2015 Procedure-Specific Mortality Measure Updates and Specifications Report

Isolated Coronary Artery Bypass Graft (CABG) Surgery – Version 2.0

Submitted By:

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1. HOW TO USE THIS REPORT

This report describes the Centers for Medicare & Medicaid Services' (CMS) procedure-specific mortality measure publicly reported on *Hospital Compare*, the hospital-level 30-day risk-standardized mortality rate (RSMR) following isolated coronary artery bypass graft (CABG) surgery. This report provides a single source of information about the measure for a wide range of readers. Reports describing condition-specific readmission and mortality outcomes (acute myocardial infarction [AMI], heart failure [HF], and pneumonia), hospital-wide readmissions, procedure-specific readmission and complication measures (hip/knee arthroplasty and CABG), and 30-day episode-of-care payment measures for AMI, HF, and pneumonia can be found on *QualityNet.*

This report provides an overview of the measure methodology, methodology updates for 2015 public reporting, and the national results for 2015 public reporting. The appendices provide detailed specifications for the measure, including tables of the condition codes used for cohort derivation, and risk adjustment.

Specifically, the report includes:

- **Section 2 - An overview of the CABG 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 score

- **Section 3 - 2015 measure updates:**
  - No updates were made to the specifications of the CABG mortality measure for 2015.

- **Section 4 - 2015 measure results**:
  - Results from the model used for public reporting on *Hospital Compare* in 2015.

- **Section 5 - Glossary**

The Appendices contain detailed measure information, including:

- Appendix A: Statistical approach to calculating RSMRs;
- Appendix B: Data quality assurance;
- Appendix C: Annual updates to measures since measure development; and
- Appendix D: Measure specifications.

For additional references, the original CABG measure methodology report is available on the Measure Methodology section under the claims-based mortality measures page of *QualityNet*:

- Hospital-Level 30-Day All-Cause Mortality Following Coronary Artery Bypass Graft Surgery Measure Technical Report[1]

2. BACKGROUND AND OVERVIEW OF MEASURE METHODOLOGY

2.1 Background on Mortality Measures

In 2015, CMS plans to report the Hospital 30-Day Coronary Artery Bypass Graft (CABG) Surgery All-Cause Mortality measure. This measure includes admissions to non-federal acute care and critical access hospitals.

The mortality measure complements the 30-day readmission measure that CMS plans to report for CABG.[1] Results for these measures will be posted on *Hospital Compare*, which CMS updates annually.

CMS contracted with the Yale-New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (CORE) to update the 30-day CABG mortality measure for 2015 public reporting through a process of measure reevaluation. Measures are reevaluated annually to improve them by responding to stakeholder input and incorporating advances in science or changes in coding.

2.2 Overview of Measure Methodology

The 2015 risk-adjusted mortality measure uses specifications from the initial measure methodology report.[1] The National Quality Forum (NQF) endorsed the CABG measure. An overview of the methodology is presented in this section.

2.2.1 Cohort

Index Admissions Included in Measures

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);
- Aged 65 or over; and
- Enrolled in Part A and Part B Medicare for the 12 months prior to the date of admission, and enrolled in Part A during the index admission;

Isolated CABG surgeries are defined as those 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; or
- Head, neck, intracranial vascular procedures.

International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes used to define the cohort for each measure are listed in Appendix D.

Index Admissions Excluded from the Measure

The CABG mortality measure excludes index admission for patients:

- With inconsistent or unknown vital status or other unreliable demographic (age and gender) data; or
- Discharged against medical advice (AMA).

For patients with more than one admission in a given year for a given condition, only one index admission for that condition is randomly selected for inclusion in 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, and stays for patients not listed in the Medicare enrollment database as well as records for providers with invalid provider IDs.

For index admissions that occur during the transition between measure reporting periods, June and July of each year, the measures include admissions only if they were the first to occur in the 30 days prior to a patient's death. Additional admissions in that 30-day period are excluded. This exclusion criterion is applied after one admission per patient per year is randomly selected to avoid assigning a single death to two admissions in two separate reporting periods. For example, for a patient who is admitted on June 18, 2012, readmitted on July 2, 2012, and who subsequently dies on July 15, 2012: if both admissions are randomly selected for inclusion (one for the July 2011-June 2012 time period and the other for the July 2012-June 2013 time period), the measure will exclude the July 2, 2012, admission to avoid assigning the death to two admissions.

The number of admissions excluded based on each criterion is shown in Section 4 in Figure 4.2.1– CABG Cohort .

Patients Transferred Between Hospitals

Following an index CABG surgery, transfer to another acute care facility after CABG is most likely due to a complication of the CABG procedure or the peri-operative 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 hospitals for their CABG surgery. Therefore, for the CABG mortality measure, the mortality outcome is attributed to the hospital performing the first ("index") CABG, regardless of whether the patient is transferred in to that admission or transferred out. This is somewhat different than the other mortality measures that always consider the first hospitalization as the index

admission. The measure identifies transferred patients as those who are admitted to an acute care hospital on the same day or following day of discharge from an eligible admission.

2.2.2 Outcome

All-Cause Mortality

There are a number of reasons for counting all deaths in the CMS mortality measures. First, from a patient perspective, a death from any cause is an adverse event. In addition, making inferences about quality issues and accountability based solely on the documented cause of death is difficult. For example, a patient hospitalized with HF 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 HF during the index admission would be inappropriate.

30-Day Time Frame

The measure assess mortality within a 30-day period from the procedure date. We chose to use the procedure date because some patients who undergo CABG surgery might be admitted on the days before the procedure date. This standard time period is necessary so that the outcome for each patient is measure uniformly. Data from 2009 Medicare FFS patients demonstrates that 25% of CABG procedures occurred more than three days after the admission date. Therefore, dating the measurement period from admission would potentially underestimate the period of risk for a substantial number of hospitals.

The use of 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

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

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

The measure does not adjust for the patients' admission source or their discharge disposition (e.g., skilled nursing facility) because these factors are associated with the structure of the healthcare system, not solely patients' clinical comorbidities. Regional

differences in the availability of post-acute care providers and practice patterns might exert an undue influence on model results.

The measure also does not adjust for socioeconomic status (SES) because the association between SES and health outcomes can be due, in part, to differences in the quality of healthcare groups of patients with varying SES receive. The intent is for the measures to adjust for patient demographic and clinical characteristics while illuminating important quality differences. Additionally, recent analyses have shown that hospitals caring for high proportions of low SES patients perform similarly on the measures to hospitals caring for low proportions of low SES patients.[3]

Refer to Table D.1.2 in Appendix D of this report for the list of comorbidity risk adjustment variables and Table D.1.3 in Appendix D of this report for the list of complications that are excluded from risk adjustment if occurring during the index admission.

2.2.4 Data Sources

The data sources for these analyses are Medicare administrative claims data and enrollment information for patients with inpatient admissions between July 1, 2011 and June 30, 2014. The datasets also contain associated inpatient, outpatient, and provider Medicare administrative claims for the 12 months prior to the index admission for patients admitted in this time period. See the original methodology reports for further descriptions of these data sources and an explanation of the three-year measurement period.[1]

2.2.5 Measure Calculation

The measures estimate hospital-level 30-day all-cause RSMR for CABG 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.[4] 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 intercept. At the hospital level, it models the hospital-specific intercepts as arising from a normal distribution. The hospital intercept represents the underlying risk of mortality at the hospital, after accounting for patient risk. The hospital-specific intercepts are given a distribution to account for the clustering (non-independence) of patients within the same hospital. If there were no differences among hospitals, then after adjusting for patient risk, the hospital intercepts 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, and 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 D.1.2) and the hospital-specific intercept on the risk of mortality. The estimated hospital-specific intercept is added to the sum of the estimated regression coefficients multiplied by the patient characteristics. The results are transformed and summed over all patients attributed to a hospital to get a predicted value. The "expected" number of deaths (the denominator) is obtained in the same manner, but a common intercept using all hospitals in our sample is added in place of the hospital-specific intercept. The results are transformed and summed over all patients in the hospital to get an expected value. To assess hospital performance for each reporting period, we re-estimate the model coefficients using the years of data in that period.

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

2.2.6 Categorizing Hospital Performance

To categorize hospital performance, CMS estimates each hospital's 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:

- "No different than U.S. national rate" if the 95% interval estimate surrounding the hospital's rate includes the national observed mortality rate;
- "Worse than U.S. national rate" if the entire 95% interval estimate surrounding the hospital's rate is higher than the national observed mortality rate; or
- "Better than U.S. national rate" if the entire 95% interval estimate surrounding the hospital's rate is lower 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: "The number of cases is too small (fewer than 25) to reliably tell how well the hospital is performing." If a hospital has fewer than 25 eligible cases, the hospital's mortality rates and interval estimates will not be publicly reported for the measure.

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

3. UPDATES TO MEASURES FOR 2015 PUBLIC REPORTING

3.1 Rationale for Measure Updates

Measure reevaluation ensures that the risk-standardized mortality models are continually assessed and remain valid, given possible changes in clinical practice and coding standards over time, while allowing for model refinements. Annual measure reevaluation is informed by review of the most recent literature related to measure conditions or outcomes, feedback from various stakeholders, and an assessment of coding trends that reveal shifts in clinical practice or billing patterns. As this report describes, for 2015 public reporting, we undertook the following measures reevaluation activities:

- Validated the performance of the model and risk-adjustment variables in three recent one-year periods (July 2011-June 2012, July 2012-June 2013, and July 2013-June 2014);
- Evaluated and validated model performance for the three years combined (July 2011-June 2014); and
- Updated the measure's SAS analytic package and documentation.

No methodological changes to the measure were made for 2015 public reporting.

The Condition Category Groups (CC) of ICD-9-CM codes were not updated this year due to the upcoming transition to International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10).

3.2 Changes to SAS Analytic Package (SAS Pack)

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

The SAS analytic package describes the data files and data elements that feed the model software. Please be aware that CMS does not provide training and 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 longitudinal patient data from the entire national sample of acute care hospitals to estimate the individual hospital-specific effects, the average hospital-specific effect, and the risk-adjustment coefficients used in the equations.

4. RESULTS FOR 2015 PUBLIC REPORTING

4.1 Assessment of Updated Models

The CABG mortality measure estimates hospital-specific 30-day all-cause RSMRs using hierarchical logistic regression models. Section 2 of this report summarizes the measure methodology and model risk-adjustment variables. Refer to prior technical reports for further details.[1]

We evaluated the performance of the models using the July 2011 to June 2014 data for 2015 public reporting. We examined differences in the frequency of patient risk factors and the model variable coefficients.

We assessed logistic regression model performance in terms of discriminant ability for each year of data and for the three-year combined period. We computed two summary statistics to assess model performance: the predictive ability and the area under the receiver operating characteristic (ROC) curve (c-statistic). The c-statistic is an indicator of the model's discriminant ability or ability to correctly classify those who have and have not died within 30 days of admission. Potential values range from 0.5, meaning no better than chance, to 1.0, meaning perfect discrimination. A c-statistic of 1.0 indicates perfect prediction, implying patients' outcomes can be predicted completely by their risk factors, and physicians and hospitals play no role in patients' outcomes.

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

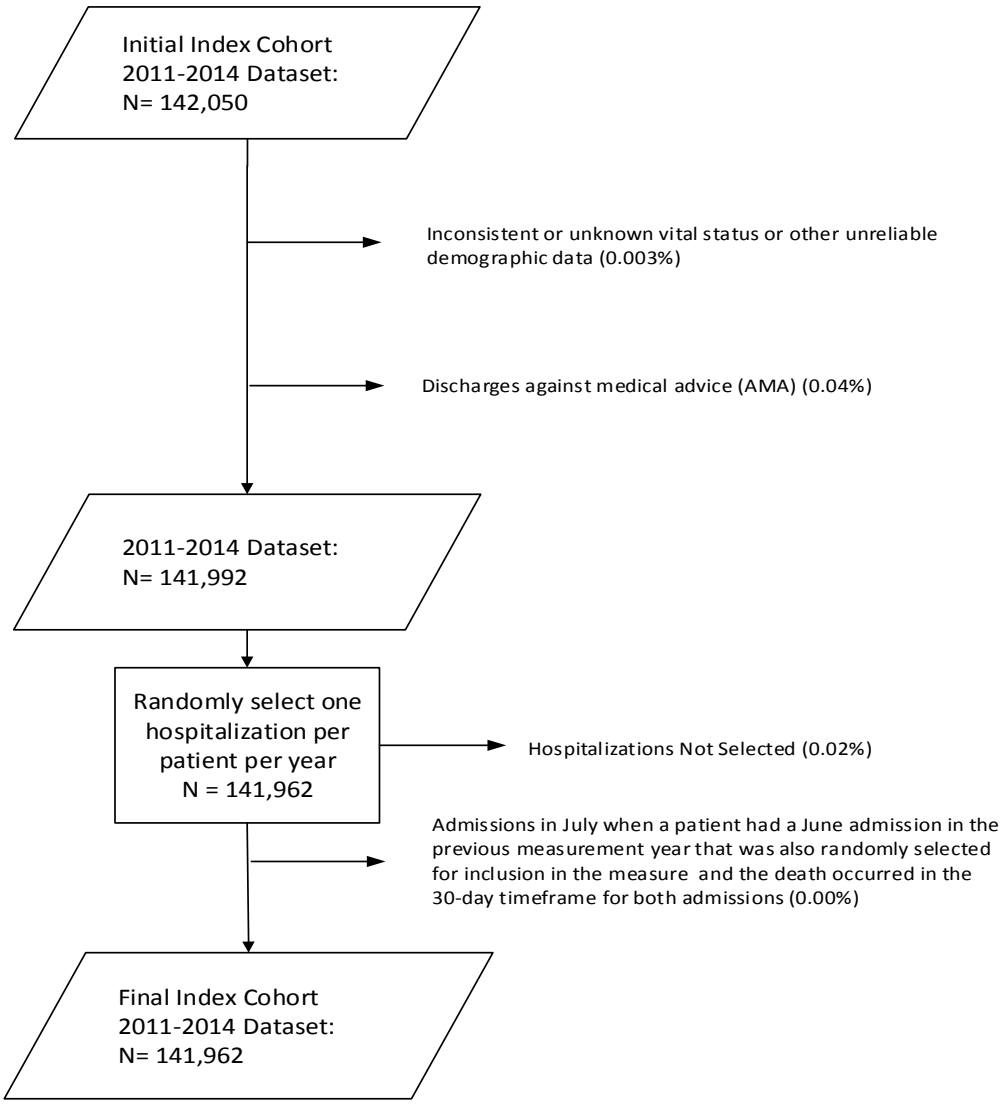
4.2 CABG Mortality 2015 Model Results

4.2.1 Index Cohort Exclusions

The exclusion criteria for the measures are presented in Section 2.2.1. The percentage of CABG patients meeting each exclusion criterion in the July 2011-June 2014 dataset is presented in Figure 4.2.1.

Admissions may have been counted in more than one exclusion category because they are not mutually exclusive. The index cohort includes hospitalizations for Medicare FFS patients aged 65 or over with a qualifying isolated CABG procedure (Table D.1.2); enrolled in Part A and Part B Medicare for the 12 months prior to the date of admission, and enrolled in Part A during the index admission; and who were alive at discharge.

Figure 4.2.1– CABG Cohort Exclusions in the July 2011-June 2014 Dataset



4.2.2 Frequency of CABG Model Variables

We examined the change in both observed mortality rate and frequency of clinical and demographic variables (Table 4.2.1). Between July 2011-June 2012 and July 2013-June 2014, the observed mortality rate decreased from 3.17% to 3.06%.

However, the frequency of some model variables increased, which may reflect an increased rate of comorbidity in the FFS population, but is also due, in part, to increased coding opportunities on administrative claims. In the 2012 update to the measures, we increased the number of diagnosis and procedure codes to align with version 5010 format changes Department of Health and Human Services (DHHS) required. Hospitals could begin to submit up to 25 diagnosis and procedure codes starting in 2010. Over time, more hospitals submitted more codes, which translated into increased frequencies for some model variables. Notable increase from 2011 to 2014 include coronary atherosclerosis (85.5% to 86.7%), other gastrointestinal disorders (54.7% to 55.9%), and renal failure (16.6% to 18.2%). A notable decrease from 2011 to 2014 includes chronic obstructive pulmonary disease (27.3% to 26.1%).

4.2.3 CABG Model Parameters and Performance

Table 4.2.2 shows model variable coefficients by individual year and for the combined three-year dataset. Table 4.2.3 shows the risk-adjusted odds ratio (ORs) and 95% confidence intervals (CIs) for the CABG mortality model by individual year and for the combined three-year dataset. Overall, the variable effect sizes were relatively constant across years. In addition, model performance was stable over the three-years; the area under the ROC curve (c-statistic) remained constant at 0.77 (Table 4.2.3).

4.2.4 Distribution of Hospital Volumes and RSMRs for CABG

Table 4.2.5 shows the distribution of hospital admission volumes and Table 4.2.6 shows the distribution of hospital RSMRs. The mean RSMR decreased over the three years, from 3.2% between July 2011 and June 2012 to 3.1% between July 2013 and June 2014. The median hospital RSMR in the combined three-year dataset was 3.1% (Interquartile Range [IQR] 2.8% - 3.6%). Table 4.2.7 shows the between-hospital variance by individual year and for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.185 (Standard Error [SE]: 0.021). If there were no systematic differences between hospitals, the between-hospital variance would be 0.

Figure 4.2.2 shows the overall distribution of the hospital RSMRs for the combined dataset. The odds of all-cause mortality if treated at a hospital one standard deviation above the national rate were 2.36 times higher than odds of all-cause mortality if treated at a hospital one standard deviation below the national rate. If there were no systematic differences between hospitals, the OR would be 1.0.[4]

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

Of 1,199 hospitals in the study cohort, 14 performed "better than the U.S. national rate," 1,037 performed "no different from the U.S. national rate," and 16 performed "worse than the U.S. national rate." 132 were classified as "number of cases too small" (fewer than 25) to reliably tell how well the hospital is performing.

Table 4.2.1 – Frequency of CABG Model Variables Over Different Time Periods (%)

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Total N	49,148	46,767	46,047	141,962
Observed mortality rate (%)	3.17	3.28	3.06	3.17
Mean age minus 65 (SD)	8.9 (5.7)	8.9 (5.8)	8.8 (5.7)	8.8 (5.7)
Male (%)	69.2	70.2	71.4	70.3
Cardiogenic Shock (ICD-9 Code 785.51)	5.2	5.2	5.6	5.4
History of Prior CABG or Valve Surgery (ICD-9 diagnosis codes: V42.2, V43.3, V45.81, 414.02, 414.03, 414.04, 414.05, 414.06, 414.07, 996.02, 996.03; ICD-9 procedure codes: 39.61)	5.4	5.6	5.3	5.4
Pneumonia (CC 111-113)	12.9	13.2	12.7	12.9
Other endocrine, metabolic/nutritional disorders (CC 24)	92.9	93.4	93.9	93.4
Protein-calorie malnutrition (CC 21)	5.0	5.0	4.6	4.9
Renal failure (CC 131)	16.6	17.5	18.2	17.4
Chronic obstructive pulmonary disease (COPD) (CC 108)	27.3	26.5	26.1	26.6
Dialysis status (CC 130)	1.9	2.1	2.0	2.0
Liver and biliary disease (CC 25-30)	6.4	6.6	6.5	6.5
Congestive heart failure (CC 80)	20.1	20.2	20.6	20.3
Other gastrointestinal disorders (CC 36)	54.7	55.3	55.9	55.3
Other acute/subacute forms of ischemic heart disease (CC82)	42.9	42.0	42.2	42.4
Coronary atherosclerosis (CC84) Includes ICD-9 Codes 414.2, 4143, 414.8, 414.9, 414.00, 414.01, 414.10, 414.11, 414.12, 414.19, 746.85	85.5	86.2	86.7	86.1
Hypertension (CC 91)	88.9	88.7	89.2	88.9
Acute myocardial infarction (CC 81)	17.0	17.6	17.7	17.4
Angina pectoris/old myocardial infarction (CC83)	42.8	42.3	42.4	42.5
Vascular or circulatory disease (CC 104-106)	34.0	33.4	33.9	33.8
Decubitus ulcer or chronic skin ulcer (CC 148-149)	3.3	3.5	3.7	3.5
Cancer (CC 7-12)	19.5	19.1	19.0	19.2
Stroke (CC 95-96)	4.9	4.7	4.7	4.8
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	3.4	3.4	3.5	3.5
Dementia or other specified brain disorders (CC 49-50)	5.9	5.9	5.7	5.8

Table 4.2.2 – Hierarchical Logistic Regression Model Variable Coefficients for CABG Over Different Time Periods

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Intercept	-3.876	-3.648	-3.799	-3.800
Age minus 65 (years above 65, continuous)	0.056	0.059	0.064	0.060
Male	-0.312	-0.421	-0.279	-0.336
Cardiogenic Shock (ICD-9 Code 785.51)	1.892	1.876	1.850	1.900
History of Prior CABG or Valve Surgery (ICD-9 diagnosis codes: V42.2, V43.3, V45.81, 414.02, 414.03, 414.04, 414.05, 414.06, 414.07, 996.02, 996.03; ICD-9 procedure codes: 39.61)	0.461	0.313	0.392	0.390
Pneumonia (CC 111-113)	0.302	0.382	0.256	0.309
Other endocrine, metabolic/nutritional disorders (CC 24)	-0.366	-0.521	-0.354	-0.399
Protein-calorie malnutrition (CC 21)	0.448	0.411	0.599	0.489
Renal failure (CC 131)	0.065	0.152	0.278	0.166
Chronic obstructive pulmonary disease (COPD) (CC 108)	0.445	0.412	0.307	0.382
Dialysis status (CC 130)	0.922	0.526	0.654	0.700
Liver and biliary disease (CC 25-30)	0.355	0.265	0.394	0.337
Congestive heart failure (CC 80)	0.134	0.148	0.164	0.152
Other gastrointestinal disorders (CC 36)	-0.175	-0.287	-0.247	-0.237
Other acute/subacute forms of ischemic heart disease (CC82)	-0.290	-0.216	-0.148	-0.218
Coronary atherosclerosis (CC84) Includes ICD-9 Codes 414.2, 4143, 414.8, 414.9, 414.00, 414.01, 414.10, 414.11, 414.12, 414.19, 746.85	0.211	0.186	0.062	0.163
Hypertension (CC 91)	-0.237	-0.183	-0.339	-0.255
Acute myocardial infarction (CC 81)	0.293	0.281	0.244	0.281
Angina pectoris/old myocardial infarction (CC83)	-0.280	-0.223	-0.191	-0.227
Vascular or circulatory disease (CC 104-106)	0.091	0.155	0.121	0.126
Decubitus ulcer or chronic skin ulcer (CC 148-149)	0.110	0.212	0.133	0.162
Cancer (CC 7-12)	0.089	-0.023	-0.170	-0.020
Stroke (CC 95-96)	0.167	-0.021	0.029	0.065
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	-0.056	0.097	0.270	0.105
Dementia or other specified brain disorders (CC 49-50)	0.214	0.213	0.184	0.196

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

Variable	07/2011-06/2012 OR (95% CI)	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2011-06/2014 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.06 (1.05-1.07)	1.06 (1.05-1.07)	1.07 (1.06-1.07)	1.06 (1.06-1.07)
Male	0.73 (0.66-0.82)	0.66 (0.59-0.73)	0.76 (0.67-0.85)	0.72 (0.67-0.76)
Cardiogenic Shock (ICD-9 Code 785.51)	6.63 (5.84-7.53)	6.53 (5.73-7.44)	6.36 (5.58-7.26)	6.69 (6.20-7.21)
History of Prior CABG or Valve Surgery (ICD-9 diagnosis codes: V42.2, V43.3, V45.81, 414.02, 414.03, 414.04, 414.05, 414.06, 414.07, 996.02, 996.03; ICD-9 procedure codes: 39.61)	1.59 (1.30-1.07)	1.37 (1.11-1.69)	1.48 (1.19-1.84)	1.48 (1.31-1.67)
Pneumonia (CC 111-113)	1.35 (1.18-1.55)	1.47 (1.28-1.68)	1.29 (1.12-1.49)	1.36 (1.26-1.48)
Other endocrine, metabolic/nutritional disorders (CC 24)	0.69 (0.58-0.83)	0.59 (0.50-0.71)	0.70 (0.58-0.85)	0.67 (0.60-0.75)
Protein-calorie malnutrition (CC 21)	1.57 (1.33-1.85)	1.51 (1.27-1.80)	1.82 (1.53-2.17)	1.63 (1.48-1.80)
Renal failure (CC 131)	1.07 (0.93-1.23)	1.17 (1.01-1.34)	1.32 (1.15-1.52)	1.18 (1.09-1.28)
Chronic obstructive pulmonary disease (COPD) (CC 108)	1.56 (1.40-1.75)	1.51 (1.35-1.69)	1.36 (1.21-1.53)	1.47 (1.37-1.57)
Dialysis status (CC 130)	2.52 (1.93-3.28)	1.69 (1.29-2.23)	1.92 (1.47-2.51)	2.01 (1.72-2.35)
Liver and biliary disease (CC 25-30)	1.43 (1.19-1.70)	1.30 (1.08-1.57)	1.48 (1.23-1.79)	1.40 (1.26-1.56)
Congestive heart failure (CC 80)	0.79 (0.68-0.92)	0.83 (0.71-0.97)	0.71 (0.61-0.84)	0.78 (0.71-0.85)
Other gastrointestinal disorders (CC 36)	0.84 (0.75-0.94)	0.75 (0.67-0.84)	0.78 (0.70-0.88)	0.79 (0.74-0.84)
Other acute/subacute forms of ischemic heart disease (CC82)	0.95 (0.72-1.23)	1.10 (0.85-1.43)	1.31 (1.01-1.69)	1.11 (0.96-1.29)
Coronary atherosclerosis (CC84) Includes ICD-9 Codes 414.2, 4143, 414.8, 414.9, 414.00, 414.01, 414.10, 414.11, 414.12, 414.19, 746.85	0.75 (0.67-0.84)	0.81 (0.72-0.90)	0.86 (0.77-0.97)	0.80 (0.75-0.86)
Hypertension (CC 91)	1.14 (1.00-1.30)	1.16 (1.02-1.32)	1.18 (1.03-1.35)	1.16 (1.08-1.26)
Acute myocardial infarction (CC 81)	1.24 (1.03-1.50)	1.24 (1.02-1.50)	1.20 (0.98-1.47)	1.22 (1.09-1.36)
Angina pectoris/old myocardial infarction (CC83)	1.34 (1.18-1.52)	1.33 (1.16-1.51)	1.28 (1.12-1.46)	1.32 (1.23-1.43)
Vascular or circulatory disease (CC 104-106)	1.10 (0.98-1.23)	1.17 (1.04-1.31)	1.13 (1.00-1.28)	1.13 (1.06-1.22)
Decubitus ulcer or chronic skin ulcer (CC 148-149)	1.12 (0.88-1.42)	1.24 (0.98-1.56)	1.14 (0.90-1.46)	1.18 (1.02-1.35)
Cancer (CC 7-12)	1.09 (0.96-1.25)	0.98 (0.85-1.12)	0.84 (0.73-0.98)	0.98 (0.91-1.06)

Variable	07/2011-06/2012 OR (95% CI)	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2011-06/2014 OR (95% CI)
Stroke (CC 95-96)	1.18 (0.94-1.48)	0.98 (0.77-1.25)	1.03 (0.80-1.32)	1.07 (0.93-1.22)
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	1.24 (1.03-1.48)	1.20 (1.00-1.45)	1.06 (0.88-1.28)	1.18 (1.06-1.31)
Dementia or other specified brain disorders (CC 49-50)	0.76 (0.67-0.85)	0.8 (0.71-0.890)	0.83 (0.73-0.93)	0.80 (0.75-0.85)

Table 4.2.4 – CABG Generalized Linear Modeling (Logistic Regression) Performance Over Different Time Periods

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Predictive ability, % (lowest decile – highest decile)	0.6 – 13.6	0.6 – 13.6	0.4 – 13.1	0.6 – 13.5
c-statistic	0.77	0.77	0.77	0.77

Table 4.2.5 – Distribution of Hospital CABG Admission Volumes Over Different Time Periods

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Number of hospitals	1,175	1,164	1,158	1,199
Mean number of admissions (SD)	41.8 (36.6)	40.2 (35.5)	39.8 (35.0)	118.4 (105.4)
Range (min. – max.)	1-270	1-249	1-268	1-750
25th percentile	17	16	16	46
50th percentile	32	29.5	29	88
75th percentile	57	55	53	160

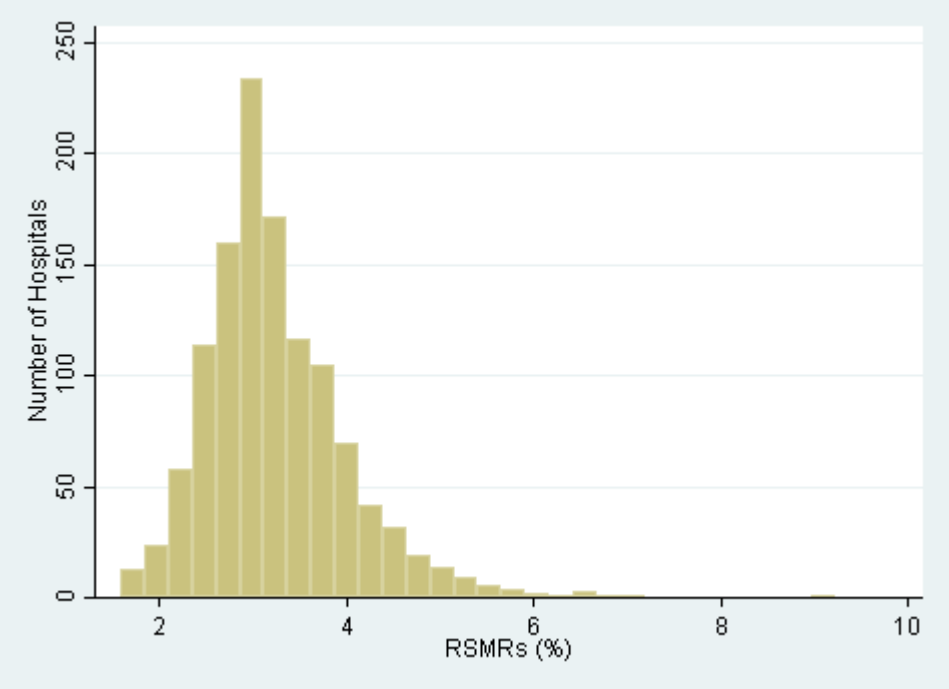
Table 4.2.6 – Distribution of Hospital CABG RSMRs Over Different Time Periods (%)

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Number of hospitals	1,175	1,164	1,158	1,199
Mean (SD)	3.2 (0.3)	3.4 (0.7)	3.1 (0.4)	3.3 (0.8)
Range (min. – max.)	2.2-4.7	1.9-8.5	2.0-5.7	1.6-9.2
25th percentile	3.0	2.9	2.8	2.8
50th percentile	3.1	3.2	3.0	3.1
75th percentile	3.3	3.7	3.3	3.6

Table 4.2.7 – Between-Hospital Variance for CABG

	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Between-hospital variance (SE)	0.110 (0.035)	0.235 (0.042)	0.149 (0.040)	0.185 (0.021)

Figure 4.2.2 – Distribution of Hospital 30-Day CABG RSMRs Between July 2011 and June 2014



N= 1,199 hospitals

5. GLOSSARY

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

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

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

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

Confidence Interval (CI): A CI is a range of probable values for an estimate that characterizes the amount of associated uncertainty. For example, the 95% CI estimates for the OR associated with risk adjustment variables in the model indicates there is 95% confidence that the OR lies between the lower and the upper limit of the interval. The 95% CI serves as a proxy for statistical significance for OR; if the CI does not contain the value of 1.0 the association is considered significant.

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

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

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

Index admission: Any admission included in the measure calculation as the initial admission for an episode of CABG 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 that CMS is 95% confident that the true value of the rate lies between the lower and the upper limit of the interval.

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

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 variable present relative to those without the risk variable present. The model coefficient for each risk variable is the log (odds) for that variable.

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

Predicted mortality: 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.

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

6. REFERENCES

1. Suter L, Wang C, Vellanky S, al e. *Hospital-Level 30-day Mortality Following Coronary ArteryBypass Graft Surgery Measure Methodology Report.* Center for Outcomes Research andEvaluation;2012.
2. Drye EE, Normand SL, Wang Y, al e. Comparison of hospital risk-standardized mortality rates calculated by using in-hospital and 30-day models: an observational study with implications for hospital profiling. *Annals of internal medicine.* Jan 3 2012;156:19-26.
3. Schwartz J, Strait K, Keshawarz A, et al. Medicare Hospital Quality Chartbook 2014: Performance Report on Outcome Measures. Prepared by Yale New Haven Health Services Corporation Center for Outcomes Research and Evaluation for the Centers for Medicare and Medicaid Services 2014; http://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/HospitalQualityInits/Downloads/Medicare-Hospital-Quality-Chartbook-2014.pdf.
4. Normand S-LT, DM S. Statistical and clinical aspects of hospital outcomes profiling. *Statistical Science.* 2007;22(2):206-226.
5. Daniels MJ, Gatsonis C. Hierarchical Generalized Linear Models in the Analysis of Variations in Health Care Utilization. *Journal of the American Statistical Association.* 1999/03/01 1999;94(445):29-42.
6. Normand SL, Wang Y, Krumholz H. Assessing surrogacy of data sources for institutional comparisons. *Health Serv Outcomes Res Method.* 2007/06/01 2007;7(1-2):79-96.

7. APPENDICES

Appendix A. Statistical Approach to Risk-Standardized Mortality Rates for CABG Measure

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

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

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

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

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

Where h(.) is a logit link, Y_{ij} is whether the j^{th} patient in the i^{th} hospital died (equal to 1 if death within 30 days, zero otherwise); α_i represents the hospital-specific intercept, $\mathbf{Z}_{ij} = (Z_{1ij}, Z_{2ij}, \ldots, Z_{pij})$ the patient-specific covariates, μ is the adjusted average hospital intercept across all hospitals in the sample, and τ^2 is the between-hospital variance component.[5] This model separates within-hospital variation from between-hospital variation. The hierarchical logistic regression models are estimated using the SAS software system (SAS 9.3 GLIMMIX).

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

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

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

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

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

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

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

Creating Interval Estimates

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

Algorithm:

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

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

$$\{\hat{\alpha}_i^{(b)}, \widehat{var}(\alpha_i^{(b)}); i = 1,2,\ldots,I\}$$

3. We generate a hospital random effect by sampling from the distribution of the hospital-specific distribution obtained in Step 2c. We approximate the distribution for each random effect by a normal distribution. Thus, we draw $\alpha_i^{(b*)} \sim N(\hat{\alpha}_i^{(b)}, \widehat{var}(\hat{\alpha}_i^{(b)}))$ for the unique set of hospitals sampled in Step 1.

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

Ninety-five percent interval estimates (or alternative interval estimates) for the hospital-standardized outcome can be computed by identifying the 2.5th and 97.5th percentiles of the B estimates (or the percentiles corresponding to the alternative desired intervals).[6]

Appendix B. Data Quality Assurance (QA)

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

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

Phase I

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

In general, we use both manual scan and descriptive analyses to conduct data validity checks, including cross-checking of complication information, distributions of ICD-9-CM codes, and frequencies of key variables. The results are reviewed for accuracy and changes compared to data from prior data sources. Any new variable constructs and other changes in formatting to the input files are also verified. We share our QA findings with our data extraction contractor as needed.

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

Phase II

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

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

Figure B.1 – CORE QA Phase I

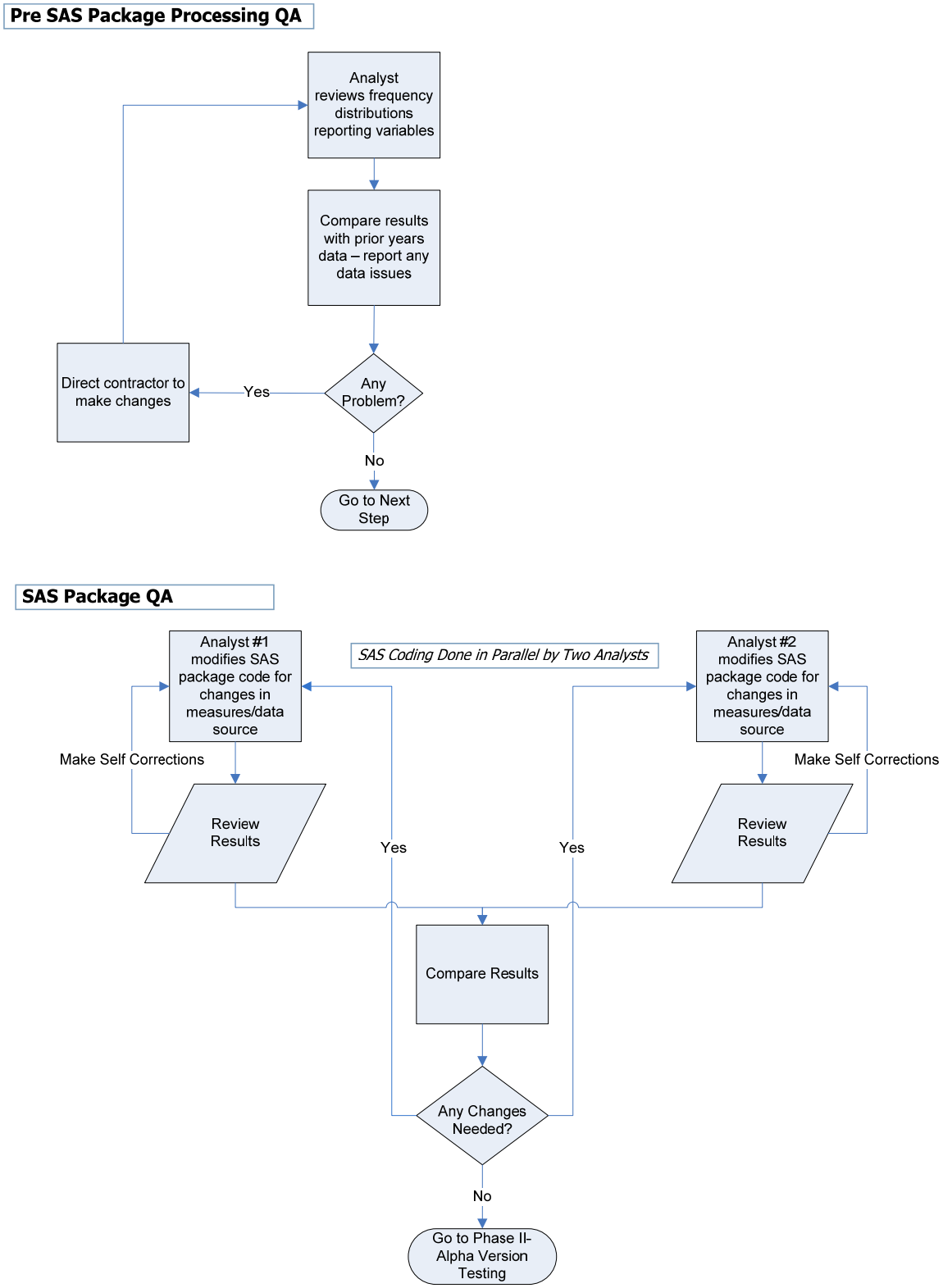
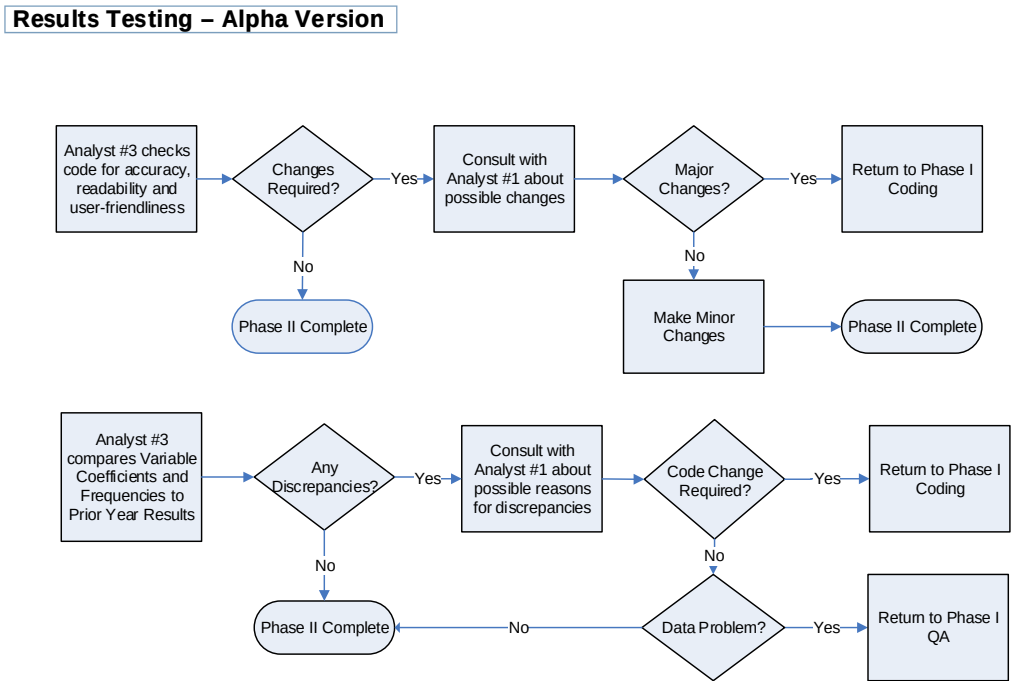


Figure B.2 – CORE QA Phase II



Appendix C. Annual Updates

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

2015

2015 Measures Updates and Specifications Report (Version 2.0-CABG)

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

2014

2014 Dry Run Technical Report CABG Mortality (Version 1.0)

1. Updates and rationales for the 2014 dry run.
   - Rationale: The report describes the CABG mortality measure, which was specified for the dry run period in 2014. The report includes details on the initial measure development and validation process.

Appendix D. Measure Specifications

Appendix D.1 CABG

Cohort

Inclusion Criteria for CABG Mortality Measure

1. **Enrolled in Medicare FFS**
   Rationale: Claims-data are consistently available only for Medicare FFS beneficiaries.
2. **Aged 65 or over**
   Rationale: Medicare patients younger than 65 usually qualify for the program due to severe disability. They are not included in the measure because Medicare patients younger than 65 are considered to be too clinically distinct from Medicare patients 65 and over.
3. **Enrolled in Part A and Part B Medicare for the 12 months prior to the date of admission, and enrolled in Part A during the index admission**
   Rationale: The 12-month prior enrollment ensures a full year of administrative data for risk adjustment. Part A is required during the index admission to ensure that no Medicare Advantage patients are included in the measures.
4. **Having a qualifying isolated CABG procedure**
   Rationale: Isolated CABG is the procedure targeted for measurement (Table D.1.1). Isolated CABG procedures are defined as those 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 (Table D.1.2):
   - **Valve procedures;**
   - **Atrial and/or ventricular septal defects;**
   - **Congenital anomalies;**
   - **Other open cardiac procedures;**
   - **Heart transplants;**
   - **Aorta or other non-cardiac arterial bypass procedures; or**
   - **Head, neck, intracranial vascular procedures.**

Exclusion Criteria for CABG Mortality Measure

1. **Discharged against medical advice (AMA)**
   Rationale: Providers did not have the opportunity to deliver full care and prepare the patient for discharge.
2. **Inconsistent or unknown vital status or other unreliable 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.

Table D.1.1 – ICD-9-CM Codes for CABG Cohort

ICD-9-CM Codes	Description
36.1x	Aortocoronary bypass for heart revascularization, not otherwise specified
36.11	(Aorto) coronary bypass of one coronary artery
36.12	(Aorto) coronary bypass of two coronary arteries
36.13	(Aorto) coronary bypass of three coronary arteries
36.14	(Aorto) coronary bypass of four or more coronary arteries
36.15	Single internal mammary- coronary artery bypass
36.16	Double internal mammary- coronary artery bypass
36.17	Abdominal- coronary artery bypass
36.19	Other bypass anastomosis for heart revascularization

The CABG mortality measure excludes admissions where any of the following ICD-9-CM procedure codes occur with ICD-9 code 36.1x:

Table D.1.2 – Codes used to Identify Non-Isolated CABG Procedures Not Included in Final Cohort

ICD-9-CM Code	Description	Category
0.61	Percutaneous angioplasty or atherectomy of precerebral (extracranial) vessel(s)	Head, neck, intracranial vascular procedure
0.62	Percutaneous angioplasty or atherectomy of intracranial vessel(s)	Head, neck, intracranial vascular procedure
0.63	Percutaneous insertion of carotid artery stent(s)	Head, neck, intracranial vascular procedure
0.64	Percutaneous insertion of other precerebral (extracranial) artery stent(s)	Head, neck, intracranial vascular procedure
0.65	Percutaneous insertion of intracranial vascular stent(s)	Head, neck, intracranial vascular procedure
32.4x	Lobectomy with segmental resection of adjacent lobes of lung, excludes that with radical dissection [excision] of thoracic structures	Lobectomy
33.5x	Lung transplant	Lung Transplant
33.6	Combined heart-lung transplantation	Lung Transplant
35.00	Closed heart valvotomy, unspecified valve	Valve procedures
35.01	Closed heart valvotomy, aortic valve	Valve procedures
35.02	Closed heart valvotomy, mitral valve	Valve procedures
35.03	Closed heart valvotomy, pulmonary valve	Valve procedures
35.04	Closed heart valvotomy, tricuspid valve	Valve procedures
35.10	Open heart valvuloplasty without replacement, unspecified valve	Valve procedures
35.11	Open heart valvuloplasty of aortic valve without replacement	Valve procedures
35.12	Open heart valvuloplasty of mitral valve without replacement	Valve procedures

ICD-9-CM Code	Description	Category
35.13	Open heart valvuloplasty of pulmonary valve without replacement	Valve procedures
35.14	Open heart valvuloplasty of tricuspid valve without replacement	Valve procedures
35.20	Replacement of unspecified heart valve	Valve procedures
35.21	Replacement of aortic valve with tissue graft	Valve procedures
35.22	Other replacement of aortic valve	Valve procedures
35.23	Replacement of mitral valve with tissue graft	Valve procedures
35.24	Other replacement of mitral valve	Valve procedures
35.25	Replacement of pulmonary valve with tissue graft	Valve procedures
35.26	Other replacement of pulmonary valve	Valve procedures
35.27	Replacement of tricuspid valve with tissue graft	Valve procedures
35.28	Other replacement of tricuspid valve	Valve procedures
35.31	Operations on papillary muscle	Valve procedures
35.32	Operations on chordae tendineae	Valve procedures
35.33	Annuloplasty	Valve procedures
35.34	Infundibulectomy	Valve procedures
35.35	Operations on trabeculae carneae cordis	Valve procedures
35.39	Operations on other structures adjacent to valves of heart	Valve procedures
35.41	Enlargement of existing atrial septal defect	Atrial Septal Defect
35.42	Creation of septal defect in heart	Atrial Septal Defect
35.50	Repair of unspecified septal defect of heart with prosthesis	Atrial Septal Defect
35.51	Repair of atrial septal defect with prosthesis, open technique	Atrial Septal Defect
35.52	Repair of atrial septal defect with prosthesis, closed technique	Atrial Septal Defect
35.53	Repair of ventricular septal defect with prosthesis, open technique	Ventricular Septal Defect
35.54	Repair of endocardial cushion defect with prosthesis	Ventricular Septal Defect
35.55	Repair of ventricular septal defect with prosthesis, closed technique	Ventricular Septal Defect
35.60	Repair of unspecified septal defect of heart with tissue graft	Ventricular Septal Defect
35.61	Repair of atrial septal defect with tissue graft	Atrial Septal Defect
35.62	Repair of ventricular septal defect with tissue graft	Ventricular Septal Defect
35.63	Repair of endocardial cushion defect with tissue graft	Ventricular Septal Defect
35.70	Other and unspecified repair of unspecified septal defect of heart	Ventricular Septal Defect
35.71	Other and unspecified repair of atrial septal defect	Atrial Septal Defect

ICD-9-CM Code	Description	Category
35.72	Other and unspecified repair of ventricular septal defect	Ventricular Septal Defect
35.73	Other and unspecified repair of endocardial cushion defect	Ventricular Septal Defect
35.81	Total repair of tetralogy of Fallot	Correction of congenital anomalies
35.82	Total repair of total anomalous pulmonary venous connection	Correction of congenital anomalies
35.83	Total repair of truncus arteriosus	Correction of congenital anomalies
35.84	Total correction of transposition of great vessels, not elsewhere classified	Correction of congenital anomalies
35.91	Interatrial transposition of venous return	Correction of congenital anomalies
35.92	Creation of conduit between right ventricle and pulmonary artery	Correction of congenital anomalies
35.93	Creation of conduit between left ventricle and aorta	Correction of congenital anomalies
35.94	Creation of conduit between atrium and pulmonary artery	Correction of congenital anomalies
35.95	Revision of corrective procedure on heart	Correction of congenital anomalies
35.96	Percutaneous valvuloplasty	Valve procedures
35.98	Other operations on septa of heart	Ventricular Septal Defect
35.99	Other operations on valves of heart	Other valve procedures
37.31	Pericardiectomy	Repair/restoration of pericardium
37.32	Excision of aneurysm of heart	Other open cardiac procedures
37.33	Excision or destruction of other lesion or tissue of heart,open approach	Other open cardiac procedures
37.35	Partial ventriculectomy	Other open cardiac procedures
37.51	Heart transplantation	Heart transplant
37.52	Implantation of total internal biventricular heart replacement system	Heart replacement procedures
37.53	Replacement or repair of thoracic unit of (total) replacement heart system	Heart replacement procedures
37.54	Replacement or repair of other implantable component of (total) replacement heart system	Heart replacement procedures
37.55	Removal of internal biventricular heart replacement system	Heart replacement procedures
37.63	Repair of heart assist system	Circulatory assist devices (includes VAD)
37.67	Implantation of cardiomyostimulation system	Circulatory assist devices (includes VAD)
38.11	Head and Neck Endarterectomy	Head, neck, intracranial vascular procedure
38.12	Endarterectomy, other vessels of head and neck	Head, neck, intracranial vascular procedure
38.14	Endarterectomy of Aorta	Aorta or other non-cardiac arterial bypass procedures
38.15	Thoracic Endarterectomy	Aorta or other non-cardiac arterial bypass procedures

ICD-9-CM Code	Description	Category
38.16	Endarterectomy : Excision of tunica intima of artery to relieve arterial walls thickened by plaque or chronic inflammation. Location includes abdominal arteries excluding abdominal aorta: Celiac, Gastric, Hepatic, Iliac, Mesenteric, Renal, Splenic, Umbi	Aorta or other non-cardiac arterial bypass procedures
38.17	Endarterectomy - abdominal veins: Iliac, Portal, Renal, Splenic, Vena cava.	Aorta or other non-cardiac arterial bypass procedures
38.34	Resection of vessel with replacement: Angiectomy, excision of aneurysm (arteriovenous), blood vessel (lesion) with anastomosis (4=aorta, abdominal)	Aorta or other non-cardiac arterial bypass procedures
38.42	Resection of vessel with replacement: Angiectomy, excision of aneurysm with replacement (2= other vessels of head and neck; carotid, jugular)	Head, neck, intracranial vascular procedure
38.44	Resection of vessel with replacement, aorta, abdominal	Aorta or other non-cardiac arterial bypass procedures
38.45	Resection of vessel with replacement, thoracic vessels	Aorta or other non-cardiac arterial bypass procedures
39.21	Caval-pulmonary artery anastomosis	Aorta or other non-cardiac arterial bypass procedures
39.22	Aorta-subclavian-carotid bypass	Aorta or other non-cardiac arterial bypass procedures
39.23	Other intrathoracic vascular shunt or bypass	Aorta or other non-cardiac arterial bypass procedures
39.24	Aorta-renal bypass	Aorta or other non-cardiac arterial bypass procedures
39.25	Aorta-iliac-femoral bypass	Aorta or other non-cardiac arterial bypass procedures
39.26	Other intra-abdominal vascular shunt or bypass	Aorta or other non-cardiac arterial bypass procedures
39.28	Extracranial-intracranial (EC-IC) vascular bypass	Head, neck, intracranial vascular procedure
39.29	Other (peripheral) vascular shunt or bypass	Aorta or other non-cardiac arterial bypass procedures
39.71	Endovascular implantation of graft in abdominal aorta	Aorta or other non-cardiac arterial bypass procedures
39.72	Endovascular embolization or occlusion of head and neck vessels	Head, neck, intracranial vascular procedure
39.73	Endovascular implantation of graft in thoracic aorta	Aorta or other non-cardiac arterial bypass procedures
39.74	Endovascular removal of obstruction from head and neck vessel(s)	Head, neck, intracranial vascular procedure
39.75	Endovascular embolization or occlusion of vessel(s) of head or neck using bare coils	Head, neck, intracranial vascular procedure
39.76	Endovascular embolization or occlusion of vessel(s) of head or neck using bioactive coils	Head, neck, intracranial vascular procedure
39.79	Other endovascular procedures on other vessels	Aorta or other non-cardiac arterial bypass procedures

ICD-9-CM Code	Description	Category
85.22	Resection of quadrant of breast	Mastectomy
85.23	Subtotal Mastectomy, which excludes quadrant resection (85.22)	Mastectomy
85.4x	Mastectomy - includes simple/extended simple, unilateral/bilateral, radical/extended radical	Mastectomy

Risk Adjustment

Table D.1.3 – Risk Variables for CABG Measure

Variable	Description
n/a	Age minus 65 (years above 65, continuous)
n/a	Male
ICD-9 Code 785.51	Cardiogenic Shock
ICD-9 diagnosis codes: V42.2, V43.3, V45.81, 414.02, 414.03, 414.04, 414.05, 414.06, 414.07, 996.02, 996.03 ICD-9 procedure codes: 39.61	History of Prior CABG or Valve Surgery
CC 111-113	Pneumonia
CC 24	Other endocrine, metabolic/nutritional disorders
CC 21	Protein-calorie malnutrition
CC 131	Renal failure CC 131)
CC 108	Chronic obstructive pulmonary disease (COPD)
CC 130	Dialysis status
CC 25-30	Liver and biliary disease
CC 80	Congestive heart failure
CC 36	Other gastrointestinal disorders
CC 82	Other acute/subacute forms of ischemic heart disease
Coronary atherosclerosis (CC 84): Includes ICD-9 Codes 414.2, 414.3, 414.8, 414.9, 414.00, 414.01, 414.10, 414.11, 414.12, 414.19, 746.85	Coronary atherosclerosis
CC 91	Hypertension
CC 81	Acute myocardial infarction
CC 83	Angina pectoris/old myocardial infarction
CC 104-106	Vascular or circulatory disease
CC 148-149	Decubitus ulcer or chronic skin ulcer
CC 7-12	Cancer
CC 95-96	Stroke

Variable	Description
CC 67-69, 100-102, 177-178	Hemiplegia, paraplegia, paralysis, functional disability
CC 49-50	Dementia or other specified brain disorders

Table D.1.4 – Complications of Care Variables Not Used in Risk Adjustment If Occurring Only During the Index Admission of CABG Measure

(Includes the subset of risk variables from Table D.1.3 that are not used in risk adjustment if occurring only during the index admission)

Variable	Description
28	Acute liver failure/disease
80	Congestive heart failure
95	Cerebral hemorrhage
96	Ischemic or unspecified stroke
100	Hemiplegia/hemiparesis
101	Cerebral palsy and other paralytic syndromes
102	Speech, language, cognitive, perceptual
104	Vascular disease with complications
105	Vascular disease
106	Other circulatory disease
111	Aspiration and specified bacterial pneumonias
112	Pneumococcal pneumonia, emphysema, lung abscess
130	Dialysis status
131	Renal failure
148	Decubitus ulcer of skin
177	Amputation status, lower limb/amputation
178	Amputation status, upper limb
ICD-9 diagnosis codes: V42.2, V43.3, V45.81, 414.02, 414.03, 414.04, 414.05, 414.06, 414.07, 996.02, 996.03 ICD-9 procedure codes: 39.61	CABG or valve surgery

Outcome

Outcome Criteria for CABG Measure

1. **30-day time frame from procedure date**
   Rationale: Outcomes occurring within 30 days of procedure date can be influenced by hospital care and early transition to the outpatient setting. The use of the 30-day time frame is a clinically meaningful period for hospitals to collaborate with their communities to reduce mortality.

2. **All-cause mortality**
   Rationale: From a patient perspective, death is the most critical outcome regardless of cause.