2022 Procedure-Specific Mortality Measure Updates and Specifications Report

Isolated Coronary Artery Bypass Graft (CABG) Surgery — Version 9.0

Submitted By:

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Prepared For:

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1. HOW TO USE THIS REPORT

This report describes the Centers for Medicare & Medicaid Services' (CMS's) procedure-specific mortality measure that is publicly reported here on Care Compare. The measure is used to calculate hospital-level 30-day risk-standardized mortality rates (RSMRs) following isolated coronary artery bypass graft (CABG) surgery. This report provides a single source of information about this measure for a wide range of readers. Reports describing other outcome measures can be found here on *QualityNet*.

Specifications that define cohort inclusions and exclusions and the risk-adjustment variables described in this report are detailed in the 2022 CABG Surgery Mortality Measure Code Specifications supplemental file posted here on *QualityNet.*

This report includes:

- **Section 2 — An overview of the CABG surgery mortality measure**:
  - Background
  - Cohort inclusions and exclusions
    - Included and excluded hospitalizations
    - How transferred patients are handled
  - Outcome
  - Risk-adjustment variables
  - Data sources
  - Mortality rate calculation
  - Categorization of hospitals' performance scores

- **Section 3 — 2022 measure updates**

- **Section 4 — 2022 measure results**

- **Section 5 — Glossary**

The appendices include:

- Appendix A: Statistical approach to calculating RSMRs
- Appendix B: Data quality assurance (QA)
- Appendix C: Annual updates to the measure since measure development
- Appendix D: Cohort inclusion/exclusion criteria and outcome criteria

The original measure methodology report and prior updates and specifications reports are available in the 'Methodology' section and 'Archived Measure Methodology' section (under 'Resources') on the mortality measures page here on *QualityNet*.

If you have questions about the information in this report or the complementary supplemental file, please submit your inquiry using the QualityNet Q&A tool: https://cmsqualitysupport.servicenowservices.com/qnet_qa?id=ask_a_question > Program: Inpatient Claims-Based Measures > Mortality > Understanding Measure Methodology.

2. BACKGROUND AND OVERVIEW OF MEASURE METHODOLOGY

2.1. Background on CABG Surgery Mortality Measure

In 2015, CMS began publicly reporting 30-day RSMRs for CABG surgery for the nation's non-federal short-term acute care hospitals (including Indian Health Service hospitals) and critical access hospitals (CAHs).

Results for this measure are posted and updated annually here on Care Compare.

CMS contracted with the Yale New Haven Health Services Corporation — Center for Outcomes Research and Evaluation (YNHHSC/CORE) to update the CABG surgery mortality measure for 2022 public reporting through a process of measure reevaluation.

2.2. Overview of Measure Methodology

The 2022 risk-adjusted CABG surgery mortality measure uses specifications from the original measure methodology report posted here on *QualityNet*, with refinements to the measure as listed in Appendix C and described in prior measure updates and specifications reports posted here on *QualityNet*. An overview of the methodology is presented in this section.

For more information on the CMS programs that use the measure for fiscal year (FY) 2023, as well as its use in future FYs, please refer to the FY 2022 Inpatient Prospective Payment System (IPPS) Final Rule posted here on the CMS website.

2.2.1 Cohort

Index Admissions Included in the Measure

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

- having a qualifying isolated CABG surgery 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 the index admission and Part A during the index admission; and
- aged 65 or over.

Isolated CABG surgeries are defined as those CABG procedures performed *without* the following concomitant valve or other major cardiac, vascular, or thoracic procedures:

- valve procedures
- atrial and/or ventricular septal defects
- congenital anomalies
- other open cardiac procedures
- heart transplants
- aorta or other non-cardiac arterial bypass procedures

- head, neck, intracranial vascular procedures
- other chest and thoracic procedures

The measure uses International Classification of Diseases, Tenth Revision, Procedure Coding System (ICD-10-PCS) codes on claims to define a CABG surgery and to identify a CABG surgery as non-isolated (and disqualify the admission from cohort inclusion). These codes are listed in the 2022 CABG Surgery Mortality Measure Code Specifications supplemental file posted here on *QualityNet*.

Index Admissions Excluded from the Measure

The CABG surgery mortality measure excludes index admissions for patients:

- with inconsistent or unknown vital status or other unreliable demographic (age and gender) data;
- discharged against medical advice; or
- with a principal diagnosis code of COVID-19 (International Classification of Diseases, Tenth Revision, Clinical Modification [ICD-10-CM] code U07.1) **or** with a secondary diagnosis code of COVID-19 coded as present on admission (POA) on the index admission claim. These code specifications are outlined in the 2022 CABG Surgery Mortality Measure Code Specifications supplemental file here on *QualityNet*.

For patients with more than one qualifying CABG surgery admission in the measurement period, the first CABG admission is selected for inclusion in the measure, and the subsequent CABG admissions are excluded from the cohort.

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, claims for patients not listed in the Medicare Enrollment Database, and records with ineligible 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 hospitalizations that result from hospital-to-hospital transfers 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 different short-term acute care hospital. Cases that meet this criterion are considered transfers regardless of whether the first institution indicates intent to transfer the patient in the discharge disposition code.

Admissions associated with transfers between acute care hospitals are not excluded from the measure. A transfer to another acute care facility after CABG surgery is most likely due to a complication of the CABG procedure or the perioperative care the patient received; and as such, the care provided by the hospital performing the CABG procedure likely dominates mortality risk, even among transferred patients. This is true also for patients that are transferred in from another hospital for their CABG surgery. Therefore, in a series of one or more transfers, the first admission where an eligible CABG procedure was done is included in the cohort, regardless of whether the patient is transferred in or transferred out. Furthermore, the measure assigns a death that occurs within 30 days of the procedure date to the hospital that performed the first ("index") CABG surgery, even if it is not the discharging hospital. For example, if a patient is admitted to Hospital A and undergoes CABG surgery and then is transferred to Hospital B, the Hospital A admission would be included in the cohort, and death within 30 days of the date of the procedure at Hospital A would be captured in Hospital A's mortality outcome. This is different than the other mortality measures that always consider the first hospitalization as the index admission and always assign a death to the hospital that initially admitted the patient.

2.2.2 Outcome

All-Cause Mortality

All deaths are considered an outcome, regardless of cause. There are a number of reasons for capturing deaths from any cause in the CABG surgery mortality measure. First, from a patient's perspective, a death from any cause is an adverse event. In addition, making inferences about quality of care based solely on the documented cause of death is difficult. For example, a patient hospitalized for CABG surgery who develops a hospital-acquired infection may ultimately die of sepsis and multi-organ failure. In this context, considering the patient's death to be unrelated to the care the patient received for the CABG surgery during the index admission would be inappropriate.

30-Day Time Frame

The measure assesses mortality within a 30-day period from the procedure date. The procedure date is used because some patients who undergo CABG surgery might be admitted during the days before the procedure date rather than on the day of the procedure. For those patients, dating the measurement period from the day of admission would underestimate the period of risk.

The measure uses a 30-day time frame because older adult patients are more vulnerable to adverse health outcomes occurring during this time.[1] Death within 30 days of the CABG surgery can be influenced by hospital care and the early transition to the non-acute care setting. The 30-day time frame is a clinically meaningful period for hospitals to collaborate with their communities in an effort to reduce mortality.[2]

2.2.3 Risk-Adjustment Variables

To account for differences in case mix among hospitals, the measure includes an adjustment for factors such as age, sex, comorbid diseases, and indicators of patient frailty, which 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 up to 12 months prior to the index admission, and all claims for the index admission itself. Inpatient, outpatient, and physician claims data from January 1, 2020 through June 30, 2020 encounters are not used due to the declared COVID-19 public health emergency (PHE), as discussed in Section 3.2.2; as a result, the pre-index admission time frame would be less than 12 months for some patients, depending on their index admission date.

The measure's adjustment for case mix differences among hospitals is 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 the time of the index admission, or any time within the preceding 12 months (or less), are included in risk adjustment. Complications that arise during the course of the hospitalization are not used in risk adjustment.

The process for determining patient comorbidities present at the time of the index admission from the index admission claim uses a POA algorithm. In brief, a secondary diagnosis ICD-10-CM code on the index admission is used in risk adjustment if **one** of the following is true:

1. The POA indicator for the secondary diagnosis code = 'Y' on the index admission.
2. The secondary diagnosis code is classified as a POA-exempt code that is considered "always POA" (as designated by our clinical experts).
3. If the index claim is void of POA coding (that is, no reported POA indicator values for any of the secondary diagnoses), then the secondary diagnosis is used in risk adjustment if it is NOT mapped to a Condition Category (CC) that is included in the potential complications list.

The POA algorithm applies only in the case of secondary diagnosis codes on the index admission that are assigned to a CC used in risk adjustment of the measure. ICD-10 code-defined risk variables, such as 'Coronary atherosclerosis,' do not use the algorithm.

Refer to the 2022 CABG Surgery Mortality Measure Code Specifications supplemental file posted here on *QualityNet* for the list of CC-defined risk-adjustment variables and the specifications for the ICD-10 code-defined risk-adjustment variables. The list of potential complications referred to in Step 3 of the algorithm is also included in the 2022 supplemental file.

CC mappings to ICD-10-CM codes, as well as the "POA-Exempt Codes Considered Always POA for 2022" table (referred to in Step 2 of the algorithm), are available here on *QualityNet.*

The measure does not include an adjustment for social risk factors because the association between social risk factors and health outcomes can be due, in part, to differences in the quality of health care that groups of patients with varying social risk factors receive. The intent is for the measure to adjust for patient demographic and clinical characteristics while illuminating important quality differences. The National Quality Forum (NQF) re-endorsed the measure without adjustment for patient-level social risk factors in the last endorsement maintenance submission prior to 2022.

2.2.4 Data Sources

The data sources for these analyses are Medicare administrative claims and enrollment information for patients having hospitalizations with discharge dates between July 1, 2018 and June 30, 2021, excluding December 2, 2019 through June 30, 2020. The datasets also contain associated inpatient, outpatient, and physician Medicare administrative claims from up to 12 months prior to the index admission (as discussed in Section 2.2.3) for patients having hospitalizations with discharge dates in the aforementioned time period. Refer to the original methodology report posted here on *QualityNet* for further descriptions of these data sources.

2.2.5 Measure Calculation

The hospital-level 30-day all-cause RSMR is estimated using a hierarchical logistic regression model. In brief, the approach simultaneously models data at the patient and hospital levels to account for variance in patient outcomes within and between hospitals.[3] At the patient level, it models the log-odds of mortality within 30 days of the procedure date 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 mortality 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.[3] If there were no differences among hospitals, then after adjusting for patient risk, the hospital effects should be identical across all hospitals.

The RSMR is calculated as the ratio of the number of "predicted" deaths to the number of "expected" deaths at a given hospital, multiplied by the national observed mortality rate. For each hospital, the numerator of the ratio is the number of deaths within 30 days predicted based on the hospital's performance with its observed case mix; the denominator is the number of deaths 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 mortality rates or better quality, while a higher ratio indicates higher-than-expected mortality rates or worse quality.

The "predicted" number of deaths (the numerator) is calculated by using the coefficients estimated by regressing the risk factors (Table 4.2.2) and the hospital-specific effect on the risk of mortality. The estimated hospital-specific effect is added to the sum of the estimated regression coefficients multiplied by the patient characteristics. The results are transformed using the inverse-link-function and summed over all patients attributed to a hospital to calculate a predicted value. The "expected" number of deaths (the denominator) is obtained in the same manner, except that a common effect using all hospitals in our sample is added in place of the hospital-specific effect. These results are also transformed using the inverse-link-function and summed over all patients attributed to a hospital to calculate an expected value. To assess hospital performance for each reporting period, we re-estimate the model coefficients using the data in each time period.

Multiplying the predicted over expected ratio by the national observed mortality rate transforms the ratio into a rate that can be compared to the national observed mortality rate. The hierarchical logistic regression model is described fully in Appendix A and in the original methodology report posted here on *QualityNet*.

2.2.6 Categorizing Hospital Performance

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

- "Better than the National Rate" if the entire 95% interval estimate surrounding the hospital's rate is lower than the national observed mortality rate
- "No Different than the National Rate" if the 95% interval estimate surrounding the hospital's rate includes the national observed mortality rate
- "Worse than the National Rate" if the entire 95% interval estimate surrounding the hospital's rate is higher than the national observed mortality 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 conclude how the hospital is performing. If a hospital has fewer than 25 eligible cases, the hospital's mortality 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 MEASURE FOR 2022 PUBLIC REPORTING

3.1. Rationale for Measure Updates

Annual measure reevaluation ensures that the risk-standardized mortality model is continually assessed and remains valid, given possible changes in clinical practice and coding standards over time. Modifications made to the measure cohort, risk model, and outcomes are informed by review of the most recent literature related to measure conditions or outcomes, feedback from various stakeholders, empirical analyses, and assessment of coding trends that reveal shifts in clinical practice or billing patterns. Input is solicited from a workgroup composed of up to 20 clinical and measure experts, inclusive of internal and external consultants and subcontractors. As this report describes, for 2022 public reporting, we made the following modifications to the measure:

- Updated the ICD-10 code-based specifications used in the measure. Specifically, we:
    - incorporated ICD-10-CM/PCS code changes into the cohort definition and risk model that occurred in the following releases:
        - April 1, 2020
        - August 1, 2020
        - October 1, 2020 (FY 2021)
        - January 1, 2021
    - applied a modified version of the FY 2021 V24 CMS-Hierarchical Condition Category (HCC) crosswalk that is maintained by RTI International to the risk model.
- Adjusted the measure specifications and methodology in response to the COVID-19 PHE.
- Added a POA algorithm to the risk-adjustment methodology.

As a part of annual reevaluation, we also undertook the following activities:

- Monitored code frequencies to identify any warranted specification changes due to possible changes in coding practices and patterns;
- Reviewed potentially clinically relevant codes that “neighbor” existing codes used in the measure to identify any warranted specification changes;
- Reviewed select pre-existing ICD-10 code-based specifications with our workgroup to confirm the appropriateness of specifications unaffected by the updates;
- Updated the measure’s SAS analytic package (SAS pack) and documentation;
- Evaluated and validated model performance for the 29 months combined (July 1, 2018 – June 30, 2021, excluding December 2, 2019 – June 30, 2020); and
- Evaluated the stability of the risk-adjustment model over the 29-month measurement period by examining the model variable frequencies, model coefficients, and the performance of the risk-adjustment model in each time period:
    - July 1, 2018 – June 30, 2019
    - July 1, 2019 – December 1, 2019
    - July 1, 2020 – June 30, 2021

3.2. Detailed Discussion of Measure Updates

3.2.1 Annual Updates to ICD-10 Code-Based Measure Specifications

Cohort Definition

We examined the code sets from the four ICD-10-PCS releases outlined above, with particular attention to newly added codes. We then solicited input from our workgroup to determine which, if any, of the newly implemented ICD-10 codes in the code sets should be added to the cohort definition. We reviewed approximately 575 new ICD-10-PCS codes. These code totals reflect new code additions since 2021 public reporting.

These processes, in addition to the surveillance and workgroup processes described above in the Rationale for Measure Updates section, led to the following changes:

- the addition of ICD-10-PCS codes to the list of codes that identify a concomitant valve or other major cardiac, vascular, or thoracic procedure and disqualify the admission from cohort inclusion; and
- the removal of COVID-19 patients from the cohort. For more details, refer to Section 3.2.2.

Risk Adjustment

We examined RTI International's FY 2021 modified version of the V24 CMS-HCC crosswalk to see how the newly implemented ICD-10 codes in the ICD-10-CM/PCS code set releases were classified, and to examine codes which RTI International reclassified from one HCC to another when they updated to the FY 2021 version. We then solicited input from our workgroup to confirm the clinical appropriateness of the HCC classifications of the newly implemented ICD-10 codes and any changes warranted due to where code shifts may have occurred. The workgroup also reviewed the newly implemented ICD-10 codes in the ICD-10-CM/PCS code set releases to determine which, if any, should be added to the singular ICD-10 code lists that are also used in risk adjustment (conditions that are not captured by CCs).

These processes, in addition to the surveillance and workgroup processes described above in the Rationale for Measure Updates section, led to the following changes:

- Minor remappings or changes in CC mapping from 2021 to 2022 public reporting
- The addition of an ICD-10-PCS code to the code list used to define the 'History of coronary artery bypass graft (CABG) or valve surgery' risk-adjustment variable

Analyses of the CC crosswalk changes showed no appreciable shifts in risk variable frequencies or changes in risk variable estimates and suggest minimal impact to mortality measure rates.

For information on additional changes made to the risk-adjustment methodology, refer to Section 3.2.2 and Section 3.2.3.

3.2.2 COVID-19

Changes Due to COVID-19

The following modifications were made to the measure, in response to the COVID-19 PHE:

- Claims data for January 1, 2020 – June 30, 2020 continue to be excluded from use in the measure under CMS's Extraordinary Circumstances Exception (ECE) policy, similar to 2021 public reporting.[4-7] As a result:
    - The measurement period for 2022 public reporting is again reduced to approximately 29 months (from the typical three years), similar to 2021 public reporting. The approximately seven months of admissions excluded as index admissions incorporates (1) the CMS-excluded January 1, 2020 – June 30, 2020 claims referred to above, and (2) December 2, 2019 – December 31, 2019 claims (where mortality outcome determination using the 30-day outcome window would use claims from CMS's excluded January 1, 2020 – June 30, 2020 time frame, in part).
    - The typical 12-month look-back period for use of claims data in risk adjustment totals less than 12 months for those patients whose 12-month period includes any portion of the January 1, 2020 – June 30, 2020 time frame.
- A new 'History of COVID-19' risk variable has been added to the risk-adjustment model.
- COVID-19 index admissions are excluded from the cohort. COVID-19 index admissions are defined by a principal diagnosis code of COVID-19 **or** a secondary diagnosis code of COVID-19 coded as POA on the index admission claim.
- A brief summary of how COVID-19 is addressed in the measure, including code specifications, can be found in the 2022 CABG Surgery Mortality Measure Code Specifications supplemental file here on *QualityNet*.

Rationale for COVID-19 Modifications

CMS's decision in March 2020 to exclude claims data for January 1, 2020 – June 30, 2020 (Q1 and Q2 of 2020) under its ECE policy was done to assist healthcare providers who were directing their resources toward caring for patients and ensuring the health and safety of staff.

The COVID-19 PHE continues to have significant and enduring effects on the provision of medical care in the country and around the world. National or regional shortages or changes in healthcare personnel, medical supplies, equipment, diagnostic tools, and patient case volumes or facility-level case mix may affect quality measurement data. Adjustments to public reporting methodology and specifications for 2022 help to ensure the intent of the measure is maintained.

For more information on the COVID-19 PHE, or for details about the CABG surgery mortality measure as included in the Hospital Value-Based Purchasing (VBP) Program, please refer to the FY 2022 IPPS Final Rule posted here on the CMS website.

Effect of COVID-19 Modifications

The frequencies of a principal diagnosis of COVID-19 or a secondary diagnosis code of COVID-19 coded as POA tend to be very small (< 0.5%) for the CABG mortality measure. These cases can be mitigated by updating the measure specifications to exclude COVID-19 cases.

Please refer to the FY 2022 IPPS Final Rule posted here on the CMS website for more information.

3.2.3 Update to Risk Adjustment Methodology

Addition of POA Coding to Risk Adjustment

A POA algorithm was added to the risk-adjustment methodology used to pull risk-adjustment variables from the index admission claim. In brief, a secondary diagnosis ICD-10-CM code on the index admission is used in risk adjustment if **one** of the following is true:

1. The POA indicator for the secondary diagnosis code = 'Y' on the index admission.
2. The secondary diagnosis code is classified as a POA-exempt code that is considered "always POA" (as designated by our clinical experts).
3. If the index claim data is void of POA coding (that is, no reported POA indicator values for any of the secondary diagnoses), then the secondary diagnosis is used in risk adjustment if it is NOT mapped to a CC that is included in the potential complications list.

In submitting claims, CMS requires IPPS hospitals to denote whether each principal and secondary diagnosis was POA for all ICD-10-CM codes, except for POA-exempt codes. Although the majority of the codes on the POA-exempt list reflect conditions that are always POA (for example, subsequent or sequela encounters, congenital conditions), some of the POA-exempt codes may not reflect health status at the time of admission. We conducted a focused review of the POA-exempt list with our clinical experts, to determine which of those codes should be considered "always POA."

The "POA-Exempt Codes Considered Always POA for 2022" table (referred to in Step 2 of the algorithm) is available here on *QualityNet.*

The POA algorithm applies only in the case of secondary diagnosis codes on the index admission that are assigned to a CC used in risk adjustment of a measure. ICD-10 code-defined risk variables, such as 'Coronary atherosclerosis,' do not use the algorithm.

Rationale for Addition of POA Coding

Many stakeholders have expressed concerns that POA indicators have not been used in risk adjustment, arguing that (1) POA coding is a logical reflection of comorbidities, and (2) use of POA indicators would help particularly in cases where the patient has not been hospitalized or had provider visits in the last year or where a comorbid condition present at the time of admission is relatively new. In both of these scenarios, historical claims (up to 12 months prior to the index admission) that include that comorbid condition would not be present. Stakeholder feedback strongly supports the incorporation of POA.

POA indicators more accurately distinguish complications of care from conditions already present at admission, in comparison to the previous methodology that utilized only the potential complications list.[8] Our analyses show that all IPPS hospitals code POA indicators, while a small proportion of CAHs do not. Therefore, the POA algorithm incorporates the previous potential complications list methodology for claims in which POA indicators are missing.

Effect of POA Coding to Risk Adjustment

To explore the impact of POA indicators on the measure, we conducted extensive analyses. Our findings[8] include:

- Model performance with POA coding was similar to performance without POA.
- Models with POA likely provide a better estimate of a patient's risk of mortality than models without POA.
- The difference in hospital RSMRs comparing models with and without POA was very small.

3.2.4 Additional Notes

The goal of these specification updates was to maintain the intent of the measure.

Changes made to the specifications are detailed in the 2022 CABG Surgery Mortality Measure Code Specifications supplemental file posted here on *QualityNet*.

The ICD-10 code listings in this report and the supplemental file reflect the current (FY 2021) labels or narrative descriptions for each code.

3.3. Changes to SAS Pack

We revised the measure SAS pack to accommodate the specification updates discussed in Section 3.1 and Section 3.2 above. The new SAS pack and documentation are available upon request. Please submit your request using the QualityNet Q&A tool: https://cmsqualitysupport.servicenowservices.com/qnet_qa?id=ask_a_question > Program: Inpatient Claims-Based Measures > Mortality > Understanding Measure Methodology. **Do *NOT* submit patient-identifiable information (for example, date of birth, Social Security number, Medicare Beneficiary Identifier/health insurance claim number) into this tool.**

The SAS pack includes descriptions of 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 RSMR calculation without the data files, which contain the longitudinal patient data from the entire national sample of acute care hospitals that is used to estimate the individual hospital-specific effects, the average hospital-specific effect, and the risk-adjustment coefficients used in the equations.

4. RESULTS FOR 2022 PUBLIC REPORTING

4.1. Assessment of Updated Model

The hospital-level 30-day all-cause RSMRs for the measure are estimated using a hierarchical logistic regression model. Refer to Section 2 for a summary of the measure methodology and model risk-adjustment variables. Refer to prior methodology and updates and specifications reports on the mortality measures page here on *QualityNet* for further details.

We evaluated the performance of the model using the July 1, 2018 through June 30, 2021 data (excluding December 2, 2019 through June 30, 2020) for the 2022 reporting period. We examined the differences in the frequencies of patient risk factors and the model parameter coefficients.

We assessed logistic regression model performance in terms of discriminant ability for each of the three time periods of data and for the 29-month combined period. We computed two summary statistics to assess model performance: the predictive ability and the area under the receiver operating characteristic (ROC) curve (c-statistic). We also computed between-hospital variance for each of the three time periods of data and for the 29-month combined period. If there were no systematic differences between hospitals, the between-hospital variance would be zero.

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

Please note that, due to seasonal fluctuations and other factors, the statistics from the second and shorter time period (July 1, 2019 – December 1, 2019) that are presented in the tables within this section are not directly comparable to the other two time periods.

4.2. CABG Surgery Mortality 2022 Model Results

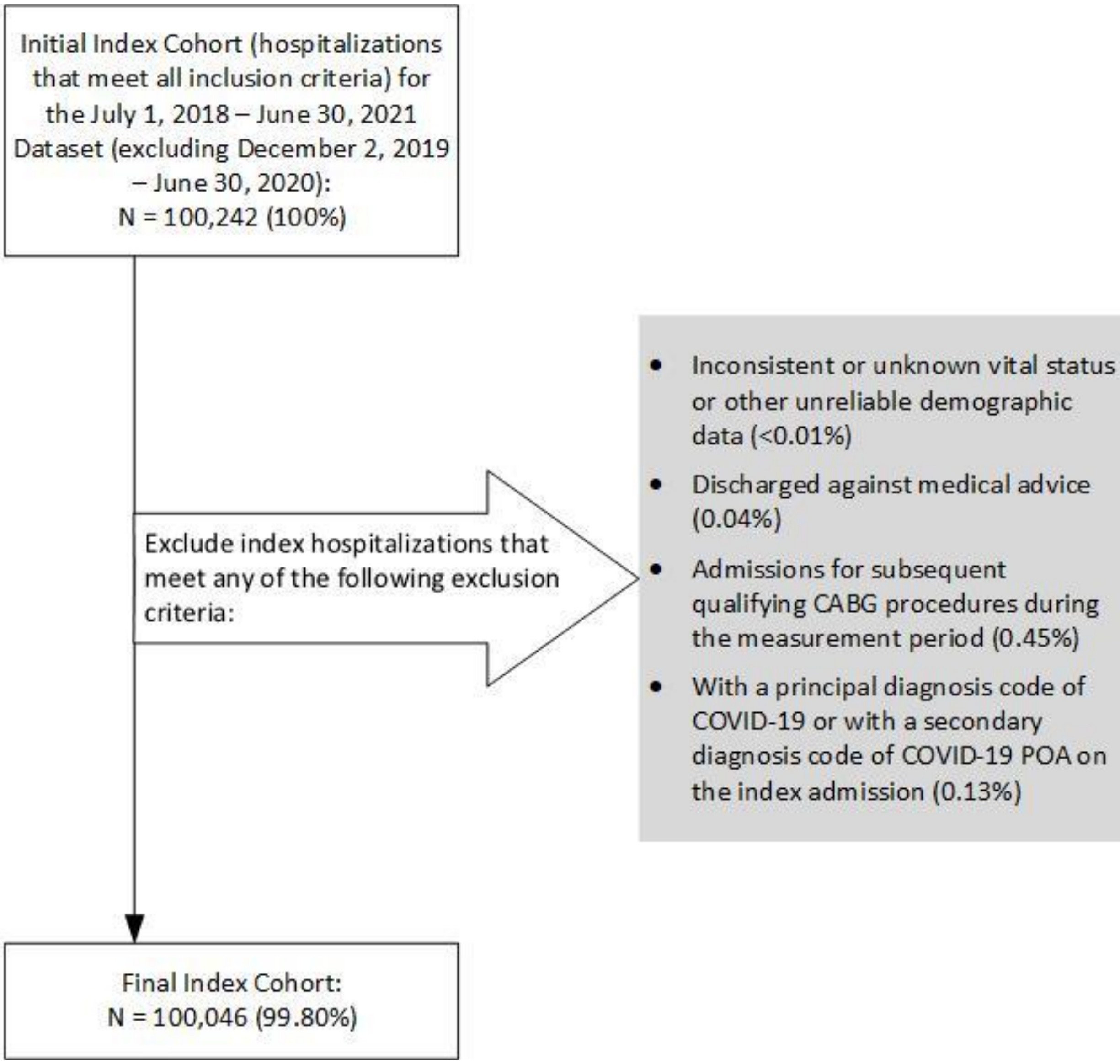
4.2.1 Index Cohort Exclusions

The exclusion criteria for this measure are presented in Section 2.2.1. The percentage of CABG surgery admissions that met each exclusion criterion in the July 1, 2018 – June 30, 2021 dataset (excluding December 2, 2019 through June 30, 2020) 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 patients:

- aged 65 or over;
- with a qualifying isolated CABG procedure; and
- enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission and Part A during the index admission.

Figure 4.2.1 — CABG Surgery Cohort Exclusions in the July 1, 2018 – June 30, 2021 Dataset (excluding December 2, 2019 through June 30, 2020)



4.2.2 Frequency of CABG Surgery Model Variables

We examined the frequencies of clinical and demographic variables. Frequencies of model variables were relatively stable over the measurement period.

Refer to Table 4.2.1 for more detail.

4.2.3 CABG Surgery Model Parameters and Performance

Table 4.2.2 shows hierarchical logistic regression model parameter coefficients by individual time period and for the combined 29-month dataset. Table 4.2.3 shows the risk-adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for the CABG surgery mortality model by individual time period and for the combined 29-month dataset. Overall, model performance was stable over the 29-month period (Table 4.2.4).

4.2.4 Distribution of Hospital Volumes and Mortality Rates for CABG Surgery

The national *observed* mortality rate in the combined 29-month dataset was 2.9%. For the three time periods, the *observed* rates were as follows:

- July 1, 2018 – June 30, 2019: 2.9%
- July 1, 2019 – December 1, 2019: 2.7%
- July 1, 2020 – June 30, 2021: 3.2%

Table 4.2.5 shows the distribution of hospital admission volumes, and Table 4.2.6 shows the distribution of hospital RSMRs. Table 4.2.7 shows the between-hospital variance by individual time period, as well as for the combined 29-month dataset.

Figure 4.2.2 shows the overall distribution of the hospital RSMRs for the combined 29-month dataset, which indicates that the hospital RSMRs are normally distributed. The odds of all-cause mortality if a patient is treated at a hospital one standard deviation (SD) above the national rate were 2.48 times higher than the odds of all-cause mortality 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.[3]

4.2.5 Distribution of Hospitals by Performance Category in the 29-Month Dataset

Of 1,128 hospitals in the study cohort, 7 performed “Better than the National Rate,” 903 performed “No Different than the National Rate,” and 12 performed “Worse than the National Rate.” 206 were classified as “Number of Cases Too Small” (fewer than 25) to reliably conclude how the hospital is performing.

Table 4.2.1 — Frequency of CABG Surgery Model Variables over Different Time Periods

Variable (% unless otherwise indicated)	7/1/2018 – 6/30/2019	7/1/2019 – 12/1/2019	7/1/2020 – 6/30/2021	7/1/2018 – 12/1/2019 and 7/1/2020 – 6/30/2021
Total N	44,399	18,535	37,112	100,046
Mean Age (SD)	73.5 (5.4)	73.4 (5.3)	73.5 (5.3)	73.5 (5.3)
Male	74.0	74.0	74.5	74.2
History of COVID-19	-	-	4.4	1.6
Cardiogenic shock	2.3	2.2	2.6	2.4
Coronary atherosclerosis	89.4	90.1	89.0	89.4
History of coronary artery bypass graft (CABG) or valve surgery	7.5	7.9	8.0	7.8
Cancer; metastatic cancer and acute leukemia (CC 8 – 14)	19.1	19.0	15.9	17.9
Protein-calorie malnutrition (CC 21)	3.0	2.8	2.7	2.8
Morbid obesity; other endocrine/metabolic/nutritional disorders (CC 22, 25 – 26)	94.9	95.2	95.1	95.0
Liver or biliary disease (CC 27 – 32)	8.1	8.4	7.5	7.9
Other gastrointestinal disorders (CC 38)	54.1	54.7	49.5	52.5
Dementia or other specified brain disorders (CC 51 – 53)	5.5	5.5	4.5	5.1
Hemiplegia, paraplegia, paralysis, functional disability (CC 70 – 74, 103 – 104, 189 – 190)	4.2	3.9	3.4	3.9
Congestive heart failure (CC 85)	35.4	35.0	36.2	35.6
Acute myocardial infarction (CC 86)	19.2	19.0	19.1	19.1
Unstable angina and other acute ischemic heart disease (CC 87)	32.1	32.1	30.5	31.5
Angina; old myocardial infarction (CC 88 plus ICD-10-CM code I25.2)	51.3	52.3	50.3	51.1
Hypertension (CC 95)	86.8	87.0	82.1	85.1
Stroke (CC 99 – 100)	4.4	4.3	3.2	3.9
Vascular or circulatory disease (CC 106 – 109)	40.3	40.7	37.5	39.4
Chronic obstructive pulmonary disease (COPD) (CC 111)	22.7	21.9	20.2	21.6
Pneumonia (CC 114 – 116)	10.0	9.5	8.1	9.2
Dialysis status (CC 134)	2.5	2.4	2.5	2.5
Renal failure (CC 135 – 140)	34.1	34.6	34.3	34.3
Decubitus ulcer or chronic skin ulcer (CC 157 – 161)	3.5	3.5	3.0	3.3

Table 4.2.2 — Hierarchical Logistic Regression Model Parameter Coefficients for CABG Surgery over Different Time Periods

Variable	7/1/2018 – 6/30/2019	7/1/2019 – 12/1/2019	7/1/2020 – 6/30/2021	7/1/2018 – 12/1/2019 and 7/1/2020 – 6/30/2021
Intercept	-3.567	-4.423	-3.224	-3.555
Years over 65 (continuous)	0.062	0.060	0.063	0.062
Male	-0.547	-0.330	-0.440	-0.465
History of COVID-19	-	-	-0.303	-0.232
Cardiogenic shock	1.177	1.200	1.108	1.158
Coronary atherosclerosis	-0.087	0.256	-0.013	-0.003
History of coronary artery bypass graft (CABG) or valve surgery	0.387	0.393	0.260	0.332
Cancer; metastatic cancer and acute leukemia (CC 8 – 14)	-0.007	-0.266	-0.061	-0.072
Protein-calorie malnutrition (CC 21)	0.341	0.726	0.599	0.518
Morbid obesity; other endocrine/metabolic/nutritional disorders (CC 22, 25 – 26)	-0.546	-0.206	-0.827	-0.601
Liver or biliary disease (CC 27 – 32)	0.427	0.280	0.237	0.335
Other gastrointestinal disorders (CC 38)	-0.211	-0.150	-0.166	-0.191
Dementia or other specified brain disorders (CC 51 – 53)	0.069	-0.106	-0.088	-0.025
Hemiplegia, paraplegia, paralysis, functional disability (CC 70 – 74, 103 – 104, 189 – 190)	0.095	-0.021	0.394	0.185
Congestive heart failure (CC 85)	0.618	0.553	0.467	0.549
Acute myocardial infarction (CC 86)	0.103	0.108	0.121	0.125
Unstable angina and other acute ischemic heart disease (CC 87)	-0.060	0.083	-0.015	-0.014
Angina; old myocardial infarction (CC 88 plus ICD-10-CM code I25.2)	-0.222	-0.306	-0.350	-0.278
Hypertension (CC 95)	-0.275	-0.217	-0.279	-0.281
Stroke (CC 99 – 100)	0.029	0.120	0.119	0.073
Vascular or circulatory disease (CC 106 – 109)	0.229	0.094	0.242	0.215
Chronic obstructive pulmonary disease (COPD) (CC 111)	0.305	0.303	0.301	0.293
Pneumonia (CC 114 – 116)	0.171	-0.027	0.134	0.112
Dialysis status (CC 134)	0.716	0.818	0.763	0.770
Renal failure (CC 135 – 140)	0.413	0.593	0.426	0.448
Decubitus ulcer or chronic skin ulcer (CC 157 – 161)	0.175	0.207	0.156	0.168

Table 4.2.3 — Adjusted OR and 95% CIs for the CABG Surgery Hierarchical Logistic Regression Model over Different Time Periods

Variable	7/1/2018 – 6/30/2019 OR (95% CI)	7/1/2019 – 12/1/2019 OR (95% CI)	7/1/2020 – 6/30/2021 OR (95% CI)	7/1/2018 – 12/1/2019 and 7/1/2020 – 6/30/2021 OR (95% CI)
Years over 65 (continuous)	1.06 (1.05 – 1.07)	1.06 (1.04 – 1.08)	1.06 1.05 – 1.08)	1.06 (1.06 – 1.07)
Male	0.58 (0.51 – 0.65)	0.72 (0.59 – 0.88)	0.64 (0.57 – 0.73)	0.63 (0.58 – 0.68)
History of COVID-19	-	-	0.74 (0.54 – 1.02)	0.79 (0.58 – 1.08)
Cardiogenic shock	3.24 (2.63 – 4.00)	3.32 (2.37 – 4.65)	3.03 (2.43 – 3.77)	3.18 (2.77 – 3.65)
Coronary atherosclerosis	0.92 (0.75 – 1.12)	1.29 (0.89 – 1.88)	0.99 (0.81 – 1.21)	1.00 (0.87 – 1.14)
History of coronary artery bypass graft (CABG) or valve surgery	1.47 (1.22 – 1.78)	1.48 (1.10 – 1.99)	1.30 (1.06 – 1.59)	1.39 (1.23 – 1.58)
Cancer; metastatic cancer and acute leukemia (CC 8 – 14)	0.99 (0.86 – 1.15)	0.77 (0.60 – 0.98)	0.94 (0.80 – 1.11)	0.93 (0.84 – 1.03)
Protein-calorie malnutrition (CC 21)	1.41 (1.11 – 1.78)	2.07 (1.47 – 2.91)	1.82 (1.43 – 2.32)	1.68 (1.44 – 1.95)
Morbid obesity; other endocrine/metabolic/nutritional disorders (CC 22, 25 – 26)	0.58 (0.47 – 0.72)	0.81 (0.55 – 1.21)	0.44 (0.36 – 0.54)	0.55 (0.48 – 0.63)
Liver or biliary disease (CC 27 – 32)	1.53 (1.28 – .83)	1.32 (0.99 – 1.77)	1.27 (1.04 – 1.55)	1.40 (1.24 – 1.58)
Other gastrointestinal disorders (CC 38)	0.81 (0.72 – 0.91)	0.86 (0.71 – 1.04)	0.85 (0.75 – 0.96)	0.83 (0.76 – 0.89)
Dementia or other specified brain disorders (CC 51 – 53)	1.07 (0.86 – 1.33)	0.90 (0.62 – 1.31)	0.92 (0.71 – 1.19)	0.98 (0.84 – 1.14)
Hemiplegia, paraplegia, paralysis, functional disability (CC 70 – 74, 103 – 104, 189 – 190)	1.10 (0.85 – 1.42)	0.98 (0.64 – 1.50)	1.48 (1.14 – 1.93)	1.20 (1.02 – 1.42)
Congestive heart failure (CC 85)	1.85 (1.64 – 2.10)	1.74 (1.42 – 2.12)	1.60 (1.40 – 1.82)	1.73 (1.59 – 1.88)
Acute myocardial infarction (CC 86)	1.11 (0.97 – 1.27)	1.11 (0.89 – 1.39)	1.13 (0.98 – 1.31)	1.13 (1.03 – 1.24)
Unstable angina and other acute ischemic heart disease (CC 87)	0.94 (0.83 – 1.07)	1.09 (0.89 – 1.32)	0.99 (0.86 – 1.13)	0.99 (0.91 – 1.07)
Angina; old myocardial infarction (CC 88 plus ICD-10-CM code I25.2)	0.80 (0.71 – 0.90)	0.74 (0.61 – 0.89)	0.70 (0.62 – 0.80)	0.76 (0.70 – 0.82)
Hypertension (CC 95)	0.76 (0.65 – 0.88)	0.81 (0.63 – 1.03)	0.76 (0.66 – 0.87)	0.76 (0.69 – 0.83)
Stroke (CC 99 – 100)	1.03 (0.79 – 1.33)	1.13 (0.75 – 1.69)	1.13 (0.83 – 1.53)	1.08 (0.90 – 1.28)

Variable	7/1/2018 – 6/30/2019 OR (95% CI)	7/1/2019 – 12/1/2019 OR (95% CI)	7/1/2020 – 6/30/2021 OR (95% CI)	7/1/2018 – 12/1/2019 and 7/1/2020 – 6/30/2021 OR (95% CI)
Vascular or circulatory disease (CC 106 – 109)	1.26 (1.12 – 1.42)	1.10 (0.90 – 1.33)	1.27 (1.12 – 1.44)	1.24 (1.15 – 1.34)
Chronic obstructive pulmonary disease (COPD) (CC 111)	1.36 (1.19 – 1.54)	1.35 (1.10 – 1.67)	1.35 (1.18 – 1.55)	1.34 (1.23 – 1.46)
Pneumonia (CC 114 – 116)	1.19 (1.01 – 1.39)	0.97 (0.74 – 1.28)	1.14 (0.95 – 1.38)	1.12 (1.00 – 1.25)
Dialysis status (CC 134)	2.05 (1.62 – 2.59)	2.26 (1.57 – 3.27)	2.14 (1.68 – 2.75)	2.16 (1.85 – 2.52)
Renal failure (CC 135 – 140)	1.51 (1.34 – 1.71)	1.81 (1.48 – 2.21)	1.53 (1.34 – 1.74)	1.57 (1.44 – 1.70)
Decubitus ulcer or chronic skin ulcer (CC 157 – 161)	1.19 (0.93 – 1.53)	1.23 (0.83 – 1.83)	1.17 (0.88 – 1.55)	1.18 (1.00 – 1.40)

Table 4.2.4 — CABG Surgery Generalized Linear Modeling (Logistic Regression) Performance over Different Time Periods

Characteristic	7/1/2018 – 6/30/2019	7/1/2019 – 12/1/2019	7/1/2020 – 6/30/2021	7/1/2018 – 12/1/2019 and 7/1/2020 – 6/30/2021
Predictive ability% (lowest decile – highest decile)	0.6 – 9.9	0.4 – 9.6	0.4 – 10.5	0.6 – 10.0
c-statistic	0.74	0.74	0.73	0.74

Table 4.2.5 — Distribution of Hospital CABG Surgery Admission Volumes over Different Time Periods

Characteristic	7/1/2018 – 6/30/2019	7/1/2019 – 12/1/2019	7/1/2020 – 6/30/2021	7/1/2018 – 12/1/2019 and 7/1/2020 – 6/30/2021
Number of hospitals	1,096	1,042	1,042	1,128
Mean number of admissions (SD)	40.5 (36.2)	17.8 (15.8)	35.6 (30.9)	88.7 (81.3)
Range (min. – max.)	1 – 274	1 – 108	1 – 242	1 – 596
25^{th} percentile	15	7	14	32
50^{th} percentile	32	13	27	68
75^{th} percentile	53	24	47	118

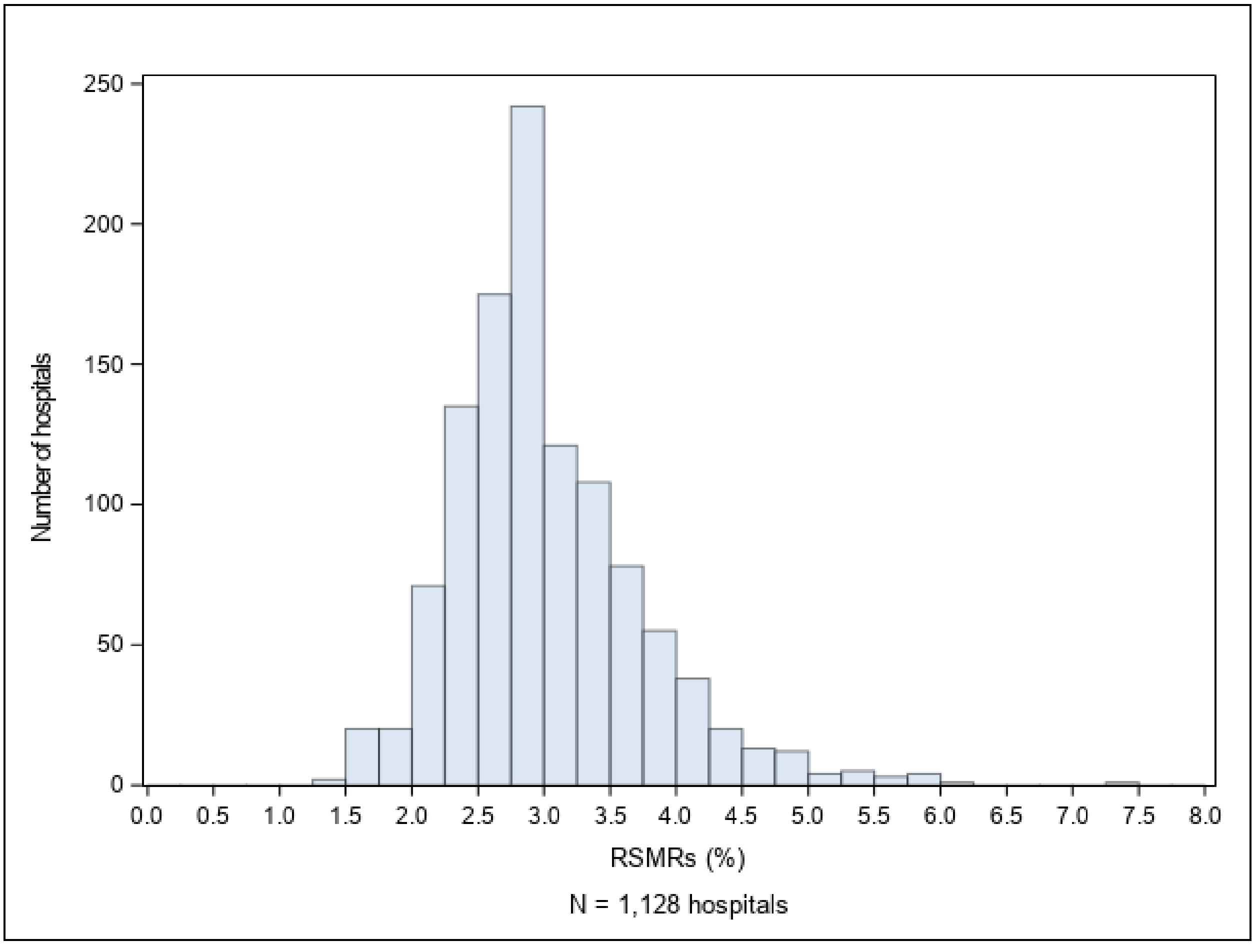
Table 4.2.6 — Distribution of Hospital CABG Surgery RSMRs over Different Time Periods

Characteristic	7/1/2018 – 6/30/2019	7/1/2019 – 12/1/2019	7/1/2020 – 6/30/2021	7/1/2018 – 12/1/2019 and 7/1/2020 – 6/30/2021
Number of hospitals	1,096	1,042	1,042	1,128
Mean (SD)	2.9 (0.6)	2.7 (0.5)	3.2 (0.6)	3.0 (0.7)
Range (min. – max.)	1.5 – 6.2	1.6 – 5.7	1.7 – 6.7	1.4 – 7.3
25th percentile	2.6	2.4	2.8	2.6
50th percentile	2.8	2.6	3.1	2.9
75th percentile	3.2	2.8	3.5	3.4

Table 4.2.7 — Between-Hospital Variance for CABG Surgery over Different Time Periods

Characteristic	7/1/2018 – 6/30/2019	7/1/2019 – 12/1/2019	7/1/2020 – 6/30/2021	7/1/2018 – 12/1/2019 and 7/1/2020 – 6/30/2021
Between-hospital variance (SE)	0.218 (0.044)	0.296 (0.092)	0.213 (0.046)	0.206 (0.026)

Figure 4.2.2 — Distribution of Hospital 30-Day CABG Surgery RSMRs between July 1, 2018 and June 30, 2021 (excluding December 2, 2019 through June 30, 2020)



5. GLOSSARY

Acute care hospital: A hospital that provides inpatient medical care for surgery and acute medical conditions or injuries. Short-term acute care hospitals provide care for short-term illnesses and conditions. In contrast, long-term acute care hospitals generally treat medically complex patients who require long-stay hospital-level care, which is generally defined as an inpatient length of stay more than 25 days.

Bootstrapping: The bootstrap is a computer-based method for estimating the standard error of an estimate when the estimate is based on a sample with an unknown probability distribution. Bootstrap methods depend on the bootstrap sample, which is a random sample of size *n* drawn with replacement from the population of *n* objects. The bootstrap algorithm works by drawing many independent bootstrap samples, evaluating the corresponding bootstrap replications, and estimating the standard error of the statistic by the empirical SD of the replications.

C-statistic: An indicator of the model's discriminant ability or ability to correctly classify those patients who have and have not died within 30 days of the procedure date. Potential values range from 0.5, meaning no better than chance, to 1.0, an indication of perfect prediction. Perfect prediction implies that patients' outcomes can be predicted completely by their risk factors, and physicians and hospitals play no role in their patients' outcomes.

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

Cohort: The index admissions used to calculate the measure after inclusion and exclusion criteria have been applied.

Comorbidities: Medical conditions the patient had in addition to their 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-10-CM diagnosis codes into clinically relevant categories, from the HCC system.[9,10] CMS uses modified groupings, but not the hierarchical logic of the system, to create risk factor variables. Mappings which show the assignment of ICD-10 codes to the CCs are available here on *QualityNet*.

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 mortality (or Expected deaths): The number of deaths expected based on average hospital performance with a given hospital's case mix.

Hierarchical Generalized Linear Model (HGLM): A widely accepted statistical method that enables fair evaluation of relative hospital performance by accounting for patient risk factors. This statistical model accounts for the hierarchical structure of the data (patients clustered within hospitals are assumed to be correlated) and accommodates modeling of the association between outcomes and patient characteristics. Based on the hierarchical model, we can evaluate:

- how much variation in hospital mortality rates overall is accounted for by patients' individual risk factors (such as age and other medical conditions); and
- how much variation is accounted for by hospital contribution to mortality risk.

A hierarchical logistic regression model is a type of HGLM used for binary outcomes.

Hospital-specific effect: A measure of a hospital's quality of care calculated using hierarchical logistic regression, taking into consideration the number of patients who are eligible for the cohort, these patients' risk factors, and the number who die. The hospital-specific effect is the calculated random effect intercept for each hospital. A hospital-specific effect less than the average hospital-specific effect indicates the hospital performed better on the measure than the average hospital with the same case mix, a hospital-specific effect greater than the average hospital-specific effect indicates the hospital performed worse than average, and a hospital-specific effect near the average hospital-specific effect indicates about average performance. The hospital-specific effect is used in the numerator to calculate "predicted" mortality.

Index admission: Any admission included in the measure calculation as the initial admission for an episode of CABG surgery 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 associated uncertainty. For example, a 95% interval estimate for a mortality rate indicates there is 95% confidence 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 directly from Medicare for each individual service provided. Patients in managed care (Medicare Advantage) are excluded from the measure.

National observed mortality 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-adjustment variable present relative to those without the risk-adjustment variable present. The model coefficient for each risk-adjustment 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 CABG surgery mortality measure, the outcome is mortality within 30 days of the procedure date.

Predicted mortality (or Predicted deaths): The number of deaths within 30 days predicted based on the hospital's performance with its observed case mix, also referred to as "adjusted actual" mortality.

Predictive ability: An indicator of the model's discriminant ability or ability to distinguish high-risk subjects from low-risk subjects. A wide range between the lowest decile and highest decile suggests better discrimination.

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

6. REFERENCES

1. Dharmarajan K, Hsieh AF, Kulkarni VT, et al. Trajectories of risk after hospitalization for heart failure, acute myocardial infarction, or pneumonia: retrospective cohort study. *BMJ.* 2015;350:h411.
2. Drye EE, Normand S-LT, Wang Y, et al. Comparison of hospital risk-standardized mortality rates calculated by using in-hospital and 30-day models: an observational study with implications for hospital profiling. *Ann Intern Med.* 2012;156(1 Pt 1):19-26.
3. Normand S-LT, Shahian DM. Statistical and clinical aspects of hospital outcomes profiling. *Statist Sci.* 2007;22(2):206-226.
4. Centers for Medicare & Medicaid Services (CMS). CMS Announces Relief for Clinicians, Providers, Hospitals and Facilities Participating in Quality Reporting Programs in Response to COVID-19. 2020; https://www.cms.gov/Newsroom/Press-Releases/Cms-Announces-Relief-Clinicians-Providers-Hospitals-And-Facilities-Participating-Quality-Reporting. Accessed March 3, 2022.
5. Centers for Medicare & Medicaid Services (CMS). COVID-19 Quality Reporting Programs Guidance Memo. 2020; https://www.cms.gov/files/document/guidance-memo-exceptions-and-extensions-quality-reporting-and-value-based-purchasing-programs.pdf. Accessed March 3, 2022.
6. Hospital Inpatient Value, Incentives, and Quality Reporting Outreach and Education Support Contractor (Health Services Advisory Group, Inc.). CMS Announces Updates on Hospital Quality Reporting and Value-based Payment Programs due to the COVID-19 Public Health Emergency. 2020; https://qualitynet.cms.gov/files/5f0707a3b8112700239dca19?filename=2020-62-IP.pdf. Accessed March 3, 2022.
7. Centers for Medicare & Medicaid Services (CMS). Frequently Asked Questions: COVID-19 Extraordinary Circumstances Exception for Inpatient Acute Care Hospitals. 2020; https://qualitynet.cms.gov/files/5f6d198d4ac8370021c54179?filename=HQR_FAQs_092420.pdf. Accessed March 3, 2022.
8. Triche EW, Xin X, Stackland S, et al. Incorporating Present-on-Admission Indicators in Medicare Claims to Inform Hospital Quality Measure Risk Adjustment Models. *JAMA Netw Open.* 2021;4(5):e218512.
9. Pope GC, Ellis RP, Ash AS, et al. Diagnostic cost group hierarchical condition category models for Medicare risk adjustment. *Final Report to the Health Care Financing Administration under Contract Number 500-95-048*. 2000; http://www.cms.hhs.gov/Reports/downloads/pope_2000_2.pdf. Accessed March 4, 2022.
10. Pope GC, Kautter J, Ingber MJ, et al. Evaluation of the CMS-HCC Risk Adjustment Model: Final Report. 2011; https://www.cms.gov/Medicare/Health-Plans/MedicareAdvtgSpecRateStats/downloads/evaluation_risk_adj_model_2011.pdf. Accessed March 3, 2022.
11. Daniels MJ, Gatsonis C. Hierarchical generalized linear models in the analysis of variations in health care utilization. *J Am Stat Assoc.* 1999;94(445):29-42.
12. Normand S-LT, Wang Y, Krumholz HM. Assessing surrogacy of data sources for institutional comparisons. *Methodol.* 2007;7(1-2):79-96.

7. APPENDICES

Appendix A. Statistical Approach for CABG Surgery Measure

The CABG surgery measure uses a hierarchical generalized linear model (HGLM) to estimate RSMRs for hospitals. This modeling approach accounts for the within-hospital correlation of the observed outcome and accommodates the assumption that underlying differences in quality across hospitals lead to systematic differences in outcomes.

In the CABG surgery measure, an HGLM model is estimated. Then for each hospital, a standardized mortality ratio (SMR) is calculated. The RSMR is calculated by multiplying the SMR for each hospital by the national observed mortality rate.

Hierarchical Generalized Linear Model

We fit an HGLM, which accounts for clustering of observations within hospitals. We assume the outcome has a known exponential family distribution and relates linearly to the covariates via a known link function, *h*. Specifically, we assume a binomial distribution and a logit link function. Further, we account for the clustering within hospitals by estimating a hospital-specific effect, α_i, which we assume follows a normal distribution with a mean μ and variance τ^2, the between-hospital variance component. The following equation defines the HGLM:

$$h\left(\Pr\left(Y_{ij} = 1 \middle| \boldsymbol{Z}_{ij} - \omega_i\right)\right) = log\left(\frac{\Pr\left(Y_{ij}=1|\boldsymbol{Z}_{ij}-\omega_i\right)}{1-\Pr\left(Y_{ij}=1|\boldsymbol{Z}_{ij}-\omega_i\right)}\right) = \alpha_i + \boldsymbol{\beta Z}_{ij} \qquad (1)$$

where $\alpha_i = \mu + \omega_i;\ \omega_i \sim N(0 - \tau^2)$

i=1,…,I; j=1,…,n_i

where Y_{ij} denotes the outcome (equal to 1 if the patient dies within 30 days, 0 otherwise) for the *j-th* patient at the *i-th* hospital; $Z_{ij} = \left(Z_{ij1} - Z_{ij2} - \ldots - Z_{ijp}\right)^T$ is a set of *p* patient-specific covariates derived from the data; and *I* denotes the total number of hospitals and n_i denotes the number of index admissions at hospital *i*. The hospital-specific intercept of the *i-th* hospital, α_i, defined above, comprises μ, the adjusted average intercept over all hospitals in the sample, and ω_i, the hospital-specific intercept deviation from μ.[11]

We estimate the HGLM using the SAS software system (GLIMMIX procedure).

Risk-Standardized Measure Score Calculation

Using the HGLM defined by Equation (1), to obtain the parameter estimates $\hat{\mu}$, $\{\hat{\alpha}_1, \hat{\alpha}_2, \ldots, \hat{\alpha}_I\}$, $\widehat{\boldsymbol{\beta}}$, and $\hat{\tau}^2$, we calculate an SMR, $\hat{s}_i$, for each hospital by computing the ratio of the number of predicted deaths to the number of expected deaths. Specifically, we calculate:

$$\text{Predicted Value: } \hat{p}_{ij} = h^{-1}\left(\hat{\alpha}_i + \widehat{\boldsymbol{\beta}}\boldsymbol{Z}_{ij}\right) = \frac{\exp\left(\hat{\alpha}_i + \widehat{\boldsymbol{\beta}}\boldsymbol{Z}_{ij}\right)}{\exp\left(\hat{\alpha}_i + \widehat{\boldsymbol{\beta}}\boldsymbol{Z}_{ij}\right)+1} \qquad (2)$$

$$\text{Expected Value: } \hat{e}_{ij} = h^{-1}\left(\hat{\mu} + \widehat{\boldsymbol{\beta}}\boldsymbol{Z}_{ij}\right) = \frac{\exp\left(\hat{\mu}+\widehat{\boldsymbol{\beta}}\boldsymbol{Z}_{ij}\right)}{\exp\left(\hat{\mu}+\widehat{\boldsymbol{\beta}}\boldsymbol{Z}_{ij}\right)+1} \quad (3)$$

$$\text{Standardized Mortality Ratio: } \hat{s}_i = \frac{\sum_{j=1}^{n_i} \hat{p}_{ij}}{\sum_{j=1}^{n_i} \hat{e}_{ij}} \quad (4)$$

We calculate an RSMR, $\widehat{RSMR}_i$, for each hospital by using the estimate from Equation (4) and multiplying by the national observed mortality rate, denoted by $\bar{y}$. Specifically, we calculate:

$$\text{Risk-Standardized Mortality Rate: } \widehat{RSMR}_i = \hat{s}_i \times \bar{y} \quad (5)$$

Creating Interval Estimates

The measure score is a complex function of parameter estimates; therefore, we use re-sampling and simulation techniques to derive an interval estimate to determine if a hospital is performing better than, worse than, or no different than expected. A hospital is considered better than expected if the upper bound of their CI falls below the national observed mortality rate, $\bar{y}$, and considered worse if the lower bound of their CI falls above $\bar{y}$. A hospital is considered no different than expected if the CI overlaps $\bar{y}$.

More specifically, we use bootstrapping procedures to compute the CIs. Because the theoretical-based standard errors are not easily derived, and to avoid making unnecessary assumptions, we use the bootstrap to empirically construct the sampling distribution for each hospital risk-standardized ratio. The bootstrapping algorithm is described below.

Bootstrapping Algorithm

Let *I* denote the total number of hospitals in the sample. We repeat steps 1 – 4 below for b = 1,2,…B times:

1. Sample *I* hospitals with replacement.
2. Fit the HGLM defined by Equation (1) using all patients within each sampled hospital. The starting values are the parameter estimates obtained by fitting the model to all hospitals. If some hospitals are selected more than once in a bootstrapped sample, we treat them as distinct so that we have *I* random effects to estimate the variance components. After Step 2, we have:
    a. The estimated regression coefficients of the risk factors, $\widehat{\boldsymbol{\beta}}^{(b)}$.
    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, $\left\{\hat{\alpha}_i^{(b)}, v\hat{a}r\left(\alpha_i^{(b)}\right); i = 1,2,\ldots,I\right\}$.
3. We generate a hospital random effect by sampling from the distribution of the hospital-specific distribution obtained in Step 2c. We approximate the distribution for each random effect by a normal distribution. Thus, we draw $\alpha_i^{(b*)} \sim N(\hat{\alpha}_i^{(b)} - v\hat{a}r\left(\alpha_i^{(b)}\right))$ 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 $\hat{p}_{ij}^{(b)}$, $\hat{e}_{ij}^{(b)}$, and $\hat{s}_i^{(b)}$ where $\widehat{\boldsymbol{\beta}}^{(b)}$ and $\hat{\mu}^{(b)}$ are obtained from Step 2 and $\alpha_i^{(b*)}$ 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 a large selected number of estimates for all hospitals (or the percentiles corresponding to the alternative desired intervals).[12]

Appendix B. Data QA

This production year required updates to the SAS pack to account for updates in ICD-10 codes and associated mappings of clinical groupers.

This section represents QA for the subset of the work YNHHSC/CORE conducted to maintain and report the CABG surgery mortality measure. It does not describe the QA for processing data and creating the input files, nor does it include the QA for the final processing of production data for public reporting, because another contractor conducts that work.

To assure the quality of measure output, we utilize a multi-phase approach to QA of the CABG surgery mortality measure.

Phase I

As the first step in the QA process, we review changes in the cohort definition as determined by the measure-specific code set files that were updated to account for changes in ICD-10 coding. This includes updates to the HCC clinical category maps.

In general, we use both manual scan and descriptive analyses to conduct data validity checks, including cross-checking mortality information, distributions of ICD-10 codes, and frequencies of key variables.

Phase II

We update the existing SAS pack to accommodate the new codes and updates to the measure. To assure accuracy in SAS pack coding, two analysts independently write SAS code for any major changes made in calculating the CABG surgery mortality measure: data preparation, sample selection, hierarchical modeling, and calculation of RSMRs. 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 III

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 when needed.

During this phase, we also compare 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. Anything that seems outside of normal coding fluctuation is further reviewed in more detail.

Appendix C. Annual Updates

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

2022

2022 Measure Updates and Specifications Report (Version 9.0 — CABG)

- Updated the ICD-10 code-based specifications used in the measure — Specifically, we:
  - incorporated the code changes that occurred in the ICD-10-CM/PCS code set releases since 2021 public reporting (namely, April 1, 2020; August 1, 2020; October 1, 2020 [FY 2021]; and January 1, 2021) into the cohort definition and risk model;
  - applied a modified version of the FY 2021 V24 CMS-HCC crosswalk that is maintained by RTI International to the risk model; and
  - made additional code specification changes prompted by the activities described in Section 3.1.
    - Rationale: Revisions to the measure specifications were warranted to accommodate updated versions of the ICD-10-CM/PCS and CMS-HCC crosswalk as well as the workgroup review activities.
- Adjusted specifications and methodology for the measure in response to the COVID-19 PHE — Specifically, we:
  - removed COVID-19 index admissions from the cohort;
  - added a new 'History of COVID-19' risk variable to the risk-adjustment model;
  - shortened the measurement period for 2022 public reporting to approximately 29 months (from the typical three-year measurement period), similar to 2021 public reporting; and
  - reduced the look-back period for use of claims data in risk adjustment to less than 12 months (from the typical 12 months) for those patients whose 12-month period included any portion of the January 1, 2020 – June 30, 2020 claims exclusion time frame.
    - Rationale: The COVID-19 PHE continues to have significant and enduring effects on the provision of medical care in the country and around the world. Adjustments to measure specifications and methodology for 2022 help to ensure the intent of the measure is maintained. The measurement period and look-back period reductions (in certain cases) are in response to CMS's decision to exclude claims data for January 1, 2020 – June 30, 2020 (Q1 and Q2 of 2020) under its ECE policy.
- Added a POA algorithm to the risk-adjustment methodology used to pull CC-defined risk-adjustment variables from the index admission claim.
  - Rationale: POA coding is a logical reflection of comorbidities. POA indicators more accurately distinguish complications of care from conditions already present at admission, in comparison to the previous methodology that utilized only the potential complications list.[8] Additionally, use of POA indicators helps particularly in cases where a patient has not been hospitalized or had provider visits in the last year or where a comorbid condition present at the time of admission is relatively new.

2021

2021 Measure Updates and Specifications Report (Version 8.0 — CABG)

- Updated the ICD-10 code-based specifications used in the measure — Specifically, we:

  - incorporated the code changes that occurred in the FY 2020 version of the ICD-10-CM/PCS (effective with October 1, 2019+ discharges) into the cohort definition and risk model;
  - applied a modified version of the FY 2020 V24 CMS-HCC crosswalk that is maintained by RTI International to the risk model; and
  - made additional code specification changes prompted by other workgroup activities, including code frequency monitoring, review of select pre-existing ICD-10 code specifications, and neighboring code searches.
    - Rationale: Revisions to the measure specifications were warranted to accommodate updated versions of the ICD-10-CM/PCS and CMS-HCC crosswalk as well as the workgroup review activities.
- Shortened the measurement period for 2021 public reporting to approximately 29 months (from the typical three-year measurement period)
  - Rationale: The measurement period reduction is in response to the COVID-19 PHE and CMS's decision to exclude claims data for January 1, 2020 – June 30, 2020 (Q1 and Q2 of 2020) under its ECE policy.
- Removed International Classification of Diseases, Ninth Revision (ICD-9) code-based specifications from the measure and SAS pack
  - Rationale: The Medicare claims for the measurement period of July 1, 2017 – December 1, 2019 are completely ICD-10 code-based. 2020 public reporting was the last year that warranted any ICD-9 code specifications.

2020

2020 Measure Updates and Specifications Report (Version 7.0 — CABG)

- Updated the ICD-10 code-based specifications used in the measure — Specifically, we:
  - incorporated the code changes that occurred in the FY 2019 version of the ICD-10-CM/PCS (effective with October 1, 2018+ discharges) into the cohort definition and risk model;
  - applied a modified version of the FY 2019 V22 CMS-HCC crosswalk that is maintained by RTI International to the risk model; and
  - made additional code specification changes prompted by other workgroup activities, including code frequency monitoring, review of select pre-existing ICD-10 code specifications, and neighboring code searches.
    - Rationale: Revisions to the measure specifications were warranted to accommodate updated versions of the ICD-10-CM/PCS and CMS-HCC crosswalk as well as the workgroup review activities.

2019

2019 Measure Updates and Specifications Report (Version 6.0 — CABG)

- Updated the ICD-10 code-based specifications used in the measure — Specifically, we:
  - incorporated the code changes that occurred in the FY 2018 version of the ICD-10-CM/PCS (effective with October 1, 2017+ discharges) into the cohort definition and risk model;
  - applied a modified version of the FY 2018 V22 CMS-HCC crosswalk that is maintained by RTI International to the risk model; and
  - made additional code specification changes prompted by other workgroup activities, including code frequency monitoring, review of select pre-existing ICD-10 code specifications, and neighboring code searches. For example, ICD-10-PCS code 021W0JG, Bypass Thoracic Aorta, Descending to Axillary Artery with Synthetic Substitute, Open Approach, was identified through a "neighboring code search" (found near existing code 021W0JD, Bypass Thoracic Aorta, Descending to Carotid with Synthetic Substitute, Open Approach) and determined through

clinical review to be a code which meets measure intent. As a result, it was added to the CABG cohort exclusion list.
        - Rationale: Revisions to the measure specifications were warranted to accommodate updated versions of the ICD-10-CM/PCS and CMS-HCC crosswalk as well as the workgroup review activities.
- A POA code requirement on the index admission claim was added to the 'Cardiogenic shock' risk-adjustment variable (for discharges prior to October 1, 2015 as well as discharges on or after October 1, 2015).
    - Rationale: Revision was made per clinical expert recommendation.

2018

2018 Measure Updates and Specifications Report (Version 5.0 — CABG)

- Updated the ICD-10 code-based specifications used in the measure — Specifically, we:
    - incorporated the code changes that occurred in the FY 2017 version of the ICD-10-CM/PCS into the cohort definition and risk model;
    - applied the FY 2017 version of the V22 CMS-HCC crosswalk maintained by RTI International to the risk model; and
    - monitored code frequencies to identify any code specification changes warranted due to possible changes in coding practices and patterns. Additionally, our clinical and measure experts reviewed the pre-existing ICD-10 code-based specifications to confirm the appropriateness of the specifications unaffected by the updates.
        - Rationale: Updated versions of the ICD-10-CM/PCS and CMS-HCC crosswalk were released. Revisions to the measure specifications were warranted to accommodate these updates.

2017

2017 Measure Updates and Specifications Report (Version 4.0 — CABG)

- Revised the measure specifications to accommodate the implementation of ICD-10 coding — Specifically, we:
    - identified the ICD-10 codes used to define the measure cohort for discharges on or after October 1, 2015; and
    - re-specified the risk model, updating the CC-based risk variables to the ICD-10-compatible HCC system version 22 and applying ICD-10 codes for certain risk variables (for example, 'History of percutaneous transluminal coronary angioplasty (PTCA)') to the model.
        - Rationale: The ICD-9 code sets used to report medical diagnoses and inpatient procedures were replaced by ICD-10 code sets on October 1, 2015. The U.S. Department of Health and Human Services (HHS) mandated that ICD-10 codes be used for medical coding, effective with October 1, 2015 discharges. The measurement period for 2017 public reporting required data from claims that include ICD-10 codes in addition to data from claims that include ICD-9 codes. Thus, re-specification was warranted to accommodate ICD-10 coding.

2016

2016 Measure Updates and Specifications Report (Version 3.0 — CABG)

- The exclusion criterion that addresses multiple CABG surgery admissions in a measurement period was corrected in the cohort exclusion descriptions and re-coded in the 2016 version of the SAS code.
    - Rationale: The 2015 updates and specifications report and the original methodology report incorrectly described the handling of multiple CABG surgery cases as a process where one CABG surgery admission is randomly selected per patient per year. This is discordant with the intentions of the measure development team to select the first CABG surgery admission for any

patient with more than one CABG surgery within the measurement period and exclude the subsequent CABG surgery admissions. This error also existed in the SAS code prior to 2016. Analyses of the impact of this error demonstrated that these cases were extremely rare, and that recalculations were not warranted, as national results and overall measure performance rates would not change.

2015

2015 Measure Updates and Specifications Report (Version 2.0 — CABG)

No updates were made to the specifications of the CABG surgery mortality measure for 2015 public reporting.

Appendix D. Measure Specifications

Appendix D.1 Hospital-Level 30-Day RSMR following CABG Surgery (NQF #2558)

<u>Cohort</u>

Inclusion Criteria for CABG Surgery Measure

- **Enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission and Part A during the index admission**
  - Rationale: The 12-month Part A and Part B prior enrollment criterion ensures that the comorbidity data used in risk adjustment can be captured from inpatient, outpatient, and physician claims data for up to 12 months prior to the index admission, to augment the index admission claim itself. Medicare Part A during the index admission is required to ensure Medicare FFS enrollment at the time of admission.
- **Aged 65 or over**
  - Rationale: Patients younger than 65 are not included in the measure because they are considered to be too clinically distinct from patients 65 or over.
- **Having a qualifying isolated CABG procedure during the index admission**
  - Rationale: Isolated CABG surgery is the procedure targeted for measurement. Isolated CABG procedures are defined as those CABG procedures performed without concomitant valve or other major cardiac, vascular, or thoracic procedures, because they represent a population of patients with higher risk. These procedure groups include:
    - valve procedures;
    - atrial and/or ventricular septal defects;
    - congenital anomalies;
    - other open cardiac procedures;
    - heart transplants;
    - aorta or other non-cardiac arterial bypass procedures;
    - head, neck, intracranial vascular procedures; and
    - other chest and thoracic procedures.

Exclusion Criteria for CABG Surgery Measure

- **Inconsistent or unknown vital status or other unreliable demographic data**
  - Rationale: We do not include stays for patients where the age is greater than 115, where the gender is neither male nor female, where the admission date is after the date of death in the Medicare Enrollment Database, or where the date of death occurs before the date of discharge but the patient was discharged alive.
- **Discharged against medical advice**
  - Rationale: Providers did not have the opportunity to deliver full care and prepare the patient for discharge.
- **Admissions for subsequent qualifying CABG procedures during the measurement period**
  - Rationale: CABG procedures are expected to last for several years without the need for revision or repeat revascularization. A repeat CABG procedure during the measurement period likely represents a complication of the original CABG procedure and is a clinically more complex and higher risk surgery. Therefore, we select the first CABG surgery

admission for inclusion in the measure and exclude subsequent CABG surgery admissions from the cohort.

- **With a principal diagnosis code of COVID-19 or with a secondary diagnosis code of COVID-19 coded as POA on the index admission claim**
  - Rationale: COVID-19 patients are removed from the CABG surgery cohort in response to the COVID-19 PHE, and to maintain alignment with the CABG surgery mortality measure included in the FY 2023 Hospital VBP Program.

The ICD-10 codes used to define the CABG surgery cohort are outlined in the 2022 CABG Surgery Mortality Measure Code Specifications supplemental file posted here on *QualityNet*.

Outcome

Outcome Criteria for CABG Surgery Measure

Death, from any cause, within 30 days from the index admission
Rationale: From a patient's perspective, death is a critical outcome regardless of cause. Outcomes occurring within 30 days of the procedure date can be influenced by hospital care and early transition to the non-acute care setting. The 30-day time frame is a clinically meaningful period for hospitals to collaborate with their communities to reduce mortality.