Measure of Hospital-Level 90-Day, All-Cause, Risk-Standardized Mortality Rate (RSMR) Following Coronary Artery Bypass Graft (CABG) Surgery

Submitted by

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Executive Summary

Goal of Measure

The goal of developing a 90-Day CABG All-Cause, Risk-Standardized Mortality Measure was to re-specify the existing 30-Day CABG All-Cause, Risk-Standardized Mortality Measure for use with alternate payment models. To accomplish this, the Center for Outcomes Research and Evaluation (CORE) will change the current measure that captures death occurring within 30 days after surgery, to capture death up to 90 days after surgery.

Background and Rationale

In 2012, CORE developed a hospital-level 30-Day Mortality Measure for patients undergoing coronary artery bypass graft (CABG) surgery to assess quality of care delivered to patients undergoing isolated CABG procedures.[1] In 2015, CMS began publicly reporting 30-day risk-standardized mortality rates (RSMRs) for CABG surgery for the nation's non-federal short-term acute care hospitals (including Indian Health Service hospitals) and critical access hospitals. In the interim, CMS continues to move towards value-based payment models and seeks to expand the available measures for use in alternative payment models. CMS also seeks to harmonize measures across programs in order to reduce burden and confusion for patients and providers.[2] Many procedural-based payment models reduce healthcare costs while incentivizing multidisciplinary care and improved care coordination.[3] Therefore, CMS tasked CORE with re-specifying an existing claims-based outcome measure, 30-day Risk-Standardized Mortality for Isolated CABG Surgery, for use across a range of alternative payment models. To accomplish this, CORE re-specified the current 30-day mortality measure for patients undergoing CABG surgery to capture a 90-day outcome ascertainment period. This document reviews the key rationales for this development project, focusing on the measure importance, scientific acceptability, feasibility, and usability in the context of the measure's anticipated benefits and unintended consequences. In brief, 90-day mortality after CABG offers an important complement to the existing 30-day measure. While overall mortality rates after CABG are low and may not change substantively in response to measurement, 90-day mortality after CABG is more likely to be influenced by multidisciplinary care coordination, a focus of alternative payment programs, and offers a critical surveillance tool to ensure cost reductions do not adversely impact care.

Measure Development Process

This measure aims to report the hospital-level, risk-standardized mortality rate within 90 days of a CABG procedure. CORE initiated development of this measure through re-specification of the previously developed 30-day CABG mortality measure. We also engaged with several stakeholder groups throughout the re-specification process. We elicited feedback on the measure concept, outcome, cohort, risk model variables, and how to develop and report measure results in a meaningful way for patients, family caregivers, and providers. These engagements have included two advisory groups in the form of a Technical Work Group and national Technical Expert Panel (TEP) consisting of a diverse set of stakeholders, including providers and patients.

Measure Specifications

This measure used Medicare administrative datasets that contain hospitalization data for Medicare Fee-for-Service (FFS) beneficiaries 65 years and older, who received a qualifying CABG procedure at an acute care facility for the three-year measure period July 2014-June 2017 and had administrative data for the 12 months prior to the index admission and the 90 days following it (Denominator). The outcome is death from any cause within 90 days of the procedure date (Numerator). CABG surgeries with concomitant valve or other major cardiac, vascular, or thoracic procedures were excluded from the measurement. The measure calculated hospital-level risk-standardized mortality rates (RSMRs) using a hierarchical logistic regression model to account for the clustering of patients within hospitals while risk-adjusting for differences in patient case-mix.

1. Introduction

1.1 Overview of Report

The Centers for Medicare & Medicaid Services (CMS) contracted with Center for Outcomes Research and Evaluation (CORE) to develop a Hospital-Level 90-Day, All-Cause, Risk-Standardized Mortality Rate (RSMR) following isolated Coronary Artery Bypass Graft (CABG) Surgery Measure. This measure is a re-specification of an existing claims-based outcome measure, hospital-level 30-Day Risk-Standardized Mortality for Isolated CABG Surgery.

Mortality is an important outcome that is meaningful to patients and providers. The majority of patients admitted to the hospital have survival as a primary goal. This important outcome is already the focus of existing CMS condition- and procedure-specific mortality quality measures; hospital-level risk-standardized mortality rates (RSMRs) are reported for patients admitted for heart failure, pneumonia, acute myocardial infarction, chronic obstructive pulmonary disease, stroke, and coronary artery bypass graft surgery.[4,5] Existing mortality measures support targeted quality improvement work around specific conditions and may have contributed to national declines in hospital mortality rates for measured conditions and/or procedures.[6,7]

In this technical report, we provide detailed information on the development and specifications of the Hospital-Level 90-Day, All-Cause, Risk-Standardized Mortality Rate (RSMR) Following Isolated Coronary Artery Bypass Graft (CABG) Surgery measure. This includes details on the cohort, outcome, risk adjustment, measure testing, and reporting considerations. Briefly, we developed the measure as an all-cause mortality measure designed to capture deaths within 90 days of an isolated CABG procedure (for example, CABG surgeries not accompanied with a valve or other major cardiac/thoracic procedure). The CABG mortality measure complies with accepted standards for outcomes measure development, including appropriate risk adjustment and transparency of specifications. The model was developed using Medicare Fee-for-Service (FFS) data and validated using data from July 2014 – June 2017 data. In our measure Development Sample from July 2014 - June 2017, there were 68, 909 inpatient admissions among Medicare fee-for-service (FFS) beneficiaries ages 65 across 1173 United States (US) acute care hospitals. The observed 90-day mortality rate was 4.8 percent.

The 90-day CABG mortality measure complies with accepted standards for outcome measure development, including appropriate risk adjustment and transparency of specifications. Our goal is to include admissions for patients for whom mortality is likely to present a quality signal and those where the hospital can influence the outcome for the patient. The mortality measure will document 90-day survival and inform quality improvement efforts targeted toward maximizing survival in the post-operative period. This report reflects specifications that have been developed with a nationally convened Technical Expert Panel (TEP) representing a diverse set of stakeholders, including patients, caregivers, and clinicians.

1.2 Background

The CMS contracted with CORE to develop an administrative claim-based hospital-level 90-Day, all-cause risk-standardized mortality rate (RSMR) measure following isolated coronary artery bypass graft (CABG) surgery intended for use in alternative payment models. In 2012, CORE, working closely with the Society for Thoracic Surgeons, developed a hospital-level 30-day mortality measure for patients undergoing isolated CABG surgery based upon administrative claims data to assess quality of care delivered to these patients.[8,9] In 2015, CMS began publicly reporting 30-day risk-standardized mortality rates (RSMRs) for CABG surgery for the nation's non-federal short-term acute care hospitals (including Indian Health Service hospitals) and critical access hospitals. CMS seeks to harmonize measures across programs in order to reduce burden and confusion for patients and providers.[10] Many procedural-based payment models aim to reduce healthcare costs while incentivizing multidisciplinary care and improved care coordination to improve quality.[3] Therefore, CMS tasked CORE with re-specifying CMS's existing claims-based outcome measure, 30-day Risk-Standardized Mortality for isolated CABG Surgery (not accompanied with a valve or other major cardiac/thoracic procedure), for use across a range of alternative payment models. To accomplish this, CORE will re-specify the current 30-day mortality measure among patients with isolated CABG to capture a 90-day outcome period.

The goal of the measure is to improve the quality of care delivered to patients undergoing CABG procedures. The 90-day mortality measure will capture short-term survival while also inform quality improvement efforts targeted toward maximizing survival in the post-operative discharge period that may require a mix of postoperative care and medical comorbidity management. The premise is that improved quality of care, including coordination and communication among providers and with patients and their caregivers can favorably influence performance on this measure. Furthermore, this measure will offer a valuable balancing measure for use in various alternative payment programs, ensuring patient outcomes are not adversely impacted by any cost reduction efforts.

In this technical report, we provide detailed information on the development and specifications of an administrative claims-based, hospital-level isolated CABG 90-day mortality measure. Briefly, we engaged with diverse stakeholders through a Technical Work Group, nationally convened a Technical Expert Panel (TEP), and issued a call for public comments to re-specify the 30-day measure to capture a 90-day period after surgery. We also performed rigorous testing to ensure scientific acceptability of the new measure. The CABG mortality measure complies with accepted standards for outcomes measure development, including appropriate risk adjustment and transparency of specifications. The measure was developed using Medicare Fee-for- Service (FFS) data from July 2014 – June 2017.

1.2.1 Importance of 90 Day CABG Mortality

CABG is a priority area for outcome measure development because it is a common procedure associated with considerable morbidity, mortality, and health care spending. Acute myocardial infarction and coronary atherosclerosis represent the 5th and 9th most costly conditions in the U.S. across all ages and payers, despite being relatively less common reasons for inpatient admission and are often treated by CABG procedures. Their rank rises further among patients 65 years and older.[11] In fiscal year 2009, isolated

CABG surgeries accounted for almost half (47.6%) of all cardiac surgery hospital admissions in Massachusetts.[7] In 2008, the average Medicare payment was $30,546 for CABG without valve and $47,669 for CABG plus valve surgery.[12,13]

Recent literature suggests that, for several specific outcomes, 90-day mortality rates are nearly double 30-day rates and a larger number of performance outliers are identified when extending a measure out to 90 days.[14-17] Mortality associated with CABG surgery occurs beyond 30 days and a longer period of follow-up naturally captures more events. Data from a Danish registry showed that the risk of mortality after CABG persists up to 90-120 days after surgery, when the risk plateaus.[18] For general hospital admissions, including both surgical and non-surgical cohorts, an analysis of French national discharge records reported that only 0.5% of 1-year mortality was missed at the 90-day threshold, compared to 7.8% missed at the 30-day threshold, suggesting that a 90-day period captures the vast majority of deaths after CABG.[16] Siregar argued that follow-up after cardiac surgery should be extended beyond the 30-day period in order to better capture the range of mortality outcomes.[18] In preliminary analyses, we found all-cause observed 90-day mortality after isolated CABG was 4.7%, compared to an observed rate of 3.1% for the 30-day outcome period. Furthermore, there was considerable variability in the hospital observed overall 90-day mortality rate, with a 10th percentile of 3.6% and a 90th percentile of 6.4% mortality. Variation in these rates suggests that there is room for improvement. Capturing mortality beyond 30 days could allow for continued improvements in patient outcomes by capturing perioperative events after 30 days as well as highlighting the need for complex comorbidity management in the extended postoperative period.

Postoperative readmission is common and is strongly associated with postoperative mortality.[19] In fact, 27% of Medicare beneficiaries who underwent surgical procedures experienced readmission within the 90-day period.[20] Several studies indicate that procedural factors (for example, wearable cardioverter defibrillators and use of extracorporeal circulation) and complications of care (for example, post-surgical impairment of renal function) may be associated with mortality up to 90 days and beyond.[21,22] As the measurement period is extended, optimal postoperative management and care coordination becomes increasingly important in reducing complications and averting deaths. For example, patients living farther away from the hospital where they underwent their CABG surgery were more likely to be readmitted to a different hospital and had an increased risk of mortality.[23] A 90-Day CABG mortality measure intended for use in alternate payment programs can reveal critical disparities such as this and help incentivize better post-operative care for all patients regardless of distance from a CABG surgery center. Hospitals are responsible for many post-acute care decisions and can further impact outcomes including mortality, by enhancing care coordination of follow-up care including admission to rehabilitation facilities and programs and of follow-up care, can impact mortality, especially in context of alternate payment models that incentivize coordinated post-discharge care.

1.3 CABG Mortality as a Measure of Quality

Mortality is an unwanted outcome for the overwhelming majority of patients admitted to US hospitals. Although mortality within 90 days of isolated CABG procedures is uncommon, when assessed among appropriate patients, it provides a concrete signal of care quality across conditions and procedures. It captures the result of care processes, such as peri-operative management protocols, and the impact of both optimal care and adverse events resulting from medical care.

Literature on hospital quality improvement measures directly targeting CABG mortality outcomes is sparse. However, there is support that hospitals can indirectly affect mortality through measures designed to increase participation in post-acute rehabilitation and medication compliance, improve discharge planning and follow-up, decrease treatment variation, and reduce surgery-related complications. Evaluating all-cause mortality encourages hospitals to take a broader approach to quality improvement initiatives such as facilitating post-acute care decisions, assessment of treatment disparities, and engaging in community partnerships. Hospitals have the potential to affect post-acute care decisions through discussions of options with patients. The post-discharge period is one of "heightened vulnerability" in which discharge planning and follow-up are essential for patient understanding and compliance.[24-28]

Cardiac rehabilitation following CABG is associated with better cardiac health and improved lifestyle choices and medication adherence.[29,30] Unfortunately, only between 16% and 44% participate in cardiac rehabilitation.[31,32] Home-based cardiac rehabilitation improved quality of life and the addition of tele rehabilitation to conventional cardiac rehabilitation was more effective than cardiac rehabilitation alone.[33,34] Simple, low-cost interventions have been effective in increasing participation in cardiac rehabilitation, having patients make positive lifestyle choices, and adhering to medication orders. A recent study estimated that increasing participation in rehabilitation from 20% to 70% would result in 25,000 lives saved and 180,000 hospitalizations prevented annually.[35]

1.4 Approach to Measure Re-specification

We developed this measure in accordance with national guidelines for publicly reported outcomes measures, and in consultation with clinical and measurement experts, key stakeholders, and the public. The proposed measure is consistent with the technical approach to outcomes measurement set forth in National Quality Forum (NQF) guidance for outcomes measures,[4] CMS's Measure Management System (MMS) guidance, and the guidance articulated in the American Heart Association scientific statement, "Standards for Statistical Models Used for Public Reporting of Health Outcomes."[5] Throughout measure development, we obtained expert and stakeholder input via three mechanisms: first, through regular discussions with a Technical Work Group, second, through meetings with a national Technical Expert Panel (TEP), and third, through public comment.

The Technical Work Group was comprised of two cardiothoracic surgeons in addition to the measure development team. The Technical Work Group meetings addressed key aspects of measure development, including detailed discussions regarding the appropriate cohort for inclusion in the measure and adequate case mix adjustment. The Technical Work Group

provided a forum for focused expert review and discussion of technical issues during measure development prior to consideration by the broader TEP and public.

In addition to the working group, and in alignment with the CMS's MMS, we convened a national TEP of diverse perspectives and backgrounds, including clinicians, consumers (patients and caregivers), coding and informatics, experts in quality improvement and other stakeholders.

To recruit the TEP, we posted a call for TEP nominations on the CMS website, which included a brief description of the measures being developed, the measure development process, and information on expected TEP member involvement. We also identified potential TEP members and relevant organizations and notified them of the call. All nominations (comprised of a signed nomination/disclosure/agreement form, a statement of interest, and a CV) were compiled, reviewed with and confirmed by CMS. The final TEP consisted of 12 members, including three patients or caregivers. (Please see Appendix A for a detailed acknowledgement list)

2. Methods

2.1 Overview

We developed a hospital-level mortality measure for patients aged 65 years and over admitted for a qualifying isolated CABG procedure to non-Federal acute care hospitals in the U.S. (including U.S. Virgin Islands, Puerto Rico, Guam, Northern Mariana Islands, and American Samoa).

To develop the measure, we used the Medicare administrative data to create two datasets (Development and Validation) by randomly splitting all patients at all hospitals in two. Each contain a random 50% sample of hospitalization data for FFS Medicare beneficiaries admitted for a qualifying CABG procedure between July 2014 and June 2017. The datasets also include administrative data on each patient for the 12 months prior to the index admission and the 90 days following it. An index admission is the hospitalization considered for the outcome.

The measure calculates hospital-level risk-standardized mortality rates (RSMRs) using a hierarchical logistic regression model to account for the clustering of patients within hospitals, while risk-adjusting for differences in patient case-mix. We risk-adjusted for patients' comorbid conditions, as identified in both inpatient and outpatient claims for the 12 months prior to the index hospitalization, as well as those present at admission. The model does not risk-adjust for diagnoses that may have been a complication of the index admission. The measure was tested using the Validation Sample as well as through comparison with external data.

2.2 Data Sources

Medicare administrative claims data and other data sources were separated into the following datasets for the purposes of measure development and measure testing:

Model Development and Validation Samples - To create the model Development and Validation Samples, we applied the inclusion and exclusion criteria to all CABG admissions (N=278, 361) from July 2014 to June 2017. We used the 137, 819 CABG admissions that met the inclusion and exclusion criteria and randomly split the sample 50-50 to create the model Development Sample and model Validation Sample. These samples used inpatient claims data to identify the measure cohort (patient population):

Inpatient data (to identify the cohort and comorbidities for risk adjustment) - contains final action claims data submitted by inpatient hospital providers for Medicare FFS beneficiaries for reimbursement of facility costs. Information in this file includes diagnoses (The International Classification of Diseases, 9th and 10th Revision, Clinical Modification, or ICD-9-CM and ICD-10-CM diagnosis codes, respectively), procedures (ICD-9-CM and ICD-10 Procedure Coding System [PCS]), dates of service, hospital provider, and beneficiary demographic information. The SAS software system, used to estimate the models, applies the appropriate version of the condition categories (CC) map based on the type of ICD, 9th or 10th revision, used. Mappings which show the assignment of ICD-9 and ICD-10 codes to the CCs are available on the QualityNet website.

We used the following data sources for risk adjustment, defining the mortality outcome, and additional measure testing:

Facility outpatient data (to identify comorbidities for risk adjustment) - contains final action claims submitted by inpatient hospital providers for Medicare FFS claims paid for the facility component of surgical or diagnostic procedures, emergency room care, and other non-inpatient services performed in a hospital outpatient department or ambulatory surgical/diagnostic center.

Physician supplier services data (to identify comorbidities for risk adjustment) - contains final action claims for physician services (regardless of setting) and other outpatient care, services, and supplies for Medicare FFS beneficiaries. For purposes of this project, services included only face-to-face encounters between a care provider and patient. We, thus, do not include services such as laboratory tests, medical supplies, or other ambulatory services.

Medicare Enrollment Database (EDB) (to determine the mortality outcome) - contains Medicare beneficiary demographic, benefit/coverage, and vital status information.

The Society of Thoracic Surgeons (STS) Adult Cardiac Surgery National Database (to assess overall measure result validity) – a large adult cardiac registry that collects and publicly reports outcomes, including isolated CABG, since 2010. (see section 2.11.4)

2.3 Outcome Definition

The outcome for this measure is 90-day all-cause mortality. We define this as death from any cause within 90 days of the CABG procedure date.

2.3.1 90-Day Timeframe

We use a standard period of assessment so that the outcome for each patient is measured consistently. Without a standard period, variation in length of stay would have an undue influence on mortality rates, and institutions would have an incentive to adopt strategies to shift deaths out of the hospital without improving quality. We start the 90-day window from the day of the CABG procedure, rather than the day of admission, as some patients are hospitalized for several days prior to undergoing CABG surgery. This also aligns with the existing CMS 30-day CABG mortality measure as well as other related measures.

We chose a 90-day window at the request of CMS to best align with existing and possible future payment models. In addition to the justification provided above, clinical experts in our working group and TEP concur that the 90-day timeframe is clinically sensible for measuring outcomes following CABG surgery to capture the effects of perioperative care as well as the effects of care provided in the post-discharge period that may require a mix of postoperative care and medical comorbidity management.

2.3.2 All-Cause Mortality

The outcome for this measure is 90-day all-cause mortality. We define this as death from any cause within 90 days of the CABG procedure date. We measure all-cause mortality rather than CABG-specific mortality, which is the same as currently publicly reported 30-day CABG risk-standardized mortality rates, for several reasons. First, limiting the measure to CABG-related mortalities may limit the focus of efforts to

improve care to a narrow set of approaches as opposed to encouraging broader initiatives aimed at improving overall care. Second, the cause of death may be unreliably recorded and it is often not possible to exclude quality issues and accountability based on the documented cause of mortality. For example, a patient hospitalized for CABG surgery who develops a hospital-acquired infection may ultimately die of sepsis (overwhelming infection) 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 misleading. Finally, from a patient perspective, death due to any cause is the outcome that matters to patients.

2.4 Cohort Definition

We used the same cohort definition as the 30-Day Risk-Standardized Mortality Measure for Isolated CABG Surgery, which was vetted in the development of that measure by a TEP of national experts and the public. The cohort includes patients aged 65 years and older who received a qualifying CABG procedure at an acute care facility. Patients are eligible for inclusion if they had a qualifying isolated CABG procedure, and continuous enrollment in Medicare FFS, 12 months prior to the first day of the index hospital stay and through 90 days post-procedure. The cohort is defined using the ICD-9 Clinical Modification (ICD-9-CM) and ICD-10 Clinical Modification (ICD-10-CM) procedure codes identified in Medicare inpatient claims data. Appendix B provides the final CABG measure cohort codes. This cohort is as harmonized as possible with other CABG mortality measures, such as The Society of Thoracic Surgeons' Risk-Adjusted Operative Mortality for CABG measure, accounting for differences in data sources (claims versus registry data).

2.4.1 Isolated CABG Cohort Definition

In order to include a clinically-coherent set of patients in the measure, we are using the same definition used in 30-Day Risk-Standardized Mortality Measure for Isolated CABG Surgery, which was developed in collaboration and input from clinical experts. Since mortality rates following other concomitant cardiac and non-cardiac procedures, such as valve replacement and carotid endarterectomy, performed simultaneous to CABG procedure are higher than those following "isolated" CABG procedures,[36,37] or CABG procedures performed without concomitant high-risk cardiac and non-cardiac procedures. All of those measures developed by the STS, including the NQF-endorsed STS Risk-Adjusted Operative Mortality for CABG measure,[36] consider isolated CABG patients separate from those undergoing CABG plus valve procedures. Limiting the measure cohort to "isolated" CABG patients is consistent with published reports of CABG outcomes[37] and the NQF-endorsed STS Risk-Adjusted Operative Mortality for CABG measure.[37]

We defined isolated CABG patients as those undergoing CABG procedures without concomitant valve or other major cardiac, vascular or thoracic procedures (Table 1).

Table 1. Concurrent Procedure Groups that Exclude Patients from Isolated CABG Cohort

Procedure groups excluded in "isolated CABG" definition:	Rationale
• 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	• Represent higher risk population of patients • Align with STS measures (to the extent possible given data limitations)

2.5 Inclusion/Exclusion Criteria

Admissions eligible for inclusion in the measure are those for patients aged 65 years or older admitted to non-federal acute care hospitals for isolated CABG procedures (for example, CABG surgeries that occur concomitantly with excluded procedures and procedure groups such as aortic valve replacement) AND continuously enrolled in Medicare FFS 12 months prior to the first day of the index hospitalization. Medicare patients younger than age 65 usually qualify for the program due to severe disability. They are not included in the measure because they are considered to be clinically distinct from Medicare patients aged 65 and over. The flow chart depicting eligible admissions is presented in Figure 5 in the Results Section. An index admission is any eligible admission to a non-federal acute care hospital assessed in the measure for the outcome (all-cause death within 30 days of the date of the index CABG procedure). Eligible index admissions are identified using the ICD-09 or ICD-10 codes listed in Appendix B.

We excluded the following admissions from the measure:

- Patients with inconsistent or unknown vital status or other unreliable data.
  Rationale: We exclude these because the outcome cannot be adequately measured in these patients.
- Patients who leave the hospital against medical advice (AMA).
  Rationale: We exclude hospital stays for patients who are discharged AMA because providers did not have the opportunity to deliver full care and prepare the patient for discharge.
- 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 very likely represents a complication of the original CABG procedure and is a clinically more complex and higher risk surgery. We therefore select the first CABG admission for inclusion in the measure and exclude subsequent CABG admissions from the cohort.

2.6 Transferred Patients and Attribution of Mortality Outcome

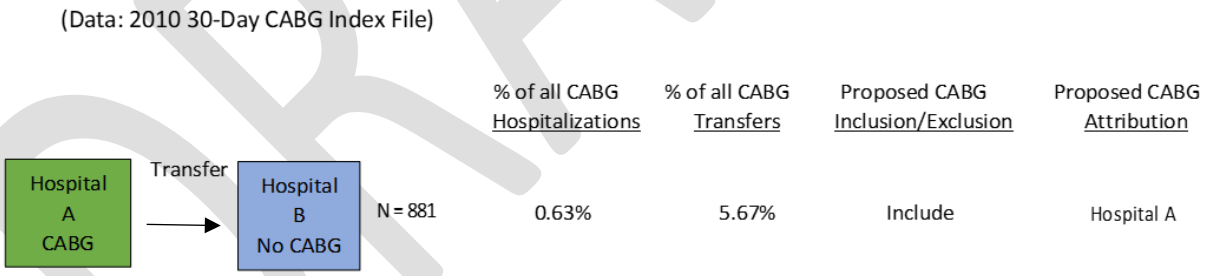
In measure development, the goal was to attribute the mortality outcome to the hospital performing the first ("index") CABG. However, patients may have more than one admission

during an acute episode of care for CABG surgery and in rare instances another CABG procedure during the mortality measurement period. For example, a patient may be admitted to Hospital A, where a qualifying CABG procedure is performed, and then transferred to Hospital B. The initial admission to Hospital A and the admission to Hospital B are considered one acute episode of care, made up of two inpatient admissions. We identified 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. Below we summarize the most common transfer scenarios arising in the CABG measure re-specification cohort and the attribution of the mortality outcome in each scenario. The following decisions are based upon the fact that transfer following a CABG procedure almost always reflects one or more serious complication(s) (and/or its sequelae) arising at the index hospital.

Transfer scenarios figures 1-3 utilize 2009 Medicare FFS data to supplement transfer scenario descriptions.

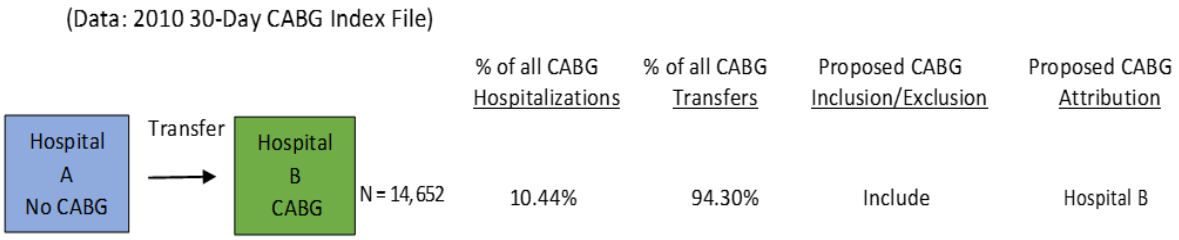
Transfer Scenario 1 (Figure 1) indicates that a patient undergoes a CABG procedure at Hospital A and then is transferred to hospital B (but does not receive additional CABG procedures). The measure will attribute the mortality outcome to Hospital A, which performed the index CABG procedure, and starts the 90-day window from the day the CABG is performed at Hospital A. This scenario is included in the measure because excluding it might miss important quality of care information. In addition, excluding this scenario might provide hospitals with an incentive to transfer sicker patients to other hospitals in order to avoid measurement.

Figure 1. Attribution of Mortality Outcomes Among Transferred Patients: Scenario 1[8]



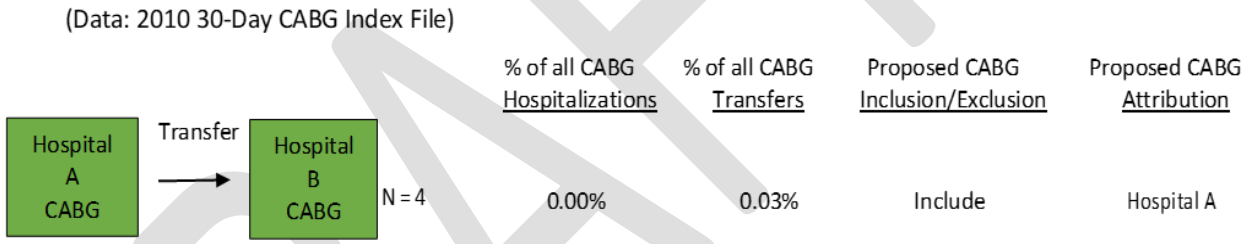
Transfer Scenario 2 (Figure 2) indicates that a patient is admitted to Hospital A (but does not receive a CABG procedure at Hospital A) and is transferred to Hospital B to receive a CABG procedure. The measure will attribute the mortality outcome to Hospital B, which performed the index CABG procedure, and starts the 90-day window from the day the CABG is performed at Hospital B. This is a common scenario arising in the CABG measure Development Sample and attributing the outcome to the second hospital is consistent with other procedure-based measures.[38,39]

Figure 2. Attribution of Mortality Outcomes Among Transferred Patients: Scenario 2[8]



Transfer Scenario 3 (Figure 3) indicates that a patient undergoes a CABG procedure at Hospital A and then is transferred to Hospital B, to receive a second (non-index) CABG procedure. The measure attributes the mortality outcome to Hospital A, which performed the index CABG procedure, and starts the 90-day window from the day the CABG is performed at Hospital A. In this scenario, the index CABG cannot occur in Hospital B.

Figure 3. Attribution of Mortality Outcomes Among Transferred Patients: Scenario 3[8]



2.7 Approach to Risk Adjustment

The goal of risk adjustment is to account for differences in patients' severity of illness across hospitals to explain differences in performance that reflect quality of care (and not differences in patients' status at presentation). The model adjusts for case mix differences based on the clinical status of the patient at the time of admission. Conditions that may represent adverse outcomes due to care received during the index admission are not considered for inclusion in the risk-adjusted model. Although they may increase the risk of mortality, including these risk variables as covariates in a risk-adjusted model could reduce the measure's ability to characterize the quality of care delivered by hospitals. Appendix C lists the conditions not adjusted for if they only appear in the index admission without being present on admission (POA) and not in the 12 months prior to admission. This methodology is consistent with NQF guidelines.

The model does not currently adjust for socioeconomic status (SES), race, or ethnicity. Variation in quality associated with these characteristics may be indicative of disparities in the quality of the care provided to vulnerable populations, and risk adjusting for these factors would obscure these disparities.[40] The model does not adjust for hospital characteristics either (for example, teaching status) since this would hold different types of hospitals to different quality standards, and because such characteristics may exist on a causal pathway to the outcome, rather than act as confounders.

2.8 Candidate and Final Risk-Adjustment Variables

Our goal was to develop a risk-adjusted model that includes clinically relevant variables associated with 90-day mortality. The candidate variables for the model were derived from 1) the index admission (with comorbidities identified from the index admission secondary diagnoses, excluding potential complications), 2) inpatient Part A data from any admissions in the 12 months prior to admission, and 3) outpatient hospital and Part B physician data from any visits in the 12 months prior to admission.

For risk model development, we started with Condition Categories (CCs) which are part of CMS's Hierarchical Condition Categories (HCC). The HCC system groups the 71,704 ICD-10-CM codes into larger clinically coherent groups (201 CCs) that are used in models to predict mortality or other outcomes. We used the ICD-09-CM or ICD-10-CM to CC assignment map (Version 22), which is maintained by CMS. For ICD-09-CM codes, we started with 189 Condition Categories (CCs) which are part of CMS's Hierarchical Condition Categories (HCC). The HCC system groups the ICD-09-CM codes into larger groups that are used in models to predict medical care utilization, mortality or other related measures. CCs are clinically relevant diagnostic groups of the more than 15,000 ICD-09 codes.[41] We used the ICD-09 to CC assignment map, which is maintained by CMS.

To select candidate variables, a team of clinicians reviewed all 201 CCs and excluded those that were not relevant to the Medicare population or that were not clinically relevant to the mortality outcome (for example, attention deficit disorder, female infertility, Appendix D). All potentially clinically relevant CCs were included as candidate variables and, consistent with CMS's other claims-based mortality measures, some of those CCs were then combined into clinically coherent CC groupings. Informed by input from our Technical Work Group and TEP, other candidate variables included age, gender, and cardiogenic shock, measures of urgency of surgery (presentation from ED), and pre-operative use of intra-aortic balloon pumps (IABP) for circulatory support (see Table 2 for ICD-09-CM/ICD-10-PCS codes).

Table 2. Candidate Model Variables for Risk Adjustment

Category	Variable	CC or ICD-09-CM or ICD-10-CM/PCS
Demographics	Age	--
	Gender	--
Comorbidities	Transferred from another Acute Care Hospital	--
	Transferred from ED	--
	Transferred from ED of another Acute Care Hospital	--
	IABP prior to procedure	ICD-09-CM procedure: 3760,3761,3762,3763,3765, 3766,3768 ICD-10-PCS: 02HA0QZ,02HA0RJ, 02HA0RS,02HA0RZ,02HA3QZ, 02HA3RJ,02HA3RS,02HA3RZ,

Category	Variable	CC or ICD-09-CM or ICD-10-CM/PCS
		02HA4QZ,02HA4RJ,02HA4RS, 02HA4RZ,02WA0QZ,02WA0RS, 02WA0RZ,02WA3QZ,02WA3RS, 02WA3RZ,02WA4QZ,02WA4RS, 02WA4RZ,5A02110,5A02116, 5A0211D,5A02210,5A02216, 5A0221D
	History of Prior CABG or Valve Surgery	ICD-09-CM: procedure (3961), diagnosis codes (V422, V423, V4581, 41402, 41403, 41404, 41405, 41406, 41407, 99602, 99603. (ICD-10-CM Codes: Available on Quality Net)
	Cardiogenic Shock	ICD-09-CM: 78551 ICD-10 code R570
	Coronary Atherosclerosis/Other Chronic Ischemic Heart Disease	ICD-09-CM diagnosis: 4142,4143,4148,4149,41400,41401, 41410,41411,41412,41419,74685 ICD-10-CM diagnosis: I2510,I25110,I25111, I25118,I25119,I253,I2541,I2542,I255,I256, I2683,I2589,I259,Q245
	Infections	CC1, CC3-CC7
	Septicemia, Sepsis, Systemic Inflammatory Response Syndrome/Shock	CC2
	Cancers	CC8-CC15
	Benign Neoplasms	CC16
	DM or DM complications	CC17-CC19, CC122-CC123
	Protein-Calorie Malnutrition	CC21
	Morbid Obesity	CC22
	Other Significant Endocrine and Metabolic Disorders	CC23
	Disorders of Fluid/Electrolyte/Acid-Base Balance	CC24
	Disorders of Lipoid Metabolism	CC25-CC26
	Liver and Biliary Disease	CC27-CC32
	Intestinal Obstruction/Perforation	CC33
	Chronic Pancreatitis	CC34
	Inflammatory Bowel Disease	CC35
	Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders	CC36
	Appendicitis	CC37
	Other Gastrointestinal Disorders	CC38

Category	Variable	CC or ICD-09-CM or ICD-10-CM/PCS
	Bone/Joint/Muscle Infections/Necrosis	CC39
	Rheumatoid Arthritis and Inflammatory Connective Tissue Disease	CC40
	Disorders of the Vertebrae and Spinal Discs	CC41
	Osteoarthritis of Hip or Knee	CC42
	Osteoporosis and Other Bone/Cartilage Disorders	CC43
	Congenital/Developmental Skeletal and Connective Tissue Disorders	CC44
	Other Musculoskeletal and Connective Tissue Disorders	CC45
	Severe Hematological Disorders	CC46
	Disorders of Immunity	CC47
	Coagulation Defects and Other Specified Hematological Disorders	CC48
	Iron Deficiency and Other/Unspecified Anemias and Blood Disease	CC49
	Dementia, Nonpsychotic Organic Brain Syndromes/Conditions	CC51-CC53
	Drug/Alcohol Psychosis/Dependence	CC54-CC56
	Major pysch disorders	CC57-CC59
	Personality Disorders	CC60
	Depression/Anxiety Disorders	CC61-CC62
	Other Psychiatric Disorders	CC63
	Intellectual Disability/Developmental Disorder	CC64-CC69
	Quadriplegia, Paraplegia, Hemiplegia/Hemiparesis, Monoplegia, Other Paralytic Syndromes	CC70-CC74, CC103-CC104, CC189-CC190
	Myasthenia Gravis/Myoneural Disorders and Guillain-Barre Syndrome/Inflammatory and Toxic Neuropathy	CC75-CC76
	Multiple Sclerosis, Parkinson's and Huntington's Diseases	CC77-CC78
	Seizure Disorders and Convulsions	CC79
	Coma, Brain Compression/Anoxic Damage	CC80

Category	Variable	CC or ICD-09-CM or ICD-10-CM/PCS
	Polyneuropathy, Mononeuropathy, and Other Neurological Conditions/Injuries	CC81
	Respirator Dependence/Tracheostomy Status, Respiratory Arrest, Cardio-Respiratory Failure and Shock	CC82-CC84
	Congestive Heart Failure	CC85
	Acute Myocardial Infarction, Unstable Angina and Other Acute Ischemic Heart Disease	CC86-CC87
	Angina Pectoris, Coronary Atherosclerosis/Other Chronic Ischemic Heart Disease	CC88-CC89
	Heart Infection/Inflammation, Except Rheumatic	CC90
	Valvular and Rheumatic Heart Disease	CC91
	Congenital Cardiac/Circulatory Defect	CC92-CC93
	Hypertensive Heart Disease, Hypertension	CC94-CC95
	Heart Arrhythmias	CC96-CC97
	Other and Unspecified Heart Disease	CC98
	Stroke	CC99-CC100
	Cerebrovascular Atherosclerosis, Aneurysm, and Other Disease	CC101-CC102, CC105
	Vascular Disease	CC106-CC109
	Cystic Fibrosis	CC110
	Chronic Obstructive Pulmonary Disease	CC111
	Fibrosis of Lung and Other Chronic Lung Disorders	CC112
	Asthma	CC113
	Pneumonias	CC114-CC117
	Other Respiratory Disorders	CC118
	Legally Blind	CC119
	Major Eye Infections/Inflammations	CC120
	Retinal Detachment	CC121
	Exudative Macular Degeneration	CC124
	Other Retinal Disorders	CC125
	Glaucoma	CC126
	Other Eye Disorders	CC128
	Significant Ear, Nose, and Throat Disorders	CC129

Category	Variable	CC or ICD-09-CM or ICD-10-CM/PCS
	Hearing Loss	CC130
	Other Ear, Nose, Throat, and Mouth Disorders	CC131
	Kidney Transplant Status, Major Organ Transplant or Replacement Status	CC132, CC186
	Dialysis Status	CC134
	Acute Renal Failure	CC135-CC140
	Nephritis	CC141
	Urinary Obstruction and Retention	CC142
	Urinary Incontinence	CC143
	Urinary Tract Infection	CC144
	Other Urinary Tract Disorders	CC145
	Pelvic Inflammatory Disease and Other Specified Female Genital Disorders	CC147
	Other Female Genital Disorders	CC148
	Male Genital Disorders	CC149
	Pressure Ulcer of Skin with Necrosis Through to Muscle, Tendon, or Bone	CC157-CC161
	Skin Burn or Condition	CC162-CC163
	Cellulitis, Local Skin Infection	CC164
	Other Dermatological Disorders	CC165
	Head Injury OR Hip/Knee injuries	CC166-CC168, CC170-174
	Vertebral Fractures without Spinal Cord Injury	CC169
	Poisonings and Allergic and Inflammatory Reactions	CC175
	Complications of Specified Implanted Device or Graft	CC176-CC177
	Major Symptoms, Abnormalities	CC178
	Minor Symptoms, Signs, Findings	CC179
	Other Organ Transplant Status/Replacement	CC187

To inform final variable selection, a modified approach to stepwise logistic regression was performed. The Development Sample was used to create 1,000 “bootstrap” samples. For each sample, we ran a logistic stepwise regression that included the candidate variables. The results (not shown in this report) were summarized to show the percentage of times that each of the candidate variables was significantly associated with mortality ($p<0.01$) in each of the 1,000 repeated samples (for example, 90 percent would mean that the candidate variable was selected as significant at $p<0.01$ in 90 percent of the times). We also assessed the direction and magnitude of the regression coefficients.

The clinical team reviewed these results and decided to retain risk adjustment variables above an 80% cutoff, because they demonstrated a strong and stable association with risk of death

and were clinically relevant. Additionally, specific variables with particular clinical relevance to the risk of death were forced into the model (regardless of percent selection) to ensure appropriate risk adjustment for CABG. These included:

Markers for end of life/frailty:

- Decubitus Ulcer or Chronic Skin Ulcer (CC 157-CC 161)
- Cancers (CC 8-CC 15)
- Hemiplegia, Paraplegia, Paralysis, Functional disability (CC 70-CC 74, CC 103, CC 104, CC 189-CC 190)
- Stroke (CC 99-CC 100)

The final model variables for risk adjustment are listed in Table 3.

Table 3. Final Model Variables for Risk Adjustment

Category	Variable	CC or ICD-09-CM ICD-10-CM/PCS
Demographics	Age	--
	Gender	--
Comorbidities	Transferred from ED	--
	IABP prior to procedure	ICD-09-CM procedure: 3760,3761,3762,3763,3765, 3766,3768 ICD-10-PCS: 02HA0QZ,02HA0RJ, 02HA0RS,02HA0RZ,02HA3QZ, 02HA3RJ,02HA3RS,02HA3RZ, 02HA4QZ,02HA4RJ,02HA4RS, 02HA4RZ,02WA0QZ,02WA0RS, 02WA0RZ,02WA3QZ,02WA3RS, 02WA3RZ,02WA4QZ,02WA4RS, 02WA4RZ,5A02110,5A02116, 5A0211D,5A02210,5A02216, 5A0221D
	History of Prior CABG or Valve Surgery	ICD-09-CM: procedure (3961), diagnosis codes (V422, V423, V4581, 41402, 41403, 41404, 41405, 41406, 41407, 99602, 99603. (ICD-10-CM Codes: Available on Quality Net)
	Cardiogenic Shock	ICD-09-CM: 78551, ICD-10 code R570
	Benign Neoplasms	CC16
	Protein-Calorie Malnutrition	CC21
	Morbid Obesity	CC22
	Disorders of Fluid/Electrolyte/Acid-Base Balance	CC24
	Disorders of Lipoid Metabolism	CC25-CC26
	Liver and Biliary Disease	CC27-CC32

Category	Variable	CC or ICD-09-CM ICD-10-CM/PCS
	Other Gastrointestinal Disorders	CC38
	Dementia, Nonpsychotic Organic Brain Syndromes/Conditions	CC51-CC53
	Respirator Dependence/Tracheostomy Status, Respiratory Arrest, Cardio-Respiratory Failure and Shock	CC82-CC84
	Congestive Heart Failure	CC85
	Hypertensive Heart Disease, Hypertension	CC94-CC95
	Vascular Disease	CC106-CC109
	Chronic Obstructive Pulmonary Disease	CC111
	Pneumonias	CC114-CC117
	Dialysis Status	CC134
	Acute Renal Failure	CC135-CC140
	Major Symptoms, Abnormalities	CC178
	Quadriplegia, Paraplegia, Hemiplegia/Hemiparesis, Monoplegia, Other Paralytic Syndromes	CC70-CC74, CC103-CC104, CC189-CC190
	Cancers	CC8-CC15
	Stroke	CC99-CC100
	Pressure Ulcer of Skin with Necrosis Through to Muscle, Tendon, or Bone	CC157-CC161

2.9 Statistical Approach to Model Development

The measure calculates mortality rates using a hierarchical logistic regression model to account for the clustering of patients within hospitals while risk-adjusting for differences in patient case-mix. We modeled the log-odds of mortality within 90 days of procedure date from an index CABG admission as a function of patient demographic and clinical characteristics, and a random hospital-specific intercept. This strategy accounts for within-hospital correlation of the observed outcomes and models the assumption that underlying differences in quality among the health care groups being evaluated lead to systematic differences in outcomes.

We then calculate hospital-specific risk-standardized mortality rates. These rates are obtained as the ratio of predicted to expected deaths, multiplied by the national unadjusted rate. The "predicted" number of deaths (the numerator) is calculated using the coefficients estimated by regressing the risk factors 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 then 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 then transformed and summed over all patients in the hospital to get an expected value. To assess hospital performance for each reporting period, we re-estimated the model coefficients using the years of data in that period.

More specifically, we estimate two types of regression models using the administrative data (Figure 4). First, we fit a logistic regression model linking the outcome to the risk factors. Let Y_{ij} denote the outcome (equal to 1 if patient is readmitted within 90-days, zero otherwise) for the j patient discharged from the i hospital; Z_{ij} denotes a set of risk factors based on the administrative data. Let I denote the total number of hospitals and n_i the number of index admissions to hospital i. We assume the outcome is related linearly to the covariates via a known linked function, h, where:

Logistic Regression Model

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

and Z_{ij} = ($Z1_{ij}$, $Z2_{ij}$, …, Zp_{ij}) is a set of p patient-specific covariates. In our case, h = the logit link.

To account for the natural clustering of observations within hospitals, we estimate a hierarchical logistic regression model that links the risk factors to the same outcomes and a hospital-specific random effect.

Hierarchical Logistic Regression Model

$$h\left(\Pr\left(Y_{ij}=1\middle|\boldsymbol{Z}_{ij},\omega_i\right)\right)=log\left(\frac{\Pr(Y_{ij}=1|\boldsymbol{Z}_{ij},\omega_i)}{1-\Pr(Y_{ij}=1|\boldsymbol{Z}_{ij},\omega_i)}\right)=\alpha_i+\boldsymbol{\beta}\boldsymbol{Z}_{ij} \qquad (2)$$

$$\text{where } \alpha_i=\mu+\omega_i;\ \omega_i\sim N(0,\tau^2) \qquad (3)$$

$$i=1,\ldots,\ I;\ j=1,\ldots,n_i$$

where α_i represents the hospital-specific intercept, Z_{ij} is defined as above, μ the adjusted average outcome over all hospitals in the sample, and τ^2 the between-hospital variance component.[42] This model separates within-hospital variation from between-hospital variation. Both hierarchical logistic regression models and logistic regression models are estimated using the SAS software system (GLIMMIX and LOGISTIC procedures respectfully).

We first fit the logistic regression model described in Equation (1) using the logit link.

Having identified the covariates that remained, we next fit the hierarchical logistic regression model described in Equations (2) and (3), again using the logit link function.

2.10 Hospital Performance Reporting

For each hospital, bootstrapping simulations were used to compute a 95% interval estimate of the RSMR to characterize the level of uncertainty around the specific point estimate. The interval estimate is similar to a 95% confidence interval. Together, the point estimate and interval estimate can be used to characterize and compare a hospital's performance to an average performing hospital with a similar case-mix (statistically significantly higher than expected, as expected, or lower than expected).

Using the set of risk factors in the logistic regression model, we fit the hierarchical logistic regression model defined by Equations (2) - (3) and estimate the parameters, $\hat{\mu}$, $\{\hat{\alpha}_i, \hat{\alpha}_2, \ldots, \hat{\alpha}_I\}$, $\hat{\beta}$, and $\hat{\tau}^2$. We calculate a risk standardized outcome, s_i, for each hospital by computing the ratio of the number of predicted deaths to the number of expected deaths, multiplied by the unadjusted overall mortality rate, $\bar{y}$. Specifically, we calculate:

Predicted Value: $$\hat{p}_{ij} = h^{-1}\left(\hat{\alpha}_i + \hat{\boldsymbol{\beta}}\boldsymbol{Z}_{ij}\right) = \frac{\exp(\hat{\alpha}_i + \hat{\boldsymbol{\beta}}\boldsymbol{Z}_{ij})}{\exp(\hat{\alpha}_i + \hat{\boldsymbol{\beta}}\boldsymbol{Z}_{ij}) + 1} \quad (4)$$

Expected Value: $$\hat{e}_{ij} = h^{-1}\left(\hat{\mu} + \hat{\boldsymbol{\beta}}\boldsymbol{Z}_{ij}\right) = \frac{\exp(\hat{\mu} + \hat{\boldsymbol{\beta}}\boldsymbol{Z}_{ij})}{\exp(\hat{\mu} + \hat{\boldsymbol{\beta}}\boldsymbol{Z}_{ij}) + 1} \quad (5)$$

Standardized Mortality Ratio: $$\hat{s}_i = \frac{\sum_{j=1}^{n_i} \hat{p}_{ij}}{\sum_{j=1}^{n_i} \hat{e}_{ij}} \quad (6)$$

We calculate an RSMR, $\widehat{RSMR}_i$, for each hospital by using the estimate from Equation (6) and multiplying by the national observed mortality rate, denoted by $\bar{y}$. Specifically, we calculate:

Risk-Standardized Mortality Rate: $$\widehat{RSMR}_i = \hat{s}_i \times \bar{y} \quad (7)$$

If the number of "predicted" deaths is higher (or lower) than the "expected" number of deaths, then that hospital's $\widehat{RSMR}_i$, will be higher (or lower) than the unadjusted average. For each hospital, we compute an interval estimate of $\widehat{RSMR}_i$, to characterize the level of uncertainty around the point estimate using bootstrapping simulations. The point estimate and interval estimate can be used to characterize and compare hospital performance (for example, higher than expected, as expected, or lower than expected).

I. Creating Interval Estimates

Because the statistic described in Equation (6) is a complex function of parameter estimates, we use re-sampling and simulation techniques to derive an interval estimate. In particular, we use bootstrapping procedures to compute confidence intervals. 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-specific RSMR.

II. 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 hierarchical logistic regression model using all patients within each sampled hospital. We use as starting values 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. 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 $\hat{s}_i(Z)^{(b)}$ in formula (4), (5), and (6) 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 a large selected number of estimates for all hospitals (or the percentiles corresponding to the alternative desired intervals).[43]

2.11 Measure Testing

2.11.1 Reliability of Data Elements

For measure development, we only use data elements in claims that have both face validity and reliability. We do not use fields that are inconsistently coded across providers. We also only use fields that are consequential for payment and which are audited. We identify these variables through empiric analyses and our understanding of CMS auditing and billing policies and do not use variables which do not meet these standards. For example, “discharge disposition” is a variable in Medicare claims data that is not consistently coded across hospitals. Thus, we construct an indicator variable as a surrogate for “discharge disposition” to identify patients that are transferred using variables in the claims data with greater reliability, including admit and discharge dates.

In addition, CMS has in place several hospital auditing programs used to assess overall claims code accuracy, ensure appropriate billing, and recoup overpayments. CMS routinely conducts data analysis to identify potential problem areas and detect fraud, and audits important data fields used in our measures, including diagnosis and procedure codes, and other elements that are consequential to payment.

2.11.2 Reliability of Model

To test the reliability of the model, we assessed model performance and the effect of the risk-adjustment variables on the outcome across the years of data. We computed several summary statistics for assessing model performance which included:[44] over-fitting indices,[45] predictive ability, area under the (ROC) curve, distribution of residuals, and model chi-square.[46]

2.11.3 Measure Results Reliability

The reliability of a measurement is the degree to which repeated measurements of the same entity agree with each other. For measures of hospital performance, the measured entity is the hospital, and reliability is the extent to which repeated measurements of the same hospital give similar results. Accordingly, our approach to assessing measure reliability is to consider the extent to which assessments of a hospital using different but randomly selected subsets of patients produce similar measures of hospital performance. That is, we take a "test-retest" approach in which hospital performance is measured once using a random subset of patients, then measured again using a second random subset exclusive of the first, and the agreement of the two resulting performance measures is compared across hospitals.[47]

For test-retest reliability of the measure in Medicare FFS patients aged 65 years and older, we randomly split the study cohort into two cohorts by sampling half of patients within each hospital into the two cohorts separately. This leads to an underestimate in the actual test-retest reliability that would be achieved if the measure were reported using the full measurement period, as evidenced by the Spearman Brown prophecy formula.[48] We use this to estimate the reliability of the measure if the whole cohort were used, based on an estimate from half the cohort. To the extent that the calculated

measures of these two subsets agree, we have evidence that the measure is assessing an attribute of the hospital, not of the patients.

As a metric of agreement we calculated the intra-class correlation (ICC) coefficient and assessed the values according to conventional standards.[49,50] Specifically, we used a three years' (July 2014 to June 2017) sample, randomly split it into two approximately equal, mutually exclusive subsets of patients, and calculated the RSMR for each hospital for each sample. The agreement of the two RSMRs was quantified for hospitals in each sample using the intra-class correlation (ICC) as defined by ICC (2,1) by Shrout and Fleiss.[50]

Using two non-overlapping random samples provides an honest estimate of the measure's reliability, compared with using two random but potentially overlapping samples which would exaggerate the agreement. Moreover, because our final measure is derived using hierarchical logistic regression, and a known property of hierarchical logistic regression models is that smaller volume hospitals contribute less 'signal', a split sample using a single three-year measurement period will introduce extra noise, potentially underestimating the actual test-retest reliability that would be achieved if the measure were reported using a full three years of data.

In addition, we also assessed signal to noise reliability that describes how well the measure can distinguish the performance of one hospital from another. The signal is the proportion of the variability in measured performance that can be explained by real differences in performance. Scores can range from 0 to 1. A reliability of zero implies that all the variability in a measure is attributable to measurement error. A reliability of one implies that all the variability is attributable to real difference in performance.

2.11.4 Measure Results Validity

To assess the empiric validity of measure results, we compared hospital performance using the 90-day CABG mortality measure to an external quality assessment. The Society of Thoracic Surgeons hospital-level CABG composite star rating (ranging from 1-3 stars) is reported online and calculated using a combination of 11 measures of isolated CABG quality divided into four broad domains (1. risk-adjusted 30-day mortality; 2. risk-adjusted major morbidity; 3. % of CABG procedures that use of internal mammary (or internal thoracic) artery for bypass grafting; and 4. prescription at discharge of beta-blockers, aspirin, and cholesterol-lowering medicines). The Star Rating calculation begins by assuming all providers are average and then determines statistically if there is at least a 99 percent probability that the performance of any specific provider is lower than average (one star) or higher than average (three star). These 11 individual measures and the overall composite measure methodology are all endorsed by the National Quality Forum. We compared the distribution of hospital-level RSMRs for the 90-day CABG mortality level across each Star Rating category. We hypothesized that three-star hospitals would have lower RSMRs (indicating lower mortality and higher quality) than one-star hospitals.

Additionally, we assessed face validity by asking the Technical Expert Panel to rate the following statements using a six-point scale (All questions use the following response options except statement three below: 1=Strongly Disagree, 2=Moderately Disagree, 3=Somewhat Disagree, 4=Somewhat Agree, 5=Moderately Agree, and 6=Strongly Agree):

1. The 90-Day CABG Mortality Measure, as specified, will be able to distinguish between better and worse quality of hospitals for the purposes of measuring quality." As specified indicates with no consideration for social risk and inclusion of all readmitted patients regardless of where they were readmitted (CABG performing versus non- CABG performing hospital).
2. The 90-Day CABG Mortality Measure, modified to include the social risk (Agency for Healthcare Research and Quality [AHRQ] Socioeconomic Status [SES] index) will be able to distinguish between better and worse quality hospitals for the purposes of measuring quality.
3. Regardless of how you responded to the prior two statements, please indicate whether and how you think CMS should consider the social risk (AHRQ SES index) in the measure specifications of this measure. (1=include social risk [AHRQ SES] in measure risk adjustment model, patients with social risk would be assumed to have an expected mortality rate that is higher than similar patients without social risk; 2=calculate/report measure results stratified by social risk [AHRQ SES], measure results would be compared across hospitals and/or patients with similar social risk; 3=some other approach to including social risk [AHRQ SES] in the measure specifications, please provide detailed input below [text box]; 4=do not consider social risk [AHRQ SES] in the measure specifications)
4. The 90-Day CABG Mortality Measure should INCLUDE all patients readmitted within 90 days after isolated CABG surgery, regardless of whether they were readmitted to the hospital that performed the index CABG procedure or another hospital. This is how the measure is currently specified.

3. Results

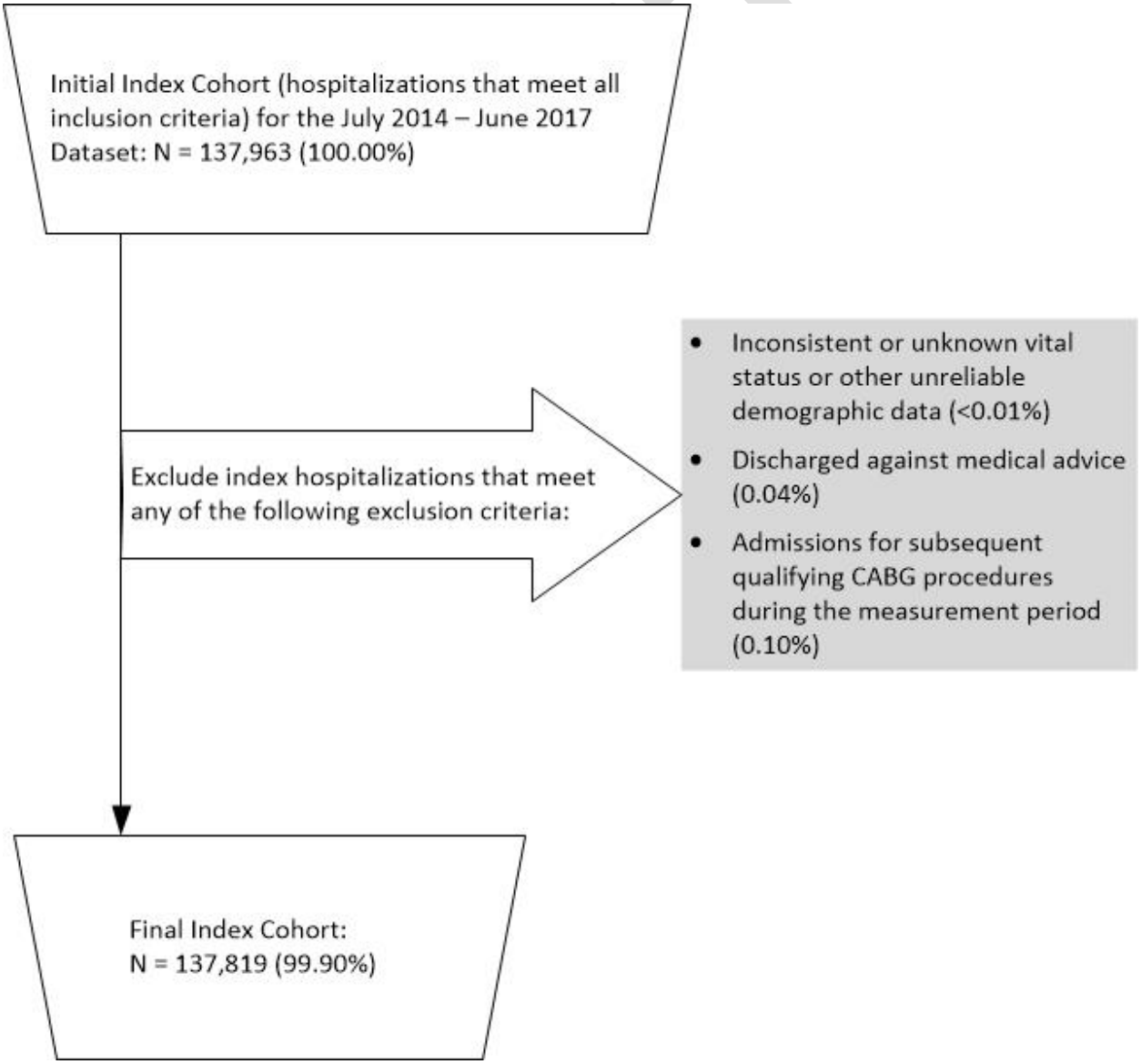
3.1 Model Results

3.1.1 Development & Validation Model

The model Development Sample included 68,909 admissions in July 2014 – June 2017 from 1,173 hospitals. The flow chart depicting eligible admissions and exclusions is presented in Figure 4.

Table 4 details the risk factor frequencies, adjusted odds ratios (ORs), 95% confidence intervals, and P-values for the model risk factors in the Development Sample.

Figure 4. CABG Surgery Proposed Cohort Exclusions July 2014 to June 2017 (Reflects full dataset, prior to random split to create Development and Validation samples)



3.1.2 Hierarchical Logistic Regression Model

Table 4 conveys the full list of risk variables in the model, including the percent of patients with the risk variable, and the Odds Ratios (ORs) with 95% confidence intervals for mortality risk using the hierarchical logistic regression model. A few of the non-statistically significant risk variables represent markers of frailty forced into the model.

Table 4. Hierarchical Logistic Regression Model Results in the Development Sample

Risk Variable Description	Odds Ratio (95% CI)	P-Value
Age (continuous, mean)	1.07 (1.06-1.07)	>0.0001
Gender	0.77 (0.71-0.83)	>0.0001
Transferred from ED	1.28 (1.14-1.43)	>0.0001
IABP prior to the procedure	1.49 (1.28-1.73)	>0.0001
History of Prior CABG or Valve Surgery	1.30 (1.13-1.50)	>0.0001
Cardiogenic Shock	2.30 (1.95-2.71)	>0.0001
Benign Neoplasms	0.80 (0.71-0.90)	>0.0001
Protein-Calorie Malnutrition	2.93 (2.62-3.28)	>0.0001
Morbid Obesity	1.27 (1.12-1.43)	>0.0001
Disorders of Fluid/Electrolyte/Acid-Base Balance	1.25 (1.4-1.36)	>0.0001
Disorders of Lipoid Metabolism	0.66 (0.58-0.75)	>0.0001
Liver and Biliary Disease	1.53 (1.37-1.72)	>0.0001
Other Gastrointestinal Disorders	0.80 (0.74-0.87)	>0.0001
Dementia, Nonpsychotic Organic Brain Syndromes/Conditions	1.34 (1.18-1.52)	>0.0001
Quadriplegia, Paraplegia, Hemiplegia/Hemiparesis, Monoplegia, Other Paralytic Syndromes	1.19 (1.00-1.43)	0.05
Cancers	1.00 (0.92-1.09)	0.99

Risk Variable Description	Odds Ratio (95% CI)	P-Value
Respirator Dependence/Tracheostomy Status, Respiratory Arrest, Cardio-Respiratory Failure and Shock	1.23 (1.11-1.37)	0.0001
Congestive Heart Failure	1.55 (1.43-1.68)	>0.0001
Hypertensive Heart Disease, Hypertension	0.79 (0.71-0.88)	>0.0001
Stroke	1.06	0.48
Vascular Disease	1.24 (1.15-1.34)	>0.0001
Chronic Obstructive Pulmonary Disease	1.33 (1.23-1.44)	>0.0001
Pneumonias	1.43 (1.31-1.56)	>0.0001
Dialysis Status	1.71 (1.45-2.02)	>0.0001
Acute Renal Failure	1.48 (1.36-1.60)	>0.0001
Pressure Ulcer of Skin with Necrosis Through to Muscle, Tendon, or Bone	1.14 (0.98-1.33)	0.09
Major Symptoms, Abnormalities	0.81 (0.74-0.90)	0.0001

3.1.3 Risk Standardized Mortality Rates

In the hierarchical logistic regression model, each hospital has its own intercept (random intercept), which is used to measure the differences in mortality between hospitals while adjusting for case-mix (patient risk factors). The hospital-level risk standardized mortality rates (RSMRs) have a mean of 4.86% and range from 2.04-11.26% in the study cohort. As shown in Figure 5 (graphic results) and Table 5 (tabular results), the median risk-standardized rate is 4.67% (25th and 75th percentiles are 4.08% and 5.49%, respectively).

Figure 5. Distribution (Histogram) of Hospital-Level 90-Day CABG Risk-Standardized Mortality Rates (RSMRs)

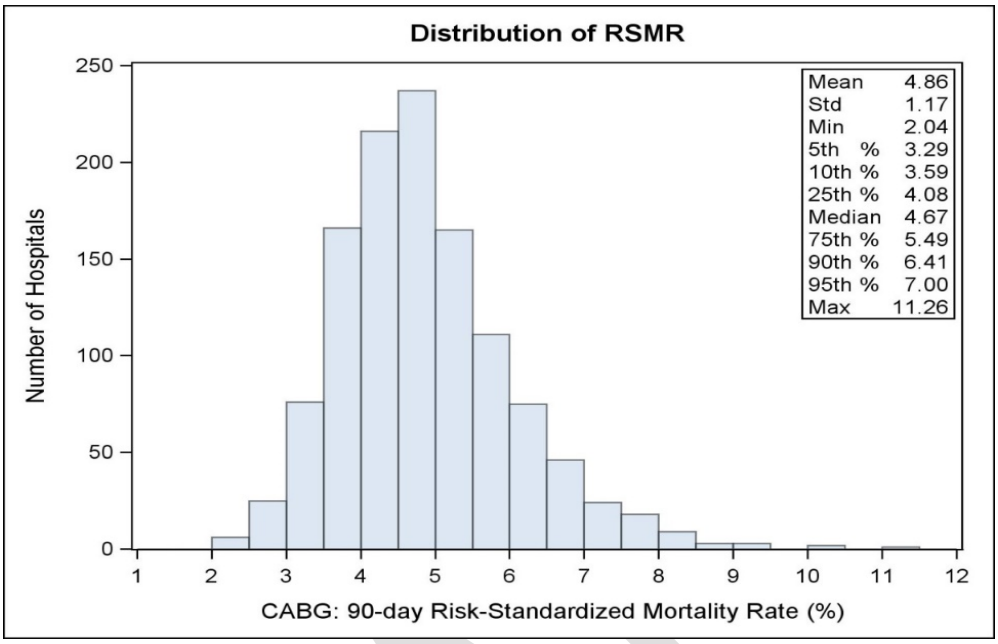


Table 5. Distribution (Table) of Hospital-Level 90-Day CABG Risk-Standardized Mortality Rates (RSMRs)

	90-Day RSMRs (%)
Number of Hospitals	1183
Mean (SD)	4.86 (1.17)
Percentile	
100% (Maximum)	11.26
99%	8.30
95%	7.00
90%	6.41
75%	5.49
50% (Median)	4.67
25%	4.08
10%	3.59
5%	3.29
1%	2.75
0% (Minimum)	2.04

3.2 Measure Testing

3.2.1 Reliability of Data Elements

To ensure that we use data elements that are reliable, we avoid the use of fields that are thought to be coded inconsistently across hospitals or providers. Additionally, CMS has in place several hospital auditing programs used to assess overall claims code accuracy, to ensure

appropriate billing and for overpayment recoupment. CMS routinely conducts data analysis to identify potential problem areas and detect fraud, and audits important data fields used in our measures.

In addition, we used data from July 2014- June 2017 to assess the data elements over time: 68,909 admissions from 1173 hospitals in the Development Sample and 68,910 admissions from 1162 hospitals in the Validation Sample. Table 6 shows the risk factor frequencies changed very little across the three-year period from July 2014-June 2017.

Table 7 shows the adjusted odds ratios (ORs) for the logistic regression (patient-level) model variables and mortality in the following years: July 2014-June 2015, July 2015-June 2016, and July 2016-June 2017. No notable differences were observed in risk factor ORs across the years of data. The consistency in the rates of the risk-adjustment variables and in their relationship to the outcome across the three years of combined data help demonstrate the reliability of the measure data elements used in risk adjustment.

Table 6. Risk Factor Frequency of Model Variables between July 2014 and June 2017

Variable	Total		July 2014 - June 2015		July 2015 - June 2016		July 2016 - June 2017	
Description	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
All	137819	100.0	46023	100.00	46224	100.00	45572	100.00
Demographics								
Mean Age (in years)	73.6	5.6	73.7	5.7	73.7	5.6	73.6	5.6
Gender	99409	72.1	33048	71.8	33234	71.9	33127	72.7
Comorbidities								
Transferred from ED	13046	9.5	4412	9.6	4337	9.	4297	9.4
IABP prior to the procedure	4924	3.6	1745	3.8	1624	3.5	1555	3.4
History of Prior CABG or Valve Surgery	7921	5.8	2541	5.5	2729	5.9	2651	5.8
Cardiogenic Shock (78551, R570)	3302	2.4	1171	2.5	1074	2.3	1057	2.3
Benign Neoplasms	19911	14.5	6346	13.8	6829	14.8	6736	14.8
Protein-Calorie Malnutrition	5881	4.3	2053	4.5	1936	4.2	1892	4.2
Morbid Obesity	12185	8.8	3868	8.4	4094	8.9	4223	9.3
Disorders of Fluid/Electrolyte/Acid-Base Balance	29651	21.5	9553	20.8	10019	21.7	10079	22.1
Disorders of Lipoid Metabolism	129232	93.8	42935	93.3	43341	93.8	42956	94.3
Liver and Biliary Disease	10004	7.3	3151	6.9	3368	7.3	3485	7.7
Other Gastrointestinal Disorders	78890	57.2	26091	56.7	26334	56.9	26465	58.1
Dementia, Nonpsychotic Organic Brain Syndromes/Conditions	7935	5.8	2571	5.6	2749	5.9	2615	5.7

Variable	Total		July 2014 - June 2015		July 2015 - June 2016		July 2016 - June 2017	
Quadriplegia, Paraplegia, Hemiplegia/Hemiparesis, Monoplegia, Other Paralytic Syndromes	4101	2.9	1230	2.7	1315	2.8	1556	3.4
Cancers	36800	26.7	12182	26.5	12474	26.9	12144	26.7
Respirator Dependence/Tracheostomy Status, Respiratory Arrest, Cardio-Respiratory Failure and Shock	16595	12.0	5515	11.9	5612	12.1	5468	12.0
Congestive Heart Failure	46999	34.1	15739	34.2	15515	33.6	15745	34.55
Hypertensive Heart Disease, Hypertension	123395	89.5	41223	89.6	41688	90.2	40484	88.8
Stroke	6476	4.7	2360	5.1	2115	4.6	2001	4.4
Vascular Disease	57950	42.1	19364	42.1	19328	41.8	19258	42.3
Chronic Obstructive Pulmonary Disease	34358	24.9	11717	25.5	11572	25.0	11069	24.3
Pneumonias	22881	16.6	7658	16.64	7782	16.84	7441	16.3
Dialysis Status	3024	2.2	990	2.2	1008	2.2	1026	2.3
Acute Renal Failure	43387	31.5	13906	30.2	14352	31.1	15129	33.2
Pressure Ulcer of Skin with Necrosis Through to Muscle, Tendon, or Bone	5097	3.70	1761	3.8	1756	3.8	1580	3.5
Major Symptoms, Abnormalities	114809	83.3	38476	83.6	38473	83.2	37860	83.1
Mortality within 90-days of the procedure	6529	4.7	2284	4.9	2157	4.7	2088	4.6

Table 7. Adjusted Odds Ratio for Model Risk Variables between July 2014 and June 2017

	July 2014 - June 2015		July 2015 - June 2016		July 2016 - June 2017	
Description	**Odds Ratio (95% CI)**	**P-value**	**Odds Ratio (95% CI)**	**P-value**	**Odds Ratio (95% CI)**	**P-value**
Age	1.07 (1.06 - 1.08)	<.0001	1.07 (1.06 – 1.08)	<.0001	1.06 (1.05 – 1.07)	<.0001
Gender	0.71 (0.65 - 0.78)	<.0001	0.72 (0.65 – 0.79)	<.0001	0.73 (0.66 – 0.81)	<.0001
Transferred from ED	1.47 (1.29 – 1.67)	<.0001	1.19 (1.03 – 1.37)	0.02	1.32 (1.14 – 1.52)	<.0001
IABP prior to procedure	1.52 (1.27 – 1.8)	<.0001	1.33 (1.1 – 1.61)	<.0001	1.71 (1.42 – 2.06)	<.0001
History of prior CABG or Valve Surgery	1.47 (1.25- 1.74)	<.0001	1.26 (1.06 – 1.49)	0.01	1.4 (1.18 – 1.66)	<.0001

	July 2014 - June 2015		July 2015 - June 2016		July 2016 - June 2017	
Cardiogenic Shock	2.00 (1.64 – 2.45)	<0.0001	2.38 (1.94 – 2.9)	<.0001	2.19 (1.78 – 2.68)	<.0001
Benign Neoplasms	0.93 (0.81 – 1.07)	0.33	0.86 (0.75 – 0.99)	0.03	0.93 (0.8 – 1.06)	0.27
Protein Calorie Malnutrition	2.88 (2.53 – 3.28)	<.0001	2.8 (2.45 – 3.21)	<.0001	3.17 (2.77 – 3.62)	<.0001
Morbid Obesity	1.54 (1.34 – 1.77)	<.0001	1.16 (1 – 1.35)	0.05	1.28 (1.11 – 1.48)	<.0001
Disorders of Fluid/Electrolyte/Acid Base Balance	1.05 (0.95 – 1.17)	0.35	1.21 (1.09 – 1.35)	<.0001	1.3 (1.17 – 1.45)	<.0001
Disorders of Lipoid Metabolism	0.78 (0.67 – 0.93)	<.0001	0.59 (0.5 – 0.69)	<.0001	0.55 (0.47 – 0.65)	<.0001
Liver and Biliary Disease	1.48 (1.28 – 1.71)	<.0001	1.42 (1.22 – 1.64)	<.0001	1.54 (1.34 – 1.78)	<.0001
Other Gastrointestinal Disorders	0.82 (0.75 – 0.9)	<.0001	0.77 (0.7 – 0.84)	<.0001	0.78 (0.71 – 0.86)	<.0001
Dementia, Nonpsychotic Organic Brain Syndromes/Conditions	1.4 (1.2 – 1.63)	<.0001	1.21 (1.04 – 1.42)	0.02	1.36 (1.16 – 1.59)	<.0001
Respirator Dependence/Tracheostomy Status, Respiratory Arrest, Cardio-Respiratory Failure and Shock	1.18 (1.04 – 1.34)	0.01	1.22 (0.7 – 1.39)	<.0001	1.23 (1.08 – 1.4)	<.0001
Congestive Heart Failure	1.62 (1.47 – 1.78)	<.0001	1.47 (1.33 – 1.62)	<.0001	1.53 (1.38 – 1.69)	<.0001
Hypertensive Heart Disease, Hypertension	0.79 (0.69 – 0.9)	<.0001	0.91 (0.79 – 1.05)	0.21	0.78 (0.89 -	<.0001
Vascular Disease	1.13 (1.03 – 1.24)	<.0001	1.35 (1.23 – 1.49)	<.0001	1.22 (1.1 – 1.34)	<.0001
Chronic Obstructive Pulmonary Disease	1.35 (1.23 – 1.49	<.0001	1.42 (1.29 – 1.57)	<.0001	1.41 (1.27 – 1.55)	<.0001
Pneumonias	1.66 (1.49 – 1.84)	<.0001	1.34 (1.2 – 1.49)	<.0001	1.54 (1.38 – 1.72)	<.0001
Dialysis Status	1.74 (1.42 – 2.14)	<.0001	1.7 (1.39 – 2.08)	<.0001	1.35 (1.1 – 1.67)	0.01
Acute Renal Failure	1.32 (1.2 – 1.46)	<.0001	1.53 (1.39 – 1.69)	<.0001	1.6 1.44 – 1.77)	<.0001
Major Symptoms, Abnormalities	0.77 (0.68 –0.87)	<.0001	0.71 (0.63 – 0.8)	<.0001	0.79 (0.7 – 0.89)	<.0001
Quadriplegia, Paraplegia, Hemiplegia/Hemiparesis, Monoplegia, Other Paralytic Syndromes	1.32 (1.06 – 1.63)	0.01	1.28 (1.03 – 1.59)	0.03	1.06 (0.85 – 1.32)	0.63

	July 2014 - June 2015		July 2015 - June 2016		July 2016 - June 2017	
Cancers	0.95 (0.86 – 1.06)	0.34	1 (0.9 – 1.11)	0.99	0.97 (0.87 – 1.08)	0.55
Stroke	1.08 (0.9 – 1.29)	0.41	0.98 (0.81 – 1.19)	0.85	1.11 (0.9 – 1.35)	0.33
Pressure Ulcer of Skin with Necrosis Through to Muscle, Tendon, or Bone	1.28 (1.07 – 1.52)	0.01	1.23 (1.02 – 1.47)	0.03	1.12 (0.92 – 1.37)	0.27

3.2.2 Reliability Measure Results

3.2.2.1 Data Element Reliability

To test the reliability of the model, we assessed model performance (Table 8) in the Development Sample and Validation Sample. Model performance was similar in Development and Validation Samples with strong model discrimination and fit. Predictive ability was also similar in both samples. The C-statistic (area under the receiver operator curve) was nearly identical for Development (0.766) and Validation Samples (0.772) (Table 8).

Additionally, the risk decile plots (Figure 6 and 7) show good discrimination. The model performs well in each of the risk deciles in both the Development and Validation Samples.

Table 8. Patient-Level Model Performance

Characteristic	Development Sample (July 2014 – July 2017) (50%)	Validation Sample (July 2014 – July 2017) (50%)
Number of Admission	68, 909	68,910
Calibration (γ0,γ1)	(0,1)	(0.00806, 1.0099)
C-Statistics	0.766	0.772
Residuals lack of fit (Pearson residual %)		
<-2	0.0	0.0
[-2, 0)	95.2	95.3
[0, 2)	0.7	0.7
[2+)	4.1	4.0

Figure 6. Model Calibration Plot in Development Sample

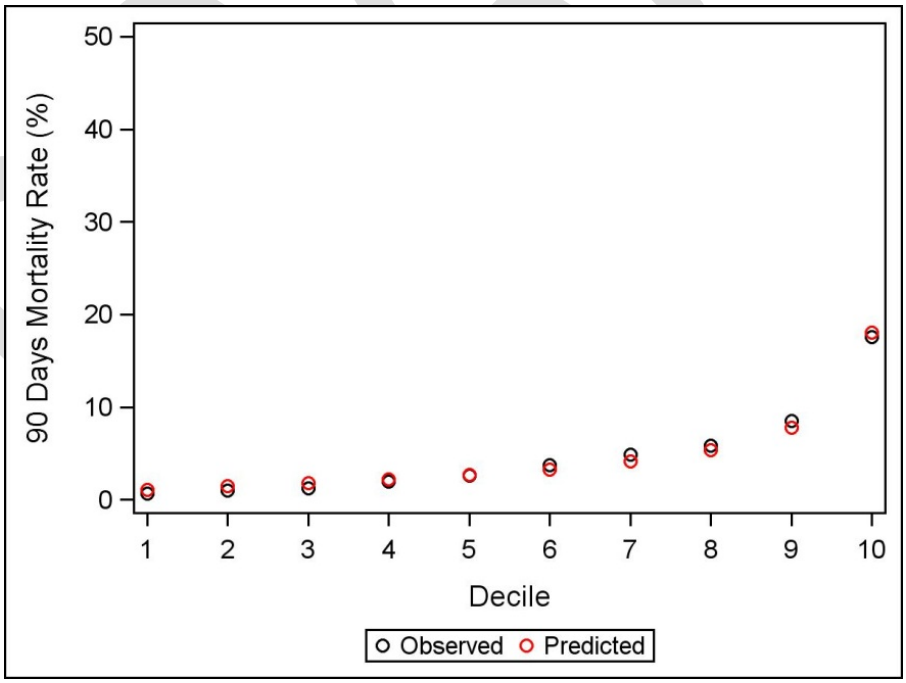
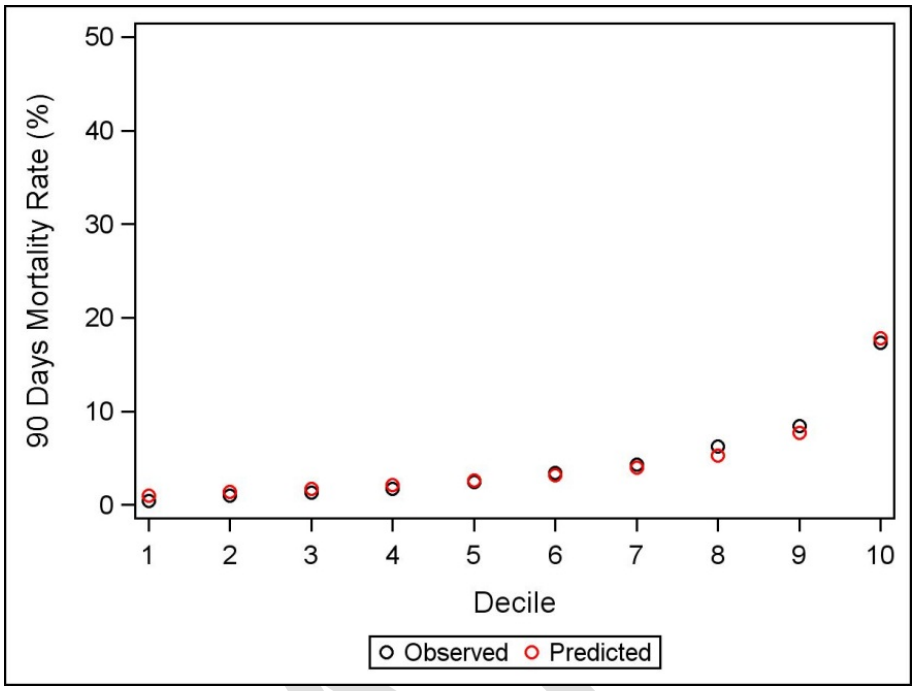


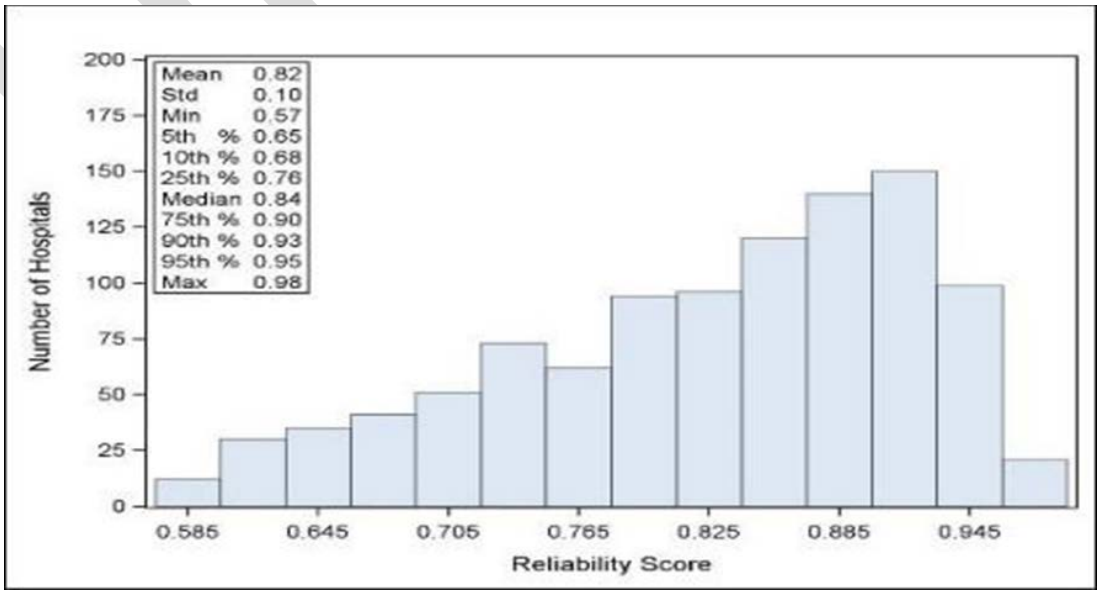
Figure 7. Model Calibration Plot in Validation sample



3.2.2.2 Measure Score Reliability

For measure result reliability, we calculated two RSMR values for each hospital using the Development and Validation Samples. The agreement was ICC[2,1]=0.53, indicating moderate measure score reliability. In addition, we calculated the signal to noise reliability score for each hospital with at least 25 admissions (Figure 8). The median reliability score was 0.84, ranging from 0.57 to 0.98. The 25th and 75th percentiles were 0.76 and 0.9, respectively.

Figure 8. Measure Score Reliability Testing: Signal to Noise Ratio Results



3.2.3 Validity of Data Elements and Measure Score

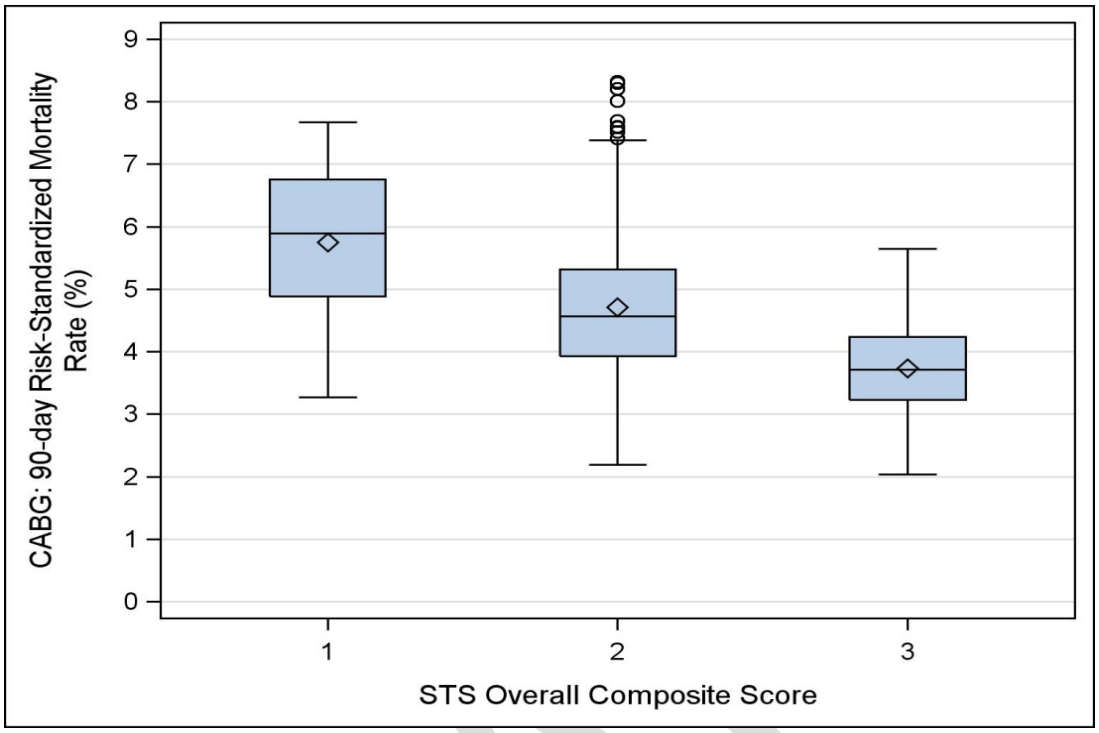
The validity of this measure is supported by both prior experience developing and validating claims-based risk models and outcome measures against clinical data, as noted below, as well as the empiric validation work we performed for this 90-day isolated CABG measure (below and Figure 9).

The CORE Project Team has already demonstrated for a number of prior measures the validity of claims-based measures for profiling hospitals by comparing either the measure results or individual data elements against medical records. CMS validated the six NQF-endorsed claims-based measures currently in public reporting (AMI, heart failure, and pneumonia mortality and readmission) against models that used medical record-abstracted data for risk adjustment. Specifically, claims model validation was conducted by building comparable models using abstracted medical record data for risk adjustment for heart failure patients (National Heart Failure data), AMI patients (Cooperative Cardiovascular Project data) and pneumonia patients (National Pneumonia Project dataset). When both models were applied to the same patient population, the hospital risk-standardized rates estimated using the claims-based risk adjustment models had a high level of agreement with the results based on the medical record model, thus supporting the use of claims-based models for public reporting.

We have also completed two national, multi-site validation efforts for two procedure-based complications measures (for primary elective hip/knee arthroplasty and implantable cardioverter defibrillator [ICD]). Both projects demonstrated strong agreement between complications coded in claims and abstracted medical record data. Comparison of measure results obtained using a claims-only measure of 30-day mortality after isolated CABG surgery compared to a registry-based measure also demonstrated high correlation.[6] These validation efforts suggest that such claims data variables are valid across a variety of conditions, procedures, and outcomes, including mortality.

Further, we performed empiric validity testing of the measure score using the Society of Thoracic Surgery (STS) CABG Composite Star Rating, which combines several measures across quality domains to score hospitals from one (low quality) to three (high quality) stars. Among the 575 hospitals with STS CABG Composite Star Ratings, 3% of hospitals have a one-star rating, 9% percent have a three-star rating, and the majority (88%) have a two-star rating. We found a stepwise trend of lower 90-day mortality with higher STS Composite Star Ratings. The median (IQR) 90-day all-cause CABG mortality RSMR was 5.89% (4.88%-6.76%) for hospitals with one-star rating (STS Overall Composite Score of 1 in Figure 9), 4.57% (3.93%-5.32%) for two-star hospitals (STS Overall Composite Score of 2 in Figure 9), and 3.71% (3.23%-4.23%) for three-star hospitals (STS Overall Composite Score of 3 in Figure 9).

Figure 9. Measure Score Validity Testing: STS CABG Composite Star Rating Results



Additionally, the Technical Expert Panel provided the following input on the measure face validity:

1. The 90-Day CABG Mortality Measure, as specified, will be able to distinguish between better and worse quality of hospitals for the purposes of measuring quality." As specified indicates with no consideration for social risk and inclusion of all readmitted patients regardless of where they were readmitted (CABG performing versus non- CABG performing hospital). 7 of 9 (78%) responding TEP members somewhat agreed or moderately agreed with this statement; 2 of 9 members moderately disagreed with this statement.
2. The 90-Day CABG Mortality Measure, modified to include the social risk (Agency for Healthcare Research and Quality [AHRQ] Socioeconomic Status [SES] index) will be able to distinguish between better and worse quality hospitals for the purposes of measuring quality. 9 of 9 responding TEP members somewhat agreed, moderately agreed, or strongly agreed with this statement; 0 TEP members strongly disagreed with this statement.
3. Regardless of how you responded to the prior two statements, please indicate whether and how you think CMS should consider the social risk (AHRQ SES index) in the measure specifications of this measure. 5 of 9 (56%) responding TEP members favored accounting for social risk(AHRQ SES) by including it in the risk adjustment model; 4 out of 9 favored for accounting social risk (AHRQ SES) by stratifying measure results by social risk; 0 favored some other approach to including social risk (AHRQ SES) in the measure specifications; and 0 favored not including social risk (AHRQ SES) in the measure specifications.
4. The 90-Day CABG Mortality Measure should INCLUDE all patients readmitted within 90 days after isolated CABG surgery, regardless of whether they were readmitted to the hospital that performed the index CABG procedure or another hospital. This is how the measure is currently

specified. 7 of 9 (78%) responding TEP members somewhat agreed or strongly agreed with this statement; 2 of 9 TEP members moderately disagreed with this statement.

4. Summary

This report summarizes the re-specification of the existing 30-Day CABG All-Cause, Risk-Standardized Mortality Measure to capture death up to 90 days after surgery for use with alternate payment models. This measure benefited from consistent input from patients, clinicians, and other stakeholders throughout the development process. The risk-standardized model meets recognized standards for outcomes measurement and was developed with extensive input from clinicians and experts in measure development.

The cohort for inclusion in the measure is appropriately defined, consisting of Medicare FFS patients 65 years or older undergoing isolated CABG procedures and excluding those procedures that may be asymmetrically performed across hospitals and constitute greatly increased risk of mortality. The hierarchical modeling accounts for the clustering of patients within hospitals and differences in sample size across hospitals, thereby allowing for valid comparisons across hospitals. We found variability in the RSMRs across hospitals ranging from 2.0-11.3%.

This measure offers several important benefits. The re-specified 90-day CABG mortality measure will capture short- and longer-term survival and inform quality improvement efforts targeted toward maximizing survival in the post-operative discharge period that may require a mix of postoperative care and medical comorbidity management. In addition, this measure will offer a valuable balancing measure for use in various alternative payment programs, ensuring patient outcomes are not adversely impacted by any cost reduction efforts.

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.

Agency for Healthcare Research and Quality [AHRQ] Socioeconomic Status [SES] index: The AHRQ SES index is based on a beneficiary 9-digit zip code level of residence. It incorporates seven census variables, including percent of unemployment, individuals living below poverty level, less than 12 grade education status, percent completing college, and household occupation per room. Based on this classification, each individual gets an SES score at the zip code level; those in the lowest quartile of this calculated index are classified as low SES.

C-statistic: An indicator of the model's discriminant ability or ability to correctly classify those 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.

CMMI: The Center for Medicare and Medicaid Innovation. The Innovation Center allows the Medicare and Medicaid programs to test models that improve care, lower costs, and better align payment systems to support patient-centered practices. The Innovation Center carefully evaluates innovative reform efforts widely used in the private sector and is unique in its ability to develop provider-proposed approaches and quickly adjust models in response to feedback from clinicians and patients.

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 his/her primary reason for admission to the hospital.

Condition categories (CCs): Groupings of ICD-9-CM/ICD-10-CM diagnosis codes in clinically relevant categories, from the HCCs system. CMS uses the grouping but not the hierarchical logic of the system to create risk factor variables. Mappings which show the assignment of ICD-9 and ICD-10 codes to the CCs are available on the QualityNet website.

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

Hierarchical model: A widely accepted statistical method that enables fair evaluation of relative hospital performance by accounting for patient risk factors as well as the number of patients 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.

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 for each individual service provided directly from Medicare. Only beneficiaries in Medicare FFS, not in managed care (Medicare Advantage), are included in the measures.

National observed 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 protein-calorie malnutrition, relative to those without protein-calorie malnutrition. 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 this CABG surgery mortality measure, the outcome is mortality within 90 days of the procedure date.

Predicted Mortality: The number of deaths within 30 days, predicted based on the hospital's performance with its observed case mix.

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

Risk-standardized mortality rate: The risk-standardized mortality rate is the standardized mortality ration (SMR) (see definition below), multiplied by the national observed mortality rate.

Re-specify: To update and/or revise measure specifications as needed for application to a different care setting or programmatic use. For this measure, we will be extending the outcome time to 90 days in place of the previously established 30 days.

Sequelae: A condition that is the consequence of a previous disease or injury.

Standardized mortality ration (SMR): For each hospital, the numerator of the ratio is the number of deaths predicted for the hospital's patients, accounting for its observed mortality rate, the number of patients, and the hospital's case- and service-line mix. The denominator is the number of deaths expected nationally for that hospital's case/service-line mix. A ratio greater than one indicates that more patients died at that hospital than expected, compared to an average hospital with similar case/service-line mix. A ratio less than one indicates that the hospital's patients have fewer deaths than expected, compared to an average hospital with a similar case/service-line mix.

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Appendix A – Acknowledgement Details

We would like to thank the members of the Technical Expert Panel (TEP). The TEP members provided important insight and feedback on key measure decisions for the development of the 90-day CABG mortality measure.

Disclaimer: The views, thoughts, and opinions expressed in this report belong solely to the author and do not represent endorsement by any entity or individual, including the Technical Working Group and Technical Expert Panel members and the organizations those members are affiliated with, as well as other contributors and consultants. Acknowledgment of input does not imply endorsement of the methodology and policy decisions.

TEP Members

Table A.1. 90-day CABG Mortality Measure TEP Members

Name	Title	Organization, Location
Vinay Badhwar, MD, FACS, FACC	Chair, Public Reporting Task Force, STS; Professor & Chair, Department of Cardiovascular and Thoracic Surgery, West Virginia University	The Society of Thoracic Surgeons (STS) and West Virginia University, Morgantown, WV
Araceli Carrera, DNP, RN, NP-C	Cardiothoracic Nurse Practitioner	New York Presbyterian Hospital Queens, Flushing, NY
Lee Fleisher, MD	Professor of Medicine; Chair of Anesthesiology and Critical Care	Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA
Renante Ignacio, MD, FACP, AGSF, CMD	Medical Director	AMDA – The Society for Post-Acute and Long-Term Care Medicine, Columbia, MD
Alexander Iribarne, MD, MS	Assistant Professor, Surgery, Geisel School of Medicine at Dartmouth; Assistant Professor, Health Policy and Clinical Practice, The Dartmouth Institute; Cardiac Surgeon; Director of Cardiac Surgical Research	Geisel School of Medicine at Dartmouth and Dartmouth-Hitchcock Medical Center, Lebanon, NH
Cristina Lisa	Patient	Patient
Jeffrey Jacobs, MD	Chair, Workforce on National Databases, STS; Professor, Surgery & Pediatrics, Johns Hopkins University; Deputy Director, Johns Hopkins All Children's Heart Institute	The Society of Thoracic Surgeons and Johns Hopkins All Children's Heart Institute, Saint Petersburg, FL and Johns Hopkins University, Baltimore, MD
Michael Mack, MD, FACC	Cardiothoracic Surgeon; Medical Director of Cardiothoracic Surgery	Baylor Scott & White Health, Plano, TX
Sean O'Brien, MS, PhD	Statistical Director, STS; Associate Professor, Biostatistics, Duke University	The Society of Thoracic Surgeons and Duke University, Durham, NC

Name	Title	Organization, Location
Lawrence Sadwin	Patient	Patient
David Shahian, MD	Chair, Council of Quality, Research & Patient Safety, STS; Vice President of Massachusetts General Hospital Center for Quality and Safety; Professor, Surgery, Harvard University	The Society of Thoracic Surgeons and Massachusetts General Hospital Center for Quality and Safety, Boston, MA and Harvard University, Cambridge, MA
Joyce Sinclair	Family Caregiver	Family Caregiver

Technical Work Group Members

Table A.2. 90-day CABG Mortality Consulting Work Group Members

Name	Title	Organization, Location
Paul Kurlansky, MD	Associate Professor of Surgery, Columbia University	The Society of Thoracic Surgeons and Columbia University, New York, NY
Arnar Geirsson, MD	Associate Professor of Surgery (Cardiac Surgery); Section Chief, Cardiac Surgery, Yale School of Medicine	Yale School of Medicine, New Haven, CT

Appendix B – Qualifying CABG Measure Cohort Codes

ICD-09 Code	ICD-10 Code	ICD-10 Description
3610	0210093	Bypass Coronary Artery, One Artery from Coronary Artery with Autologous Venous Tissue, Open Approach
3610	02100A3	Bypass Coronary Artery, One Artery from Coronary Artery with Autologous Arterial Tissue, Open Approach
3610	02100J3	Bypass Coronary Artery, One Artery from Coronary Artery with Synthetic Substitute, Open Approach
3610	02100K3	Bypass Coronary Artery, One Artery from Coronary Artery with Nonautologous Tissue Substitute, Open Approach
3610	02100Z3	Bypass Coronary Artery, One Artery from Coronary Artery, Open Approach
3610	0210493	Bypass Coronary Artery, One Artery from Coronary Artery with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3610	02104A3	Bypass Coronary Artery, One Artery from Coronary Artery with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3610	02104J3	Bypass Coronary Artery, One Artery from Coronary Artery with Synthetic Substitute, Percutaneous Endoscopic Approach
3610	02104K3	Bypass Coronary Artery, One Artery from Coronary Artery with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3610	02104Z3	Bypass Coronary Artery, One Artery from Coronary Artery, Percutaneous Endoscopic Approach
3611	021008W	Bypass Coronary Artery, One Artery from Aorta with Zooplastic Tissue, Open Approach
3611	021048W	Bypass Coronary Artery, One Artery from Aorta with Zooplastic Tissue, Percutaneous Endoscopic Approach
3611	021009W	Bypass Coronary Artery, One Artery from Aorta with Autologous Venous Tissue, Open Approach
3611	02100AW	Bypass Coronary Artery, One Artery from Aorta with Autologous Arterial Tissue, Open Approach
3611	02100JW	Bypass Coronary Artery, One Artery from Aorta with Synthetic Substitute, Open Approach
3611	02100KW	Bypass Coronary Artery, One Artery from Aorta with Nonautologous Tissue Substitute, Open Approach
3611	021049W	Bypass Coronary Artery, One Artery from Aorta with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3611	02104AW	Bypass Coronary Artery, One Artery from Aorta with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3611	02104JW	Bypass Coronary Artery, One Artery from Aorta with Synthetic Substitute, Percutaneous Endoscopic Approach
3611	02104KW	Bypass Coronary Artery, One Artery from Aorta with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3612	021108W	Bypass Coronary Artery, Two Arteries from Aorta with Zooplastic Tissue, Open Approach
3612	021148W	Bypass Coronary Artery, Two Arteries from Aorta with Zooplastic Tissue, Percutaneous Endoscopic Approach

ICD-09 Code	ICD-10 Code	ICD-10 Description
3612	021109W	Bypass Coronary Artery, Two Arteries from Aorta with Autologous Venous Tissue, Open Approach
3612	02110AW	Bypass Coronary Artery, Two Arteries from Aorta with Autologous Arterial Tissue, Open Approach
3612	02110JW	Bypass Coronary Artery, Two Arteries from Aorta with Synthetic Substitute, Open Approach
3612	02110KW	Bypass Coronary Artery, Two Arteries from Aorta with Nonautologous Tissue Substitute, Open Approach
3612	021149W	Bypass Coronary Artery, Two Arteries from Aorta with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3612	02114AW	Bypass Coronary Artery, Two Arteries from Aorta with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3612	02114JW	Bypass Coronary Artery, Two Arteries from Aorta with Synthetic Substitute, Percutaneous Endoscopic Approach
3612	02114KW	Bypass Coronary Artery, Two Arteries from Aorta with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3613	021248W	Bypass Coronary Artery, Three Arteries from Aorta with Zooplastic Tissue, Percutaneous Endoscopic Approach
3613	021208W	Bypass Coronary Artery, Three Arteries from Aorta with Zooplastic Tissue, Open Approach
3613	021209W	Bypass Coronary Artery, Three Arteries from Aorta with Autologous Venous Tissue, Open Approach
3613	02120AW	Bypass Coronary Artery, Three Arteries from Aorta with Autologous Arterial Tissue, Open Approach
3613	02120JW	Bypass Coronary Artery, Three Arteries from Aorta with Synthetic Substitute, Open Approach
3613	02120KW	Bypass Coronary Artery, Three Arteries from Aorta with Nonautologous Tissue Substitute, Open Approach
3613	021249W	Bypass Coronary Artery, Three Arteries from Aorta with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3613	02124AW	Bypass Coronary Artery, Three Arteries from Aorta with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3613	02124JW	Bypass Coronary Artery, Three Arteries from Aorta with Synthetic Substitute, Percutaneous Endoscopic Approach
3613	02124KW	Bypass Coronary Artery, Three Arteries from Aorta with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3614	021348W	Bypass Coronary Artery, Four or More Arteries from Aorta with Zooplastic Tissue, Percutaneous Endoscopic Approach
3614	021308W	Bypass Coronary Artery, Four or More Arteries from Aorta with Zooplastic Tissue, Open Approach
3614	021309W	Bypass Coronary Artery, Four or More Arteries from Aorta with Autologous Venous Tissue, Open Approach
3614	02130AW	Bypass Coronary Artery, Four or More Arteries from Aorta with Autologous Arterial Tissue, Open Approach
3614	02130JW	Bypass Coronary Artery, Four or More Arteries from Aorta with Synthetic Substitute, Open Approach

ICD-09 Code	ICD-10 Code	ICD-10 Description
3614	02130KW	Bypass Coronary Artery, Four or More Arteries from Aorta with Nonautologous Tissue Substitute, Open Approach
3614	021349W	Bypass Coronary Artery, Four or More Arteries from Aorta with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3614	02134AW	Bypass Coronary Artery, Four or More Arteries from Aorta with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3614	02134JW	Bypass Coronary Artery, Four or More Arteries from Aorta with Synthetic Substitute, Percutaneous Endoscopic Approach
3614	02134KW	Bypass Coronary Artery, Four or More Arteries from Aorta with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3615	021008C	Bypass Coronary Artery, One Artery from Thoracic Artery with Zooplastic Tissue, Open Approach
3615	0210089	Bypass Coronary Artery, One Artery from Left Internal Mammary with Zooplastic Tissue, Open Approach
3615	0210088	Bypass Coronary Artery, One Artery from Right Internal Mammary with Zooplastic Tissue, Open Approach
3615	0210489	Bypass Coronary Artery, One Artery from Left Internal Mammary with Zooplastic Tissue, Percutaneous Endoscopic Approach
3615	0210488	Bypass Coronary Artery, One Artery from Right Internal Mammary with Zooplastic Tissue, Percutaneous Endoscopic Approach
3615	021048C	Bypass Coronary Artery, One Artery from Thoracic Artery with Zooplastic Tissue, Percutaneous Endoscopic Approach
3615	0210098	Bypass Coronary Artery, One Artery from Right Internal Mammary with Autologous Venous Tissue, Open Approach
3615	0210099	Bypass Coronary Artery, One Artery from Left Internal Mammary with Autologous Venous Tissue, Open Approach
3615	021009C	Bypass Coronary Artery, One Artery from Thoracic Artery with Autologous Venous Tissue, Open Approach
3615	02100A8	Bypass Coronary Artery, One Artery from Right Internal Mammary with Autologous Arterial Tissue, Open Approach
3615	02100A9	Bypass Coronary Artery, One Artery from Left Internal Mammary with Autologous Arterial Tissue, Open Approach
3615	02100AC	Bypass Coronary Artery, One Artery from Thoracic Artery with Autologous Arterial Tissue, Open Approach
3615	02100J8	Bypass Coronary Artery, One Artery from Right Internal Mammary with Synthetic Substitute, Open Approach
3615	02100J9	Bypass Coronary Artery, One Artery from Left Internal Mammary with Synthetic Substitute, Open Approach
3615	02100JC	Bypass Coronary Artery, One Artery from Thoracic Artery with Synthetic Substitute, Open Approach
3615	02100K8	Bypass Coronary Artery, One Artery from Right Internal Mammary with Nonautologous Tissue Substitute, Open Approach
3615	02100K9	Bypass Coronary Artery, One Artery from Left Internal Mammary with Nonautologous Tissue Substitute, Open Approach
3615	02100KC	Bypass Coronary Artery, One Artery from Thoracic Artery with Nonautologous Tissue Substitute, Open Approach

ICD-09 Code	ICD-10 Code	ICD-10 Description
3615	02100Z8	Bypass Coronary Artery, One Artery from Right Internal Mammary, Open Approach
3615	02100Z9	Bypass Coronary Artery, One Artery from Left Internal Mammary, Open Approach
3615	02100ZC	Bypass Coronary Artery, One Artery from Thoracic Artery, Open Approach
3615	0210498	Bypass Coronary Artery, One Artery from Right Internal Mammary with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3615	0210499	Bypass Coronary Artery, One Artery from Left Internal Mammary with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3615	021049C	Bypass Coronary Artery, One Artery from Thoracic Artery with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3615	02104A8	Bypass Coronary Artery, One Artery from Right Internal Mammary with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3615	02104A9	Bypass Coronary Artery, One Artery from Left Internal Mammary with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3615	02104AC	Bypass Coronary Artery, One Artery from Thoracic Artery with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3615	02104J8	Bypass Coronary Artery, One Artery from Right Internal Mammary with Synthetic Substitute, Percutaneous Endoscopic Approach
3615	02104J9	Bypass Coronary Artery, One Artery from Left Internal Mammary with Synthetic Substitute, Percutaneous Endoscopic Approach
3615	02104JC	Bypass Coronary Artery, One Artery from Thoracic Artery with Synthetic Substitute, Percutaneous Endoscopic Approach
3615	02104K8	Bypass Coronary Artery, One Artery from Right Internal Mammary with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3615	02104K9	Bypass Coronary Artery, One Artery from Left Internal Mammary with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3615	02104KC	Bypass Coronary Artery, One Artery from Thoracic Artery with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3615	02104Z8	Bypass Coronary Artery, One Artery from Right Internal Mammary, Percutaneous Endoscopic Approach
3615	02104Z9	Bypass Coronary Artery, One Artery from Left Internal Mammary, Percutaneous Endoscopic Approach
3615	02104ZC	Bypass Coronary Artery, One Artery from Thoracic Artery, Percutaneous Endoscopic Approach
3616	021248C	Bypass Coronary Artery, Three Arteries from Thoracic Artery with Zooplastic Tissue, Percutaneous Endoscopic Approach
3616	0212488	Bypass Coronary Artery, Three Arteries from Right Internal Mammary with Zooplastic Tissue, Percutaneous Endoscopic Approach
3616	0212489	Bypass Coronary Artery, Three Arteries from Left Internal Mammary with Zooplastic Tissue, Percutaneous Endoscopic Approach
3616	0213488	Bypass Coronary Artery, Four or More Arteries from Right Internal Mammary with Zooplastic Tissue, Percutaneous Endoscopic Approach
3616	0213089	Bypass Coronary Artery, Four or More Arteries from Left Internal Mammary with Zooplastic Tissue, Open Approach

ICD-09 Code	ICD-10 Code	ICD-10 Description
3616	021308C	Bypass Coronary Artery, Four or More Arteries from Thoracic Artery with Zooplastic Tissue, Open Approach
3616	0211489	Bypass Coronary Artery, Two Arteries from Left Internal Mammary with Zooplastic Tissue, Percutaneous Endoscopic Approach
3616	0211488	Bypass Coronary Artery, Two Arteries from Right Internal Mammary with Zooplastic Tissue, Percutaneous Endoscopic Approach
3616	021148C	Bypass Coronary Artery, Two Arteries from Thoracic Artery with Zooplastic Tissue, Percutaneous Endoscopic Approach
3616	0211089	Bypass Coronary Artery, Two Arteries from Left Internal Mammary with Zooplastic Tissue, Open Approach
3616	0211088	Bypass Coronary Artery, Two Arteries from Right Internal Mammary with Zooplastic Tissue, Open Approach
3616	021108C	Bypass Coronary Artery, Two Arteries from Thoracic Artery with Zooplastic Tissue, Open Approach
3616	0213489	Bypass Coronary Artery, Four or More Arteries from Left Internal Mammary with Zooplastic Tissue, Percutaneous Endoscopic Approach
3616	021348C	Bypass Coronary Artery, Four or More Arteries from Thoracic Artery with Zooplastic Tissue, Percutaneous Endoscopic Approach
3616	021208C	Bypass Coronary Artery, Three Arteries from Thoracic Artery with Zooplastic Tissue, Open Approach
3616	0212089	Bypass Coronary Artery, Three Arteries from Left Internal Mammary with Zooplastic Tissue, Open Approach
3616	0212088	Bypass Coronary Artery, Three Arteries from Right Internal Mammary with Zooplastic Tissue, Open Approach
3616	0213088	Bypass Coronary Artery, Four or More Arteries from Right Internal Mammary with Zooplastic Tissue, Open Approach
3616	0211098	Bypass Coronary Artery, Two Arteries from Right Internal Mammary with Autologous Venous Tissue, Open Approach
3616	0211099	Bypass Coronary Artery, Two Arteries from Left Internal Mammary with Autologous Venous Tissue, Open Approach
3616	021109C	Bypass Coronary Artery, Two Arteries from Thoracic Artery with Autologous Venous Tissue, Open Approach
3616	02110A8	Bypass Coronary Artery, Two Arteries from Right Internal Mammary with Autologous Arterial Tissue, Open Approach
3616	02110A9	Bypass Coronary Artery, Two Arteries from Left Internal Mammary with Autologous Arterial Tissue, Open Approach
3616	02110AC	Bypass Coronary Artery, Two Arteries from Thoracic Artery with Autologous Arterial Tissue, Open Approach
3616	02110J8	Bypass Coronary Artery, Two Arteries from Right Internal Mammary with Synthetic Substitute, Open Approach
3616	02110J9	Bypass Coronary Artery, Two Arteries from Left Internal Mammary with Synthetic Substitute, Open Approach
3616	02110JC	Bypass Coronary Artery, Two Arteries from Thoracic Artery with Synthetic Substitute, Open Approach
3616	02110K8	Bypass Coronary Artery, Two Arteries from Right Internal Mammary with Nonautologous Tissue Substitute, Open Approach

ICD-09 Code	ICD-10 Code	ICD-10 Description
3616	02110K9	Bypass Coronary Artery, Two Arteries from Left Internal Mammary with Nonautologous Tissue Substitute, Open Approach
3616	02110KC	Bypass Coronary Artery, Two Arteries from Thoracic Artery with Nonautologous Tissue Substitute, Open Approach
3616	02110Z8	Bypass Coronary Artery, Two Arteries from Right Internal Mammary, Open Approach
3616	02110Z9	Bypass Coronary Artery, Two Arteries from Left Internal Mammary, Open Approach
3616	02110ZC	Bypass Coronary Artery, Two Arteries from Thoracic Artery, Open Approach
3616	0211498	Bypass Coronary Artery, Two Arteries from Right Internal Mammary with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3616	0211499	Bypass Coronary Artery, Two Arteries from Left Internal Mammary with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3616	021149C	Bypass Coronary Artery, Two Arteries from Thoracic Artery with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3616	02114A8	Bypass Coronary Artery, Two Arteries from Right Internal Mammary with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3616	02114A9	Bypass Coronary Artery, Two Arteries from Left Internal Mammary with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3616	02114AC	Bypass Coronary Artery, Two Arteries from Thoracic Artery with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3616	02114J8	Bypass Coronary Artery, Two Arteries from Right Internal Mammary with Synthetic Substitute, Percutaneous Endoscopic Approach
3616	02114J9	Bypass Coronary Artery, Two Arteries from Left Internal Mammary with Synthetic Substitute, Percutaneous Endoscopic Approach
3616	02114JC	Bypass Coronary Artery, Two Arteries from Thoracic Artery with Synthetic Substitute, Percutaneous Endoscopic Approach
3616	02114K8	Bypass Coronary Artery, Two Arteries from Right Internal Mammary with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3616	02114K9	Bypass Coronary Artery, Two Arteries from Left Internal Mammary with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3616	02114KC	Bypass Coronary Artery, Two Arteries from Thoracic Artery with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3616	02114Z8	Bypass Coronary Artery, Two Arteries from Right Internal Mammary, Percutaneous Endoscopic Approach
3616	02114Z9	Bypass Coronary Artery, Two Arteries from Left Internal Mammary, Percutaneous Endoscopic Approach
3616	02114ZC	Bypass Coronary Artery, Two Arteries from Thoracic Artery, Percutaneous Endoscopic Approach
3616	0212098	Bypass Coronary Artery, Three Arteries from Right Internal Mammary with Autologous Venous Tissue, Open Approach
3616	0212099	Bypass Coronary Artery, Three Arteries from Left Internal Mammary with Autologous Venous Tissue, Open Approach

ICD-09 Code	ICD-10 Code	ICD-10 Description
3616	021209C	Bypass Coronary Artery, Three Arteries from Thoracic Artery with Autologous Venous Tissue, Open Approach
3616	02120A8	Bypass Coronary Artery, Three Arteries from Right Internal Mammary with Autologous Arterial Tissue, Open Approach
3616	02120A9	Bypass Coronary Artery, Three Arteries from Left Internal Mammary with Autologous Arterial Tissue, Open Approach
3616	02120AC	Bypass Coronary Artery, Three Arteries from Thoracic Artery with Autologous Arterial Tissue, Open Approach
3616	02120J8	Bypass Coronary Artery, Three Arteries from Right Internal Mammary with Synthetic Substitute, Open Approach
3616	02120J9	Bypass Coronary Artery, Three Arteries from Left Internal Mammary with Synthetic Substitute, Open Approach
3616	02120JC	Bypass Coronary Artery, Three Arteries from Thoracic Artery with Synthetic Substitute, Open Approach
3616	02120K8	Bypass Coronary Artery, Three Arteries from Right Internal Mammary with Nonautologous Tissue Substitute, Open Approach
3616	02120K9	Bypass Coronary Artery, Three Arteries from Left Internal Mammary with Nonautologous Tissue Substitute, Open Approach
3616	02120KC	Bypass Coronary Artery, Three Arteries from Thoracic Artery with Nonautologous Tissue Substitute, Open Approach
3616	02120Z8	Bypass Coronary Artery, Three Arteries from Right Internal Mammary, Open Approach
3616	02120Z9	Bypass Coronary Artery, Three Arteries from Left Internal Mammary, Open Approach
3616	02120ZC	Bypass Coronary Artery, Three Arteries from Thoracic Artery, Open Approach
3616	0212498	Bypass Coronary Artery, Three Arteries from Right Internal Mammary with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3616	0212499	Bypass Coronary Artery, Three Arteries from Left Internal Mammary with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3616	021249C	Bypass Coronary Artery, Three Arteries from Thoracic Artery with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3616	02124A8	Bypass Coronary Artery, Three Arteries from Right Internal Mammary with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3616	02124A9	Bypass Coronary Artery, Three Arteries from Left Internal Mammary with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3616	02124AC	Bypass Coronary Artery, Three Arteries from Thoracic Artery with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3616	02124J8	Bypass Coronary Artery, Three Arteries from Right Internal Mammary with Synthetic Substitute, Percutaneous Endoscopic Approach
3616	02124J9	Bypass Coronary Artery, Three Arteries from Left Internal Mammary with Synthetic Substitute, Percutaneous Endoscopic Approach
3616	02124JC	Bypass Coronary Artery, Three Arteries from Thoracic Artery with Synthetic Substitute, Percutaneous Endoscopic Approach

ICD-09 Code	ICD-10 Code	ICD-10 Description
3616	02124K8	Bypass Coronary Artery, Three Arteries from Right Internal Mammary with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3616	02124K9	Bypass Coronary Artery, Three Arteries from Left Internal Mammary with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3616	02124KC	Bypass Coronary Artery, Three Arteries from Thoracic Artery with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3616	02124Z8	Bypass Coronary Artery, Three Arteries from Right Internal Mammary, Percutaneous Endoscopic Approach
3616	02124Z9	Bypass Coronary Artery, Three Arteries from Left Internal Mammary, Percutaneous Endoscopic Approach
3616	02124ZC	Bypass Coronary Artery, Three Arteries from Thoracic Artery, Percutaneous Endoscopic Approach
3616	0213098	Bypass Coronary Artery, Four or More Arteries from Right Internal Mammary with Autologous Venous Tissue, Open Approach
3616	0213099	Bypass Coronary Artery, Four or More Arteries from Left Internal Mammary with Autologous Venous Tissue, Open Approach
3616	021309C	Bypass Coronary Artery, Four or More Arteries from Thoracic Artery with Autologous Venous Tissue, Open Approach
3616	02130A8	Bypass Coronary Artery, Four or More Arteries from Right Internal Mammary with Autologous Arterial Tissue, Open Approach
3616	02130A9	Bypass Coronary Artery, Four or More Arteries from Left Internal Mammary with Autologous Arterial Tissue, Open Approach
3616	02130AC	Bypass Coronary Artery, Four or More Arteries from Thoracic Artery with Autologous Arterial Tissue, Open Approach
3616	02130J8	Bypass Coronary Artery, Four or More Arteries from Right Internal Mammary with Synthetic Substitute, Open Approach
3616	02130J9	Bypass Coronary Artery, Four or More Arteries from Left Internal Mammary with Synthetic Substitute, Open Approach
3616	02130JC	Bypass Coronary Artery, Four or More Arteries from Thoracic Artery with Synthetic Substitute, Open Approach
3616	02130K8	Bypass Coronary Artery, Four or More Arteries from Right Internal Mammary with Nonautologous Tissue Substitute, Open Approach
3616	02130K9	Bypass Coronary Artery, Four or More Arteries from Left Internal Mammary with Nonautologous Tissue Substitute, Open Approach
3616	02130KC	Bypass Coronary Artery, Four or More Arteries from Thoracic Artery with Nonautologous Tissue Substitute, Open Approach
3616	02130Z8	Bypass Coronary Artery, Four or More Arteries from Right Internal Mammary, Open Approach
3616	02130Z9	Bypass Coronary Artery, Four or More Arteries from Left Internal Mammary, Open Approach
3616	02130ZC	Bypass Coronary Artery, Four or More Arteries from Thoracic Artery, Open Approach

ICD-09 Code	ICD-10 Code	ICD-10 Description
3616	0213498	Bypass Coronary Artery, Four or More Arteries from Right Internal Mammary with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3616	0213499	Bypass Coronary Artery, Four or More Arteries from Left Internal Mammary with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3616	021349C	Bypass Coronary Artery, Four or More Arteries from Thoracic Artery with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3616	02134A8	Bypass Coronary Artery, Four or More Arteries from Right Internal Mammary with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3616	02134A9	Bypass Coronary Artery, Four or More Arteries from Left Internal Mammary with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3616	02134AC	Bypass Coronary Artery, Four or More Arteries from Thoracic Artery with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3616	02134J8	Bypass Coronary Artery, Four or More Arteries from Right Internal Mammary with Synthetic Substitute, Percutaneous Endoscopic Approach
3616	02134J9	Bypass Coronary Artery, Four or More Arteries from Left Internal Mammary with Synthetic Substitute, Percutaneous Endoscopic Approach
3616	02134JC	Bypass Coronary Artery, Four or More Arteries from Thoracic Artery with Synthetic Substitute, Percutaneous Endoscopic Approach
3616	02134K8	Bypass Coronary Artery, Four or More Arteries from Right Internal Mammary with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3616	02134K9	Bypass Coronary Artery, Four or More Arteries from Left Internal Mammary with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3616	02134KC	Bypass Coronary Artery, Four or More Arteries from Thoracic Artery with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3616	02134Z8	Bypass Coronary Artery, Four or More Arteries from Right Internal Mammary, Percutaneous Endoscopic Approach
3616	02134Z9	Bypass Coronary Artery, Four or More Arteries from Left Internal Mammary, Percutaneous Endoscopic Approach
3616	02134ZC	Bypass Coronary Artery, Four or More Arteries from Thoracic Artery, Percutaneous Endoscopic Approach
3617	021208F	Bypass Coronary Artery, Three Arteries from Abdominal Artery with Zooplastic Tissue, Open Approach
3617	021148F	Bypass Coronary Artery, Two Arteries from Abdominal Artery with Zooplastic Tissue, Percutaneous Endoscopic Approach
3617	021108F	Bypass Coronary Artery, Two Arteries from Abdominal Artery with Zooplastic Tissue, Open Approach

ICD-09 Code	ICD-10 Code	ICD-10 Description
3617	021048F	Bypass Coronary Artery, One Artery from Abdominal Artery with Zooplastic Tissue, Percutaneous Endoscopic Approach
3617	021008F	Bypass Coronary Artery, One Artery from Abdominal Artery with Zooplastic Tissue, Open Approach
3617	021348F	Bypass Coronary Artery, Four or More Arteries from Abdominal Artery with Zooplastic Tissue, Percutaneous Endoscopic Approach
3617	021308F	Bypass Coronary Artery, Four or More Arteries from Abdominal Artery with Zooplastic Tissue, Open Approach
3617	021248F	Bypass Coronary Artery, Three Arteries from Abdominal Artery with Zooplastic Tissue, Percutaneous Endoscopic Approach
3617	021009F	Bypass Coronary Artery, One Artery from Abdominal Artery with Autologous Venous Tissue, Open Approach
3617	02100AF	Bypass Coronary Artery, One Artery from Abdominal Artery with Autologous Arterial Tissue, Open Approach
3617	02100JF	Bypass Coronary Artery, One Artery from Abdominal Artery with Synthetic Substitute, Open Approach
3617	02100KF	Bypass Coronary Artery, One Artery from Abdominal Artery with Nonautologous Tissue Substitute, Open Approach
3617	02100ZF	Bypass Coronary Artery, One Artery from Abdominal Artery, Open Approach
3617	021049F	Bypass Coronary Artery, One Artery from Abdominal Artery with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3617	02104AF	Bypass Coronary Artery, One Artery from Abdominal Artery with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3617	02104JF	Bypass Coronary Artery, One Artery from Abdominal Artery with Synthetic Substitute, Percutaneous Endoscopic Approach
3617	02104KF	Bypass Coronary Artery, One Artery from Abdominal Artery with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3617	02104ZF	Bypass Coronary Artery, One Artery from Abdominal Artery, Percutaneous Endoscopic Approach
3617	021109F	Bypass Coronary Artery, Two Arteries from Abdominal Artery with Autologous Venous Tissue, Open Approach
3617	02110AF	Bypass Coronary Artery, Two Arteries from Abdominal Artery with Autologous Arterial Tissue, Open Approach
3617	02110JF	Bypass Coronary Artery, Two Arteries from Abdominal Artery with Synthetic Substitute, Open Approach
3617	02110KF	Bypass Coronary Artery, Two Arteries from Abdominal Artery with Nonautologous Tissue Substitute, Open Approach
3617	02110ZF	Bypass Coronary Artery, Two Arteries from Abdominal Artery, Open Approach
3617	021149F	Bypass Coronary Artery, Two Arteries from Abdominal Artery with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3617	02114AF	Bypass Coronary Artery, Two Arteries from Abdominal Artery with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3617	02114JF	Bypass Coronary Artery, Two Arteries from Abdominal Artery with Synthetic Substitute, Percutaneous Endoscopic Approach

ICD-09 Code	ICD-10 Code	ICD-10 Description
3617	02114KF	Bypass Coronary Artery, Two Arteries from Abdominal Artery with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3617	02114ZF	Bypass Coronary Artery, Two Arteries from Abdominal Artery, Percutaneous Endoscopic Approach
3617	021209F	Bypass Coronary Artery, Three Arteries from Abdominal Artery with Autologous Venous Tissue, Open Approach
3617	02120AF	Bypass Coronary Artery, Three Arteries from Abdominal Artery with Autologous Arterial Tissue, Open Approach
3617	02120JF	Bypass Coronary Artery, Three Arteries from Abdominal Artery with Synthetic Substitute, Open Approach
3617	02120KF	Bypass Coronary Artery, Three Arteries from Abdominal Artery with Nonautologous Tissue Substitute, Open Approach
3617	02120ZF	Bypass Coronary Artery, Three Arteries from Abdominal Artery, Open Approach
3617	021249F	Bypass Coronary Artery, Three Arteries from Abdominal Artery with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3617	02124AF	Bypass Coronary Artery, Three Arteries from Abdominal Artery with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3617	02124JF	Bypass Coronary Artery, Three Arteries from Abdominal Artery with Synthetic Substitute, Percutaneous Endoscopic Approach
3617	02124KF	Bypass Coronary Artery, Three Arteries from Abdominal Artery with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3617	02124ZF	Bypass Coronary Artery, Three Arteries from Abdominal Artery, Percutaneous Endoscopic Approach
3617	021309F	Bypass Coronary Artery, Four or More Arteries from Abdominal Artery with Autologous Venous Tissue, Open Approach
3617	02130AF	Bypass Coronary Artery, Four or More Arteries from Abdominal Artery with Autologous Arterial Tissue, Open Approach
3617	02130JF	Bypass Coronary Artery, Four or More Arteries from Abdominal Artery with Synthetic Substitute, Open Approach
3617	02130KF	Bypass Coronary Artery, Four or More Arteries from Abdominal Artery with Nonautologous Tissue Substitute, Open Approach
3617	02130ZF	Bypass Coronary Artery, Four or More Arteries from Abdominal Artery, Open Approach
3617	021349F	Bypass Coronary Artery, Four or More Arteries from Abdominal Artery with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3617	02134AF	Bypass Coronary Artery, Four or More Arteries from Abdominal Artery with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3617	02134JF	Bypass Coronary Artery, Four or More Arteries from Abdominal Artery with Synthetic Substitute, Percutaneous Endoscopic Approach
3617	02134KF	Bypass Coronary Artery, Four or More Arteries from Abdominal Artery with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3617	02134ZF	Bypass Coronary Artery, Four or More Arteries from Abdominal Artery, Percutaneous Endoscopic Approach

ICD-09 Code	ICD-10 Code	ICD-10 Description
3619	0211483	Bypass Coronary Artery, Two Arteries from Coronary Artery with Zooplastic Tissue, Percutaneous Endoscopic Approach
3619	0212083	Bypass Coronary Artery, Three Arteries from Coronary Artery with Zooplastic Tissue, Open Approach
3619	0211083	Bypass Coronary Artery, Two Arteries from Coronary Artery with Zooplastic Tissue, Open Approach
3619	0210083	Bypass Coronary Artery, One Artery from Coronary Artery with Zooplastic Tissue, Open Approach
3619	0210483	Bypass Coronary Artery, One Artery from Coronary Artery with Zooplastic Tissue, Percutaneous Endoscopic Approach
3619	0213483	Bypass Coronary Artery, Four or More Arteries from Coronary Artery with Zooplastic Tissue, Percutaneous Endoscopic Approach
3619	0212483	Bypass Coronary Artery, Three Arteries from Coronary Artery with Zooplastic Tissue, Percutaneous Endoscopic Approach
3619	0213083	Bypass Coronary Artery, Four or More Arteries from Coronary Artery with Zooplastic Tissue, Open Approach
3619	0210093	Bypass Coronary Artery, One Artery from Coronary Artery with Autologous Venous Tissue, Open Approach
3619	02100A3	Bypass Coronary Artery, One Artery from Coronary Artery with Autologous Arterial Tissue, Open Approach
3619	02100J3	Bypass Coronary Artery, One Artery from Coronary Artery with Synthetic Substitute, Open Approach
3619	02100K3	Bypass Coronary Artery, One Artery from Coronary Artery with Nonautologous Tissue Substitute, Open Approach
3619	02100Z3	Bypass Coronary Artery, One Artery from Coronary Artery, Open Approach
3619	0210493	Bypass Coronary Artery, One Artery from Coronary Artery with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3619	02104A3	Bypass Coronary Artery, One Artery from Coronary Artery with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3619	02104J3	Bypass Coronary Artery, One Artery from Coronary Artery with Synthetic Substitute, Percutaneous Endoscopic Approach
3619	02104K3	Bypass Coronary Artery, One Artery from Coronary Artery with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3619	02104Z3	Bypass Coronary Artery, One Artery from Coronary Artery, Percutaneous Endoscopic Approach
3619	0211093	Bypass Coronary Artery, Two Arteries from Coronary Artery with Autologous Venous Tissue, Open Approach
3619	02110A3	Bypass Coronary Artery, Two Arteries from Coronary Artery with Autologous Arterial Tissue, Open Approach
3619	02110J3	Bypass Coronary Artery, Two Arteries from Coronary Artery with Synthetic Substitute, Open Approach
3619	02110K3	Bypass Coronary Artery, Two Arteries from Coronary Artery with Nonautologous Tissue Substitute, Open Approach
3619	02110Z3	Bypass Coronary Artery, Two Arteries from Coronary Artery, Open Approach

ICD-09 Code	ICD-10 Code	ICD-10 Description
3619	0211493	Bypass Coronary Artery, Two Arteries from Coronary Artery with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3619	02114A3	Bypass Coronary Artery, Two Arteries from Coronary Artery with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3619	02114J3	Bypass Coronary Artery, Two Arteries from Coronary Artery with Synthetic Substitute, Percutaneous Endoscopic Approach
3619	02114K3	Bypass Coronary Artery, Two Arteries from Coronary Artery with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3619	02114Z3	Bypass Coronary Artery, Two Arteries from Coronary Artery, Percutaneous Endoscopic Approach
3619	0212093	Bypass Coronary Artery, Three Arteries from Coronary Artery with Autologous Venous Tissue, Open Approach
3619	02120A3	Bypass Coronary Artery, Three Arteries from Coronary Artery with Autologous Arterial Tissue, Open Approach
3619	02120J3	Bypass Coronary Artery, Three Arteries from Coronary Artery with Synthetic Substitute, Open Approach
3619	02120K3	Bypass Coronary Artery, Three Arteries from Coronary Artery with Nonautologous Tissue Substitute, Open Approach
3619	02120Z3	Bypass Coronary Artery, Three Arteries from Coronary Artery, Open Approach
3619	0212493	Bypass Coronary Artery, Three Arteries from Coronary Artery with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3619	02124A3	Bypass Coronary Artery, Three Arteries from Coronary Artery with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3619	02124J3	Bypass Coronary Artery, Three Arteries from Coronary Artery with Synthetic Substitute, Percutaneous Endoscopic Approach
3619	02124K3	Bypass Coronary Artery, Three Arteries from Coronary Artery with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3619	02124Z3	Bypass Coronary Artery, Three Arteries from Coronary Artery, Percutaneous Endoscopic Approach
3619	0213093	Bypass Coronary Artery, Four or More Arteries from Coronary Artery with Autologous Venous Tissue, Open Approach
3619	02130A3	Bypass Coronary Artery, Four or More Arteries from Coronary Artery with Autologous Arterial Tissue, Open Approach
3619	02130J3	Bypass Coronary Artery, Four or More Arteries from Coronary Artery with Synthetic Substitute, Open Approach
3619	02130K3	Bypass Coronary Artery, Four or More Arteries from Coronary Artery with Nonautologous Tissue Substitute, Open Approach
3619	02130Z3	Bypass Coronary Artery, Four or More Arteries from Coronary Artery, Open Approach
3619	0213493	Bypass Coronary Artery, Four or More Arteries from Coronary Artery with Autologous Venous Tissue, Percutaneous Endoscopic Approach
3619	02134A3	Bypass Coronary Artery, Four or More Arteries from Coronary Artery with Autologous Arterial Tissue, Percutaneous Endoscopic Approach
3619	02134J3	Bypass Coronary Artery, Four or More Arteries from Coronary Artery with Synthetic Substitute, Percutaneous Endoscopic Approach

ICD-09 Code	ICD-10 Code	ICD-10 Description
3619	02134K3	Bypass Coronary Artery, Four or More Arteries from Coronary Artery with Nonautologous Tissue Substitute, Percutaneous Endoscopic Approach
3619	02134Z3	Bypass Coronary Artery, Four or More Arteries from Coronary Artery, Percutaneous Endoscopic Approach

Appendix C – Conditions Categories that May Represent Adverse Outcomes of Care Received During Index Admission

To identify potential complications of care, we first searched the secondary diagnosis codes in the index admission claim and identified the presence of any ICD-9 and ICD-10 code associated with a CMS-CC (see table below). If these codes appeared only in the index admission claim, we flagged them because they are potential to complications of care. Next, we determined if these potential complications of care were associated with a "present on admission" flag. Any potential complication of care with an associated "present on admission" flag was kept in the risk model; any potential complication of care without an associated "present on admission" code was removed under the assumption that it represented a complication of care.

V22 CC	Description
2	Septicemia/Shock
7	Other Infectious Diseases
17	Diabetes with Acute Complications
24	Disorders of Fluid/Electrolyte/Acid-Base
30	Acute Liver Failure/Disease
33	Intestinal Obstruction/Perforation
36	Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders
48	Coagulation Defects and Other Specified Hematological Disorders
49	Iron Deficiency and Other/ Unspecified Anemias and Blood Disease
50	Delirium and Encephalopathy
54	Drug/Alcohol Psychosis
80	Coma, Brain Compression/Anoxic Damage
82	Respirator Dependence/Tracheostomy Status
83	Respiratory Arrest
84	Cardio-respiratory failure and shock
85	Congestive heart failure
90	Heart Infection/Inflammation, Except Rheumatic
91	Valvular and Rheumatic Heart Disease
96	Specified Heart Arrhythmias
97	Other Heart Rhythm and Conduction Disorders
99	Cerebral Hemorrhage
100	Ischemic or Unspecified Stroke
101	Precerebral Arterial Occlusion and Transient Cerebral Ischemia
103	Hemiplegia/Hemiparesis
104	Monoplegia, Other Paralytic Syndromes
106	Atherosclerosis of the Extremities with Ulceration or Gangrene
107	Vascular Disease with Complications
108	Vascular Disease
109	Other Circulatory Disease
114	Aspiration and Specified Bacterial Pneumonias
115	Pneumococcal Pneumonia, Empyema, Lung Abscess

V22 CC	Description
117	Pleural Effusion/Pneumothorax
134	Dialysis Status
135	Acute Renal Failure
140	Unspecified Renal Failure
142	Urinary Obstruction and Retention
144	Urinary Tract Infection
157	Pressure Ulcer of Skin with Necrosis Through to Muscle, Tendon, or Bone
158	Pressure Ulcer of Skin with Full Thickness Skin Loss
159	Pressure Ulcer of Skin with Partial Thickness Skin Loss
160	Pressure Pre-Ulcer Skin Changes or Unspecified Stage
164	Cellulitis, Local Skin Infection
166	Severe Head Injury
167	Major Head Injury
168	Concussion or Unspecified Head Injury
170	Hip Fracture/Dislocation
171	Major Fracture, Except of Skull, Vertebrae, or Hip
172	Internal Injuries
175	Poisonings and Allergic Reactions
176	Complications of Specified Implanted Device or Graft
173	Major Complications of Medical Care and Trauma
177	Other Complications of Medical Care
178	Major Symptoms, Abnormalities
189	Amputation Status, Lower Limb/Amputation Complications
190	Amputation Status, Upper Limb

Appendix D – Conditions Categories that May Represent Potential Complication of Care Received During Index Admission

V22 CC	Description
69	Attention Deficit Disorder
127	Cataract
133	End Stage Renal Disease
146	Female Infertility
150	Ectopic Pregnancy
151	Miscarriage/Abortion
152	Completed Pregnancy With Major Complications
153	Completed Pregnancy With Complications
154	Completed Pregnancy Without Complications (Normal Delivery)
155	Uncompleted Pregnancy With Complications
156	Uncompleted Pregnancy With No or Minor Complications
180	Extremely Low Birthweight Neonates
181	Very Low Birthweight Neonates
182	Serious Perinatal Problem Affecting Newborn
183	Other Perinatal Problems Affecting Newborn
184	Normal, Single Birth
185	Major Organ Transplant (procedure)
188	Artificial Openings for Feeding or Elimination
191	Post-Surgical States/Aftercare/Elective
192	Radiation Therapy
193	Chemotherapy
194	Rehabilitation
195	Screening/Observation/Special Exams
196	History of Disease
197	Supplemental Oxygen
198	CPAP/IPPB/Nebulizers
199	Patient Lifts, Power Operated Vehicles, Beds
200	Wheelchairs, Commodes
201	Walkers