FFS Admission Volume			
Q1: 28 – 69 admissions	52.8	93.1	0.87
Q2: 70 – 101 admissions	47.9	89.9	0.80
Q3: 102 – 147 admissions	48.3	87.1	0.77
Q4: 148 – 231 admissions	45.2	84.8	0.80
Q5: 232 – 1,118 admissions	53.9	87.7	0.86

Note: Quintile percentages represent the percent of hospitals that stayed in their same (1st column) or within one (2nd column) performance quintile ranking after the addition of MA admissions.
Total N=1,542, representing hospitals with 25 or more FFS admissions

Table 4.10.9: Shifts in RSMR Hospital Performance Quintile Rankings for Stroke, Overall and Based on Hospitals' Percentages of MA Admissions and Total Admission Volume, Comparing FFS-only Cohort with CC-Based Variables to the FFS+MA Cohort with Reselected ICD-10-Based Risk Variables, CY 2022

Description	Same quintile (%)	±1 quintile (%)	Correlation
Overall	34.4	71.7	0.52
By Percent of MA Admissions			
Q1: 0.0% – 34.2%	34.7	76.9	0.56
Q2: 34.2% – 43.6%	37.9	71.5	0.56
Q3: 43.7% – 51.0%	37.7	70.1	0.50
Q4: 51.1% – 58.9%	34.6	71.2	0.50
Q5: 58.9% – 89.0%	27.3	68.5	0.46
By MA+FFS Admission Volume			
Q1: 28 – 69 admissions	38.4	79.0	0.58
Q2: 70 – 101 admissions	31.5	72.2	0.53
Q3: 102 – 147 admissions	31.8	69.2	0.48
Q4: 148 – 231 admissions	31.3	68.7	0.48
Q5: 232 – 1,118 admissions	39.3	69.2	0.57

Note: Quintile percentages represent the percent of hospitals that stayed in their same (1st column) or within one (2nd column) performance quintile ranking after the addition of MA admissions and with reselected ICD-10-based risk variables.
Total N=1,542, representing hospitals with 25 or more FFS admissions

4.2. Elective Primary Total Hip Arthroplasty (THA) and/or Total Knee Arthroplasty (TKA) Complication Results

THA/TKA Admission Volume and Observed Complication Rate

As presented in Table 4.2.1, the FFS+MA cohort included 147,065 unique admissions from January 1 – December 30, 2022 (93,365 FFS and 53,700 MA). The observed (unadjusted) complication rate for the FFS+MA cohort for THA/TKA was 3.4%. The observed complication rate was 3.2% among FFS beneficiaries compared to 3.7% among MA beneficiaries (difference -0.5%).

Table 4.2.1: Number of Admissions and Observed Complication Rate for THA/TKA, FFS versus MA admissions, CY 2022

THA/TKA	MA + FFS	FFS	MA	Difference FFS - MA
N	147,065	93,365	53,700	NA
Complication Rate (%)	3.4	3.2	3.7	-0.5

Frequency of THA/TKA Risk Variables

We examined the frequencies of variables used for risk adjustment in FFS and MA admissions. The variables from the original CC-based risk model are presented in Table 4.2.2, and the reselected ICD-10-based variables in Table 4.2.3. Frequencies of model variables were generally higher in MA than FFS admissions for both the CC- and ICD-10-based variables. The median difference in risk variable prevalence between FFS and MA (%FFS – %MA) was -0.7% for CC-based variables with a range from -12.5% to 1.9%. There was less of a difference overall in risk variable prevalence between FFS and MA for ICD-10-based variables with a median difference of -0.2% (range from -5.6% to 2.9%), however, for ICD-10 codes in the 12 months prior to admission (pre-index codes), the differences were more pronounced. Table 4.2.3 also presents adjusted OR and 95% CIs for the hierarchical logistic regression model using FFS+MA admissions.

Table 4.2.2: Frequency of CC-Based Risk Variables in the THA/TKA Cohort, FFS versus MA Admissions, CY 2022

Variable (% unless otherwise indicated)	MA + FFS (N= 147,065)	FFS (N= 93,365)	MA (N= 53,700)	FFS - MA
Age, mean (SD)	74.8 (6.1)	75.0 (6.1)	74.6 (6.1)	0.4
Male	34.3	35.0	33.1	1.9
Elective THA procedure	37.0	36.9	37.2	-0.4
Number of procedures (two vs. one)	2.1	2.0	2.1	-0.1
Metastatic cancer or acute leukemia (CC 8)	1.0	1.0	1.0	0.0
Other major cancers (CC 9 – 12)	13.8	14.3	12.9	1.3
Respiratory/heart/digestive/urinary/other neoplasms (CC 13 – 15)	19.9	20.1	19.7	0.4
Diabetes mellitus (DM) or DM complications (CC 17 – 19, 122 – 123)	32.9	29.8	38.3	-8.5

Variable (% unless otherwise indicated)	MA + FFS (N= 147,065)	FFS (N= 93,365)	MA (N= 53,700)	FFS - MA
Protein-calorie malnutrition (CC 21)	1.4	1.2	1.7	-0.5
Bone/joint/muscle infections/necrosis (CC 39)	4.5	4.1	5.2	-1.1
Rheumatoid arthritis and inflammatory connective tissue disease (CC 40)	13.1	11.9	15.1	-3.2
Osteoarthritis of hip or knee (CC 42)	99.8	99.8	99.8	0.0
Osteoporosis and other bone/cartilage disorders (CC 43)	30.7	28.8	34.0	-5.2
Dementia or other specified brain disorders (CC 51 – 53)	7.1	6.3	8.6	-2.2
Major psychiatric disorders (CC 57 – 59)	12.7	9.1	18.9	-9.8
Hemiplegia, paraplegia, paralysis, functional disability (CC 70 – 74, 103 – 104, 189 – 190)	2.9	2.5	3.7	-1.2
Cardio-respiratory failure and shock (CC 84), plus ICD-10-CM codes R09.01 and R09.02	5.7	5.2	6.7	-1.6
Coronary atherosclerosis or angina (CC 88 – 89)	28.4	28.0	29.1	-1.0
Stroke (CC 99 – 100)	3.0	2.8	3.3	-0.6
Vascular or circulatory disease (CC 106 – 109)	34.4	29.8	42.3	-12.5
Chronic obstructive pulmonary disease (COPD) (CC 111)	14.5	12.5	17.9	-5.4
Pneumonia (CC 114 – 116)	4.4	4.1	4.8	-0.8
Pleural effusion/pneumothorax (CC 117)	2.1	1.9	2.4	-0.5
Dialysis status (CC 134)	0.4	0.4	0.5	-0.1
Renal failure (CC 135 – 140)	24.3	21.6	29.1	-7.5
Decubitus ulcer or chronic skin ulcer (CC 157 – 161)	3.1	3.1	3.2	-0.1
Trauma (CC 166 – 168, 170 – 173)	7.1	6.6	7.9	-1.3
Vertebral fractures without spinal cord injury (CC 169)	1.5	1.5	1.6	-0.1
Other injuries (CC 174)	27.2	26.9	27.9	-1.0
Major complications of medical care and trauma (CC 176 – 177)	6.4	6.3	6.6	-0.3
Morbid obesity (CC 22)	15.8	13.0	20.7	-7.7
Skeletal deformities (ICD-9 code 755.63, ICD – 10 code Q65.89, Q65.9 – CC 204)	2.6	1.0	5.4	-4.4
Post traumatic osteoarthritis (ICD-9 codes 716.15, 716.16, ICD-10 code M12.551, M12.552, M12.559 – CC 205)	1.7	1.6	1.9	-0.2
History of COVID-19	13.8	14.3	13.1	1.2

Table 4.2.3: Frequency of ICD-10-Based Risk Variables in the THA/TKA Cohort, FFS versus MA Admissions, and Adjusted OR and 95% Confidence Intervals for the THA/TKA Hierarchical Logistic Regression Model Using FFS+MA Admissions, CY 2022

Variable	Description	MA + FFS (%) (N= 147,065)	FFS (%) (N= 93,365)	MA (%) (N= 53,700)	FFS - MA (%)	FFS + MA OR (95% CI)
AGE	Age, mean (SD)	74.8 (6.1)	75.0 (6.1)	74.6 (6.1)	0.4	1.02 (1.02, 1.03)
ICD-10 codes during the index admission						
D631	Anemia in chronic kidney disease	1.1	1.0	1.3	-0.3	1.71 (1.42, 2.06)
D638	Anemia in other chronic diseases classified elsewhere	0.6	0.5	0.7	-0.1	1.91 (1.49, 2.46)
E7800	Pure hypercholesterolemia, unspecified	14.0	14.5	13.0	1.5	0.87 (0.79, 0.95)
E8342	Hypomagnesemia	0.6	0.6	0.7	-0.1	1.56 (1.20, 2.03)
F0390	Unspecified dementia without behavioral disturbance	1.1	1.1	1.1	-0.1	1.41 (1.14, 1.73)
I130	Hypertensive heart and chronic kidney disease with heart failure and stage 1 through stage 4 chronic kidney disease, or unspecified chronic kidney disease	2.4	2.3	2.8	-0.5	1.50 (1.31, 1.71)
I255	Ischemic cardiomyopathy	0.6	0.6	0.7	-0.1	1.61 (1.27, 2.05)
I2720	Pulmonary hypertension, unspecified	1.5	1.4	1.5	-0.1	1.59 (1.35, 1.88)
I428	Other cardiomyopathies	0.5	0.5	0.6	-0.1	1.19 (0.88, 1.61)
I4820	Chronic atrial fibrillation, unspecified	1.5	1.5	1.4	0.1	1.36 (1.14, 1.63)
I509	Heart failure, unspecified	2.1	2.1	2.3	-0.2	0.77 (0.64, 0.91)
J439	Emphysema, unspecified	0.9	0.8	1.1	-0.3	1.45 (1.17, 1.80)
N179	Acute kidney failure, unspecified	1.8	1.6	2.1	-0.5	1.58 (1.35, 1.83)
Z6842	Body mass index [BMI] 45.0-49.9, adult	1.4	1.3	1.5	-0.1	1.47 (1.20, 1.81)
Z803	Family history of malignant neoplasm of breast	0.8	0.8	0.7	0.1	0.42 (0.25, 0.69)
Z853	Personal history of malignant neoplasm of breast	4.9	5.2	4.2	1.0	0.84 (0.73, 0.97)
ICD-10 codes in the 12 months prior to admission						
E785	Hyperlipidemia, unspecified	48.9	43.9	57.5	-13.6	0.90 (0.85, 0.96)
F419	Anxiety disorder, unspecified	11.5	10.6	13.0	-2.4	1.14 (1.05, 1.24)
I10	Essential (primary) hypertension	75.4	72.4	80.6	-8.1	1.16 (1.07, 1.25)
L820	Inflamed seborrheic keratosis	7.5	8.8	5.3	3.6	0.78 (0.69, 0.88)
M9901	Segmental and somatic dysfunction of cervical region	3.4	3.6	3.0	0.6	0.80 (0.67, 0.96)
S0990XA	Unspecified injury of head, initial encounter	3.2	3.1	3.4	-0.4	1.30 (1.14, 1.48)

Variable	Description	MA + FFS (%) (N= 147,065)	FFS (%) (N= 93,365)	MA (%) (N= 53,700)	FFS - MA (%)	FFS + MA OR (95% CI)
Z79891	Long term (current) use of opiate analgesic	3.6	3.1	4.5	-1.4	1.31 (1.16, 1.48)
ICD-10 codes either during the index admission or 12 months prior to admission						
E669	Obesity, unspecified	26.9	25.5	29.3	-3.7	1.13 (1.06, 1.21)
E871	Hypo-osmolality and hyponatremia	6.4	6.5	6.4	0.1	1.29 (1.17, 1.42)
F32A	Depression, unspecified	15.0	14.5	15.8	-1.3	1.27 (1.17, 1.37)
I110	Hypertensive heart disease with heart failure	8.1	6.9	10.2	-3.3	1.30 (1.18, 1.42)
I2510	Atherosclerotic heart disease of native coronary artery without angina pectoris	25.3	25.4	25.3	0.1	1.20 (1.12, 1.28)
I739	Peripheral vascular disease, unspecified	8.3	6.3	11.9	-5.6	1.23 (1.13, 1.35)
J449	Chronic obstructive pulmonary disease, unspecified	12.5	10.8	15.5	-4.7	1.27 (1.17, 1.37)
M1611	Unilateral primary osteoarthritis, right hip	25.5	25.2	26.1	-1.0	0.94 (0.86, 1.04)
M1612	Unilateral primary osteoarthritis, left hip	15.6	15.9	14.9	1.0	0.95 (0.86, 1.04)
M1711	Unilateral primary osteoarthritis, right knee	45.9	45.4	46.8	-1.4	0.99 (0.92, 1.07)
M1712	Unilateral primary osteoarthritis, left knee	42.7	42.3	43.4	-1.1	0.99 (0.92, 1.06)
M1990	Unspecified osteoarthritis, unspecified site	16.6	14.6	20.0	-5.4	1.10 (1.03, 1.19)
Z6841	Body mass index [BMI] 40.0 – 44.9, adult	7.7	6.6	9.6	-3.0	1.35 (1.23, 1.49)
Z794	Long term (current) use of insulin	6.5	5.7	8.1	-2.4	1.18 (1.06, 1.30)
Z9181	History of falling	4.7	4.2	5.4	-1.2	1.17 (1.05, 1.31)
Other risk variables						
MCCFI	Multiple Chronic Conditions Frailty Index	22.0	20.7	24.4	-3.7	1.16 (1.08, 1.24)
PROC_THA	Elective THA procedure	37.0	36.9	37.2	-0.4	1.83 (1.62, 2.07)
TWOPROC	Number of procedures (two vs. one)	2.1	2.0	2.1	-0.1	1.43 (1.16, 1.75)
HX_COVID	History of COVID-19	13.8	14.3	13.1	1.2	1.00 (0.92, 1.08)
MA	MA (versus FFS)	36.5	NA	NA	NA	1.02 (0.96, 1.09)

THA/TKA Model Performance

Table 4.2.4 presents model performance for the THA/TKA measure across three scenarios: the FFS-only cohort with CC-based risk variables, the FFS+MA cohort with CC-based risk variables, and the FFS+MA cohort with ICD-10-based risk variables. Predictive ability and c-statistics were similar between the FFS-only and FFS+MA cohorts using the original CC-based variables. For the MA+FFS cohort, the model using reselected ICD-10-based risk variables also had a similar predictive ability and c-statistic compared to the original CC-based model. Calibration performance was generally acceptable across all modeling approaches in the overall cohort and in subgroups, including male versus female, MA versus FFS, and quartiles of hospital volume (figures not shown).

Table 4.2.4: THA/TKA Complication: Predictive Ability and C-Statistics Comparing FFS-only and FFS+MA Cohorts with CC-Based and ICD-10-Based Risk Variables, CY 2022

Value	FFS-only cohort with CC-based risk variables	FFS+MA cohort with CC-based risk variables	FFS+MA cohort with ICD-10-based risk variables
Predictive Ability, % (lowest decile – highest decile)	1.1 – 8.0	1.1 – 8.5	1.3 – 8.6
c-statistic	0.67	0.67	0.67

Note: These statistics were calculated using the patient-level logistic model.

Risk-Standardized Complication Rates for THA/TKA

Tables 4.2.5 and 4.2.6 present distribution of hospital volume, SCR, and RSCR for all hospitals (Table 4.2.5) and for hospitals with 25 or more eligible admissions (Table 4.2.6). Numbers of hospitals and admissions were higher in the combined FFS+MA data compared to the FFS-only data. With the addition of MA data, 183 additional hospitals were included in the measure (3,007 versus 2,824) and 398 additional hospitals met the 25 or more admissions cutoff for public reporting (1,270 versus 872). For all hospitals, the mean RSCR was 3.3% for the FFS-only cohort with CC-based risk variables, 3.5% for the FFS+MA cohort with CC-based risk variables, and 3.5% for the FFS+MA cohort with reselected ICD-10-based risk variables. Among hospitals with 25 or more admissions, mean RSCRs were 3.2%, 3.4%, and 3.4%, respectively.

Table 4.2.5: THA/TKA Complication: Hospital Volume, Standardized Complication Ratio (SCR), and Risk-Standardized Complication Rate (RSCR) Comparing FFS-only and FFS+MA Cohorts with CC-Based and ICD-10-Based Risk Variables, CY 2022, for All Hospitals

Value	FFS-Only cohort with CC-based risk variables (N= 2,824 hospitals)		FFS+MA cohort with CC-based risk variables (N= 3,007 hospitals)		FFS+MA cohort with ICD-10-based risk variables (N= 3,007 hospitals)	
	Mean (SD)	Median (25% Q1, 75% Q3)	Mean (SD)	Median (25% Q1, 75% Q3)	Mean (SD)	Median (25% Q1, 75% Q3)
Hospital Volume	33.1 (86.6)	11 (4, 31)	48.9 (108.1)	18 (6, 50)	48.9 (108.1)	18 (6, 50)
SCR	1.01 (0.13)	0.99 (0.95, 1.06)	1.01 (0.16)	0.99 (0.93, 1.09)	1.01 (0.16)	0.99 (0.93, 1.09)
RSCR (%)	3.3 (0.4)	3.2 (3.1, 3.5)	3.5 (0.5)	3.4 (3.2, 3.7)	3.5 (0.5)	3.4 (3.2, 3.7)

Table 4.2.6: THA/TKA Complication: Hospital Volume, Standardized Complication Ratio (SCR), and Risk-Standardized Complication Rate (RSCR) Comparing FFS-only and FFS+MA Cohorts with CC-Based and ICD-10-Based Risk Variables, CY 2022, for Hospitals with 25 or More Admissions

Value	FFS-Only cohort with CC-based risk variables (N= 872 hospitals)		FFS+MA cohort with CC-based risk variables (N= 1,270 hospitals)		FFS+MA cohort with ICD-10-based risk variables (N= 1,270 hospitals)	
	Mean (SD)	Median (25% Q1, 75% Q3)	Mean (SD)	Median (25% Q1, 75% Q3)	Mean (SD)	Median (25% Q1, 75% Q3)
Hospital Volume	89.3 (140.1)	53 (35, 98)	103.6 (149.9)	61 (38, 111)	103.6 (149.9)	61 (38, 111)
SCR	0.99 (0.19)	0.96 (0.87, 1.09)	1.00 (0.21)	0.97 (0.85, 1.11)	1.00 (0.21)	0.97 (0.86, 1.11)
RSCR (%)	3.2 (0.6)	3.1 (2.8, 3.6)	3.4 (0.7)	3.3 (2.9, 3.8)	3.4 (0.7)	3.3 (2.9, 3.8)

Measure Reliability for THA/TKA

Between hospital variance and STNR for the measure score comparing the addition of MA admissions to the FFS-only cohort and reselected ICD-10-based variables to the CC-based variables in the FFS+MA cohort are noted in Table 4.2.7. Median STNR, calculated based on between hospital variance and hospital volume, was 0.711 for the FFS-only cohort with CC-based risk variables, 0.751 for the FFS+MA cohort with CC-based risk variables, and 0.748 for the FFS+MA cohort with reselected ICD-10-based risk variables.

Table 4.2.7: THA/TKA Complication: Between Hospital Variance and Signal-to-Noise Reliability (STNR) Comparing FFS-only and FFS+MA Cohorts with CC-Based and ICD-10-Based Risk Variables, CY 2022, for Hospitals with 25 or More Admissions

Value	FFS-only cohort with CC-based risk variables	FFS+MA cohort with CC-based risk variables	FFS+MA cohort with ICD-10-based risk variables
Number of Hospitals	872	1,270	1,270
Between Hospital Variance	0.152	0.164	0.161
STNR: Median (Q1, Q3)	0.711 (0.619, 0.819)	0.751 (0.654, 0.847)	0.748 (0.651, 0.845)

Change in Hospital Performance for THA/TKA

Table 4.2.8 shows the quintile shifts in RSCR across hospitals with at least 25 FFS admissions for the THA/TKA measure in the combined FFS+MA cohort as compared to the FFS-only cohort in hospitals for the model with the original CC-based variables. After adding MA admissions to the FFS-only cohort, approximately half (56.1%) of hospitals remained in the same performance quintile, and 92.0% remained within +/- 1 quintile. Correlation between hospital RSRRs was 0.85. As hospitals' proportion of MA admissions increased, fewer hospitals remained in the same performance quintile (80.3% among hospitals in the lowest quintile of percent MA admissions; 44.3% of hospitals in the highest quintile of percent of MA admissions). As hospital volume increased, the trend in RSCR shifts was less pronounced.

Table 4.2.9 shows the quintile shifts in RSCR across hospitals with at least 25 FFS admissions for the THA/TKA measure after both measure updates, comparing the combined FFS+MA cohort using the reselected ICD-10-based risk variables to the FFS-only cohort using the CC-based variables. With the addition of the MA admissions and the ICD-10-based risk variables, 55.8% of hospitals remained in the same performance quintile and 91.3% remained within +/- 1 quintile. Correlation between hospital RSCRs was 0.85. As hospitals' proportion of MA admissions increased, fewer hospitals remained in the same performance quintile (77.5% among hospitals in the lowest quintile of percent MA admissions; 46.6% of hospitals in the highest quintile of percent of MA admissions).

Table 4.2.8: Shifts in RSCR Hospital Performance Quintile Rankings for THA/TKA, Overall and Based on Hospitals' Percentages of MA Admissions and Total Admission Volume, Comparing FFS-Only Cohort to the FFS+MA Cohort, CC-Based Variables, CY 2022

Description	Same quintile (%)	±1 quintile (%)	Correlation
Overall	56.1	92.0	0.85
By Percent of MA Admissions			
Q1: 0.0% – 13.2%	80.3	97.7	0.98
Q2: 13.3% – 23.6%	61.9	96.6	0.89
Q3: 23.7% – 33.3%	50.6	92.5	0.86
Q4: 33.5% – 44.4%	43.4	88.0	0.79
Q5: 44.4% – 89.2%	44.3	85.1	0.81
By MA+FFS Admission Volume			
Q1: 25 – 47 admissions	64.0	95.4	0.86
Q2: 48 – 67 admissions	52.4	95.9	0.84
Q3: 68 – 99 admissions	54.2	93.3	0.87
Q4: 100 – 179 admissions	49.4	87.4	0.83
Q5: 180 – 3,515 admissions	60.3	87.9	0.84

Note: Quintile percentages represent the percent of hospitals that stayed in their same (1st column) or within one (2nd column) performance quintile ranking after the addition of MA admissions.
Total N= 872 representing hospitals with 25 or more FFS admissions

Table 4.2.9: Shifts in RSCR Hospital Performance Quintile Rankings for THA/TKA, Overall and Based on Hospitals' Percentages of MA Admissions and Total Admission Volume, Comparing FFS-only Cohort with CC-Based variables to the FFS+MA Cohort with Reselected ICD-10-Based Risk Variables, CY 2022

Description	Same quintile (%)	±1 quintile (%)	Correlation
Overall	55.8	91.3	0.85
By Percent of MA Admissions			
Q1: 0.0% – 13.2%	77.5	97.1	0.97
Q2: 13.3% – 23.6%	61.9	95.5	0.90
Q3: 23.7% – 33.3%	47.7	90.8	0.85
Q4: 33.5% – 44.4%	45.7	88.6	0.78
Q5: 44.4% – 89.2%	46.6	84.5	0.80
By MA+FFS Admission Volume			
Q1: 25 – 47 admissions	59.4	94.9	0.86
Q2: 48 – 67 admissions	54.7	94.7	0.83
Q3: 68 – 99 admissions	52.0	93.3	0.88
Q4: 100 – 179 admissions	50.0	87.9	0.84
Q5: 180 – 3,515 admissions	63.2	85.6	0.81

Note: Quintile percentages represent the percent of hospitals that stayed in their same (1st column) or within one (2nd column) performance quintile ranking after the addition of MA admissions and with reselected ICD-10-based risk variables.
Total N=872, representing hospitals with 25 or more FFS admissions

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