2016 Condition-Specific Measures Updates and Specifications Report
Hospital-Level 30-Day Risk-Standardized Mortality Measures

Acute Myocardial Infarction – Version 10.0
Chronic Obstructive Pulmonary Disease – Version 5.0
Heart Failure – Version 10.0
Pneumonia – Version 10.0
Stroke – Version 5.0

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1. HOW TO USE THIS REPORT

This report describes the Centers for Medicare & Medicaid Services' (CMS's) condition-specific mortality measures used in the Hospital Inpatient Quality Reporting program and publicly reported on *Hospital Compare*. The measures report hospital-level 30-day risk-standardized mortality rates (RSMRs) following acute myocardial infarction (AMI), chronic obstructive pulmonary disease (COPD), heart failure (HF), pneumonia, and stroke. This report provides a single source of information about these measures for a wide range of readers. Reports describing coronary artery bypass graft (CABG) surgery mortality, condition-specific readmission, and other outcome measures can be found on *QualityNet*.

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

Specifically, the report includes:

- **Section 2 - An overview of the AMI, COPD, HF, pneumonia, and stroke mortality measures:**
  - Background
  - Cohort inclusions and exclusions
    - included and excluded hospitalizations
    - how transferred patients are handled
    - differences in how the AMI, HF, and pneumonia measure scores are calculated for the Hospital Inpatient Quality Reporting program and the Hospital Value-Based Purchasing (VBP) program
  - Outcome
  - Risk-adjustment variables
  - Data sources
  - Mortality rate calculation
  - Categorization of hospitals' performance score

- **Section 3 - 2016 measure updates**

- **Section 4 - 2016 measure results**

- **Section 5 - Glossary**

The Appendices contain detailed measure information, including:

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

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

- Risk-Adjustment Models for AMI and HF 30-Day Mortality Methodology (Version 1.0)[1]
- Hospital-level 30-day Mortality Following Admission for an Acute Exacerbation of Chronic Obstructive Pulmonary Disease Measure Methodology Report (Version 1.0)[2]
- Risk-Adjustment Methodology for Hospital Monitoring/Surveillance and Public Reporting Supplement #1: 30-Day Mortality Model for Pneumonia (Version 1.0)[3]
- 30-Day Mortality Following Acute Ischemic Stroke Hospitalization Measure Methodology Report (Version 1.0)[4]
- 2008-2012 Measure Maintenance Technical Reports: Acute Myocardial Infarction, Heart Failure, and Pneumonia 30-Day Risk-Standardized Mortality Measures[5-9]
- 2013 Condition-Based Measure Updates and Specifications: AMI, HF, and Pneumonia 30-Day Risk-Standardized Mortality Measures[10]
- 2013 Measure Updates and Specifications Report: COPD 30-Day Mortality Measure[11]
- 2013 Measure Updates and Specifications Report: Hospital 30-Day Mortality Following an Admission for an Acute Ischemic Stroke (Version 2.0)[12]
- 2014 Condition-Based Measure Updates and Specifications: AMI, COPD, HF, Pneumonia, and Stroke 30-Day Risk-Standardized Mortality Measures[13]
- 2015 Measure Updates and Specifications Report: Hospital-Level 30-Day Risk-Standardized Mortality Measures; Acute Myocardial Infarction, Heart Failure, Pneumonia, Chronic Obstructive Pulmonary Disease, and Stroke[14]

The AMI, COPD, HF, and pneumonia mortality measure methodologies are also described in the peer-reviewed medical literature.[15-18]

2. BACKGROUND AND OVERVIEW OF MEASURE METHODOLOGY

2.1 Background on Mortality Measures

In June 2007, CMS began publicly reporting 30-day RSMRs for AMI and HF for the nation's non-federal short-term acute care hospitals (including Indian Health Services hospitals) and critical access hospitals, and added the pneumonia mortality measure in August 2008. In 2014, CMS began publicly reporting two additional hospital 30-day mortality measures; namely, COPD and ischemic stroke. These two measures also include admissions to non-federal acute care hospitals and critical access hospitals.

Results for all five of these mortality measures are posted on *Hospital Compare*, which CMS updates annually.

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

2.2 Overview of Measure Methodology

The 2016 risk-adjusted mortality measures use specifications from the initial measure methodology reports with refinements to the measures, as listed in Appendix C and described in the prior measures updates and specifications reports.[1-14] An overview of the methodology is presented in this section.

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

2.2.1 Cohort

Index Admissions Included in the Measures

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

- Having a principal discharge diagnosis of AMI, COPD, HF, pneumonia, or ischemic stroke for each respective measure;
    - The COPD measure cohort also includes admissions with a principal discharge diagnosis of respiratory failure and secondary diagnosis of COPD with exacerbation
    - The pneumonia measure cohort also includes admissions with a principal discharge diagnosis of sepsis (not including severe sepsis) that have a secondary discharge diagnosis of pneumonia coded as present on admission (POA) and no secondary diagnosis of severe sepsis coded as POA

- Enrolled in Medicare fee-for-service (FFS) Part A and Part B for the 12 months prior to the date of the index admission, and enrolled in Part A during the index admission;
- Aged 65 or over; and,
- Not transferred from another acute care facility.

International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes used to define the cohort inclusions for each measure are listed in Appendix D, in Table D.1.1, Table D.2.1, Table D.3.1, Table D.4.1, and Table D.5.1 for AMI, COPD, HF, pneumonia, and stroke, respectively.

Index Admissions Excluded from the Measures

The mortality measures exclude index admissions for patients:

- With inconsistent or unknown vital status or other unreliable demographic (age and gender) data;
- Enrolled in the Medicare hospice program any time in the 12 months prior to the index admission, including the first day of the index admission; or,
- Discharged against medical advice (AMA).

An additional exclusion criterion for the AMI, HF, and pneumonia cohorts is that patients discharged alive on the day of admission or the following day who were not transferred to another acute care facility are excluded as index admissions.

An additional exclusion criterion for the HF cohort is that patients with a procedure code for left ventricular assist device (LVAD) implantation or heart transplantation (Table D.3.2) either during the index admission or in the 12 months prior to the index admission are excluded as index admissions because these patients represent a clinically distinct, highly-selected group.

For patients with more than one eligible admission for a given condition in a given year, only one index admission for that condition is randomly selected for inclusion in the cohort. Additional admissions within that year are excluded.

For index admissions that occur during the transition between two years within the measurement period (that is, June/July 2013 or June/July 2014), and both are randomly selected for inclusion in the measure, the measure includes only the June admission. July admissions are excluded to avoid assigning a single death to two admissions. For example, for a patient who is admitted on June 18, 2013, readmitted on July 2, 2013, and subsequently dies on July 15, 2013: if both admissions are randomly selected for inclusion (one for the July 2012-June 2013 time period and the other for the July 2013-June 2014 time period), the measure will exclude the July 2, 2013 admission to avoid assigning the death to two admissions.

As a part of data processing prior to the measure calculation, records are removed for non-short-term acute care facilities such as psychiatric facilities, rehabilitation facilities, or long-term care hospitals. Additional data cleaning steps include removing claims with

stays longer than one year, claims with overlapping dates, and stays for patients not listed in the Medicare enrollment database, as well as records for providers with invalid provider IDs.

The percentage of admissions excluded based on each criterion is shown in Section 4 in Figure 4.2.1, Figure 4.3.1, Figure 4.4.1, Figure 4.5.1, and Figure 4.6.1 for AMI, COPD, HF, pneumonia, and stroke, respectively.

Patients Transferred Between Hospitals

Transfer patients are identified by tracking claims for inpatient short-term acute care hospitalizations over time. To qualify as a transfer, the second inpatient admission must occur on the same day or the next calendar day following discharge from the first inpatient admission at a short-term acute care hospital. Cases that meet this criterion are considered transfers regardless of whether or not the first institution indicates intent to transfer the patient in the discharge disposition code, and regardless of whether the hospitalizations that follow the first (index) admission for a given condition meet the inclusion/exclusion criteria for that measure.

For patients transferred from one short-term acute care hospital to another, only the first admission in the transfer chain is eligible for inclusion in the cohort. The subsequent admissions are not included. The measures assign a death that occurs within 30 days to the hospital that initially admitted the patient as an inpatient. For example, if a patient is admitted to Hospital A for pneumonia and then transfers to Hospital B, only the Hospital A admission (the index admission) would be included in the cohort, and death within 30 days of the Hospital A admission would be captured in Hospital A's pneumonia mortality outcome. In another example, if a patient is seen for pneumonia in the emergency department at Hospital A (and not admitted to an inpatient acute care bed), and then transfers to Hospital B for inpatient admission, the Hospital B admission would be included in the cohort (the index admission), and a death within 30 days would be captured in Hospital B's pneumonia mortality outcome.

Hospital VBP Program

CMS uses the AMI, HF, and pneumonia mortality measures in the Hospital VBP program for fiscal year 2017.

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

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

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

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

2.2.2 Outcome

All-Cause Mortality

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

30-Day Time Frame

The measures assess mortality within a 30-day period from the date of the index admission. The measures use a 30-day time frame because older adult patients are more vulnerable to adverse health outcomes occurring during this time.[19] Death within 30 days of admission can be influenced by hospital care and the early transition to the non-acute care setting. The 30-day time frame is a clinically meaningful period for hospitals to collaborate with their communities in an effort to reduce mortality.[20]

2.2.3 Risk-Adjustment Variables

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

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

The measures do not adjust for socioeconomic status (SES) because the association between SES and health outcomes can be due, in part, to differences in the quality of healthcare that groups of patients with varying SES receive. The intent is for the measures to adjust for patient demographic and clinical characteristics while illuminating important quality differences. Additionally, recent analyses have shown that hospitals caring for high proportions of low-SES patients perform similarly on the measures to hospitals caring for low proportions of low-SES patients.[21] Please note that the Office of the Assistant Secretary for Planning and Evaluation (ASPE) is conducting research to examine the impact of SES on quality measures, resource use, and other measures under the Medicare program as directed by the IMPACT Act. ASPE will issue an initial report to Congress by October 2016 and a final report to Congress by October 2019. The findings in these reports will be considered in future reevaluation of these measures.

Refer to Table D.1.2, Table D.2.2, Table D.3.3, Table D.4.2, and Table D.5.2 in Appendix D of this report for the list of comorbidity risk-adjustment variables and the list of complications that are excluded from risk adjustment if they occur during the index admission, for AMI, COPD, HF, pneumonia, and stroke, respectively.

2.2.4 Data Sources

The data sources for these analyses are Medicare administrative claims data and enrollment information for patients with hospitalizations between July 1, 2012 and June 30, 2015. The datasets also contain associated inpatient, outpatient, and physician Medicare administrative claims for the 12 months prior to the index admission for patients admitted in this time period. See the original methodology reports for further descriptions of these data sources and an explanation of the three-year measurement period.[1-4]

2.2.5 Measure Calculation

The measures estimate hospital-level 30-day all-cause RSMRs for each condition using hierarchical logistic regression models. In brief, the approach simultaneously models data at the patient and hospital levels to account for the variance in patient outcomes within and between hospitals.[22] At the patient level, it models the log-odds of mortality within 30 days of the index admission using age, sex (in the AMI, HF, pneumonia, and stroke measures), selected clinical covariates, and a hospital-specific effect. At the hospital level, the approach models the hospital-specific effects as arising from a normal distribution. The hospital effect represents the underlying risk of mortality at the hospital, after accounting for patient risk. The hospital-specific effects are given a distribution to account for the clustering (non-independence) of patients within the same hospital.[22] If there were no differences among hospitals, then after adjusting for patient risk, the hospital effects should be identical across all hospitals.

The RSMR is calculated as the ratio of the number of "predicted" deaths to the number of "expected" deaths at a given hospital, multiplied by the national observed mortality rate. For each hospital, the numerator of the ratio is the number of deaths within 30 days predicted based on the hospital's performance with its observed case mix, and the

denominator is the number of deaths expected based on the nation's performance with that hospital's case mix. This approach is analogous to a ratio of "observed" to "expected" used in other types of statistical analyses. It conceptually allows a particular hospital's performance, given its case mix, to be compared to an average hospital's performance with the same case mix. Thus, a lower ratio indicates lower-than-expected mortality rates or better quality, while a higher ratio indicates higher-than-expected mortality rates or worse quality.

The "predicted" number of deaths (the numerator) is calculated by using the coefficients estimated by regressing the risk factors (Table D.1.2, Table D.2.2, Table D.3.3, Table D.4.2, and Table D.5.2 for the AMI, COPD, HF, pneumonia, and stroke measures, respectively) and the hospital-specific effect on the risk of mortality. The estimated hospital-specific effect is added to the sum of the estimated regression coefficients multiplied by the patient characteristics. The results are log 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 effect using all hospitals in our sample is added in place of the hospital-specific effect. The results are log transformed and summed over all patients in the hospital to get an expected value. To assess hospital performance for each reporting period, we re-estimate the model coefficients using the years of data in that period.

This calculation transforms the ratio of predicted over expected into a rate that is compared to the national observed mortality rate. The hierarchical logistic regression models are described fully in Appendix A and in the original methodology reports.[1-4]

2.2.6 Categorizing Hospital Performance

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

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

If a hospital has fewer than 25 eligible cases for a measure, CMS assigns the hospital to a separate category, "Number of Cases Too Small". This category is used when the number of cases is too small (fewer than 25) to reliably tell how well the hospital is performing. If a hospital has fewer than 25 eligible cases, the hospital's mortality rates and interval estimates will not be publicly reported for the measure.

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

3. UPDATES TO MEASURES FOR 2016 PUBLIC REPORTING

3.1 Rationale for Measure Updates

Measure reevaluation ensures that the risk-standardized mortality models are continually assessed and remain valid, given possible changes in clinical practice and coding standards over time, while allowing for model refinements. Modifications made to measure cohorts, risk models, and outcomes are informed by review of the most recent literature related to measure conditions or outcomes, feedback from various stakeholders, and empirical analyses including assessment of coding trends that reveal shifts in clinical practice or billing patterns. As this report describes, for 2016 public reporting, we made the following modifications to the measures:

- Updated the pneumonia measure specifications:
    - Expanded the cohort to include admissions for aspiration pneumonia as well as sepsis admissions (not including severe sepsis) with a secondary diagnosis of pneumonia (including aspiration pneumonia) coded as POA and no secondary diagnosis of severe sepsis coded as POA;
    - Updated the risk variable list in response to the cohort expansion;
- Updated the HF cohort to exclude patients with a procedure code for LVAD implantation or heart transplantation either during the index admission or in the 12 months prior to the index admission; and,
- Updated the stroke cohort to include the diagnosis code for "Acute, but ill-defined, cerebrovascular disease" (ICD-9-CM code 436).

In addition, each year we assess measure characteristics and revise the statistical software code used to calculate measure results. As a part of these annual reevaluation activities, we undertook the following activities:

- Validated the performance of each condition-specific model and its corresponding risk-adjustment variables in three recent one-year periods (July 2012-June 2013, July 2013-June 2014, and July 2014-June 2015);
- Evaluated and validated model performance for the three years combined (July 2012-June 2015); and,
- Updated the measures' SAS analytic package (SAS pack) and documentation.

Although hospitals are using International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) coding for discharges effective on or after October 1, 2015, ICD-10 codes for use in defining the cohorts and ICD-10-based Condition Category (CC) Groups for use in risk adjustment were not incorporated into the measure specifications this year, as the measurement period for 2016 public reporting does not include claims data after June 30, 2015.

3.2 Detailed Discussion of Measure Updates

3.2.1 Updates to Pneumonia Measure

Expansion of Pneumonia Cohort

The pneumonia cohort was expanded to include:

- Admissions with aspiration pneumonia as a principal discharge diagnosis; and,
- Admissions with sepsis (not including severe sepsis) as a principal discharge diagnosis that have a secondary diagnosis of pneumonia (including aspiration pneumonia) coded as POA and no secondary diagnosis of severe sepsis coded as POA.

Rationale for Pneumonia Cohort Expansion

This expansion is intended to ensure that the pneumonia mortality measure more fully reflects the population of Medicare FFS beneficiaries being treated for pneumonia at hospitals in the U.S. The previous version of this measure in reporting programs did not include patients hospitalized with pneumonia when sepsis was considered the principal diagnosis. Clinically, these sepsis patients may represent more severely ill patients with pneumonia, but are often treated by the same groups of physicians and staff, using similar treatment strategies. Similarly, the previously reported measure did not include patients with aspiration pneumonia, despite the fact that it is often difficult to differentiate aspiration syndromes from other forms of pneumonia. These aspiration pneumonia patients are also treated using similar approaches, by the same groups of physicians and staff. The measure inclusion criteria have been broadened to include aspiration pneumonia and sepsis admissions, as described above, in order to capture a broader population of patients admitted for pneumonia and a more consistent clinical cohort across hospitals. The need to make these changes was further underscored by wide variation across hospitals in the use of sepsis codes amongst pneumonia patients and, to a lesser extent, aspiration pneumonia codes. This variation suggests systematic differences in hospital coding practice that could potentially bias efforts to compare hospital performance for pneumonia hospitalizations.

Effect of Pneumonia Cohort Expansion on Measure

To determine the impact of expanding the cohort, we conducted analyses of Medicare FFS hospitalizations between July 2010 and June 2013 using the national pneumonia mortality measure cohort data. Results are summarized in Table 3.2.1 and Table 3.2.2. The cohort expansion adds a large number of admissions to the measure. Hospitalizations in the expanded cohort of pneumonia patients had a higher 30-day mortality rate when compared to the current cohort. Lastly, cohort expansion resulted in an increase in the number of hospitals considered outliers as well as changes in the outlier status classification of hospitals; however, much of the observed movement of hospitals between the two cohort definitions can be attributed to the increase in cohort size and in turn increased hospital volumes.

For more information on the rationale for the cohort expansion or the history behind the change, or for details of the analyses supporting the re-specified cohort, refer to the Reevaluation and Re-Specification Report of the Hospital-Level 30-Day Risk-Standardized Measures Following Hospitalization for Pneumonia, zip file “AMI, HF, PN, COPD, and Stroke Readmission Updates”, posted to the CMS website in July 2015.[23]

Table 3.2.1 – Effect of Pneumonia Cohort Expansion on Pneumonia Admission Volume and Observed Mortality Rates

Characteristic	Previous Measure Cohort (version 9.0)	Expanded Measure Cohort (version 9.2)
Number of admissions	1,040,845	1,364,389
Mortality rate	11.9%	16.9%

Table 3.2.2 – Hospital-Level Reclassification of Outlier Status for the Previous Pneumonia Measure Cohort and the Expanded Pneumonia Measure Cohort

Previous Measure Cohort (version 9.0)	Expanded Measure Cohort (version 9.2) Number of Hospitals		
	Better than the National Rate	No Different than the National Rate	Worse than the National Rate
Better than the National Rate	135	68	0
No Different than the National Rate	113	3,609	193
Worse than the National Rate	0	76	115

Addition of Risk-Adjustment Variables

1. Incorporated the following new risk-adjustment variables if present in the 12 months prior to the index admission:
   - Septicemia/shock (CC 2)
   - Disorders of fluid/electrolyte/acid-base balance (CC 23)
   - Delirium and encephalopathy (CC 48)
   - Respiratory dependence/tracheostomy status (CC 77)
   - Decubitus ulcer of skin (CC 148)

2. Modified two currently included clinical risk variables as follows:
   - Pleural effusion/pneumothorax (CC 114) was added to the previously defined Pneumonia (CC 111-113) risk variable, redefining it as Pneumonia; pleural effusion/pneumothorax (CC 111-114); and,
   - Respiratory arrest (CC 78) was added to the previously defined Cardio-respiratory failure and shock (CC 79) risk variable, redefining it as Cardio-respiratory failure and shock; respiratory arrest (CC 78–79) in the risk model.

Rationale for Addition of Risk-Adjustment Variables

During measure reevaluation, we determined that all of these risk variables were common (that is, with a prevalence of greater than 10% in the population) and had strong associations with mortality (odds ratio [OR] greater than 1.5) in the expanded pneumonia cohort. These risk variables also had high levels of face validity in terms of the clinical expectation that these conditions would be associated with worse outcomes if they occurred during the 12 months prior to the index admission.

3.2.2 Update to HF Cohort Exclusions

Exclusion of LVADs and Heart Transplants from Cohort

The exclusion criteria for the HF measure have been modified to remove patients with an ICD-9 procedure code for LVAD implantation or heart transplantation either during the index admission or in the 12 months prior to the index admission from the HF measure cohort (Table D.3.2).

Rationale for LVAD/Heart Transplant Exclusion

Patients with HF who receive an LVAD or undergo heart transplantation represent a highly-selected, clinically distinct group that are appropriate exclusions for the measure. Over the past five to ten years, there has been a marked increase in the use of LVADs, especially for "destination" therapy.[24] These LVAD patients essentially define a new cohort of patients that did not exist when the HF measure was originally developed. HF patients with an LVAD or who undergo heart transplantation have the most severe and clinically advanced heart failure and often complex coexisting medical conditions.

Effect of LVAD/Heart Transplant Exclusion on Measure

Patients receiving an LVAD or heart transplant during the index admission or in the year prior to admission accounted for only 0.16% of the overall measure cohort. RSMRs are not significantly different based on whether these admissions are included or excluded from the estimates.

3.2.3 Update to Stroke Measure

Addition of ICD-9 Code 436 to Cohort

The ischemic stroke cohort was expanded to include admissions with an ICD-9 principal discharge diagnosis code of 436, "Acute, but ill-defined, cerebrovascular disease".

Rationale for Addition of ICD-9 Code 436

Although ICD-9 code 436 is not specific and could, in theory, include intracerebral hemorrhage, these codes are most commonly ischemic strokes coded as 436.[25] This code may be used either because there is insufficient documentation to use a more specific code, or because some hospitals use older coding terminology to assign diagnoses of cerebrovascular accidents. Admissions coded with ICD-9 code 436 as the principal discharge diagnosis are appropriate inclusions for the stroke measure. Addition of this code will allow for a more comprehensive cohort of true ischemic stroke patients, across all hospitals.

Effect of Addition of ICD-9 Code 436

Patients with a principal discharge diagnosis of 436, "Acute, but ill-defined, cerebrovascular disease", accounted for only 0.13% of the overall measure cohort.

3.3 Changes to SAS Pack

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

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

4. RESULTS FOR 2016 PUBLIC REPORTING

4.1 Assessment of Updated Models

The mortality measures estimate hospital-specific 30-day all-cause RSMRs using hierarchical logistic regression models. See Section 2 for a summary of the measure methodology and model risk-adjustment variables. Refer to prior methodology and technical reports for further details.[1-14]

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

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

The results of these analyses for each of the five measures (AMI, COPD, HF, pneumonia, and stroke) are presented in Sections 4.2, 4.3, 4.4, 4.5, and 4.6, respectively.

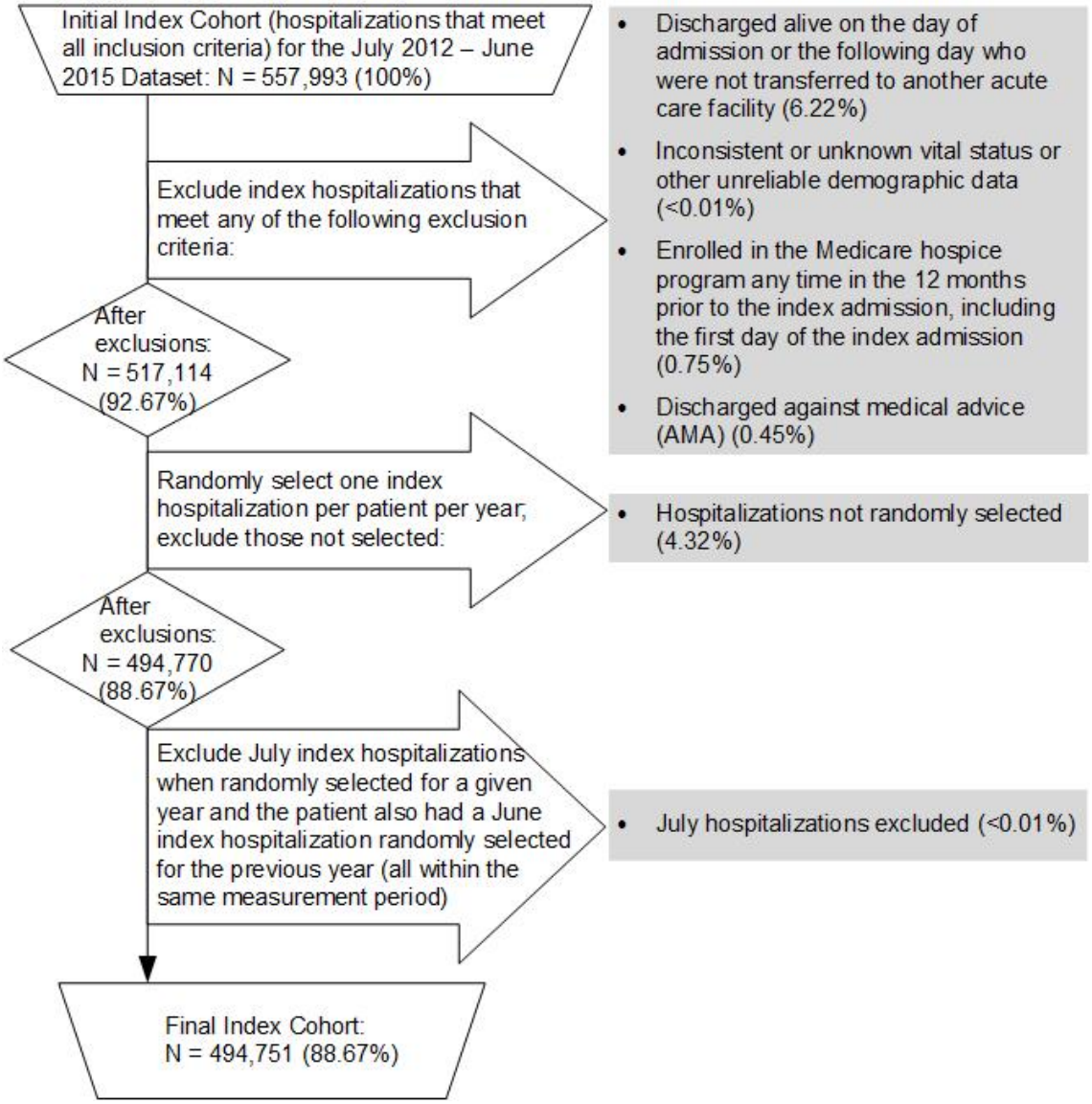
4.2 AMI Mortality 2016 Model Results

4.2.1 Index Cohort Exclusions

The exclusion criteria for the measure are presented in Section 2.2.1. The percentage of AMI admissions meeting each exclusion criterion in the July 2012-June 2015 dataset is presented in Figure 4.2.1.

Admissions may have been counted in more than one exclusion category because they are not mutually exclusive. The index cohort includes short-term acute care hospitalizations for Medicare patients aged 65 or over with a principal discharge diagnosis of AMI; enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission; and who were not transferred from another acute care facility.

Figure 4.2.1 – AMI Cohort Exclusions in the July 2012-June 2015 Dataset



4.2.2 Frequency of AMI Model Variables

We examined the change in both observed mortality rates and frequency of clinical and demographic variables. Between July 2012-June 2013 and July 2014-June 2015, the observed mortality rate decreased from 14.6% to 14.0%. Notable changes in the frequencies for model variables include:

- Decreases in Congestive heart failure (30.2% to 28.9%), Acute myocardial infarction (13.4% to 12.0%), Cerebrovascular disease (20.9% to 19.7%), and Pneumonia (23.7% to 22.6%)
- Increases in Male % (51.3% to 52.6%), History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (16.9% to 18.5%), and Renal failure (26.5% to 27.8%)

Refer to Table 4.2.1 for more detail.

4.2.3 AMI Model Parameters and Performance

Table 4.2.2 shows hierarchical regression model variable coefficients by individual year and for the combined three-year dataset. Table 4.2.3 shows the risk-adjusted ORs and 95% confidence intervals (CIs) for the AMI mortality model by individual year and for the combined three-year dataset. Overall, the variable effect sizes were relatively constant across years. In addition, model performance was stable over the three-year time period; the c-statistic remained constant at 0.72 (Table 4.2.4).

4.2.4 Distribution of Hospital Volumes and RSMRs for AMI

Table 4.2.5 shows the distribution of hospital admission volumes and Table 4.2.6 shows the distribution of hospital RSMRs. The mean RSMR decreased over the three-year period, from 14.6% between July 2012 and June 2013 to 14.0% between July 2014 and June 2015. The median hospital RSMR in the combined three-year dataset was 14.2% (Interquartile Range [IQR] 13.7% - 14.6%). Table 4.2.7 shows the between-hospital variance by individual year and for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.036 (Standard Error [SE]: 0.003). If there were no systematic differences between hospitals, the between-hospital variance would be 0.

Figure 4.2.2 shows the overall distribution of the hospital RSMRs for the combined dataset. The odds of all-cause mortality if treated at a hospital one standard deviation (SD) above the national rate were 1.46 times higher than the odds of all-cause mortality if treated at a hospital one SD below the national rate. If there were no systematic differences between hospitals, the OR would be 1.0.[22]

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

Of 4,365 hospitals in the study cohort, 57 performed "Better than the National Rate," 2,375 performed "No Different from the National Rate," and 24 performed "Worse than the National Rate." 1,909 were classified as "Number of Cases Too Small" (fewer than 25) to reliably tell how well the hospital is performing.

Table 4.2.1 – Frequency of AMI Model Variables Over Different Time Periods

Variable	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Total N	171,124	161,337	162,290	494,751
Observed mortality rate (%)	14.6	13.8	14.0	14.1
Mean age minus 65 (SD)	14.0 (8.4)	13.7 (8.4)	13.7 (8.4)	13.8 (8.4)
Male (%)	51.3	52.2	52.6	52.0
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 diagnosis code V45.82; ICD-9 procedure codes 00.66, 36.06, 36.07)	16.9	17.5	18.5	17.6
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 diagnosis code V45.81; ICD-9 procedure codes 36.10-36.16)	12.2	11.8	12.1	12.0
Congestive heart failure (CC 80)	30.2	29.2	28.9	29.4
Acute myocardial infarction (CC 81)	13.4	12.8	12.0	12.7
Other acute/subacute forms of ischemic heart disease (CC 82)	13.2	13.1	12.9	13.1
Anterior myocardial infarction (ICD-9 diagnosis codes 410.00-410.12)	8.0	7.8	7.5	7.8
Other location of myocardial infarction (ICD-9 diagnosis codes 410.20-410.62)	11.9	12.0	11.6	11.8
Coronary atherosclerosis or angina (CC 83-84)	84.5	84.8	84.9	84.7
Cardio-respiratory failure and shock (CC 79)	10.5	10.9	11.3	10.9
Valvular or rheumatic heart disease (CC 86)	32.0	31.6	32.2	31.9
Hypertensive heart and renal disease or encephalopathy; hypertension (CC 89, 91)	89.2	89.1	89.6	89.3
Stroke (CC 95-96)	7.2	7.1	7.0	7.1
Cerebrovascular disease (CC 97-99, 103)	20.9	20.2	19.7	20.3
Renal failure (CC 131)	26.5	27.0	27.8	27.1
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	30.8	30.0	29.9	30.2
Pneumonia (CC 111-113)	23.7	22.4	22.6	22.9
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 15-19, 120)	46.9	47.2	47.3	47.1
Protein-calorie malnutrition (CC 21)	6.6	6.4	6.5	6.5
Dementia or other specified brain disorders (CC 49-50)	20.4	19.7	19.5	19.9
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	6.5	6.4	6.4	6.4
Vascular disease and complications (CC 104-105)	27.5	27.1	26.9	27.2
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	3.9	3.9	3.9	3.9
Trauma in last year (CC 154-156, 158-162)	31.4	31.3	31.7	31.5
Major psychiatric disorders (CC 54-56)	7.9	8.0	8.0	8.0
Chronic liver disease (CC 25-27)	1.5	1.5	1.7	1.6

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

Variable	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Intercept	-2.721	-2.825	-2.779	-2.766
Age minus 65 (years above 65, continuous)	0.056	0.056	0.056	0.056
Male	0.144	0.132	0.133	0.138
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 diagnosis code V45.82; ICD-9 procedure codes 00.66, 36.06, 36.07)	-0.286	-0.277	-0.275	-0.278
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 diagnosis code V45.81; ICD-9 procedure codes 36.10-36.16)	0.144	0.077	0.081	0.101
Congestive heart failure (CC 80)	0.284	0.271	0.273	0.276
Acute myocardial infarction (CC 81)	-0.013	-0.051	0.044	-0.008
Other acute/subacute forms of ischemic heart disease (CC 82)	-0.080	-0.111	-0.055	-0.078
Anterior myocardial infarction (ICD-9 diagnosis codes 410.00-410.12)	0.785	0.818	0.827	0.810
Other location of myocardial infarction (ICD-9 diagnosis codes 410.20-410.62)	0.501	0.523	0.489	0.505
Coronary atherosclerosis or angina (CC 83-84)	-0.511	-0.458	-0.475	-0.478
Cardio-respiratory failure and shock (CC 79)	0.124	0.187	0.137	0.148
Valvular or rheumatic heart disease (CC 86)	0.056	0.095	0.071	0.078
Hypertensive heart and renal disease or encephalopathy; hypertension (CC 89, 91)	-0.319	-0.290	-0.332	-0.315
Stroke (CC 95-96)	0.031	0.045	-0.014	0.021
Cerebrovascular disease (CC 97-99, 103)	-0.066	-0.039	-0.015	-0.041
Renal failure (CC 131)	0.191	0.205	0.197	0.197
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	0.133	0.100	0.101	0.109
Pneumonia (CC 111-113)	0.425	0.424	0.413	0.420
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 15-19, 120)	0.094	0.097	0.139	0.109
Protein-calorie malnutrition (CC 21)	0.475	0.551	0.553	0.528
Dementia or other specified brain disorders (CC 49-50)	0.400	0.371	0.380	0.383
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	0.222	0.182	0.219	0.209
Vascular disease and complications (CC 104-105)	0.073	0.080	0.078	0.080
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	0.682	0.679	0.685	0.687
Trauma in last year (CC 154-156, 158-162)	0.010	-0.005	0.046	0.018
Major psychiatric disorders (CC 54-56)	0.056	0.106	0.032	0.064
Chronic liver disease (CC 25-27)	0.485	0.397	0.459	0.452

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

Variable	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2012-06/2015 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.06 (1.06 - 1.06)	1.06 (1.06 - 1.06)	1.06 (1.06 - 1.06)	1.06 (1.06 - 1.06)
Male	1.16 (1.12 - 1.19)	1.14 (1.11 - 1.18)	1.14 (1.11 - 1.18)	1.15 (1.13 - 1.17)
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 diagnosis code V45.82; ICD-9 procedure codes 00.66, 36.06, 36.07)	0.75 (0.72 - 0.79)	0.76 (0.73 - 0.79)	0.76 (0.73 - 0.79)	0.76 (0.74 - 0.78)
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 diagnosis code V45.81; ICD-9 procedure codes 36.10-36.16)	1.15 (1.11 - 1.21)	1.08 (1.03 - 1.13)	1.08 (1.04 - 1.14)	1.11 (1.08 - 1.14)
Congestive heart failure (CC 80)	1.33 (1.28 - 1.38)	1.31 (1.26 - 1.36)	1.31 (1.27 - 1.36)	1.32 (1.29 - 1.35)
Acute myocardial infarction (CC 81)	0.99 (0.94 - 1.03)	0.95 (0.90 - 1.00)	1.05 (0.99 - 1.10)	0.99 (0.96 - 1.02)
Other acute/subacute forms of ischemic heart disease (CC 82)	0.92 (0.88 - 0.97)	0.90 (0.85 - 0.94)	0.95 (0.90 - 1.00)	0.92 (0.90 - 0.95)
Anterior myocardial infarction (ICD-9 diagnosis codes 410.00-410.12)	2.19 (2.09 - 2.30)	2.27 (2.15 - 2.38)	2.29 (2.17 - 2.41)	2.25 (2.18 - 2.32)
Other location of myocardial infarction (ICD-9 diagnosis codes 410.20-410.62)	1.65 (1.58 - 1.73)	1.69 (1.61 - 1.77)	1.63 (1.55 - 1.71)	1.66 (1.61 - 1.70)
Coronary atherosclerosis or angina (CC 83-84)	0.60 (0.58 - 0.62)	0.63 (0.61 - 0.66)	0.62 (0.60 - 0.65)	0.62 (0.61 - 0.63)
Cardio-respiratory failure and shock (CC 79)	1.13 (1.08 - 1.18)	1.21 (1.15 - 1.26)	1.15 (1.09 - 1.20)	1.16 (1.13 - 1.19)
Valvular or rheumatic heart disease (CC 86)	1.06 (1.03 - 1.09)	1.10 (1.06 - 1.14)	1.07 (1.04 - 1.11)	1.08 (1.06 - 1.10)
Hypertensive heart and renal disease or encephalopathy; hypertension (CC 89, 91)	0.73 (0.69 - 0.76)	0.75 (0.71 - 0.79)	0.72 (0.68 - 0.75)	0.73 (0.71 - 0.75)
Stroke (CC 95-96)	1.03 (0.98 - 1.09)	1.05 (0.99 - 1.11)	0.99 (0.93 - 1.04)	1.02 (0.99 - 1.06)
Cerebrovascular disease (CC 97-99, 103)	0.94 (0.90 - 0.97)	0.96 (0.93 - 1.00)	0.99 (0.95 - 1.02)	0.96 (0.94 - 0.98)
Renal failure (CC 131)	1.21 (1.17 - 1.25)	1.23 (1.18 - 1.27)	1.22 (1.18 - 1.26)	1.22 (1.19 - 1.24)
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	1.14 (1.11 - 1.18)	1.11 (1.07 - 1.14)	1.11 (1.07 - 1.14)	1.12 (1.09 - 1.14)
Pneumonia (CC 111-113)	1.53 (1.48 - 1.58)	1.53 (1.47 - 1.58)	1.51 (1.46 - 1.57)	1.52 (1.49 - 1.55)
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 15-19, 120)	1.10 (1.07 - 1.13)	1.10 (1.07 - 1.14)	1.15 (1.11 - 1.19)	1.12 (1.10 - 1.14)
Protein-calorie malnutrition (CC 21)	1.61 (1.53 - 1.69)	1.74 (1.65 - 1.82)	1.74 (1.65 - 1.83)	1.70 (1.65 - 1.75)
Dementia or other specified brain disorders (CC 49-50)	1.49 (1.44 - 1.54)	1.45 (1.40 - 1.50)	1.46 (1.41 - 1.52)	1.47 (1.44 - 1.50)
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	1.25 (1.18 - 1.32)	1.20 (1.13 - 1.27)	1.24 (1.18 - 1.32)	1.23 (1.19 - 1.27)
Vascular disease and complications (CC 104-105)	1.08 (1.04 - 1.11)	1.08 (1.05 - 1.12)	1.08 (1.05 - 1.12)	1.08 (1.06 - 1.11)
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	1.98 (1.86 - 2.10)	1.97 (1.85 - 2.10)	1.98 (1.86 - 2.11)	1.99 (1.92 - 2.06)
Trauma in last year (CC 154-156, 158-162)	1.01 (0.98 - 1.04)	1.00 (0.96 - 1.03)	1.05 (1.01 - 1.08)	1.02 (1.00 - 1.04)
Major psychiatric disorders (CC 54-56)	1.06 (1.01 - 1.11)	1.11 (1.06 - 1.17)	1.03 (0.98 - 1.09)	1.07 (1.04 - 1.10)
Chronic liver disease (CC 25-27)	1.62 (1.47 - 1.80)	1.49 (1.34 - 1.65)	1.58 (1.43 - 1.75)	1.57 (1.48 - 1.67)

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

Characteristic	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Predictive ability, % (lowest decile – highest decile)	3.0 - 35.5	3.0 - 34.5	3.0 - 34.3	3.0 - 34.8
c-statistic	0.72	0.72	0.72	0.72

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

Characteristic	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Number of hospitals	4,032	3,951	3,878	4,365
Mean number of admissions (SD)	42.4 (57.0)	40.8 (54.8)	41.8 (55.8)	113.3 (162.3)
Range (min. – max.)	1 - 513	1 - 472	1 - 503	1 - 1,488
25th percentile	4	4	4	8
50th percentile	18	17	18	38
75th percentile	62	59	61	164

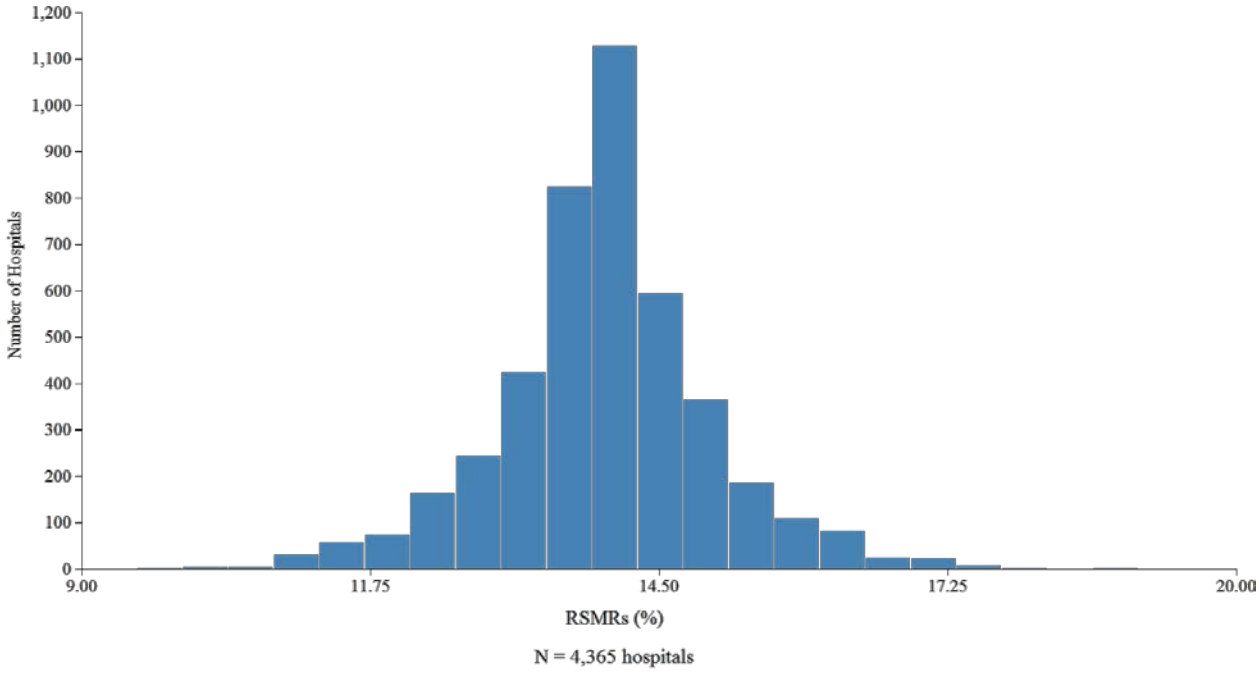
Table 4.2.6 – Distribution of Hospital AMI RSMRs Over Different Time Periods

Characteristic	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Number of hospitals	4,032	3,951	3,878	4,365
Mean (SD)	14.6 (0.7)	13.8 (0.5)	14.0 (0.7)	14.2 (1.0)
Range (min. – max.)	11.1 - 19.2	11.2 - 17.0	10.3 - 18.3	9.4 - 20.0
25th percentile	14.3	13.6	13.7	13.7
50th percentile	14.5	13.8	13.9	14.2
75th percentile	14.9	14.1	14.3	14.6

Table 4.2.7 – Between-Hospital Variance for AMI

	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Between-hospital variance (SE)	0.035 (0.005)	0.026 (0.005)	0.034 (0.005)	0.036 (0.003)

Figure 4.2.2 – Distribution of Hospital 30-Day AMI RSMRs Between July 2012 and June 2015



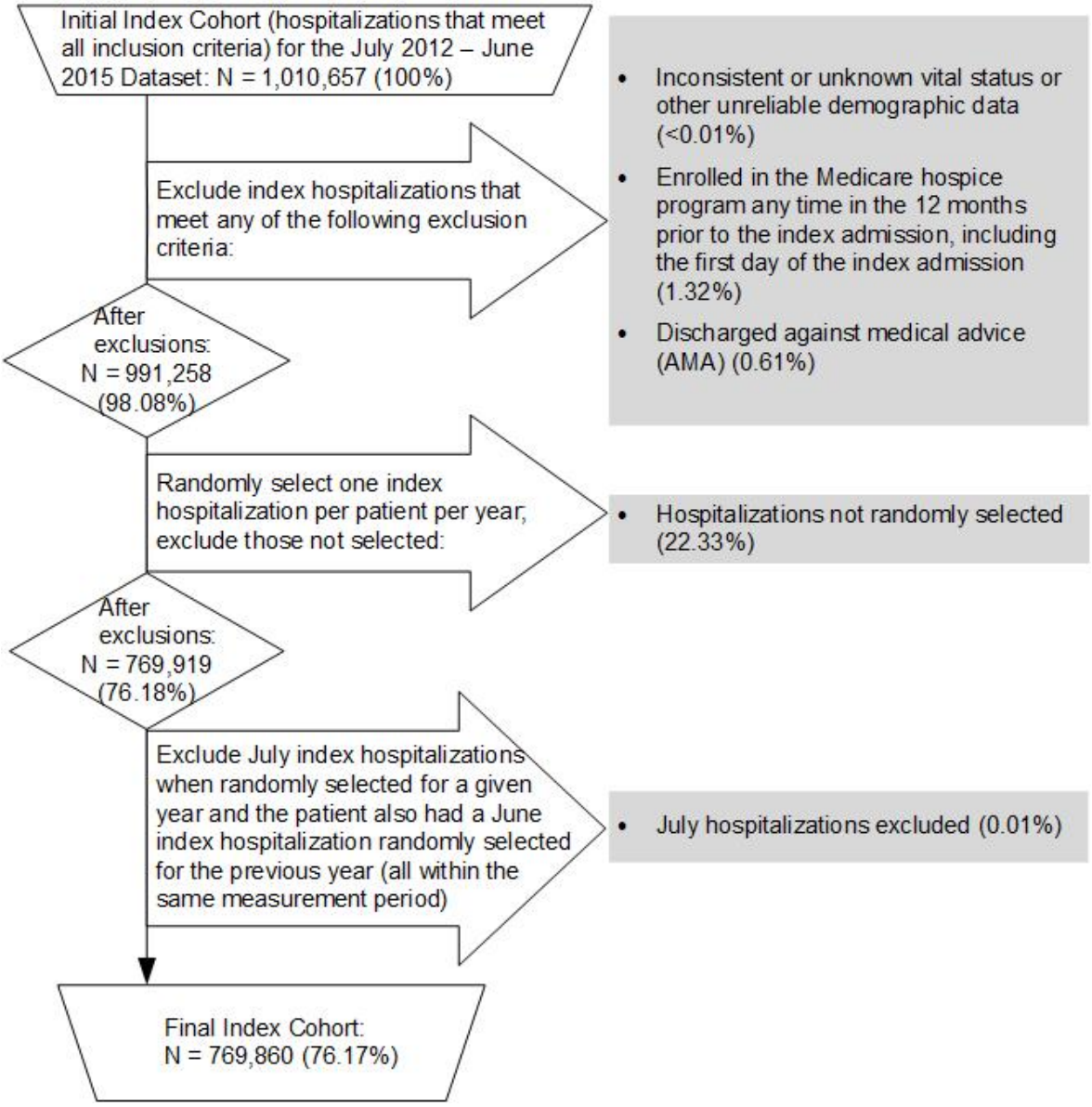
4.3 COPD Mortality 2016 Model Results

4.3.1 Index Cohort Exclusions

The exclusion criteria for the measures are presented in Section 2.2.1. The percentage of COPD admissions meeting each exclusion criterion in the July 2012-June 2015 dataset is presented in Figure 4.3.1.

Admissions may have been counted in more than one exclusion category because they are not mutually exclusive. The index cohort includes short-term acute care hospitalizations for Medicare patients aged 65 or over with a principal discharge diagnosis of COPD or principal discharge diagnosis of respiratory failure with a secondary diagnosis of COPD with exacerbation; enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission; and who were not transferred from another acute care facility.

Figure 4.3.1 – COPD Cohort Exclusions in the July 2012-June 2015 Dataset



4.3.2 Frequency of COPD Model Variables

We examined the change in both observed mortality rates and frequency of clinical and demographic variables. Between July 2012-June 2013 and July 2014-June 2015, the observed mortality rate decreased from 8.1% to 8.0%. Notable changes in the frequencies for model variables include:

- Decreases in Coronary atherosclerosis or angina (52.4% to 51.3%), Fibrosis of lung or other chronic lung disorders (15.1% to 14.1%), Pneumonia (48.5% to 47.5%), and Other lung disorders (49.5% to 47.9%)
- Increases in Sleep apnea (17.6% to 19.9%), History of mechanical ventilation (8.1% to 9.2%), Cardio-respiratory failure and shock (32.2% to 36.1%), Other endocrine/metabolic/nutritional disorders (81.6% to 83.5%), Drug/alcohol abuse, without dependence (31.3% to 32.5%), Other psychiatric disorders (28.3% to 31.7%), Mononeuropathy, other neurological conditions/injuries (15.4% to 16.5%), and Renal failure (25.7% to 27.6%)

Refer to Table 4.3.1 for more detail.

4.3.3 COPD Model Parameters and Performance

Table 4.3.2 shows hierarchical regression model variable coefficients by individual year and for the combined three-year dataset. Table 4.3.3 shows the risk-adjusted ORs and 95% CIs for the COPD mortality model by individual year and for the combined three-year dataset. Overall, the variable effect sizes were relatively constant across years. In addition, model performance was stable over the three-year period; the c-statistic remained constant at 0.72 (Table 4.3.4).

4.3.4 Distribution of Hospital Volumes and RSMRs for COPD

Table 4.3.5 shows the distribution of hospital admission volumes and Table 4.3.6 shows the distribution of hospital RSMRs. The mean RSMR decreased over the three-year period, from 8.1% between July 2012 and June 2013 to 8.0% between July 2014 and June 2015. The median hospital RSMR in the combined three-year dataset was 8.0% (IQR 7.5% - 8.6%). Table 4.3.7 shows the between-hospital variance by individual year and for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.062 (SE: 0.003). If there were no systematic differences between hospitals, the between-hospital variance would be 0.

Figure 4.3.2 shows the overall distribution of the hospital RSMRs for the combined dataset. The odds of all-cause mortality if treated at a hospital one SD above the national rate were 1.65 times higher than the odds of all-cause mortality if treated at a hospital one SD below the national rate. If there were no systematic differences between hospitals, the OR would be 1.0.[22]

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

Of 4.643 hospitals in the study cohort, 57 performed “Better than the National Rate,” 3,580 performed “No Different from the National Rate,” and 107 performed “Worse

than the National Rate." 899 were classified as "Number of Cases Too Small" (fewer than 25) to reliably tell how well the hospital is performing.

Table 4.3.1 – Frequency of COPD Model Variables Over Different Time Periods

Variable	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Total N	279,618	241,457	248,785	769,860
Observed mortality rate (%)	8.1	7.9	8.0	8.0
Mean age minus 65 (SD)	12.1 (7.6)	11.8 (7.6)	12.0 (7.7)	12.0 (7.6)
Sleep apnea (ICD-9 diagnosis codes 327.20, 327.21, 327.23, 327.27, 327.29, 780.51, 780.53, 780.57)	17.6	19.0	19.9	18.7
History of mechanical ventilation (ICD-9 procedure codes 93.90, 96.70, 96.71, 96.72)	8.1	9.2	9.2	8.8
Respirator dependence/respiratory failure (CC 77-78)	1.1	1.2	1.1	1.1
Cardio-respiratory failure and shock (CC 79)	32.2	35.3	36.1	34.5
Congestive heart failure (CC 80)	41.6	42.3	41.7	41.9
Coronary atherosclerosis or angina (CC 83-84)	52.4	51.9	51.3	51.9
Specified arrhythmias and other heart rhythm disorders (CC 92-93)	41.2	41.9	41.9	41.6
Vascular or circulatory disease (CC 104-106)	41.6	41.8	41.7	41.7
Fibrosis of lung or other chronic lung disorders (CC 109)	15.1	14.7	14.1	14.7
Asthma (CC 110)	16.3	16.3	15.8	16.1
Pneumonia (CC 111-113)	48.5	48.9	47.5	48.3
Pleural effusion/pneumothorax (CC 114)	13.6	14.0	13.9	13.8
Other lung disorders (CC 115)	49.5	48.3	47.9	48.6
Metastatic cancer or acute leukemia (CC 7)	2.8	2.9	2.9	2.8
Lung, upper digestive tract, and other severe cancers (CC 8)	6.4	6.7	6.6	6.6
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other cancers and tumors; other respiratory and heart neoplasms (CC 9-11)	14.1	14.2	14.0	14.1
Other digestive and urinary neoplasms (CC 12)	6.7	6.6	6.5	6.6
Diabetes mellitus (DM) or DM complications (CC 15-19, 119-120)	42.9	42.6	42.4	42.6
Protein-calorie malnutrition (CC 21)	9.9	10.4	10.3	10.2
Disorders of fluid/electrolyte/acid-base (CC 22-23)	37.2	38.3	37.9	37.8
Other endocrine/metabolic/nutritional disorders (CC 24)	81.6	82.6	83.5	82.5
Other gastrointestinal disorders (CC 36)	63.9	64.3	64.4	64.2
Osteoarthritis of hip or knee (CC 40)	10.8	10.9	11.2	11.0
Other musculoskeletal and connective tissue disorders (CC 43)	70.3	70.7	71.2	70.7
Iron deficiency or other unspecified anemias and blood disease (CC 47)	50.2	51.0	50.1	50.4
Dementia or other specified brain disorders (CC 49-50)	19.0	18.5	18.2	18.6
Drug/alcohol abuse, without dependence (CC 53)	31.3	32.4	32.5	32.0
Other psychiatric disorders (CC 60)	28.3	30.8	31.7	30.2
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	5.7	5.7	5.8	5.8
Mononeuropathy, other neurological conditions/injuries (CC 76)	15.4	16.1	16.5	16.0
Hypertension and hypertensive disease (CC 90-91)	84.9	84.9	85.1	85.0
Stroke (CC 95-96)	6.1	6.1	6.0	6.1
Retinal disorders, except detachment and vascular retinopathies (CC 121)	12.4	12.4	12.8	12.5
Other eye disorders (CC 124)	20.1	20.0	20.4	20.1

Variable	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Other ear, nose, throat and mouth disorders (CC 127)	37.2	37.4	37.4	37.4
Renal failure (CC 131)	25.7	27.0	27.6	26.7
Decubitus ulcer or chronic skin ulcer (CC 148-149)	8.0	8.1	7.9	8.0
Other dermatological disorders (CC 153)	31.2	31.1	31.6	31.3
Trauma (CC 154-156, 158-161)	10.3	10.4	10.7	10.5
Vertebral fractures (CC 157)	4.7	4.9	5.0	4.9
Major complications of medical care and trauma (CC 164)	5.7	5.6	5.5	5.6

Table 4.3.2 – Hierarchical Logistic Regression Model Variable Coefficients for COPD Over Different Time Periods

Variable	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Intercept	-3.030	-2.946	-3.032	-3.018
Age minus 65 (years above 65, continuous)	0.037	0.034	0.037	0.036
Sleep apnea (ICD-9 diagnosis codes 327.20, 327.21, 327.23, 327.27, 327.29, 780.51, 780.53, 780.57)	-0.090	-0.069	-0.055	-0.073
History of mechanical ventilation (ICD-9 procedure codes 93.90, 96.70, 96.71, 96.72)	0.252	0.222	0.196	0.225
Respirator dependence/respiratory failure (CC 77-78)	-0.154	-0.031	-0.229	-0.132
Cardio-respiratory failure and shock (CC 79)	0.383	0.360	0.370	0.368
Congestive heart failure (CC 80)	0.226	0.223	0.217	0.223
Coronary atherosclerosis or angina (CC 83-84)	-0.047	-0.031	-0.014	-0.030
Specified arrhythmias and other heart rhythm disorders (CC 92-93)	0.083	0.077	0.072	0.077
Vascular or circulatory disease (CC 104-106)	0.036	0.034	-0.012	0.021
Fibrosis of lung or other chronic lung disorders (CC 109)	0.123	0.117	0.124	0.125
Asthma (CC 110)	-0.387	-0.380	-0.371	-0.376
Pneumonia (CC 111-113)	0.240	0.209	0.226	0.227
Pleural effusion/pneumothorax (CC 114)	0.127	0.212	0.172	0.168
Other lung disorders (CC 115)	-0.168	-0.180	-0.173	-0.172
Metastatic cancer or acute leukemia (CC 7)	0.857	0.868	0.864	0.864
Lung, upper digestive tract, and other severe cancers (CC 8)	0.610	0.622	0.592	0.610
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other cancers and tumors; other respiratory and heart neoplasms (CC 9-11)	-0.013	-0.007	0.020	0.001
Other digestive and urinary neoplasms (CC 12)	-0.157	-0.239	-0.185	-0.188
Diabetes mellitus (DM) or DM complications (CC 15-19, 119-120)	-0.071	-0.046	-0.035	-0.048
Protein-calorie malnutrition (CC 21)	0.777	0.737	0.773	0.769
Disorders of fluid/electrolyte/acid-base (CC 22-23)	0.127	0.130	0.132	0.130
Other endocrine/metabolic/nutritional disorders (CC 24)	-0.198	-0.198	-0.165	-0.188
Other gastrointestinal disorders (CC 36)	-0.138	-0.154	-0.178	-0.156
Osteoarthritis of hip or knee (CC 40)	-0.266	-0.309	-0.289	-0.285
Other musculoskeletal and connective tissue disorders (CC 43)	-0.149	-0.168	-0.200	-0.169
Iron deficiency or other unspecified anemias and blood disease (CC 47)	0.240	0.237	0.217	0.233
Dementia or other specified brain disorders (CC 49-50)	0.178	0.172	0.184	0.182
Drug/alcohol abuse, without dependence (CC 53)	-0.118	-0.150	-0.100	-0.125
Other psychiatric disorders (CC 60)	0.135	0.134	0.162	0.143

Variable	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	0.010	0.049	0.073	0.044
Mononeuropathy, other neurological conditions/injuries (CC 76)	-0.153	-0.098	-0.128	-0.129
Hypertension and hypertensive disease (CC 90-91)	-0.165	-0.195	-0.141	-0.164
Stroke (CC 95-96)	-0.043	-0.111	-0.020	-0.056
Retinal disorders, except detachment and vascular retinopathies (CC 121)	-0.052	-0.073	-0.093	-0.075
Other eye disorders (CC 124)	-0.112	-0.143	-0.125	-0.124
Other ear, nose, throat and mouth disorders (CC 127)	-0.238	-0.205	-0.237	-0.227
Renal failure (CC 131)	0.079	0.036	0.049	0.057
Decubitus ulcer or chronic skin ulcer (CC 148-149)	0.279	0.330	0.308	0.305
Other dermatological disorders (CC 153)	-0.094	-0.117	-0.114	-0.107
Trauma (CC 154-156, 158-161)	0.030	0.014	0.032	0.024
Vertebral fractures (CC 157)	0.261	0.200	0.251	0.236
Major complications of medical care and trauma (CC 164)	-0.170	-0.163	-0.115	-0.151

Table 4.3.3 – Adjusted OR and 95% CIs for the COPD Hierarchical Logistic Regression Model Over Different Time Periods

Variable	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2012-06/2015 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.04 (1.04-1.04)	1.04 (1.03-1.04)	1.04 (1.04-1.04)	1.04 (1.04-1.04)
Sleep apnea (ICD-9 diagnosis codes 327.20, 327.21, 327.23, 327.27, 327.29,780.51, 780.53, 780.57)	0.91 (0.88-0.95)	0.93 (0.89-0.98)	0.95 (0.91-0.99)	0.93 (0.91-0.95)
History of mechanical ventilation (ICD-9 procedure codes 93.90, 96.70, 96.71, 96.72)	1.29 (1.23-1.35)	1.25 (1.19-1.31)	1.22 (1.16-1.28)	1.25 (1.22-1.29)
Respirator dependence/respiratory failure (CC 77-78)	0.86 (0.77-0.96)	0.97 (0.86-1.09)	0.80 (0.70-0.90)	0.88 (0.82-0.94)
Cardio-respiratory failure and shock (CC 79)	1.47 (1.42-1.52)	1.43 (1.38-1.49)	1.45 (1.40-1.50)	1.44 (1.42-1.47)
Congestive heart failure (CC 80)	1.25 (1.21-1.30)	1.25 (1.20-1.30)	1.24 (1.20-1.29)	1.25 (1.22-1.28)
Coronary atherosclerosis or angina (CC 83-84)	0.95 (0.92-0.98)	0.97 (0.94-1.00)	0.99 (0.95-1.02)	0.97 (0.95-0.99)
Specified arrhythmias and other heart rhythm disorders (CC 92-93)	1.09 (1.05-1.12)	1.08 (1.04-1.12)	1.07 (1.04-1.11)	1.08 (1.06-1.10)
Vascular or circulatory disease (CC 104-106)	1.04 (1.00-1.07)	1.03 (1.00-1.07)	0.99 (0.96-1.02)	1.02 (1.00-1.04)
Fibrosis of lung or other chronic lung disorders (CC 109)	1.13 (1.09-1.17)	1.12 (1.08-1.17)	1.13 (1.09-1.18)	1.13 (1.11-1.16)
Asthma (CC 110)	0.68 (0.65-0.71)	0.68 (0.65-0.72)	0.69 (0.66-0.72)	0.69 (0.67-0.71)
Pneumonia (CC 111-113)	1.27 (1.23-1.31)	1.23 (1.19-1.28)	1.25 (1.21-1.30)	1.25 (1.23-1.28)
Pleural effusion/pneumothorax (CC 114)	1.14 (1.09-1.18)	1.24 (1.19-1.29)	1.19 (1.14-1.24)	1.18 (1.16-1.21)
Other lung disorders (CC 115)	0.85 (0.82-0.87)	0.84 (0.81-0.86)	0.84 (0.81-0.87)	0.84 (0.83-0.86)
Metastatic cancer or acute leukemia (CC 7)	2.36 (2.20-2.52)	2.38 (2.22-2.56)	2.37 (2.21-2.55)	2.37 (2.28-2.47)
Lung, upper digestive tract, and other severe cancers (CC 8)	1.84 (1.75-1.94)	1.86 (1.77-1.96)	1.81 (1.71-1.91)	1.84 (1.79-1.90)
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other cancers and tumors; other respiratory and heart neoplasms (CC 9-11)	0.99 (0.95-1.03)	0.99 (0.95-1.04)	1.02 (0.98-1.07)	1.00 (0.98-1.03)

Variable	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2012-06/2015 OR (95% CI)
Other digestive and urinary neoplasms (CC 12)	0.86 (0.80-0.91)	0.79 (0.73-0.84)	0.83 (0.78-0.89)	0.83 (0.80-0.86)
Diabetes mellitus (DM) or DM complications (CC 15-19, 119-120)	0.93 (0.90-0.96)	0.96 (0.92-0.99)	0.97 (0.93-1.00)	0.95 (0.94-0.97)
Protein-calorie malnutrition (CC 21)	2.17 (2.10-2.26)	2.09 (2.01-2.18)	2.17 (2.08-2.25)	2.16 (2.11-2.21)
Disorders of fluid/electrolyte/acid-base (CC 22-23)	1.14 (1.10-1.17)	1.14 (1.10-1.18)	1.14 (1.10-1.18)	1.14 (1.12-1.16)
Other endocrine/metabolic/nutritional disorders (CC 24)	0.82 (0.79-0.85)	0.82 (0.79-0.86)	0.85 (0.81-0.88)	0.83 (0.81-0.85)
Other gastrointestinal disorders (CC 36)	0.87 (0.84-0.90)	0.86 (0.83-0.89)	0.84 (0.81-0.87)	0.86 (0.84-0.87)
Osteoarthritis of hip or knee (CC 40)	0.77 (0.73-0.81)	0.73 (0.69-0.78)	0.75 (0.71-0.79)	0.75 (0.73-0.78)
Other musculoskeletal and connective tissue disorders (CC 43)	0.86 (0.83-0.89)	0.85 (0.82-0.88)	0.82 (0.79-0.85)	0.84 (0.83-0.86)
Iron deficiency or other unspecified anemias and blood disease (CC 47)	1.27 (1.23-1.31)	1.27 (1.22-1.31)	1.24 (1.20-1.28)	1.26 (1.24-1.29)
Dementia or other specified brain disorders (CC 49-50)	1.19 (1.15-1.24)	1.19 (1.14-1.23)	1.20 (1.16-1.25)	1.20 (1.18-1.23)
Drug/alcohol abuse, without dependence (CC 53)	0.89 (0.86-0.92)	0.86 (0.83-0.89)	0.90 (0.87-0.94)	0.88 (0.87-0.90)
Other psychiatric disorders (CC 60)	1.14 (1.11-1.18)	1.14 (1.10-1.18)	1.18 (1.14-1.22)	1.15 (1.13-1.18)
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	1.01 (0.95-1.07)	1.05 (0.99-1.12)	1.08 (1.01-1.14)	1.05 (1.01-1.08)
Mononeuropathy, other neurological conditions/injuries (CC 76)	0.86 (0.82-0.89)	0.91 (0.87-0.95)	0.88 (0.84-0.92)	0.88 (0.86-0.90)
Hypertension and hypertensive disease (CC 90-91)	0.85 (0.82-0.88)	0.82 (0.79-0.86)	0.87 (0.83-0.91)	0.85 (0.83-0.87)
Stroke (CC 95-96)	0.96 (0.90-1.02)	0.90 (0.84-0.96)	0.98 (0.92-1.04)	0.95 (0.91-0.98)
Retinal disorders, except detachment and vascular retinopathies (CC 121)	0.95 (0.91-0.99)	0.93 (0.89-0.97)	0.91 (0.87-0.95)	0.93 (0.90-0.95)
Other eye disorders (CC 124)	0.89 (0.86-0.93)	0.87 (0.83-0.90)	0.88 (0.85-0.92)	0.88 (0.86-0.90)
Other ear, nose, throat and mouth disorders (CC 127)	0.79 (0.76-0.81)	0.81 (0.79-0.84)	0.79 (0.76-0.82)	0.80 (0.78-0.81)
Renal failure (CC 131)	1.08 (1.05-1.12)	1.04 (1.00-1.08)	1.05 (1.01-1.09)	1.06 (1.04-1.08)
Decubitus ulcer or chronic skin ulcer (CC 148-149)	1.32 (1.26-1.38)	1.39 (1.32-1.46)	1.36 (1.29-1.43)	1.36 (1.32-1.40)
Other dermatological disorders (CC 153)	0.91 (0.88-0.94)	0.89 (0.86-0.92)	0.89 (0.86-0.92)	0.90 (0.88-0.92)
Trauma (CC 154-156, 158-161)	1.03 (0.99-1.08)	1.01 (0.97-1.06)	1.03 (0.99-1.08)	1.02 (1.00-1.05)
Vertebral fractures (CC 157)	1.30 (1.23-1.37)	1.22 (1.15-1.30)	1.28 (1.21-1.36)	1.27 (1.22-1.31)
Major complications of medical care and trauma (CC 164)	0.84 (0.80-0.89)	0.85 (0.80-0.91)	0.89 (0.84-0.95)	0.86 (0.83-0.89)

Table 4.3.4 – COPD Generalized Linear Modeling (Logistic Regression) Performance Over Different Time Periods

Characteristic	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Predictive ability, % (lowest decile – highest decile)	1.5 – 22.5	1.6 – 22.0	1.5 – 21.9	1.5 – 22.1
c-statistic	0.72	0.72	0.72	0.72

Table 4.3.5 – Distribution of Hospital COPD Admission Volumes Over Different Time Periods

Characteristic	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Number of hospitals	4,518	4,498	4,464	4,643
Mean number of admissions (SD)	61.9 (67.6)	53.7 (58.9)	55.7 (62.1)	165.8 (186.3)
Range (min. – max.)	1 – 788	1 – 723	1 – 727	1 – 2,238
25th percentile	14	12	12	34
50th percentile	38	33	34	98
75th percentile	88	77	80	238

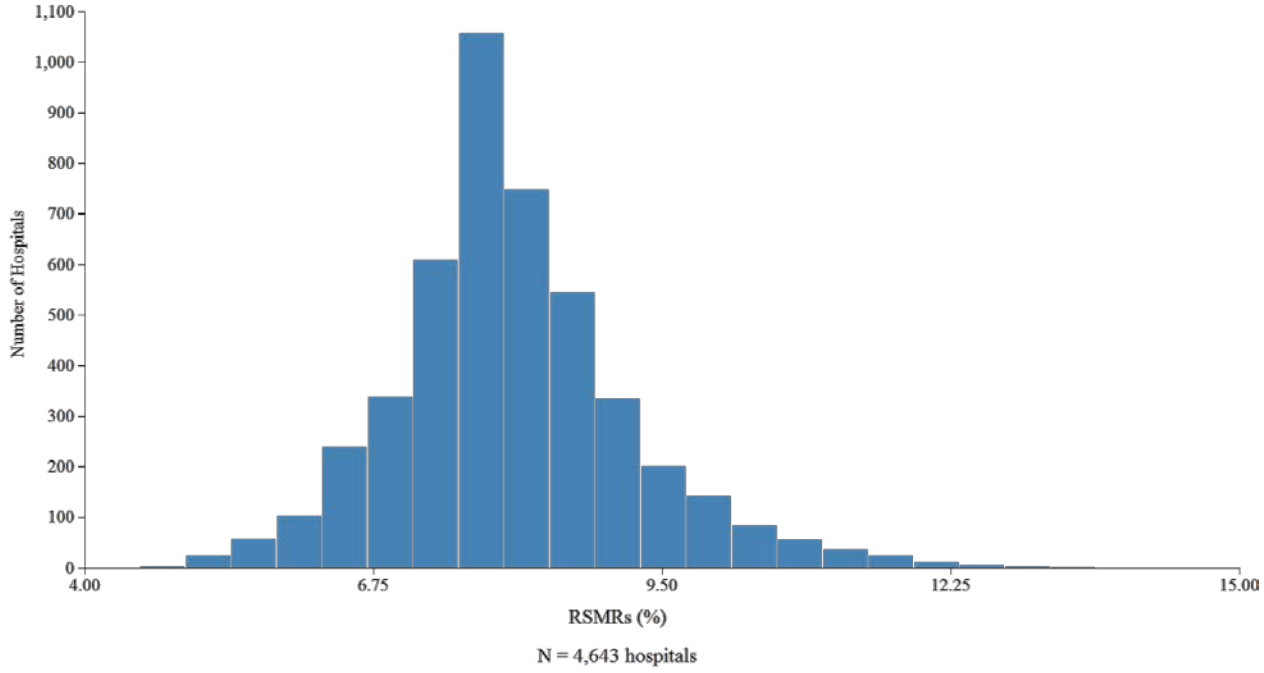
Table 4.3.6 – Distribution of Hospital COPD RSMRs Over Different Time Periods

Characteristic	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Number of hospitals	4,518	4,498	4,464	4,643
Mean (SD)	8.1 (0.8)	8.0 (0.7)	8.0 (0.7)	8.1 (1.0)
Range (min. – max.)	5.6 – 12.5	5.3 – 12.6	5.3 – 12.2	4.6 – 14.1
25th percentile	7.7	7.6	7.7	7.5
50th percentile	8.1	7.9	7.9	8.0
75th percentile	8.5	8.3	8.3	8.6

Table 4.3.7 – Between-Hospital Variance for COPD

	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Between-hospital variance (SE)	0.062 (0.006)	0.060 (0.006)	0.060 (0.006)	0.062 (0.003)

Figure 4.3.2 – Distribution of Hospital 30-Day COPD RSMRs Between July 2012 and June 2015



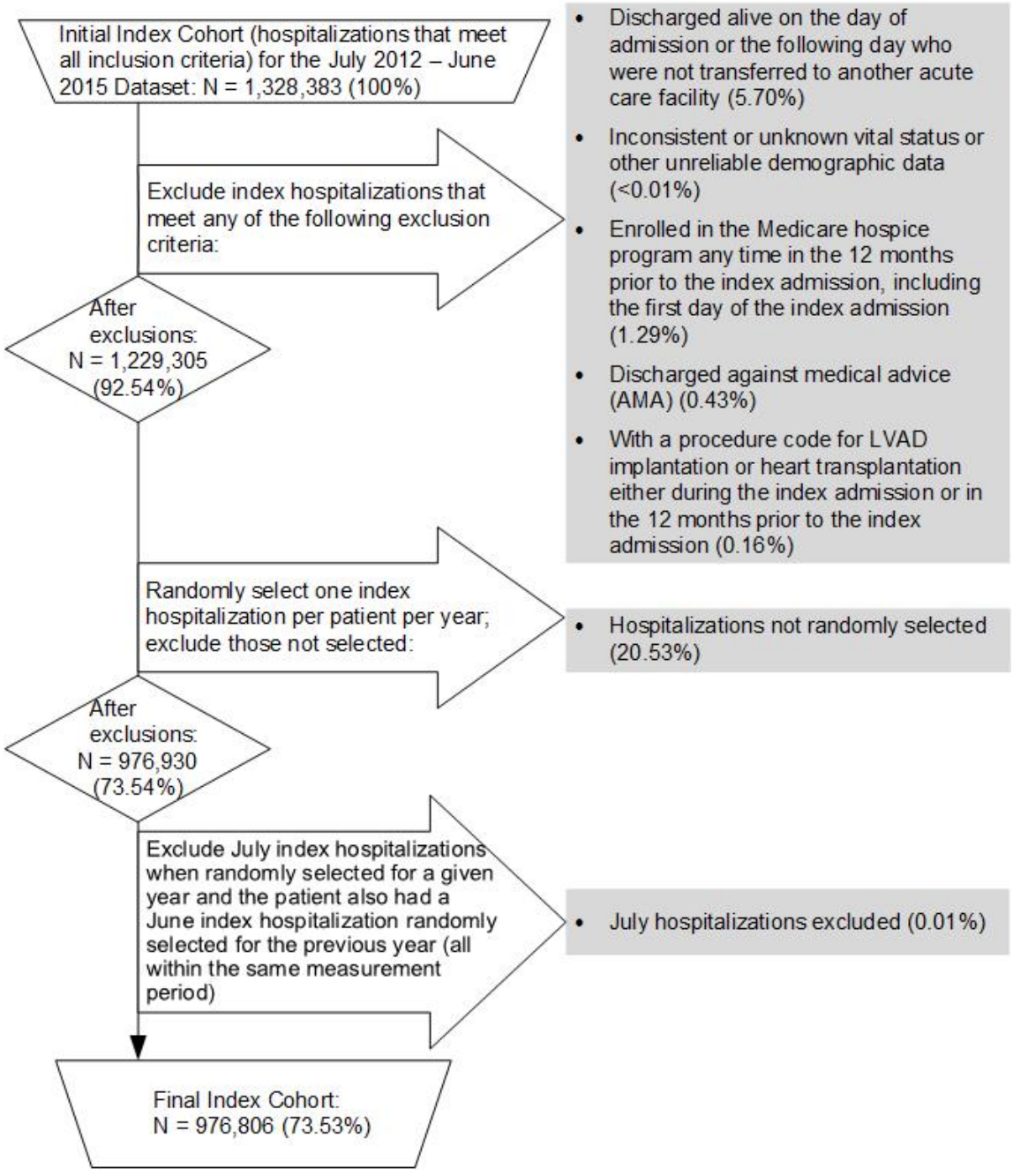
4.4 HF Mortality 2016 Model Results

4.4.1 Index Cohort Exclusions

The exclusion criteria for the measure are presented in Section 2.2.1. The percentage of HF admissions meeting each exclusion criterion in the July 2012-June 2015 dataset is presented in Figure 4.4.1.

Admissions may have been counted in more than one exclusion category because they are not mutually exclusive. The index cohort includes short-term acute care hospitalizations for Medicare patients aged 65 or over with a principal discharge diagnosis of HF; enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission; and who were not transferred from another acute care facility.

Figure 4.4.1 – HF Cohort Exclusions in the July 2012-June 2015 Dataset



4.4.2 Frequency of HF Model Variables

We examined the change in both observed mortality rates and frequency of clinical and demographic variables. Between July 2012-June 2013 and July 2014-June 2015, the observed mortality rate decreased from 12.3% to 12.1%. Notable changes in the frequencies for model variables include:

- Decrease in Coronary atherosclerosis or angina (72.6% to 70.9%)
- Increases in History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (13.5% to 14.5%), Cardio-respiratory failure and shock (26.6% to 29.3%), and Renal failure (49.5% to 51.1%)

Refer to Table 4.4.1 for more detail.

4.4.3 HF Model Parameters and Performance

Table 4.4.2 shows hierarchical regression model variable coefficients by individual year and for the combined three-year dataset. Table 4.4.3 shows the risk-adjusted ORs and 95% CIs for the HF mortality model by individual year and for the combined three-year dataset. Overall, the variable effect sizes were relatively constant across years. In addition, model performance was stable over the three-year time period; the c-statistic remained constant at 0.68 (Table 4.4.4).

4.4.4 Distribution of Hospital Volumes and RSMRs for HF

Table 4.4.5 shows the distribution of hospital admission volumes and Table 4.4.6 shows the distribution of hospital RSMRs. The mean RSMR decreased over the three-year period, from 12.3% between July 2012 and June 2013 to 12.2% between July 2014 and June 2015. The median hospital RSMR in the combined three-year dataset was 12.1% (IQR 11.4% - 12.9%). Table 4.4.7 shows the between-hospital variance by individual year and for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.047 (SE: 0.002). If there were no systematic differences between hospitals, the between-hospital variance would be 0.

Figure 4.4.2 shows the overall distribution of the hospital RSMRs for the combined dataset. The odds of all-cause mortality if treated at a hospital one SD above the national rate were 1.54 times higher than the odds of all-cause mortality if treated at a hospital one SD below the national rate. If there were no systematic differences between hospitals, the OR would be 1.0.[22]

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

Of 4,639 hospitals in the study cohort, 168 performed “Better than the National Rate,” 3,510 performed “No Different from the National Rate,” and 89 performed “Worse than the National Rate.” 873 were classified as “Number of Cases Too Small” (fewer than 25) to reliably tell how well the hospital is performing.

Table 4.4.1 – Frequency of HF Model Variables Over Different Time Periods

Variable	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Total N	327,667	319,909	329,230	976,806
Observed mortality rate (%)	12.3	11.9	12.1	12.1
Mean age minus 65 (SD)	16.2 (8.3)	16.1 (8.4)	16.1 (8.4)	16.1 (8.4)
Male (%)	44.7	45.5	45.6	45.3
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 diagnosis code V45.82; ICD-9 procedure codes 00.66, 36.06, 36.07)	13.5	14.0	14.5	14.0
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 diagnosis code V45.81; ICD-9 procedure codes 36.10-36.16)	19.0	18.9	18.6	18.8
Congestive heart failure (CC 80)	73.6	73.3	72.7	73.2
Acute myocardial infarction (CC 81)	9.7	9.5	9.4	9.5
Other acute/subacute forms of ischemic heart disease (CC 82)	12.2	12.1	12.2	12.2
Coronary atherosclerosis or angina (CC 83-84)	72.6	71.9	70.9	71.8
Cardio-respiratory failure and shock (CC 79)	26.6	28.0	29.3	28.0
Valvular or rheumatic heart disease (CC 86)	53.7	53.7	54.1	53.8
Hypertensive heart and renal disease or encephalopathy; hypertension (CC 89, 91)	93.3	93.7	93.9	93.6
Stroke (CC 95-96)	9.3	9.1	9.1	9.2
Renal failure (CC 131)	49.5	50.4	51.1	50.3
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	48.6	48.0	47.8	48.1
Pneumonia (CC 111-113)	45.7	45.1	45.2	45.3
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 15-19, 120)	53.5	53.9	53.7	53.7
Protein-calorie malnutrition (CC 21)	10.5	10.3	10.3	10.4
Dementia or other specified brain disorders (CC 49-50)	25.2	24.8	24.5	24.8
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	8.6	8.5	8.4	8.5
Vascular disease and complications (CC 104-105)	38.4	38.4	37.8	38.2
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	4.4	4.5	4.6	4.5
Trauma in last year (CC 154-156, 158-162)	40.4	40.5	41.1	40.6
Major psychiatric disorders (CC 54-56)	10.7	10.8	10.9	10.8
Chronic liver disease (CC 25-27)	3.1	3.3	3.5	3.3

Table 4.4.2 – Hierarchical Logistic Regression Model Variable Coefficients for HF Over Different Time Periods

Variable	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Intercept	-3.275	-3.322	-3.343	-3.313
Age minus 65 (years above 65, continuous)	0.051	0.050	0.050	0.051
Male	0.255	0.253	0.246	0.251
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 diagnosis code V45.82; ICD-9 procedure codes 00.66, 36.06, 36.07)	-0.265	-0.275	-0.285	-0.276
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 diagnosis code V45.81; ICD-9 procedure codes 36.10-36.16)	-0.092	-0.093	-0.069	-0.086
Congestive heart failure (CC 80)	0.181	0.188	0.182	0.184

Variable	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Acute myocardial infarction (CC 81)	0.244	0.222	0.229	0.230
Other acute/subacute forms of ischemic heart disease (CC 82)	-0.053	-0.061	-0.027	-0.042
Coronary atherosclerosis or angina (CC 83-84)	-0.052	-0.031	-0.041	-0.037
Cardio-respiratory failure and shock (CC 79)	0.168	0.153	0.167	0.162
Valvular or rheumatic heart disease (CC 86)	0.051	0.084	0.112	0.086
Hypertensive heart and renal disease or encephalopathy; hypertension (CC 89, 91)	-0.413	-0.392	-0.378	-0.394
Stroke (CC 95-96)	-0.038	-0.076	-0.067	-0.058
Renal failure (CC 131)	0.184	0.207	0.189	0.196
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	0.083	0.062	0.087	0.076
Pneumonia (CC 111-113)	0.266	0.270	0.245	0.261
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 15-19, 120)	-0.022	-0.046	-0.006	-0.021
Protein-calorie malnutrition (CC 21)	0.649	0.684	0.669	0.674
Dementia or other specified brain disorders (CC 49-50)	0.313	0.313	0.327	0.320
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	0.095	0.097	0.098	0.098
Vascular disease and complications (CC 104-105)	0.010	0.007	0.015	0.016
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	0.564	0.611	0.551	0.578
Trauma in last year (CC 154-156, 158-162)	0.087	0.077	0.071	0.077
Major psychiatric disorders (CC 54-56)	0.100	0.130	0.075	0.102
Chronic liver disease (CC 25-27)	0.432	0.453	0.381	0.429

Table 4.4.3 – Adjusted OR and 95% CIs for the HF Hierarchical Logistic Regression Model Over Different Time Periods

Variable	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2012-06/2015 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.05 (1.05-1.05)	1.05 (1.05-1.05)	1.05 (1.05-1.05)	1.05 (1.05-1.05)
Male	1.29 (1.26-1.32)	1.29 (1.26-1.32)	1.28 (1.25-1.31)	1.29 (1.27-1.30)
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 diagnosis code V45.82; ICD-9 procedure codes 00.66, 36.06, 36.07)	0.77 (0.74-0.80)	0.76 (0.73-0.79)	0.75 (0.73-0.78)	0.76 (0.74-0.77)
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 diagnosis code V45.81; ICD-9 procedure codes 36.10-36.16)	0.91 (0.89-0.94)	0.91 (0.88-0.94)	0.93 (0.91-0.96)	0.92 (0.90-0.93)
Congestive heart failure (CC 80)	1.20 (1.16-1.23)	1.21 (1.17-1.24)	1.20 (1.17-1.24)	1.20 (1.18-1.22)
Acute myocardial infarction (CC 81)	1.28 (1.23-1.33)	1.25 (1.20-1.30)	1.26 (1.21-1.31)	1.26 (1.23-1.29)
Other acute/subacute forms of ischemic heart disease (CC 82)	0.95 (0.91-0.99)	0.94 (0.90-0.98)	0.97 (0.94-1.01)	0.96 (0.94-0.98)
Coronary atherosclerosis or angina (CC 83-84)	0.95 (0.92-0.98)	0.97 (0.94-1.00)	0.96 (0.93-0.99)	0.96 (0.95-0.98)
Cardio-respiratory failure and shock (CC 79)	1.18 (1.15-1.21)	1.17 (1.14-1.20)	1.18 (1.15-1.21)	1.18 (1.16-1.19)
Valvular or rheumatic heart disease (CC 86)	1.05 (1.03-1.08)	1.09 (1.06-1.11)	1.12 (1.09-1.14)	1.09 (1.08-1.10)
Hypertensive heart and renal disease or encephalopathy; hypertension (CC 89, 91)	0.66 (0.64-0.69)	0.68 (0.65-0.71)	0.69 (0.66-0.72)	0.67 (0.66-0.69)
Stroke (CC 95-96)	0.96 (0.93-1.00)	0.93 (0.89-0.96)	0.94 (0.90-0.97)	0.94 (0.92-0.96)
Renal failure (CC 131)	1.20 (1.17-1.23)	1.23 (1.20-1.26)	1.21 (1.18-1.24)	1.22 (1.20-1.23)

Variable	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2012-06/2015 OR (95% CI)
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	1.09 (1.06-1.11)	1.06 (1.04-1.09)	1.09 (1.07-1.12)	1.08 (1.06-1.09)
Pneumonia (CC 111-113)	1.31 (1.27-1.34)	1.31 (1.28-1.34)	1.28 (1.25-1.31)	1.30 (1.28-1.32)
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 15-19, 120)	0.98 (0.96-1.00)	0.96 (0.93-0.98)	0.99 (0.97-1.02)	0.98 (0.97-0.99)
Protein-calorie malnutrition (CC 21)	1.91 (1.86-1.97)	1.98 (1.92-2.04)	1.95 (1.89-2.01)	1.96 (1.93-2.00)
Dementia or other specified brain disorders (CC 49-50)	1.37 (1.33-1.40)	1.37 (1.33-1.40)	1.39 (1.35-1.42)	1.38 (1.36-1.40)
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	1.10 (1.06-1.14)	1.10 (1.06-1.15)	1.10 (1.06-1.15)	1.10 (1.08-1.13)
Vascular disease and complications (CC 104-105)	1.01 (0.99-1.03)	1.01 (0.98-1.03)	1.02 (0.99-1.04)	1.02 (1.00-1.03)
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	1.76 (1.68-1.84)	1.84 (1.76-1.93)	1.74 (1.66-1.81)	1.78 (1.74-1.83)
Trauma in last year (CC 154-156, 158-162)	1.09 (1.07-1.12)	1.08 (1.06-1.11)	1.07 (1.05-1.10)	1.08 (1.07-1.09)
Major psychiatric disorders (CC 54-56)	1.11 (1.07-1.14)	1.14 (1.10-1.18)	1.08 (1.04-1.11)	1.11 (1.09-1.13)
Chronic liver disease (CC 25-27)	1.54 (1.46-1.63)	1.57 (1.49-1.66)	1.46 (1.39-1.54)	1.54 (1.49-1.59)

Table 4.4.4 – HF Generalized Linear Modeling (Logistic Regression) Performance Over Different Time Periods

Characteristic	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Predictive ability, % (lowest decile – highest decile)	3.4 - 26.7	3.3 - 26.4	3.2 - 26.1	3.3 - 26.3
c-statistic	0.68	0.68	0.68	0.68

Table 4.4.5 – Distribution of Hospital HF Admission Volumes Over Different Time Periods

Characteristic	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Number of hospitals	4,533	4,492	4,467	4,639
Mean number of admissions (SD)	72.3 (87.6)	71.2 (87.3)	73.7 (91.7)	210.6 (263.6)
Range (min. – max.)	1 - 954	1 - 980	1 - 1,086	1 - 3,020
25th percentile	13	12	12	34
50th percentile	38	36	37	102
75th percentile	102	101	104	299

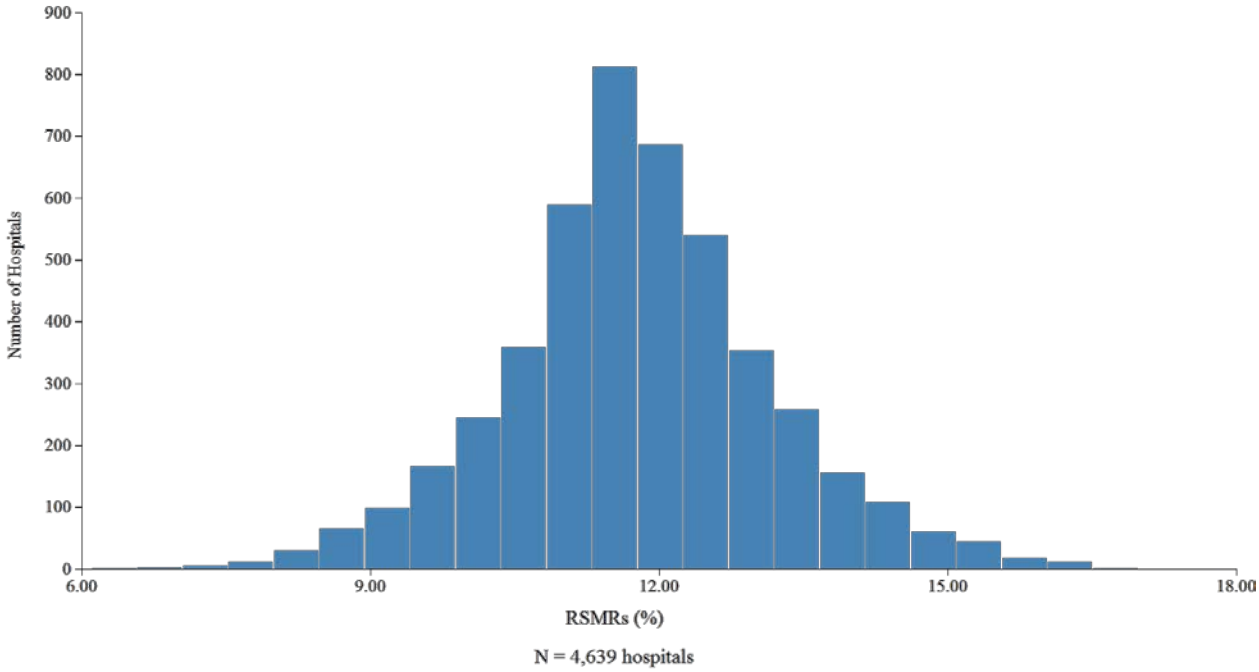
Table 4.4.6 – Distribution of Hospital HF RSMRs Over Different Time Periods

Characteristic	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Number of hospitals	4,533	4,492	4,467	4,639
Mean (SD)	12.3 (0.9)	12.0 (0.9)	12.2 (1.1)	12.2 (1.3)
Range (min. – max.)	8.4 - 17.6	7.6 - 17.0	7.7 - 17.7	6.8 - 18.0
25th percentile	11.8	11.5	11.6	11.4
50th percentile	12.3	11.9	12.1	12.1
75th percentile	12.8	12.4	12.7	12.9

Table 4.4.7 – Between-Hospital Variance for HF

	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Between-hospital variance (SE)	0.041 (0.004)	0.043 (0.004)	0.050 (0.004)	0.047 (0.002)

Figure 4.4.2 – Distribution of Hospital 30-Day HF RSMRs Between July 2012 and June 2015



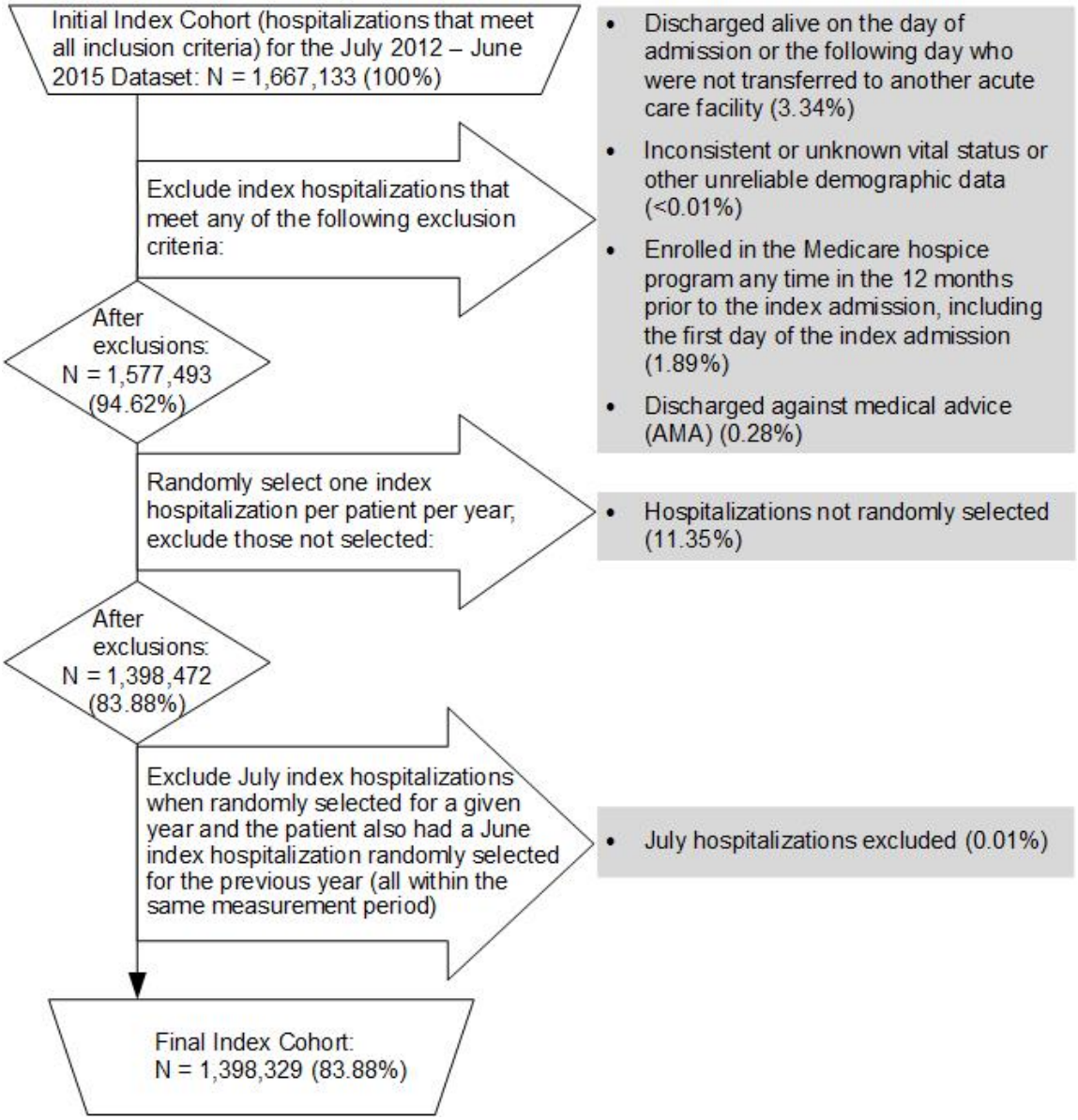
4.5 Pneumonia Mortality 2016 Model Results

4.5.1 Index Cohort Exclusions

The exclusion criteria for the measure are presented in Section 2.2.1. The percentage of pneumonia admissions meeting each exclusion criterion in the July 2012-June 2015 dataset is presented in Figure 4.5.1.

Admissions may have been counted in more than one exclusion category because they are not mutually exclusive. The index cohort includes short-term acute care hospitalizations for Medicare patients aged 65 or over with either a principal discharge diagnosis of pneumonia (including aspiration pneumonia) or a principal discharge diagnosis of sepsis (not including severe sepsis) with a secondary diagnosis of pneumonia (including aspiration pneumonia) coded as POA and no secondary diagnosis of severe sepsis coded as POA; enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission; and who were not transferred from another acute care facility.

Figure 4.5.1 – Pneumonia Cohort Exclusions in the July 2012-June 2015 Dataset



4.5.2 Frequency of Pneumonia Model Variables

We examined the change in both observed mortality rates and frequency of clinical and demographic variables. Between July 2012-June 2013 and July 2014-June 2015, the observed mortality rate decreased from 16.7% to 15.8%. Notable changes in the frequencies for model variables include:

- Decreases in Coronary atherosclerosis or angina (48.9% to 47.6%), Cerebrovascular disease (23.6% to 22.3%), Chronic Obstructive Pulmonary Disease (COPD) (51.7% to 50.6%), Pneumonia; pleural effusion/pneumothorax (46.0% to 44.0%), Dementia or other specified brain disorders (37.2% to 36.2%), Iron deficiency or other unspecified anemias and blood disease (60.0% to 58.6%), and Fibrosis of lung or other chronic lung disorders (13.4% to 12.4%)
- Increases in Cardio-respiratory failure and shock; respiratory arrest (22.6% to 24.5%), Renal failure (31.1% to 32.8%), Septicemia/shock (10.8% to 12.5%), and Delirium and encephalopathy (10.4% to 11.7%)

Refer to Table 4.5.1 for more detail.

4.5.3 Pneumonia Model Parameters and Performance

Table 4.5.2 shows hierarchical regression model variable coefficients by individual year and for the combined three-year dataset. Table 4.5.3 shows the risk-adjusted ORs and 95% CIs for the pneumonia mortality model by individual year and for the combined three-year dataset. Overall, the variable effect sizes were relatively constant across years. In addition, model performance was stable over the three-year time period; the c-statistic remained relatively constant at 0.72 (Table 4.5.4).

4.5.4 Distribution of Hospital Volumes and RSMRs for Pneumonia

Table 4.5.5 shows the distribution of hospital admission volumes and Table 4.5.6 shows the distribution of hospital RSMRs. The mean RSMR decreased over the three-year period, from 16.7% between July 2012 and June 2013 to 15.9% between July 2014 and June 2015. The median hospital RSMR in the combined three-year dataset was 16.2% (IQR 15.1% - 17.5%). Table 4.5.7 shows the between-hospital variance by individual year and for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.050 (SE: 0.002). If there were no systematic differences between hospitals, the between-hospital variance would be 0.

Figure 4.5.2 shows the overall distribution of the hospital RSMRs for the combined dataset. The odds of all-cause mortality if treated at a hospital one SD above the national rate were 1.56 times higher than the odds of all-cause mortality if treated at a hospital one SD below the national rate. If there were no systematic differences between hospitals, the OR would be 1.0.[22]

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

Of 4,689 hospitals in the study cohort, 252 performed “Better than the National Rate,” 3,783 performed “No Different from the National Rate,” and 267 performed “Worse

than the National Rate." 387 were classified as "Number of Cases Too Small" (fewer than 25) to reliably tell how well the hospital is performing.

Table 4.5.1 – Frequency of Pneumonia Model Variables Over Different Time Periods

Variable	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Total N	487,148	439,545	471,636	1,398,329
Observed mortality rate (%)	16.7	16.3	15.8	16.3
Mean age minus 65 (SD)	15.9 (8.5)	15.6 (8.5)	15.8 (8.6)	15.8 (8.5)
Male (%)	46.0	46.5	46.4	46.3
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 diagnosis code V45.82; ICD-9 procedure codes 00.66, 36.06, 36.07)	6.9	7.3	7.6	7.3
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 diagnosis code V45.81; ICD-9 procedure codes 36.10-36.16)	8.9	8.8	8.8	8.8
Congestive heart failure (CC 80)	38.4	38.5	37.8	38.2
Acute myocardial infarction (CC 81)	4.2	4.2	4.0	4.1
Other acute/subacute forms of ischemic heart disease (CC 82)	5.8	5.9	5.8	5.8
Coronary atherosclerosis or angina (CC 83-84)	48.9	48.6	47.6	48.3
Cardio-respiratory failure and shock; respiratory arrest (CC 78-79)	22.6	24.2	24.5	23.8
Hypertensive heart and renal disease or encephalopathy; hypertension (CC 89, 91)	87.0	87.4	87.4	87.3
Stroke (CC 95-96)	10.9	10.8	10.5	10.7
Cerebrovascular disease (CC 97-99, 103)	23.6	23.3	22.3	23.1
Renal failure (CC 131)	31.1	32.4	32.8	32.1
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	51.7	51.9	50.6	51.4
Pneumonia; pleural effusion/pneumothorax (CC 111-114)	46.0	45.9	44.0	45.3
Protein-calorie malnutrition (CC 21)	17.1	17.3	17.0	17.1
Dementia or other specified brain disorders (CC 49-50)	37.2	36.5	36.2	36.6
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	11.3	11.4	11.2	11.3
Vascular disease and complications (CC 104-105)	32.3	32.5	32.0	32.3
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	9.1	9.6	9.3	9.3
Trauma in last year (CC 154-156, 158-162)	42.6	43.2	43.4	43.1
Major psychiatric disorders (CC 54-56)	15.5	15.7	15.7	15.6
Chronic liver disease (CC 25-27)	2.2	2.4	2.5	2.4
Severe hematological disorders (CC 44)	2.3	2.2	2.0	2.2
Iron deficiency or other unspecified anemias and blood disease (CC 47	60.0	60.3	58.6	59.6
Depression (CC 58)	25.5	26.1	26.2	25.9
Parkinson's or Huntington's disease (CC 73)	5.3	5.2	5.1	5.2
Seizure disorders and convulsions (CC 74)	7.2	7.4	7.2	7.2
Fibrosis of lung or other chronic lung disorders (CC 109)	13.4	13.1	12.4	13.0
Asthma (CC 110)	10.7	10.9	10.9	10.8
Vertebral fractures (CC 157)	5.3	5.5	5.5	5.4
Septicemia/shock (CC 2)	10.8	11.9	12.5	11.7
Respiratory dependence/tracheostomy status (CC 77)	1.2	1.3	1.1	1.2
Disorders of fluid/electrolyte/acid-base balance (CC 23)	38.5	39.2	38.4	38.7
Delirium and encephalopathy (CC 48)	10.4	11.3	11.7	11.1
Decubitus ulcer of skin (CC 148)	7.8	7.9	7.5	7.7

Table 4.5.2 – Hierarchical Logistic Regression Model Variable Coefficients for Pneumonia Over Different Time Periods

Variable	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Intercept	-3.216	-3.169	-3.281	-3.232
Age minus 65 (years above 65, continuous)	0.049	0.046	0.048	0.048
Male	0.213	0.224	0.207	0.214
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 diagnosis code V45.82; ICD-9 procedure codes 00.66, 36.06, 36.07)	-0.229	-0.217	-0.287	-0.246
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 diagnosis code V45.81; ICD-9 procedure codes 36.10-36.16)	-0.077	-0.103	-0.121	-0.101
Congestive heart failure (CC 80)	0.163	0.170	0.161	0.165
Acute myocardial infarction (CC 81)	0.140	0.177	0.210	0.174
Other acute/subacute forms of ischemic heart disease (CC 82)	-0.037	-0.046	-0.030	-0.034
Coronary atherosclerosis or angina (CC 83-84)	-0.023	-0.009	-0.003	-0.010
Cardio-respiratory failure and shock; respiratory arrest (CC 78-79)	0.169	0.134	0.167	0.157
Hypertensive heart and renal disease or encephalopathy; hypertension (CC 89, 91)	-0.166	-0.158	-0.124	-0.150
Stroke (CC 95-96)	0.080	0.060	0.087	0.076
Cerebrovascular disease (CC 97-99, 103)	-0.068	-0.072	-0.066	-0.068
Renal failure (CC 131)	0.041	0.049	0.053	0.048
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	-0.054	-0.084	-0.056	-0.065
Pneumonia; pleural effusion/pneumothorax (CC 111-114)	0.111	0.100	0.106	0.106
Protein-calorie malnutrition (CC 21)	0.718	0.738	0.759	0.745
Dementia or other specified brain disorders (CC 49-50)	0.489	0.474	0.506	0.490
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	0.151	0.184	0.156	0.164
Vascular disease and complications (CC 104-105)	0.019	0.011	-0.003	0.012
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	0.998	0.991	0.992	0.997
Trauma in last year (CC 154-156, 158-162)	0.066	0.043	0.054	0.054
Major psychiatric disorders (CC 54-56)	0.074	0.086	0.053	0.072
Chronic liver disease (CC 25-27)	0.343	0.344	0.324	0.342
Severe hematological disorders (CC 44)	0.169	0.196	0.181	0.186
Iron deficiency or other unspecified anemias and blood disease (CC 47	0.115	0.104	0.116	0.115
Depression (CC 58)	-0.036	-0.041	-0.040	-0.039
Parkinson's or Huntington's disease (CC 73)	0.188	0.146	0.136	0.161
Seizure disorders and convulsions (CC 74)	0.059	0.015	0.038	0.039
Fibrosis of lung or other chronic lung disorders (CC 109)	0.055	0.093	0.068	0.075
Asthma (CC 110)	-0.355	-0.322	-0.359	-0.343
Vertebral fractures (CC 157)	0.115	0.108	0.093	0.104
Septicemia/shock (CC 2)	-0.114	-0.138	-0.137	-0.129
Respiratory dependence/tracheostomy status (CC 77)	-0.351	-0.442	-0.394	-0.389
Disorders of fluid/electrolyte/acid-base balance (CC 23)	0.153	0.168	0.141	0.154
Delirium and encephalopathy (CC 48)	0.015	-0.002	0.025	0.015
Decubitus ulcer of skin (CC 148)	0.311	0.304	0.297	0.307

Table 4.5.3 – Adjusted OR and 95% CIs for the Pneumonia Hierarchical Logistic Regression Model Over Different Time Periods

Variable	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2012-06/2015 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.05 (1.05 - 1.05)	1.05 (1.05 - 1.05)	1.05 (1.05 - 1.05)	1.05 (1.05 - 1.05)
Male	1.24 (1.22 - 1.26)	1.25 (1.23 - 1.27)	1.23 (1.21 - 1.25)	1.24 (1.23 - 1.25)
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 diagnosis code V45.82; ICD-9 procedure codes 00.66, 36.06, 36.07)	0.80 (0.77 - 0.82)	0.80 (0.78 - 0.83)	0.75 (0.72 - 0.78)	0.78 (0.77 - 0.80)
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 diagnosis code V45.81; ICD-9 procedure codes 36.10-36.16)	0.93 (0.90 - 0.95)	0.90 (0.87 - 0.93)	0.89 (0.86 - 0.91)	0.90 (0.89 - 0.92)
Congestive heart failure (CC 80)	1.18 (1.16 - 1.20)	1.19 (1.16 - 1.21)	1.17 (1.15 - 1.20)	1.18 (1.17 - 1.19)
Acute myocardial infarction (CC 81)	1.15 (1.10 - 1.20)	1.19 (1.14 - 1.25)	1.23 (1.18 - 1.29)	1.19 (1.16 - 1.22)
Other acute/subacute forms of ischemic heart disease (CC 82)	0.96 (0.93 - 1.00)	0.96 (0.92 - 0.99)	0.97 (0.93 - 1.01)	0.97 (0.95 - 0.99)
Coronary atherosclerosis or angina (CC 83-84)	0.98 (0.96 - 1.00)	0.99 (0.97 - 1.01)	1.00 (0.98 - 1.02)	0.99 (0.98 - 1.00)
Cardio-respiratory failure and shock; respiratory arrest (CC 78-79)	1.18 (1.16 - 1.21)	1.14 (1.12 - 1.17)	1.18 (1.16 - 1.21)	1.17 (1.15 - 1.18)
Hypertensive heart and renal disease or encephalopathy; hypertension (CC 89, 91)	0.85 (0.83 - 0.87)	0.85 (0.83 - 0.88)	0.88 (0.86 - 0.91)	0.86 (0.85 - 0.87)
Stroke (CC 95-96)	1.08 (1.06 - 1.11)	1.06 (1.03 - 1.09)	1.09 (1.06 - 1.12)	1.08 (1.06 - 1.10)
Cerebrovascular disease (CC 97-99, 103)	0.93 (0.92 - 0.95)	0.93 (0.91 - 0.95)	0.94 (0.92 - 0.96)	0.93 (0.92 - 0.95)
Renal failure (CC 131)	1.04 (1.02 - 1.06)	1.05 (1.03 - 1.07)	1.05 (1.03 - 1.07)	1.05 (1.04 - 1.06)
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	0.95 (0.93 - 0.96)	0.92 (0.90 - 0.94)	0.95 (0.93 - 0.96)	0.94 (0.93 - 0.95)
Pneumonia; pleural effusion/pneumothorax (CC 111-114)	1.12 (1.10 - 1.14)	1.11 (1.08 - 1.13)	1.11 (1.09 - 1.13)	1.11 (1.10 - 1.12)
Protein-calorie malnutrition (CC 21)	2.05 (2.01 - 2.09)	2.09 (2.05 - 2.14)	2.14 (2.09 - 2.18)	2.11 (2.08 - 2.13)
Dementia or other specified brain disorders (CC 49-50)	1.63 (1.60 - 1.66)	1.61 (1.58 - 1.64)	1.66 (1.63 - 1.69)	1.63 (1.62 - 1.65)
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	1.16 (1.13 - 1.19)	1.20 (1.17 - 1.23)	1.17 (1.14 - 1.20)	1.18 (1.16 - 1.20)
Vascular disease and complications (CC 104-105)	1.02 (1.00 - 1.04)	1.01 (0.99 - 1.03)	1.00 (0.98 - 1.02)	1.01 (1.00 - 1.02)
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	2.71 (2.65 - 2.78)	2.69 (2.63 - 2.76)	2.70 (2.63 - 2.76)	2.71 (2.67 - 2.75)
Trauma in last year (CC 154-156, 158-162)	1.07 (1.05 - 1.09)	1.04 (1.03 - 1.06)	1.05 (1.04 - 1.07)	1.06 (1.05 - 1.07)
Major psychiatric disorders (CC 54-56)	1.08 (1.05 - 1.10)	1.09 (1.06 - 1.12)	1.05 (1.03 - 1.08)	1.07 (1.06 - 1.09)
Chronic liver disease (CC 25-27)	1.41 (1.34 - 1.48)	1.41 (1.34 - 1.48)	1.38 (1.32 - 1.45)	1.41 (1.37 - 1.45)
Severe hematological disorders (CC 44)	1.18 (1.13 - 1.24)	1.22 (1.16 - 1.28)	1.20 (1.14 - 1.26)	1.20 (1.17 - 1.24)
Iron deficiency or other unspecified anemias and blood disease (CC 47	1.12 (1.10 - 1.14)	1.11 (1.09 - 1.13)	1.12 (1.10 - 1.14)	1.12 (1.11 - 1.13)
Depression (CC 58)	0.97 (0.95 - 0.98)	0.96 (0.94 - 0.98)	0.96 (0.94 - 0.98)	0.96 (0.95 - 0.97)
Parkinson's or Huntington's disease (CC 73)	1.21 (1.17 - 1.25)	1.16 (1.12 - 1.20)	1.15 (1.11 - 1.19)	1.17 (1.15 - 1.20)
Seizure disorders and convulsions (CC 74)	1.06 (1.03 - 1.09)	1.01 (0.98 - 1.05)	1.04 (1.01 - 1.07)	1.04 (1.02 - 1.06)
Fibrosis of lung or other chronic lung disorders (CC 109)	1.06 (1.03 - 1.08)	1.10 (1.07 - 1.12)	1.07 (1.04 - 1.10)	1.08 (1.06 - 1.09)
Asthma (CC 110)	0.70 (0.68 - 0.72)	0.72 (0.70 - 0.75)	0.70 (0.68 - 0.72)	0.71 (0.70 - 0.72)

Variable	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2012-06/2015 OR (95% CI)
Vertebral fractures (CC 157)	1.12 (1.09 - 1.16)	1.11 (1.08 - 1.15)	1.10 (1.06 - 1.13)	1.11 (1.09 - 1.13)
Septicemia/shock (CC 2)	0.89 (0.87 - 0.92)	0.87 (0.85 - 0.89)	0.87 (0.85 - 0.89)	0.88 (0.87 - 0.89)
Respiratory dependence/tracheostomy status (CC 77)	0.70 (0.66 - 0.76)	0.64 (0.60 - 0.69)	0.67 (0.62 - 0.73)	0.68 (0.65 - 0.71)
Disorders of fluid/electrolyte/acid-base balance (CC 23)	1.17 (1.14 - 1.19)	1.18 (1.16 - 1.21)	1.15 (1.13 - 1.17)	1.17 (1.15 - 1.18)
Delirium and encephalopathy (CC 48)	1.01 (0.99 - 1.04)	1.00 (0.97 - 1.03)	1.03 (1.00 - 1.05)	1.01 (1.00 - 1.03)
Decubitus ulcer of skin (CC 148)	1.36 (1.33 - 1.40)	1.35 (1.32 - 1.39)	1.35 (1.31 - 1.38)	1.36 (1.34 - 1.38)

Table 4.5.4 – Pneumonia Generalized Linear Modeling (Logistic Regression) Performance Over Different Time Periods

Characteristic	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Predictive ability, % (lowest decile – highest decile)	3.0 - 37.1	3.1 - 36.5	2.8 - 36.0	3.0 - 36.5
c-statistic	0.72	0.71	0.72	0.72

Table 4.5.5 – Distribution of Hospital Pneumonia Admission Volumes Over Different Time Periods

Characteristic	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Number of hospitals	4,608	4,581	4,547	4,689
Mean number of admissions (SD)	105.7 (111.6)	95.9 (103.1)	103.7 (112.8)	298.2 (324.4)
Range (min. – max.)	1 - 1,083	1 - 1,048	1 - 1,166	1 - 3,255
25th percentile	27	24	25	71
50th percentile	67	59	63	182
75th percentile	148	136	148	425

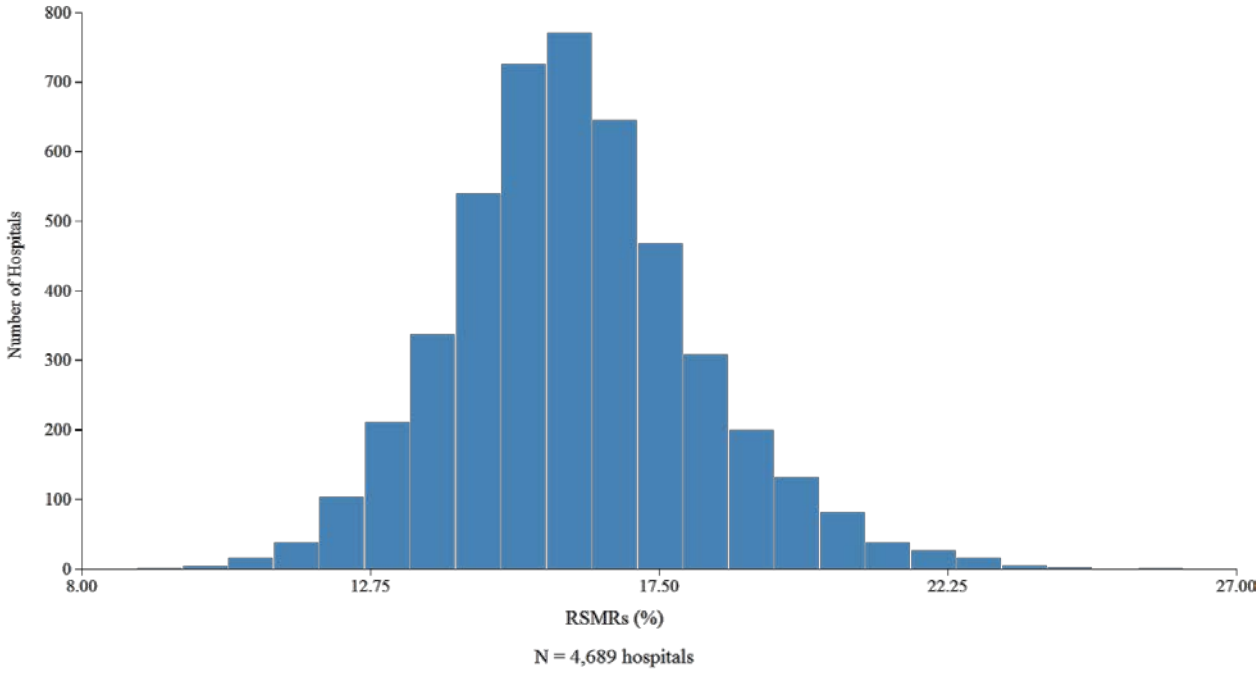
Table 4.5.6 – Distribution of Hospital Pneumonia RSMRs Over Different Time Periods

Characteristic	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Number of hospitals	4,608	4,581	4,547	4,689
Mean (SD)	16.7 (1.6)	16.3 (1.5)	15.9 (1.5)	16.4 (2.0)
Range (min. – max.)	10.8 - 26.5	10.5 - 23.3	10.9 - 22.8	8.7 - 26.8
25th percentile	15.8	15.4	15.1	15.1
50th percentile	16.6	16.2	15.8	16.2
75th percentile	17.6	17.2	16.7	17.5

Table 4.5.7 – Between-Hospital Variance for Pneumonia

	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Between-hospital variance (SE)	0.050 (0.003)	0.050 (0.003)	0.047 (0.003)	0.050 (0.002)

Figure 4.5.2 – Distribution of Hospital 30-Day Pneumonia RSMRs Between July 2012 and June 2015



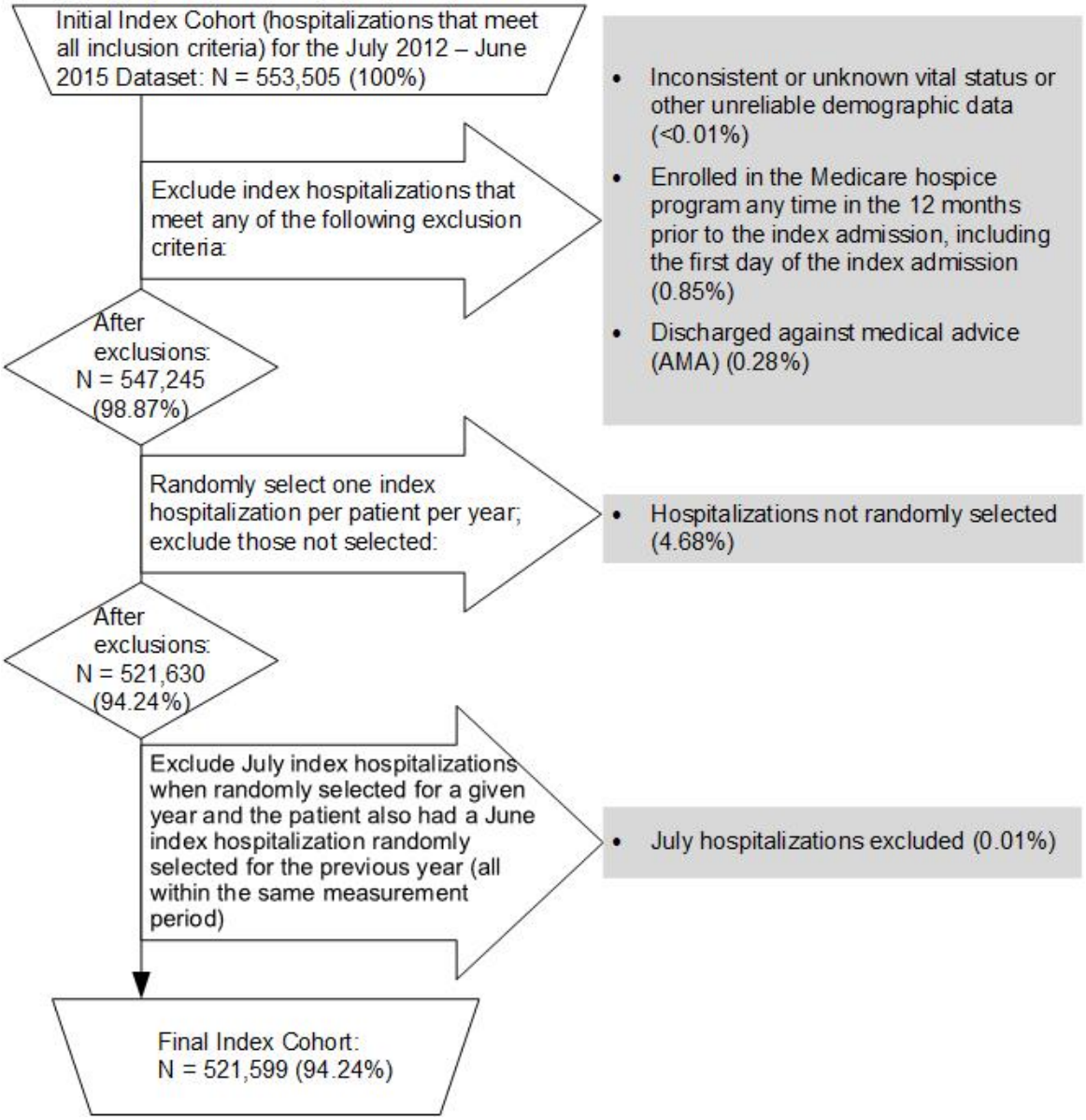
4.6 Stroke Mortality 2016 Model Results

4.6.1 Index Cohort Exclusions

The exclusion criteria for the measure are presented in Section 2.2.1. The percentage of stroke admissions meeting each exclusion criterion in the July 2012-June 2015 dataset is presented in Figure 4.6.1.

Admissions may have been counted in more than one exclusion category because they are not mutually exclusive. The index cohort includes short-term acute care hospitalizations for Medicare patients aged 65 or over with a principal discharge diagnosis of ischemic stroke; enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission; and who were not transferred from another acute care facility.

Figure 4.6.1 – Stroke Cohort Exclusions in the July 2012-June 2015 Dataset



4.6.2 Frequency of Stroke Model Variables

We examined the change in both observed mortality rates and frequency of clinical and demographic variables. Between July 2012-June 2013 and July 2014-June 2015, the observed mortality rate decreased from 15.1% to 14.8%. Notable changes in the frequencies for model variables include:

- Decrease in Pneumonia (16.1% to 15.1%)
- Increases in Transfer from another ED (8.7% to 10.1%), Disorders of fluid/electrolyte/acid-base; other endocrine/metabolic/nutritional disorders (87.0% to 88.1%), Other musculoskeletal and connective tissue disorders (69.8% to 71.1%), Multiple sclerosis; mononeuropathy, other neurological conditions/injuries (13.2% to 14.2%), and Renal failure (20.8% to 22.4%)

Refer to Table 4.6.1 for more detail.

4.6.3 Stroke Model Parameters and Performance

Table 4.6.2 shows hierarchical regression model variable coefficients by individual year and for the combined three-year dataset. Table 4.6.3 shows the risk-adjusted ORs and 95% CIs for the stroke mortality model by individual year and for the combined three-year dataset. Overall, the variable effect sizes were relatively constant across years. In addition, model performance was stable over the three-year time period; the c-statistic remained constant at 0.74 (Table 4.6.4).

4.6.4 Distribution of Hospital Volumes and RSMRs for Stroke

Table 4.6.5 shows the distribution of hospital admission volumes and Table 4.6.6 shows the distribution of hospital RSMRs. The mean RSMR decreased over the three-year period, from 15.1% between July 2012 and June 2013 to 14.8% between July 2014 and June 2015. The median hospital RSMR in the combined three-year dataset was 14.9% (IQR 14.3% - 15.7%). Table 4.6.7 shows the between-hospital variance by individual year and for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.051 (SE: 0.003). If there were no systematic differences between hospitals, the between-hospital variance would be 0.

Figure 4.6.2 shows the overall distribution of the hospital RSMRs for the combined dataset. The odds of all-cause mortality if treated at a hospital one SD above the national rate were 1.57 times higher than the odds of all-cause mortality if treated at a hospital one SD below the national rate. If there were no systematic differences between hospitals, the OR would be 1.0.[22]

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

Of 4,465 hospitals in the cohort, 70 performed “Better than the National Rate,” 2,615 performed “No Different from the National Rate,” and 76 performed “Worse than the National Rate.” 1,704 were classified as “Number of Cases Too Small” (fewer than 25) to reliably tell how well the hospital is performing.

Table 4.6.1 – Frequency of Stroke Model Variables Over Different Time Periods

Variable	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Total N	174,929	172,854	173,816	521,599
Observed mortality rate (%)	15.1	14.9	14.8	14.9
Mean age minus 65 (SD)	15.2 (8.2)	15.2 (8.3)	15.2 (8.4)	15.2 (8.3)
Male (%)	41.7	42.2	42.6	42.2
Transfer from another ED	8.7	9.3	10.1	9.4
Congestive heart failure (CC 80)	24.5	24.1	23.6	24.1
Valvular or rheumatic heart disease (CC 86)	25.4	25.3	25.6	25.4
Congenital cardiac/circulatory defects (CC 87-88)	2.4	2.5	2.4	2.4
Hypertensive heart disease (CC 90)	5.2	4.7	4.3	4.7
Specified arrhythmias (CC 92)	30.9	30.6	30.3	30.6
Cerebral hemorrhage (CC 95)	2.0	2.1	2.1	2.0
Ischemic or unspecified stroke (CC 96)	22.9	22.7	22.0	22.5
Precerebral arterial occlusion and transient cerebral ischemia (CC 97)	22.6	22.0	21.7	22.1
Cerebral atherosclerosis and aneurysm (CC 98)	11.8	11.7	10.9	11.5
Hemiplegia/hemiparesis (CC 100)	5.2	5.2	5.1	5.2
History of infection (CC 1, 3-6)	27.6	27.6	27.4	27.5
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	3.8	3.9	3.9	3.9
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other major cancers (CC 9-13)	24.3	24.1	24.5	24.3
Protein-calorie malnutrition (CC 21)	6.5	6.5	6.5	6.5
Disorders of fluid/electrolyte/acid-base; other endocrine/metabolic/nutritional disorders (CC 22-24)	87.0	87.7	88.1	87.6
Other gastrointestinal disorders (CC 36)	50.6	50.8	51.1	50.9
Disorders of the vertebrae and spinal discs (CC 39)	20.1	20.5	20.8	20.5
Osteoarthritis of hip or knee (CC 40)	11.6	11.8	12.0	11.8
Other musculoskeletal and connective tissue disorders (CC 43)	69.8	70.4	71.1	70.4
Iron deficiency or other unspecified anemia and blood disease (CC 47)	37.3	37.1	36.8	37.1
Dementia or other specified brain disorders (CC 49-50)	31.5	31.2	31.1	31.3
Major psychiatric disorders (CC 54-56)	10.4	10.7	10.8	10.7
Quadriplegia, other extensive paralysis; paraplegia; spinal cord disorders/injuries (CC 67-69)	1.5	1.6	1.7	1.6
Multiple sclerosis; mononeuropathy, other neurological conditions/injuries (CC 72, 76)	13.2	13.6	14.2	13.7
Seizure disorders and convulsions (CC 74)	7.6	7.7	7.6	7.6
Hypertensive heart and renal disease or encephalopathy; hypertension (CC 89, 91)	92.3	92.3	92.6	92.4
Vascular disease and complications (CC 104-105)	24.1	24.0	23.6	23.9
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	22.5	22.1	21.8	22.1
Pneumonia (CC 111-113)	16.1	15.6	15.1	15.6
Pleural effusion/pneumothorax (CC 114)	7.4	7.5	7.4	7.4
Other eye disorders (CC 124)	20.2	20.5	20.7	20.5
Other ear, nose, throat, and mouth disorders (CC 127)	28.4	28.8	28.5	28.6
Dialysis status (CC 130)	1.6	1.6	1.6	1.6
Renal failure (CC 131)	20.8	21.6	22.4	21.6
Urinary tract infection (CC 135)	21.9	21.5	21.4	21.6
Male genital disorders (CC 140)	14.4	14.7	14.9	14.7

Variable	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Decubitus ulcer of skin (CC 148)	2.7	2.7	2.6	2.6
Chronic ulcer of skin, except decubitus (CC 149)	5.2	5.3	5.1	5.2
Other dermatological disorders (CC 153)	31.9	32.3	32.7	32.3

Table 4.6.2 – Hierarchical Logistic Regression Model Variable Coefficients for Stroke Over Different Time Periods

Variable	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Intercept	-2.873	-2.841	-2.885	-2.870
Age minus 65 (years above 65, continuous)	0.070	0.069	0.069	0.069
Male	-0.025	-0.003	0.014	-0.006
Transfer from another ED	0.383	0.360	0.299	0.323
Congestive heart failure (CC 80)	0.285	0.238	0.249	0.258
Valvular or rheumatic heart disease (CC 86)	-0.090	-0.099	-0.123	-0.101
Congenital cardiac/circulatory defects (CC 87-88)	-0.433	-0.290	-0.443	-0.390
Hypertensive heart disease (CC 90)	-0.207	-0.157	-0.160	-0.162
Specified arrhythmias (CC 92)	0.455	0.463	0.464	0.459
Cerebral hemorrhage (CC 95)	0.198	0.196	0.150	0.181
Ischemic or unspecified stroke (CC 96)	-0.098	-0.114	-0.091	-0.101
Precerebral arterial occlusion and transient cerebral ischemia (CC 97)	-0.222	-0.263	-0.256	-0.247
Cerebral atherosclerosis and aneurysm (CC 98)	-0.183	-0.170	-0.244	-0.197
Hemiplegia/hemiparesis (CC 100)	0.239	0.244	0.230	0.240
History of infection (CC 1, 3-6)	0.094	0.098	0.099	0.103
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	0.988	0.985	0.951	0.978
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other major cancers (CC 9-13)	-0.061	-0.060	-0.052	-0.057
Protein-calorie malnutrition (CC 21)	0.557	0.548	0.528	0.547
Disorders of fluid/electrolyte/acid-base; other endocrine/metabolic/nutritional disorders (CC 22-24)	-0.346	-0.309	-0.332	-0.329
Other gastrointestinal disorders (CC 36)	-0.107	-0.134	-0.108	-0.119
Disorders of the vertebrae and spinal discs (CC 39)	-0.113	-0.134	-0.164	-0.137
Osteoarthritis of hip or knee (CC 40)	-0.162	-0.192	-0.177	-0.177
Other musculoskeletal and connective tissue disorders (CC 43)	-0.114	-0.146	-0.143	-0.136
Iron deficiency or other unspecified anemia and blood disease (CC 47)	0.162	0.197	0.211	0.193
Dementia or other specified brain disorders (CC 49-50)	0.288	0.295	0.330	0.306
Major psychiatric disorders (CC 54-56)	0.028	0.054	0.081	0.055
Quadriplegia, other extensive paralysis; paraplegia; spinal cord disorders/injuries (CC 67-69)	0.360	0.418	0.443	0.416
Multiple sclerosis; mononeuropathy, other neurological conditions/injuries (CC 72, 76)	-0.161	-0.173	-0.115	-0.151
Seizure disorders and convulsions (CC 74)	0.346	0.322	0.421	0.365
Hypertensive heart and renal disease or encephalopathy; hypertension (CC 89, 91)	-0.122	-0.160	-0.129	-0.135
Vascular disease and complications (CC 104-105)	0.092	0.119	0.091	0.106
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	0.079	0.100	0.112	0.095
Pneumonia (CC 111-113)	0.385	0.390	0.336	0.371

Variable	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Pleural effusion/pneumothorax (CC 114)	0.098	0.123	0.129	0.116
Other eye disorders (CC 124)	-0.098	-0.098	-0.126	-0.106
Other ear, nose, throat, and mouth disorders (CC 127)	-0.144	-0.132	-0.096	-0.125
Dialysis status (CC 130)	0.183	0.096	0.221	0.174
Renal failure (CC 131)	0.108	0.100	0.125	0.109
Urinary tract infection (CC 135)	0.095	0.101	0.062	0.085
Male genital disorders (CC 140)	-0.182	-0.207	-0.164	-0.182
Decubitus ulcer of skin (CC 148)	0.207	0.196	0.185	0.199
Chronic ulcer of skin, except decubitus (CC 149)	0.192	0.193	0.167	0.184
Other dermatological disorders (CC 153)	-0.114	-0.113	-0.128	-0.119

Table 4.6.3 – Adjusted OR and 95% CIs for the Stroke Hierarchical Logistic Regression Model Over Different Time Periods

Variable	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2012-06/2015 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.07 (1.07-1.07)	1.07 (1.07-1.07)	1.07 (1.07-1.07)	1.07 (1.07-1.07)
Male	0.98 (0.94-1.01)	1.00 (0.96-1.03)	1.01 (0.98-1.05)	0.99 (0.97-1.01)
Transfer from another ED	1.47 (1.40-1.54)	1.43 (1.36-1.51)	1.35 (1.29-1.41)	1.38 (1.34-1.42)
Congestive heart failure (CC 80)	1.33 (1.28-1.38)	1.27 (1.22-1.31)	1.28 (1.24-1.33)	1.29 (1.27-1.32)
Valvular or rheumatic heart disease (CC 86)	0.91 (0.88-0.94)	0.91 (0.88-0.94)	0.88 (0.86-0.91)	0.90 (0.89-0.92)
Congenital cardiac/circulatory defects (CC 87-88)	0.65 (0.58-0.72)	0.75 (0.67-0.83)	0.64 (0.57-0.72)	0.68 (0.64-0.72)
Hypertensive heart disease (CC 90)	0.81 (0.76-0.87)	0.85 (0.80-0.92)	0.85 (0.79-0.92)	0.85 (0.82-0.88)
Specified arrhythmias (CC 92)	1.58 (1.53-1.63)	1.59 (1.54-1.64)	1.59 (1.54-1.64)	1.58 (1.55-1.61)
Cerebral hemorrhage (CC 95)	1.22 (1.11-1.33)	1.22 (1.11-1.33)	1.16 (1.06-1.27)	1.20 (1.14-1.26)
Ischemic or unspecified stroke (CC 96)	0.91 (0.87-0.94)	0.89 (0.86-0.93)	0.91 (0.88-0.95)	0.90 (0.88-0.92)
Precerebral arterial occlusion and transient cerebral ischemia (CC 97)	0.80 (0.77-0.83)	0.77 (0.74-0.80)	0.77 (0.74-0.80)	0.78 (0.76-0.80)
Cerebral atherosclerosis and aneurysm (CC 98)	0.83 (0.80-0.87)	0.84 (0.81-0.88)	0.78 (0.75-0.82)	0.82 (0.80-0.84)
Hemiplegia/hemiparesis (CC 100)	1.27 (1.19-1.35)	1.28 (1.20-1.36)	1.26 (1.18-1.34)	1.27 (1.23-1.32)
History of infection (CC 1, 3-6)	1.10 (1.06-1.13)	1.10 (1.07-1.14)	1.10 (1.07-1.14)	1.11 (1.09-1.13)
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	2.69 (2.52-2.86)	2.68 (2.51-2.85)	2.59 (2.43-2.76)	2.66 (2.57-2.76)
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other major cancers (CC 9-13)	0.94 (0.91-0.97)	0.94 (0.91-0.98)	0.95 (0.92-0.98)	0.94 (0.93-0.96)
Protein-calorie malnutrition (CC 21)	1.74 (1.66-1.83)	1.73 (1.65-1.82)	1.70 (1.62-1.78)	1.73 (1.68-1.78)
Disorders of fluid/electrolyte/acid-base; other endocrine/metabolic/nutritional disorders (CC 22-24)	0.71 (0.68-0.74)	0.73 (0.70-0.77)	0.72 (0.69-0.75)	0.72 (0.70-0.74)
Other gastrointestinal disorders (CC 36)	0.90 (0.87-0.93)	0.87 (0.85-0.90)	0.90 (0.87-0.93)	0.89 (0.87-0.90)
Disorders of the vertebrae and spinal discs (CC 39)	0.89 (0.86-0.93)	0.87 (0.84-0.91)	0.85 (0.82-0.88)	0.87 (0.85-0.89)
Osteoarthritis of hip or knee (CC 40)	0.85 (0.81-0.89)	0.83 (0.79-0.86)	0.84 (0.80-0.88)	0.84 (0.82-0.86)
Other musculoskeletal and connective tissue disorders (CC 43)	0.89 (0.86-0.92)	0.86 (0.84-0.89)	0.87 (0.84-0.90)	0.87 (0.86-0.89)

Variable	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2012-06/2015 OR (95% CI)
Iron deficiency or other unspecified anemia and blood disease (CC 47)	1.18 (1.14-1.21)	1.22 (1.18-1.26)	1.24 (1.20-1.27)	1.21 (1.19-1.24)
Dementia or other specified brain disorders (CC 49-50)	1.33 (1.29-1.37)	1.34 (1.30-1.39)	1.39 (1.35-1.43)	1.36 (1.33-1.38)
Major psychiatric disorders (CC 54-56)	1.03 (0.98-1.08)	1.06 (1.01-1.10)	1.08 (1.04-1.13)	1.06 (1.03-1.08)
Quadriplegia, other extensive paralysis; paraplegia; spinal cord disorders/injuries (CC 67-69)	1.43 (1.29-1.59)	1.52 (1.38-1.68)	1.56 (1.41-1.72)	1.52 (1.43-1.60)
Multiple sclerosis; mononeuropathy, other neurological conditions/injuries (CC 72, 76)	0.85 (0.81-0.89)	0.84 (0.80-0.88)	0.89 (0.85-0.93)	0.86 (0.84-0.88)
Seizure disorders and convulsions (CC 74)	1.41 (1.35-1.48)	1.38 (1.31-1.45)	1.52 (1.45-1.60)	1.44 (1.40-1.48)
Hypertensive heart and renal disease or encephalopathy; hypertension (CC 89, 91)	0.89 (0.84-0.93)	0.85 (0.81-0.90)	0.88 (0.83-0.93)	0.87 (0.85-0.90)
Vascular disease and complications (CC 104-105)	1.10 (1.06-1.13)	1.13 (1.09-1.17)	1.09 (1.06-1.13)	1.11 (1.09-1.13)
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	1.08 (1.05-1.12)	1.11 (1.07-1.14)	1.12 (1.08-1.16)	1.10 (1.08-1.12)
Pneumonia (CC 111-113)	1.47 (1.42-1.53)	1.48 (1.42-1.53)	1.40 (1.35-1.45)	1.45 (1.42-1.48)
Pleural effusion/pneumothorax (CC 114)	1.10 (1.05-1.16)	1.13 (1.08-1.19)	1.14 (1.08-1.20)	1.12 (1.09-1.16)
Other eye disorders (CC 124)	0.91 (0.87-0.94)	0.91 (0.87-0.94)	0.88 (0.85-0.91)	0.90 (0.88-0.92)
Other ear, nose, throat, and mouth disorders (CC 127)	0.87 (0.84-0.89)	0.88 (0.85-0.90)	0.91 (0.88-0.94)	0.88 (0.87-0.90)
Dialysis status (CC 130)	1.20 (1.08-1.33)	1.10 (0.99-1.23)	1.25 (1.12-1.38)	1.19 (1.12-1.26)
Renal failure (CC 131)	1.11 (1.07-1.15)	1.10 (1.07-1.15)	1.13 (1.09-1.17)	1.12 (1.09-1.14)
Urinary tract infection (CC 135)	1.10 (1.06-1.14)	1.11 (1.07-1.15)	1.06 (1.03-1.10)	1.09 (1.07-1.11)
Male genital disorders (CC 140)	0.83 (0.79-0.88)	0.81 (0.77-0.85)	0.85 (0.81-0.89)	0.83 (0.81-0.86)
Decubitus ulcer of skin (CC 148)	1.23 (1.14-1.32)	1.22 (1.13-1.31)	1.20 (1.12-1.30)	1.22 (1.17-1.27)
Chronic ulcer of skin, except decubitus (CC 149)	1.21 (1.14-1.28)	1.21 (1.14-1.29)	1.18 (1.11-1.25)	1.20 (1.16-1.24)
Other dermatological disorders (CC 153)	0.89 (0.86-0.92)	0.89 (0.86-0.92)	0.88 (0.85-0.91)	0.89 (0.87-0.90)

Table 4.6.4 – Stroke Generalized Linear Modeling (Logistic Regression) Performance Over Different Time Periods

Characteristic	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Predictive ability, % (lowest decile – highest decile)	2.5 - 39.3	2.6 - 39.3	2.5 - 38.6	2.6 - 38.9
c-statistic	0.74	0.74	0.74	0.74

Table 4.6.5 – Distribution of Hospital Stroke Admission Volumes Over Different Time Periods

Characteristic	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Number of hospitals	4,235	4,165	4,116	4,465
Mean number of admissions (SD)	41.3 (53.9)	41.5 (54.6)	42.2 (56.8)	116.8 (161.5)
Range (min. – max.)	1 - 485	1 - 477	1 - 547	1 - 1,424
25th percentile	6	5	5	12
50th percentile	18	18	18	45
75th percentile	58	59	59	162

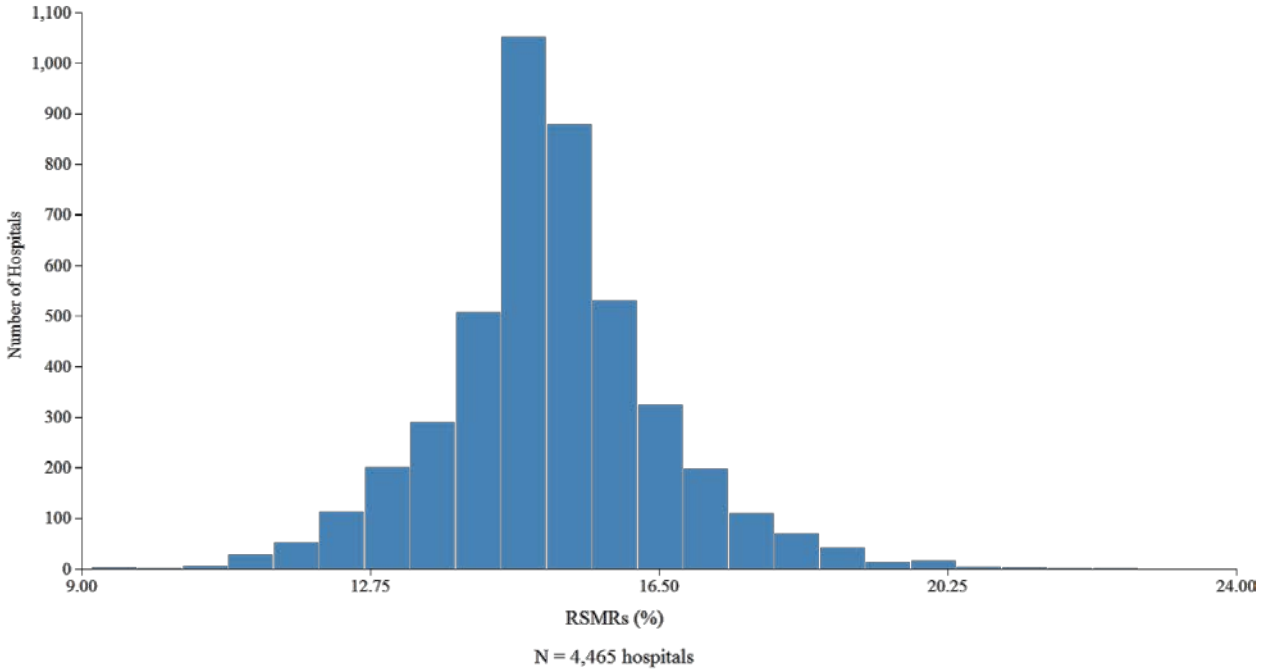
Table 4.6.6 – Distribution of Hospital Stroke RSMRs Over Different Time Periods

Characteristic	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Number of hospitals	4,235	4,165	4,116	4,465
Mean (SD)	15.1 (0.9)	14.9 (1.0)	14.8 (0.9)	15.0 (1.4)
Range (min. – max.)	10.9 - 20.7	11.1 - 21.4	10.6 - 19.9	9.3 - 23.3
25th percentile	14.7	14.4	14.4	14.3
50th percentile	15.1	14.8	14.7	14.9
75th percentile	15.6	15.4	15.2	15.7

Table 4.6.7 – Between-Hospital Variance for Stroke

	07/2012-06/2013	07/2013-06/2014	07/2014-06/2015	07/2012-06/2015
Between-hospital variance (SE)	0.044 (0.005)	0.050 (0.005)	0.045 (0.005)	0.051 (0.003)

Figure 4.6.2 – Distribution of Hospital 30-Day Stroke RSMRs Between July 2012 and June 2015



5. GLOSSARY

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

Cohort: The index admissions 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.

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

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

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

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

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

Hospital-specific effect: A measure of the hospital quality of care calculated through hierarchical logistic regression, taking into consideration how many patients were eligible for the cohort, these patients' risk factors, and how many died. The hospital-specific effect is the calculated random effect intercept for each hospital. The hospital-specific effect will be negative for a better-than-average hospital, positive for a worse-than-average hospital, and close to zero for an average hospital. The hospital-specific effect is used in the numerator to calculate "predicted" mortality.

Index admission: Any admission included in the measure calculation as the initial admission for an episode of AMI, COPD, HF, pneumonia, or stroke care and evaluated for the outcome.

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

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

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

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

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

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

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

6. REFERENCES

1. Krumholz H, Normand S, Galusha D, et al. Risk-Adjustment Models for AMI and HF 30-Day Mortality Methodology. 2005; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier4&cid=1163010421830. Accessed March 21, 2016.
2. Grosso L, Lindenauer P, Wang C, et al. Hospital-level 30-day Mortality Following Admission for an Acute Exacerbation of Chronic Obstructive Pulmonary Disease Measure Methodology Report. 2011; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier4&cid=1163010421830. Accessed March 21, 2016.
3. Krumholz H, Normand S, Galusha D, et al. Risk-Adjustment Methodology for Hospital Monitoring/Surveillance and Public Reporting Supplement #1: 30-Day Mortality Model for Pneumonia. 2006; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier4&cid=1163010421830. Accessed March 21, 2016.
4. Bernheim S, Wang C, Wang Y, et al. Hospital 30-Day Mortality Following Acute Ischemic Stroke Hospitalization Measure Methodology Report. 2010; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier4&cid=1163010421830. Accessed March 21, 2016.
5. Bhat K, Drye E, Krumholz H, et al. 2008 Acute Myocardial Infarction, Heart Failure, and Pneumonia Mortality Measures Maintenance Technical Report. 2008; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier3&cid=1228774398696. Accessed March 21, 2016.
6. Grosso L, Schreiner G, Wang Y, et al. 2009 Measures Maintenance Technical Report: Acute Myocardial Infarction, Heart Failure, and Pneumonia 30-Day Risk-Standardized Mortality Measures. 2009; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier3&cid=1228774398696. Accessed March 21, 2016.
7. Bernheim S, Wang Y, Bhat K, et al. 2010 Measures Maintenance Technical Report: Acute Myocardial Infarction, Heart Failure, and Pneumonia 30-day Risk Standardized Mortality Measures. 2010; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier3&cid=1228774398696. Accessed March 21, 2016.
8. Bernheim S, Wang Y, Grady J, et al. 2011 Measures Maintenance Technical Report: Acute Myocardial Infarction, Heart Failure, and Pneumonia 30-day Risk Standardized Mortality Measures. 2011; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier3&cid=1228774398696. Accessed March 21, 2016.
9. Bernheim S, Wang Y, Grady J, et al. 2012 Measures Maintenance Technical Report: Acute Myocardial Infarction, Heart Failure, and Pneumonia 30-Day Risk-Standardized Mortality Measure. 2012; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier3&cid=1228774398696. Accessed March 21, 2016.
10. Grady J, Lin Z, Wang Y, et al. 2013 Measures Updates and Specifications: Acute Myocardial Infarction, Heart Failure, and Pneumonia 30-Day Risk-Standardized Mortality Measure (Version 7.0). 2013;

https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier3&cid=1228774398696. Accessed March 21, 2016.
11. Drye E, Lindenauer P, Wang C, et al. 2013 Measure Updates and Specifications Report: Hospital-level 30-day Mortality Following an Admission for an Acute Exacerbation of Chronic Obstructive Pulmonary Disease (Version 2.0). 2013; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier3&cid=1228774398696. Accessed March 21, 2016.
12. Bernheim S, Wang C, Wang Y, et al. 2013 Measure Updates and Specifications Report: Hospital 30-day Mortality Following an Admission for an Acute Ischemic Stroke (Version 2.0). 2013; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier3&cid=1228774398696. Accessed March 21, 2016.
13. Dorsey K, Grady J, Wang C, et al. 2014 Measures Updates and Specifications Report: Hospital-Level 30-Day Risk-Standardized Mortality Measures; Acute Myocardial Infarction – Version 8.0, Heart Failure – Version 8.0, Pneumonia – Version 8.0, Chronic Obstructive Pulmonary Disease – Version 3.0, Stroke – Version 3.0. 2014; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier3&cid=1228774398696. Accessed March 21, 2016.
14. Dorsey K, Grady J, Desai N, et al. 2015 Condition-Specific Measures Updates and Specifications Report: Hospital-Level 30-Day Risk-Standardized Mortality Measures; Acute Myocardial Infarction – Version 9.0, Heart Failure – Version 9.0, Pneumonia – Version 9.0, Chronic Obstructive Pulmonary Disease – Version 4.0, and Stroke – Version 4.0. 2015; https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier3&cid=1228774398696. Accessed Available as of April 22, 2016.
15. Bratzler D, Normand S, Wang Y, et al. An administrative claims model for profiling hospital 30-day mortality rates for pneumonia patients. *PLoS One.* 2011;6(4):e17401.
16. Krumholz H, Wang Y, Mattera J, et al. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with an acute myocardial infarction. *Circulation.* Apr 4 2006;113(13):1683-1692.
17. Krumholz H, Wang Y, Mattera J, et al. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with heart failure. *Circulation.* Apr 4 2006;113(13):1693-1701.
18. Lindenauer P, Grosso L, Wang C, et al. Development, validation, and results of a risk-standardized measure of hospital 30-day mortality for patients with exacerbation of chronic obstructive pulmonary disease. *J Hosp Med.* Aug 2013;8(8):428-435.
19. Dharmarajan K, Hsieh AF, Kulkarni VT, et al. Trajectories of risk after hospitalization for heart failure, acute myocardial infarction, or pneumonia: retrospective cohort study. *BMJ (Clinical research ed.).* 2015;350:h411.
20. Drye E, Normand S, Wang Y, et al. Comparison of hospital risk-standardized mortality rates calculated by using in-hospital and 30-day models: an observational study with implications for hospital profiling. *Annals of internal medicine.* Jan 3 2012;156(1 Pt 1):19-26.
21. 2015 Medicare Hospital Quality Chartbook. Prepared by Yale New Haven Health Services Corporation Center for Outcomes Research and Evaluation for the Centers for Medicare and Medicaid Services. 2015; https://www.cms.gov/medicare/quality-initiatives-patient-assessment-instruments/hospitalqualityinits/outcomemeasures.html. Accessed March 21, 2016.
22. Normand S-L, Shahian D. Statistical and clinical aspects of hospital outcomes profiling. *Statistical Science.* 2007;22(2):206-226.
23. Lindenauer P, Ross J, Strait K, et al. Reevaluation and Re-Specification Report of the Hospital-Level 30-Day Risk-Standardized Measures Following Hospitalization for Pneumonia: Pneumonia

Mortality – Version 9.2, Pneumonia Readmission – Version 8.2. 2015; https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/HospitalQualityInits/Measure-Methodology.html. Accessed March 21, 2016.
24. Lampropulos JF, Kim N, Wang Y, et al. Trends in left ventricular assist device use and outcomes among Medicare beneficiaries, 2004-2011. *Open heart.* 2014;1(1):e000109.
25. Goldstein LB. Accuracy of ICD-9-CM coding for the identification of patients with acute ischemic stroke: effect of modifier codes. *Stroke; a journal of cerebral circulation.* Aug 1998;29(8):1602-1604.
26. Daniels M, Gatsonis C. Hierarchical Generalized Linear Models in the Analysis of Variations in Health Care Utilization. *Journal of the American Statistical Association.* 1999/03/01 1999;94(445):29-42.
27. Normand S-L, Wang Y, Krumholz H. Assessing surrogacy of data sources for institutional comparisons. *Health Serv Outcomes Res Method.* 2007/06/01 2007;7(1-2):79-96.

7. APPENDICES

Appendix A. Statistical Approach to RSMRs for AMI, COPD, HF, Pneumonia, and Stroke Measures

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

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

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

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

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

Where h(.) is a logit link, Y_{ij} is whether the j^{th} patient in the i^{th} hospital died (equal to 1 if death, zero otherwise); α_i represents the hospital-specific intercept, $\mathbf{Z}_{ij} = (Z_{1ij}, Z_{2ij}, \ldots, Z_{pij})$ the patient-specific covariates, μ is the adjusted average hospital intercept across all hospitals in the sample, and τ^2 is the between-hospital variance component.[26] This model separates within-hospital variation from between-hospital variation. The hierarchical logistic regression models are estimated using the SAS software system (SAS 9.3 GLIMMIX).

Hospital Performance Reporting

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

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

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

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

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

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

Creating Interval Estimates

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

Algorithm:

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

1. Sample *I* hospitals with replacement.

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

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 $\widetilde{RSMR}_{(Z)}^{(B)}$ where $\hat{\beta}^{(b)}$ and $\hat{\mu}^{(b)}$ are obtained from Step 2 and $\hat{\alpha}_i^{(b^*)}$ is obtained from Step 3.

Ninety-five percent interval estimates (or alternative interval estimates) for the hospital-standardized outcome can be computed by identifying the 2.5th and 97.5th percentiles of the B estimates (or the percentiles corresponding to the alternative desired intervals).[27]

Appendix B. Data QA

We have a two-phase approach to internal QA for the mortality measures' reevaluation process. Refer to Figure B.1 for a detailed outline of phase I and Figure B.2 for a detailed outline of phase II.

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

Phase I

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

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

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

Phase II

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

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

Figure B.1 – CORE QA Phase I

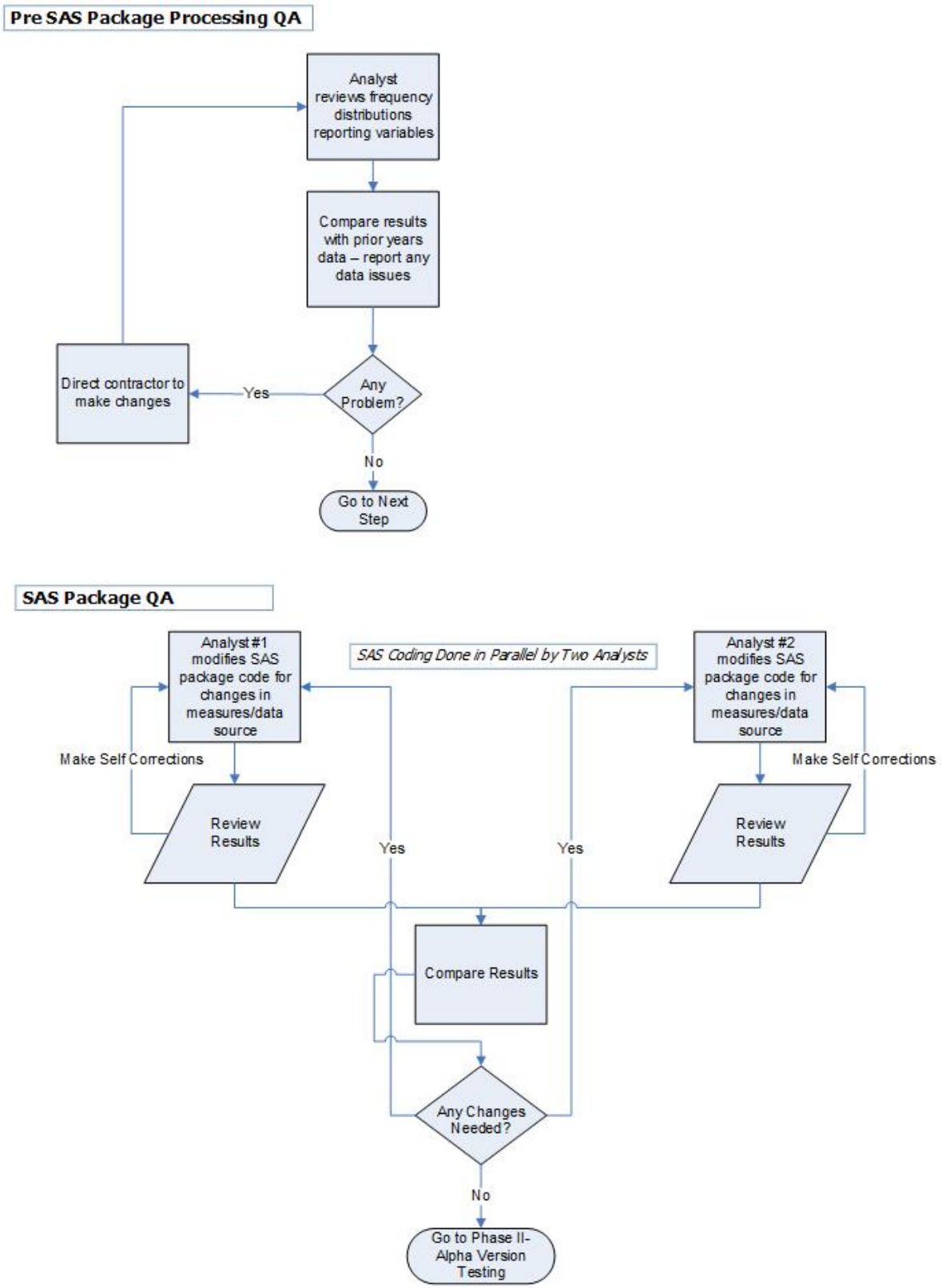
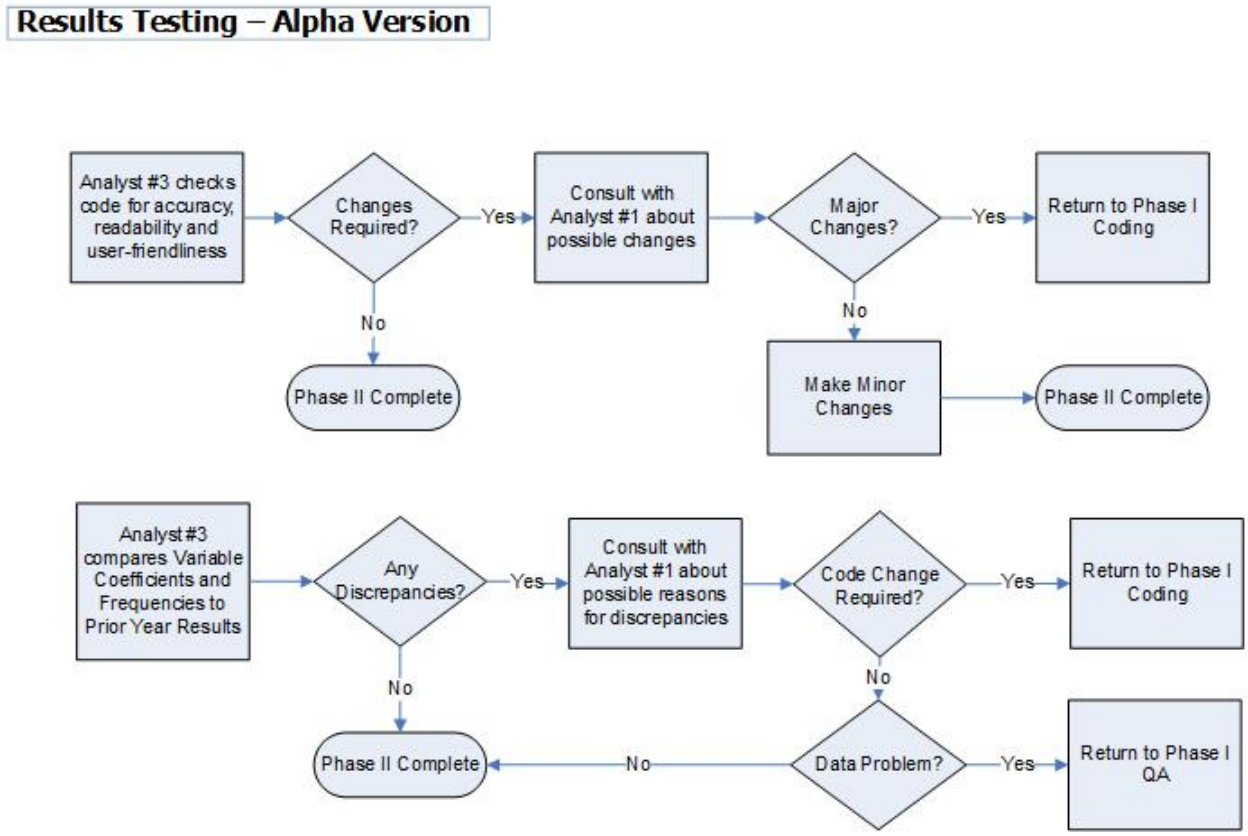


Figure B.2 – CORE QA Phase II



Appendix C. Annual Updates

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

2016

2016 Measures Updates and Specifications Report (Version 10.0 - AMI, HF, and Pneumonia) (Version 5.0 - COPD and Stroke)

1. Updated the pneumonia measure specifications:
    - ICD-9 cohort codes include aspiration pneumonia admissions as well as sepsis admissions (not including severe sepsis) that have a secondary diagnosis of pneumonia (including aspiration pneumonia) coded as POA and no secondary diagnosis of severe sepsis coded as POA.
        - Rationale: This expansion of the cohort allows the measure to capture a broader population of patients admitted for pneumonia and a more consistent clinical cohort across hospitals. This update was made in response to changes in coding practice leading to more pneumonia patients being coded with a principal discharge diagnosis of sepsis, which led to bias in hospital comparisons.
    - Updated the risk variable list in concordance with the expanded cohort (CCs 2, 23, 48, 77, 78, 114, and 148 added).
        - Rationale: Presence of Septicemia/shock (CC 2), Disorders of fluid/electrolyte/acid-base balance (CC 23), Delirium and encephalopathy (CC 48), Respiratory dependence/tracheostomy status (CC 77), Respiratory arrest (CC 78), Pleural effusion/pneumothorax (CC 114) and Decubitus ulcer of skin (CC 148) in the 12 months prior to the index admission all had strong associations with mortality in the expanded pneumonia cohort and had high levels of face validity in terms of the clinical expectation that these conditions would be associated with worse outcomes if occurred during the 12-month time frame.
2. Updated HF cohort to exclude patients with an LVAD implantation or heart transplantation either during the index admission or in the 12 months prior to the index admission.
    - Rationale: The use of LVADs, in particular, has increased dramatically since the time of measure development. These patients represent a clinically distinct, highly-selected group.
3. Added one ischemic stroke code (436 Acute, but ill-defined, cerebrovascular disease).
    - Rationale: Although ICD-9 code 436 is not specific and could, in theory, include intracerebral hemorrhage, these codes are most commonly ischemic strokes coded as 436. This code may be used either because there is insufficient documentation to use a more specific code, or because some hospitals use older coding terminology to assign diagnoses of cerebrovascular accidents. Admissions coded with ICD-9 code 436 as the principal discharge diagnosis are appropriate inclusions for the stroke measure. Addition of this code will allow for a more comprehensive cohort of true ischemic stroke patients, across all hospitals.

2015

2015 Measures Updates and Specifications Report (Version 9.0- AMI, HF, and Pneumonia and Version 4.0-COPD and Stroke)

No updates were made to the specifications of the AMI, HF, pneumonia, COPD, and stroke mortality measures for 2015 public reporting.

2014

2014 Measures Updates and Specifications Report (Version 8.0- AMI, HF, and Pneumonia and Version 3.0-COPD and Stroke)

No updates were made to the specifications of the AMI, HF, pneumonia, COPD, and stroke mortality measures for 2014 public reporting.

2013

2013 Measures Updates and Specifications Report AMI, HF, Pneumonia (Version 7.0)

1. Updated CC map.
   - Rationale: Prior to 2014, the ICD-9-CM CC map was updated annually to capture all relevant comorbidities coded in patient administrative claims data.

2013 Measure Updates and Specifications Report COPD (Version 2.0)

1. Updated CC map.
   - Rationale: Prior to 2014, the ICD-9-CM CC map was updated annually to capture all relevant comorbidities coded in patient administrative claims data.

2013 Measures Updates and Specifications Report Stroke (Version 2.0)

1. Updated CC map.
   - Rationale: Prior to 2014, the ICD-9-CM CC map was updated annually to capture all relevant comorbidities coded in patient administrative claims data.
2. Incorporating Risk Adjustment for Emergency Department-transfer Patients
   - Rationale: ED-transfer patients may be at higher risk of mortality.
3. Removed ICD-9-CM code 436 from measure cohort
   - Rationale: ICD-9-CM code 436 is not commonly used to define acute ischemic stroke.

2012

2012 Measures Maintenance Report AMI, HF, Pneumonia (Version 6.0)

1. Included VA one-day stays.
   - Rationale: Stays of less than 24 hours that result in death, discharge against medical advice, or transfer (or that follow a transfer) are not likely to be observation stays because the time frame of the admissions was determined not by clinical necessity but by other factors such as death or transfer. These stays had been previously excluded from the measure.
2. Excluded patients based on enrollment in VA hospice
   - Rationale: VA patients who have a history of VA hospice care in the 12 months prior to the index admission are now excluded.
3. Incorporated Version 5010 format.
   - Rationale: Version 5010 increased the number of diagnoses and procedures hospitals could code on Medicare claims. The inclusion of 15 additional codes for diagnoses and 19 additional codes for procedures allows us to identify additional comorbidities, thereby increasing the accuracy of risk adjustment.

4. Updated CC map.
    - Rationale: Prior to 2014, the ICD-9-CM CC map was updated annually to capture all relevant comorbidities coded in patient administrative claims data.

2011

2011 Measures Maintenance Report AMI, HF, Pneumonia (Version 5.0)

1. Added two pneumonia codes (482.42 and 488.11).
    - Rationale: CMS updated ICD-9 cohort codes to distinguish between Methicillin susceptible and resistant Staphylococcus aureus pneumonia (482.41 and 482.42), and added a new code for viral pneumonia cases (488.11) to reflect the emergence of H1N1 influenza virus.
2. Included VA hospitals.
    - Rationale: Creates a more inclusive perspective of the relative quality of US hospitals.
3. Updated CC map.
    - Rationale: Prior to 2014, the ICD-9-CM CC map was updated annually to capture all relevant comorbidities coded in patient administrative claims data.

2010

2010 Measures Maintenance Report AMI, HF, Pneumonia (Version 4.0)

1. Revised period for collecting comorbidities from claims codes.
    - Rationale: The revised models use comorbidities coded within 365 days of admission rather than 365 days of discharge. This revision includes more clinical covariates for risk adjustment.
2. Updated CC map.
    - Rationale: Prior to 2014, the ICD-9-CM CC map was updated annually to capture all relevant comorbidities coded in patient administrative claims data.

2009

2009 Measures Maintenance Report AMI, HF, Pneumonia (Version 3.0)

1. Randomly selected one AMI admission per patient per year for inclusion in the cohort
    - Rationale: Three-year data increased the number of multiple AMI admissions, which would be statistically correlated. Randomly selecting one AMI admission per year aligned the measure with HF and PN.
2. Used three years of claims and enrollment data for public reporting.
    - Rationale: Three years of data increased the precision of the hospital RSMR estimates by increasing the number of admissions used to calculate the rates. CMS developed the measures using one year of data.
3. Excluded patients discharged AMA.
    - Rationale: Providers are unable to deliver full care and prepare the patient for discharge when patients leave AMA.
4. Updated CC map.
    - Rationale: Prior to 2014, the ICD-9-CM CC map was updated annually to capture all relevant comorbidities coded in patient administrative claims data.

2008

2008 Measures Maintenance Report (Version 2.0)

1. Added three viral pneumonia codes (480.0, 480.1, and 480.2)

- Rationale: Viral pneumonias are common causes of pneumonia in the elderly.

2. Excluded patients with a history of Medicare hospice enrollment in the 12 months prior to or on the index admission date
    - Rationale: These patients are likely continuing to seek comfort measures only; thus mortality is not necessarily an adverse outcome or signal of poor quality care.
3. Added checks for cases with unreliable mortality, vital status, age, and gender data and excluded such cases
    - Additional checks include patients over 115 years of age; date of discharge is before the date of admission; unknown gender; two hospitals have conflicting death information for the same patient.
4. Modified list of complications
    - Rationale: The models do not adjust for risk factors present on an index admission if the conditions may represent complications of care.
5. Discontinued use of hierarchical component of the HCC system
    - Rationale: The hierarchical logic is meant to predict expenditures, not to estimate prevalence of comorbidities. Dropping the hierarchy allowed the risk factor coefficients to better reflect the true disease burden.
6. Updated CC map
    - Rationale: Prior to 2014, the ICD-9-CM CC map was updated annually to capture all relevant comorbidities coded in patient administrative claims data.

Appendix D. Measure Specifications

Appendix D.1 Hospital-Level 30-Day RSMR Following AMI (NQF #0230)

Cohort

Inclusion Criteria for AMI Measure

1. **Principal discharge diagnosis of AMI**
   Rationale: AMI is the condition targeted for measurement (Table D.1.1).
2. **Enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission**
   Rationale: Claims data are consistently available only for Medicare FFS beneficiaries. The 12-month prior enrollment criterion ensures that patients were Medicare FFS beneficiaries and that their comorbidities are captured from claims for risk adjustment. Medicare Part A is required at the time of admission to ensure that no Medicare Advantage patients are included in the measure.
3. **Aged 65 or over**
   Rationale: Medicare patients younger than 65 usually qualify for the program due to severe disability. They are not included in the measure because they are considered to be too clinically distinct from Medicare patients 65 and over.
4. **Not transferred from another acute care facility**
   Rationale: Hospitalizations in which a patient was transferred in from another acute care facility are not included because it is the hospital where the patient was initially admitted that initiates patient management and is responsible for making critical acute care decisions (including the decision to transfer and where to transfer).

Exclusion Criteria for AMI Measure

1. **Discharged alive on the day of admission or the following day who were not transferred to another acute care facility**
   Rationale: It is unlikely that these patients had clinically significant AMI.
2. **Inconsistent or unknown vital status or other unreliable demographic data**
   Rationale: We do not include stays for patients where the age is greater than 115, where the gender is neither male nor female, where the admission date is after the date of death in the Medicare Enrollment Database, or where the date of death occurs before the date of discharge but the patient was discharged alive.
3. **Enrolled in the Medicare hospice program any time in the 12 months prior to the index admission, including the first day of the index admission**
   Rationale: These patients are likely continuing to seek comfort measures only, so mortality is not necessarily an adverse outcome or signal of poor quality care.
4. **Discharged against medical advice (AMA)**
   Rationale: Providers did not have the opportunity to deliver full care and prepare the patient for discharge.

   After exclusions #1-4 are applied, the measure randomly selects one index admission per patient per year for inclusion in the cohort so that each episode of care is mutually independent with the same probability of the outcome. Additional admissions within that year are excluded. For each patient, the probability of death increases with each subsequent admission and

therefore the episodes of care are not mutually independent. Similarly, for the three year combined data, when index admissions occur during the transition between measure reporting periods (June and July of each year) and both are randomly selected for inclusion in the measure, the measure includes only the June admission. July admissions are excluded to avoid assigning a single death to two admissions.

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

ICD-9-CM Diagnosis Codes	Description
410.00	Acute myocardial infarction of anterolateral wall, episode of care unspecified
410.01	Acute myocardial infarction of anterolateral wall, initial episode of care
410.10	Acute myocardial infarction of other anterior wall, episode of care unspecified
410.11	Acute myocardial infarction of other anterior wall, initial episode of care
410.20	Acute myocardial infarction of inferolateral wall, episode of care unspecified
410.21	Acute myocardial infarction of inferolateral wall, initial episode of care
410.30	Acute myocardial infarction of inferoposterior wall, episode of care unspecified
410.31	Acute myocardial infarction of inferoposterior wall, initial episode of care
410.40	Acute myocardial infarction of other inferior wall, episode of care unspecified
410.41	Acute myocardial infarction of other inferior wall, initial episode of care
410.50	Acute myocardial infarction of other lateral wall, episode of care unspecified
410.51	Acute myocardial infarction of other lateral wall, initial episode of care
410.60	True posterior wall infarction, episode of care unspecified
410.61	True posterior wall infarction, initial episode of care
410.70	Subendocardial infarction, episode of care unspecified
410.71	Subendocardial infarction, initial episode of care
410.80	Acute myocardial infarction of other specified sites, episode of care unspecified
410.81	Acute myocardial infarction of other specified sites, initial episode of care
410.90	Acute myocardial infarction of unspecified site, episode of care unspecified
410.91	Acute myocardial infarction of unspecified site, initial episode of care

Risk Adjustment

Table D.1.2 – Risk Variables for AMI Measure

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
Age minus 65 (years above 65, continuous)	n/a	
Male	n/a	
History of Percutaneous Transluminal Coronary Angioplasty (PTCA)	ICD-9 diagnosis code V45.82; ICD-9 procedure codes 00.66, 36.06, 36.07	
History of Coronary Artery Bypass Graft (CABG) surgery	ICD-9 diagnosis code V45.81; ICD-9 procedure codes 36.10–36.16	
Congestive heart failure	CC 80 Congestive heart failure	X
Acute myocardial infarction	CC 81 Acute myocardial infarction	X
Other acute/subacute forms of ischemic heart disease	CC 82 Other acute/subacute forms of ischemic heart disease	X
Anterior myocardial infarction	ICD-9 diagnosis codes 410.00-410.12	
Other location of myocardial infarction	ICD-9 diagnosis codes 410.20-410.62	
Coronary atherosclerosis or angina	CC 83 Angina pectoris/old myocardial infarction	
	CC 84 Coronary atherosclerosis/other chronic ischemic heart disease	
Cardio-respiratory failure and shock	CC 79 Cardio-respiratory failure and shock	X
Valvular or rheumatic heart disease	CC 86 Valvular or rheumatic heart disease	
Hypertension	CC 89 Hypertensive heart and renal disease or encephalopathy	
	CC 91 Hypertension	
Stroke	CC 95 Cerebral hemorrhage	X
	CC 96 Ischemic or unspecified stroke	X
Cerebrovascular disease	CC 97 Precerebral arterial occlusion and transient cerebral ischemia	X
	CC 98 Cerebral atherosclerosis and aneurysm	
	CC 99 Cerebrovascular disease, unspecified	
	CC 103 Cerebrovascular disease late effects, unspecified	
Renal failure	CC 131 Renal failure	X
Chronic Obstructive Pulmonary Disease (COPD)	CC 108 Chronic Obstructive Pulmonary Disease (COPD)	
Pneumonia	CC 111 Aspiration and specified bacterial pneumonias	X
	CC 112 Pneumococcal pneumonia, emphysema, lung abscess	X
	CC 113 Viral and unspecified pneumonia, pleurisy	
Diabetes mellitus (DM) or DM complications except proliferative retinopathy	CC 15 Diabetes with renal manifestation	
	CC 16 Diabetes with neurologic or peripheral circulatory manifestation	
	CC 17 Diabetes with acute complications	X

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
	CC 18 Diabetes with ophthalmologic manifestation	
	CC 19 Diabetes with no or unspecified complications	
	CC 120 Diabetic and other vascular retinopathies	
Protein-calorie malnutrition	CC 21 Protein-calorie malnutrition	
Dementia and other specified brain disorders	CC 49 Dementia	
	CC 50 Senility, nonpsychotic organic brain syndromes/conditions	
Hemiplegia, paraplegia, paralysis, functional disability	CC 67 Quadriplegia, other extensive paralysis	
	CC 68 Paraplegia	
	CC 69 Spinal cord disorders/injuries	
	CC 100 Hemiplegia/hemiparesis	X
	CC 101 Diplegia (upper), monoplegia, and other paralytic syndromes	X
	CC 102 Speech, language, cognitive, perceptual deficits	X
	CC 177 Amputation status, lower limb/amputation complications	X
	CC 178 Amputation status, upper limb	X
Vascular disease and complications	CC 104 Vascular disease with complications	X
	CC 105 Vascular disease	X
Metastatic cancer, acute leukemia and other severe cancers	CC 7 Metastatic cancer or acute leukemia	
	CC 8 Lung, upper digestive tract, and other severe cancers	
Trauma in last year	CC 154 Severe head injury	X
	CC 155 Major head injury	X
	CC 156 Concussion or unspecified head injury	X
	CC 158 Hip fracture/dislocation	X
	CC 159 Major fracture, except of skull, vertebrae, or hip	X
	CC 160 Internal injuries	
	CC 161 Traumatic amputation	
	CC 162 Other injuries	
Major psychiatric disorders	CC 54 Schizophrenia	
	CC 55 Major depressive, bipolar, and paranoid disorders	
	CC 56 Reactive and unspecified psychosis	
Chronic liver disease	CC 25 End-stage liver disease	
	CC 26 Cirrhosis of liver	
	CC 27 Chronic hepatitis	

Outcome

Outcome Criteria for AMI Measure

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

Appendix D.2 Hospital-Level 30-Day RSMR Following COPD (NQF #1893)

Cohort

Inclusion Criteria for COPD Measure

1. **Principal discharge diagnosis of COPD or principal discharge diagnosis of respiratory failure with a secondary diagnosis of COPD with exacerbation**
   Rationale: COPD is the condition targeted for measurement. Respiratory failure admissions with a secondary diagnosis of COPD are also included in order to capture the full spectrum of severity among patients hospitalized with exacerbations of COPD (Table D.2.1).
2. **Enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission**
   Rationale: Claims data are consistently available only for Medicare FFS beneficiaries. The 12-month prior enrollment criterion ensures that patients were Medicare FFS beneficiaries and that their comorbidities are captured from claims for risk adjustment. Medicare Part A is required at the time of admission to ensure that no Medicare Advantage patients are included in the measure.
3. **Aged 65 or over**
   Rationale: Medicare patients younger than 65 usually qualify for the program due to severe disability. They are not included in the measure because they are considered to be too clinically distinct from Medicare patients 65 and over.
4. **Not transferred from another acute care facility**
   Rationale: Hospitalizations in which a patient was transferred in from another acute care facility are not included because it is the hospital where the patient was initially admitted that initiates patient management and is responsible for making critical acute care decisions (including the decision to transfer and where to transfer).

Exclusion Criteria for COPD Measure

1. **Inconsistent or unknown vital status or other unreliable demographic data**
   Rationale: We do not include stays for patients where the age is greater than 115, where the gender is neither male nor female, where the admission date is after the date of death in the Medicare Enrollment Database, or where the date of death occurs before the date of discharge but the patient was discharged alive.
2. **Enrolled in the Medicare hospice program any time in the 12 months prior to the index admission, including the first day of the index admission**
   Rationale: These patients are likely continuing to seek comfort measures only; thus, mortality is not necessarily an adverse outcome or signal of poor quality care.
3. **Discharged against medical advice (AMA)**
   Rationale: Providers did not have the opportunity to deliver full care and prepare the patient for discharge.

   After exclusions #1-3 are applied, the measure randomly selects one index admission per patient per year for inclusion in the cohort so that each episode of care is mutually independent with the same probability of the outcome. Additional admissions within that year are excluded. For each patient, the probability of death increases with each subsequent admission and therefore the episodes of care are not mutually independent. Similarly, for the three year

combined data, when index admissions occur during the transition between measure reporting periods (June and July of each year) and both are randomly selected for inclusion in the measure, the measure includes only the June admission. The July admissions are excluded to avoid assigning a single death to two admissions.

Table D.2.1 – ICD-9-CM Codes for COPD Cohort

ICD-9-CM Diagnosis Codes	Description
491.21	Obstructive chronic bronchitis with (acute) exacerbation
491.22	Obstructive chronic bronchitis with acute bronchitis
491.8	Other chronic bronchitis
491.9	Unspecified chronic bronchitis
492.8	Other emphysema
493.20	Chronic obstructive asthma, unspecified
493.21	Chronic obstructive asthma with status asthmaticus
493.22	Chronic obstructive asthma with (acute) exacerbation
496	Chronic airway obstruction, not elsewhere classified
Principal discharge diagnosis codes included in cohort if combined with a secondary diagnosis of COPD with exacerbation (491.21, 491.22, 493.21, or 493.22)	
518.81	Acute respiratory failure
518.82	Other pulmonary insufficiency, not elsewhere classified
518.84	Acute and chronic respiratory failure
799.1	Respiratory arrest

Risk Adjustment

Table D.2.2 – Risk Variables for COPD Measure

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
Age minus 65 (years above 65, continuous)	n/a	
History of mechanical ventilation	ICD-9 procedure codes 93.90, 96.70, 96.71, 96.72	
Sleep apnea	ICD-9 diagnosis codes 327.20, 327.21, 327.23, 327.27, 327.29, 780.51, 780.53, 780.57	
Respirator dependence/respiratory failure	CC 77 Respirator dependence/tracheostomy status	X
	CC 78 Respiratory arrest	X
Cardio-respiratory failure and shock	CC 79 Cardio-respiratory failure and shock	X
Congestive heart failure	CC 80 Congestive heart failure	X
Coronary atherosclerosis or angina	CC 83 Angina pectoris/old myocardial infarction	
	CC 84 Coronary atherosclerosis/other chronic ischemic heart disease	
Specified arrhythmias and other heart rhythm disorders	CC 92 Specified arrhythmias	X
	CC 93 Other heart rhythm and conduction disorders	X
Vascular or circulatory disease	CC 104 Vascular disease with complications	X
	CC 105 Vascular disease	X
	CC 106 Other circulatory disease	X
Fibrosis of lung or other chronic lung disorders	CC 109 Fibrosis of lung or other chronic lung disorders	
Asthma	CC 110 Asthma	
Pneumonia	CC 111 Aspiration and specified bacterial pneumonias	X
	CC 112 Pneumococcal pneumonia, emphysema, lung abscess	X
	CC 113 Viral and unspecified pneumonia, pleurisy	
Pleural effusion/pneumothorax	CC 114 Pleural effusion/pneumothorax	X
Other lung disorders	CC 115 Other lung disorders	
Metastatic cancer or acute leukemia	CC 7 Metastatic cancer or acute leukemia	
Lung, upper digestive tract, and other severe cancers	CC 8 Lung, upper digestive tract, and other severe cancers	
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other cancers and tumors; other respiratory and heart neoplasms	CC 9 Lymphatic, head and neck, brain, and other major cancers	
	CC 10 Breast, prostate, colorectal and other cancers and tumors	
	CC 11 Other respiratory and heart neoplasms	
Other digestive and urinary neoplasms	CC 12 Other digestive and urinary neoplasms	
Diabetes mellitus (DM) or DM complications	CC 15 Diabetes with renal manifestation	

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
	CC 16 Diabetes with neurologic or peripheral circulatory manifestation	
	CC 17 Diabetes with acute complications	X
	CC 18 Diabetes with ophthalmologic manifestation	
	CC 19 Diabetes with no or unspecified complications	
	CC 119 Proliferative diabetic retinopathy and vitreous hemorrhage	
	CC 120 Diabetic and other vascular retinopathies	
Protein-calorie malnutrition	CC 21 Protein-calorie malnutrition	
Disorders of fluid/electrolyte/acid-base	CC 22 Other significant endocrine and metabolic disorders	
	CC 23 Disorders of fluid/electrolyte/acid-base balance	X
Other endocrine/metabolic/nutritional disorders	CC 24 Other endocrine/metabolic/nutritional disorders	
Other gastrointestinal disorders	CC 36 Other gastrointestinal disorders	
Osteoarthritis of hip or knee	CC 40 Osteoarthritis of hip or knee	
Other musculoskeletal and connective tissue disorders	CC 43 Other musculoskeletal and connective tissue disorders	
Iron deficiency or other unspecified anemias and blood disease	CC 47 Iron deficiency or other unspecified anemias and blood disease	
Dementia or other specified brain disorders	CC 49 Dementia	
	CC 50 Senility, nonpsychotic organic brain syndromes/conditions	
Drug/alcohol abuse, without dependence	CC 53 Drug/alcohol abuse, without dependence	
Other psychiatric disorders	CC 60 Other psychiatric disorders	
Hemiplegia, paraplegia, paralysis, functional disability	CC 67 Quadriplegia, other extensive paralysis	
	CC 68 Paraplegia	
	CC 69 Spinal cord disorders/injuries	
	CC 100 Hemiplegia/hemiparesis	X
	CC 101 Diplegia (upper), monoplegia, and other paralytic syndromes	X
	CC 102 Speech, language, cognitive, perceptual deficits	X
	CC 177 Amputation status, lower limb/amputation complications	X
	CC 178 Amputation status, upper limb	X
Mononeuropathy, other neurological conditions/injuries	CC 76 Mononeuropathy, other neurological conditions/injuries	
Hypertension and hypertensive disease	CC 90 Hypertensive heart disease	
	CC 91 Hypertension	
Stroke	CC 95 Cerebral hemorrhage	X

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
	CC 96 Ischemic or unspecified stroke	X
Retinal disorders, except detachment and vascular retinopathies	CC 121 Retinal disorders, except detachment and vascular retinopathies	
Other eye disorders	CC 124 Other eye disorders	
Other ear, nose, throat and mouth disorders	CC 127 Other ear, nose, throat and mouth disorders	
Renal failure	CC 131 Renal failure	X
Decubitus ulcer or chronic skin ulcer	CC 148 Decubitus ulcer of skin	X
	CC 149 Chronic ulcer of skin, except decubitus	
Other dermatological disorders	CC 153 Other dermatological disorders	
Trauma	CC 154 Severe head injury	X
	CC 155 Major head injury	X
	CC 156 Concussion or unspecified head injury	X
	CC 158 Hip fracture/dislocation	X
	CC 159 Major fracture, except of skull, vertebrae, or hip	X
	CC 160 Internal injuries	
	CC 161 Traumatic amputation	
Vertebral fractures	CC 157 Vertebral fractures	
Major complications of medical care and trauma	CC 164 Major complications of medical care and trauma	X

Outcome

Outcome Criteria for COPD Measure

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

Appendix D.3 Hospital-Level 30-Day RSMR Following HF (NQF #0229)

Cohort

Inclusion Criteria for HF Measure

1. **Principal discharge diagnosis of HF**
   Rationale: HF is the condition targeted for measurement (Table D.3.1).
2. **Enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission**
   Rationale: Claims data are consistently available only for Medicare FFS beneficiaries. The 12-month prior enrollment criterion ensures that patients were Medicare FFS beneficiaries and that their comorbidities are captured from claims for risk adjustment. Medicare Part A is required at the time of admission to ensure that no Medicare Advantage patients are included in the measure.
3. **Aged 65 or over**
   Rationale: Medicare patients younger than 65 usually qualify for the program due to severe disability. They are not included in the measure because they are considered to be too clinically distinct from Medicare patients 65 and over.
4. **Not transferred from another acute care facility**
   Rationale: Hospitalizations in which a patient was transferred in from another acute care facility are not included because it is the hospital where the patient was initially admitted that initiates patient management and is responsible for making critical acute care decisions (including the decision to transfer and where to transfer).

Exclusion Criteria for HF Measure

1. **Discharged alive on the day of admission or the following day who were not transferred to another acute care facility**
   Rationale: It is unlikely that these patients had clinically significant HF.
2. **Inconsistent or unknown vital status or other unreliable demographic data**
   Rationale: We do not include stays for patients where the age is greater than 115, where the gender is neither male nor female, where the admission date is after the date of death in the Medicare Enrollment Database, or where the date of death occurs before the date of discharge but the patient was discharged alive.
3. **Enrolled in the Medicare hospice program any time in the 12 months prior to the index admission, including the first day of the index admission**
   Rationale: These patients are likely continuing to seek comfort measures only; thus, mortality is not necessarily an adverse outcome or signal of poor quality care.
4. **Discharged against medical advice (AMA)**
   Rationale: Providers did not have the opportunity to deliver full care and prepare the patient for discharge.
5. **With a procedure code for LVAD implantation or heart transplantation either during the index admission or in the 12 months prior to the index admission**
   Rationale: These patients represent a clinically distinct, highly-selected group (Table D.3.2).

   After exclusions #1-5 are applied, the measure randomly selects one index admission per patient per year for inclusion in the cohort so that each episode of care is mutually independent

with the same probability of the outcome. Additional admissions within that year are excluded. For each patient, the probability of death increases with each subsequent admission and therefore the episodes of care are not mutually independent. Similarly, for the three year combined data, when index admissions occur during the transition between measure reporting periods (June and July of each year) and both are randomly selected for inclusion in the measure, the measure includes only the June admission. The July admissions are excluded to avoid assigning a single death to two admissions.

Table D.3.1 – ICD-9-CM Codes for Inclusion in HF Cohort

ICD-9-CM Diagnosis Codes	Description
402.01	Malignant hypertensive heart disease with heart failure
402.11	Benign hypertensive heart disease with heart failure
402.91	Unspecified hypertensive heart disease with heart failure
404.01	Hypertensive heart and chronic kidney disease, malignant, with heart failure and with chronic kidney disease stage I through stage IV, or unspecified
404.03	Hypertensive heart and chronic kidney disease, malignant, with heart failure and with chronic kidney disease stage V or end stage renal disease
404.11	Hypertensive heart and chronic kidney disease, benign, with heart failure and with chronic kidney disease stage I through stage IV, or unspecified
404.13	Hypertensive heart and chronic kidney disease, benign, with heart failure and chronic kidney disease stage V or end stage renal disease
404.91	Hypertensive heart and chronic kidney disease, unspecified, with heart failure and with chronic kidney disease stage I through stage IV, or unspecified
404.93	Hypertensive heart and chronic kidney disease, unspecified, with heart failure and chronic kidney disease stage V or end stage renal disease
428.0	Congestive heart failure, unspecified
428.1	Left heart failure
428.20	Systolic heart failure, unspecified
428.21	Acute systolic heart failure
428.22	Chronic systolic heart failure
428.23	Acute on chronic systolic heart failure
428.30	Diastolic heart failure, unspecified
428.31	Acute diastolic heart failure
428.32	Chronic diastolic heart failure
428.33	Acute on chronic diastolic heart failure
428.40	Combined systolic and diastolic heart failure, unspecified
428.41	Acute combined systolic and diastolic heart failure
428.42	Chronic combined systolic and diastolic heart failure
428.43	Acute on chronic combined systolic and diastolic heart failure
428.9	Heart failure, unspecified

Table D.3.2 – ICD-9-CM LVAD and Heart Transplant Codes Which Exclude an Admission from HF Cohort

ICD-9-CM Procedure Codes	Description
33.6	Combined heart-lung transplantation
37.51	Heart transplantation
37.60	Implantation or insertion of biventricular external heart assist system
37.62	Insertion of temporary non-implantable extracorporeal circulatory assist device
37.65	Implant of single ventricular (extracorporeal) external heart assist system
37.66	Insertion of implantable heart assist system
37.68	Insertion of percutaneous external heart assist device

Risk Adjustment

Table D.3.3 – Risk Variables for HF Measure

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
Age minus 65 (years above 65, continuous)	n/a	
Male	n/a	
History of Percutaneous Transluminal Coronary Angioplasty (PTCA)	ICD-9 diagnosis code V45.82; ICD-9 procedure codes 00.66, 36.06, 36.07	
History of Coronary Artery Bypass Graft (CABG) surgery	ICD-9 diagnosis code V45.81; ICD-9 procedure codes 36.10–36.16	
Congestive heart failure	CC 80 Congestive heart failure	X
Acute myocardial infarction	CC 81 Acute myocardial infarction	X
Other acute/subacute forms of ischemic heart disease	CC 82 Other acute/subacute forms of ischemic heart disease	X
Coronary atherosclerosis or angina	CC 83 Angina pectoris/old myocardial infarction	
	CC 84 Coronary atherosclerosis/other chronic ischemic heart disease	
Cardio-respiratory failure and shock	CC 79 Cardio-respiratory failure and shock	X
Valvular or rheumatic heart disease	CC 86 Valvular or rheumatic heart disease	
Hypertension	CC 89 Hypertensive heart and renal disease or encephalopathy	
	CC 91 Hypertension	
Stroke	CC 95 Cerebral hemorrhage	X
	CC 96 Ischemic or unspecified stroke	X
Renal failure	CC 131 Renal failure	X
Chronic Obstructive Pulmonary Disease (COPD)	CC 108 Chronic Obstructive Pulmonary Disease (COPD)	
Pneumonia	CC 111 Aspiration and specified bacterial pneumonias	X
	CC 112 Pneumococcal pneumonia, emphysema, lung abscess	X

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
	CC 113 Viral and unspecified pneumonia, pleurisy	
Diabetes mellitus (DM) or DM complications except proliferative retinopathy	CC 15 Diabetes with renal manifestation	
	CC 16 Diabetes with neurologic or peripheral circulatory manifestation	
	CC 17 Diabetes with acute complications	X
	CC 18 Diabetes with ophthalmologic manifestation	
	CC 19 Diabetes with no or unspecified complications	
	CC 120 Diabetic and other vascular retinopathies	
Protein-calorie malnutrition	CC 21 Protein-calorie malnutrition	
Dementia or other specified brain disorders	CC 49 Dementia	
	CC 50 Senility, nonpsychotic organic brain syndromes/conditions	
Hemiplegia, paraplegia, paralysis, functional disability	CC 67 Quadriplegia, other extensive paralysis	
	CC 68 Paraplegia	
	CC 69 Spinal cord disorders/injuries	
	CC 100 Hemiplegia/hemiparesis	X
	CC 101 Diplegia (upper), monoplegia, and other paralytic syndromes	X
	CC 102 Speech, language, cognitive, perceptual deficits	X
	CC 177 Amputation status, lower limb/amputation complications	X
	CC 178 Amputation status, upper limb	X
Vascular disease and complications	CC 104 Vascular disease with complications	X
	CC 105 Vascular disease	X
Metastatic cancer, acute leukemia and other severe cancers	CC 7 Metastatic cancer or acute leukemia	
	CC 8 Lung, upper digestive tract, and other severe cancers	
Trauma in last year	CC 154 Severe head injury	X
	CC 155 Major head injury	X
	CC 156 Concussion or unspecified head injury	X
	CC 158 Hip fracture/dislocation	X
	CC 159 Major fracture, except of skull, vertebrae, or hip	X
	CC 160 Internal injuries	
	CC 161 Traumatic amputation	
	CC 162 Other injuries	
Major psychiatric disorders	CC 54 Schizophrenia	
	CC 55 Major depressive, bipolar, and paranoid disorders	
	CC 56 Reactive and unspecified psychosis	
Chronic liver disease	CC 25 End-stage liver disease	
	CC 26 Cirrhosis of liver	

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
	CC 27 Chronic hepatitis	

Outcome

Outcome Criteria for HF Measure

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

Appendix D.4 Hospital-Level 30-Day RSMR Following Pneumonia (NQF #0468)

Cohort

Inclusion Criteria for Pneumonia Measure

1. **Principal discharge diagnosis of:**
   - **Pneumonia (including aspiration pneumonia); or,**
   - **Sepsis (not including severe sepsis) with a secondary diagnosis of pneumonia (including aspiration pneumonia) coded as POA and no secondary diagnosis of severe sepsis coded as POA**

   Rationale: Pneumonia is the condition targeted for measurement. Sepsis admissions with a secondary diagnosis of pneumonia, as described above, are also included in order for the measure to more fully reflect the population of Medicare FFS beneficiaries being treated for pneumonia (Table D.4.1).
2. **Enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission**
   Rationale: Claims data are consistently available only for Medicare FFS beneficiaries. The 12-month prior enrollment criterion ensures that patients were Medicare FFS beneficiaries and that their comorbidities are captured from claims for risk adjustment. Medicare Part A is required at the time of admission to ensure that no Medicare Advantage patients are included in the measure.
3. **Aged 65 or over**
   Rationale: Medicare patients younger than 65 usually qualify for the program due to severe disability. They are not included in the measure because they are considered to be too clinically distinct from Medicare patients 65 and over.
4. **Not transferred from another acute care facility**
   Rationale: Hospitalizations in which a patient was transferred in from another acute care facility are not included because it is the hospital where the patient was initially admitted that initiates patient management and is responsible for making critical acute care decisions (including the decision to transfer and where to transfer).

Exclusion Criteria for Pneumonia Measure

1. **Discharged alive on the day of admission or the following day who were not transferred to another acute care facility**
   Rationale: It is unlikely that these patients had clinically significant pneumonia.
2. **Inconsistent or unknown vital status or other unreliable demographic data**
   Rationale: We do not include stays for patients where the age is greater than 115, where the gender is neither male nor female, where the admission date is after the date of death in the Medicare Enrollment Database or where the date of death occurs before the date of discharge but the patient was discharged alive.
3. **Enrolled in the Medicare hospice program any time in the 12 months prior to the index admission, including the first day of the index admission**
   Rationale: These patients are likely continuing to seek comfort measures only; thus, mortality is not necessarily an adverse outcome or signal of poor quality care for these patients.
4. **Discharged against medical advice (AMA)**

Rationale: Providers did not have the opportunity to deliver full care and prepare the patient for discharge.

After exclusions #1-4 are applied, the measure randomly selects one index admission per patient per year for inclusion in the cohort so that each episode of care is mutually independent with the same probability of the outcome. Additional admissions within that year are excluded. For each patient, the probability of death increases with each subsequent admission and therefore the episodes of care are not mutually independent. Similarly, for the three year combined data, when index admissions occur during the transition between measure reporting periods (June and July of each year) and both are randomly selected for inclusion in the measure, the measure includes only the June admission. The July admissions are excluded to avoid assigning a single death to two admissions.

Table D.4.1 – ICD-9-CM Codes for Pneumonia Cohort

ICD-9-CM Diagnosis Codes	Description
480.0	Pneumonia due to adenovirus
480.1	Pneumonia due to respiratory syncytial virus
480.2	Pneumonia due to parainfluenza virus
480.3	Pneumonia due to SARS-associated coronavirus
480.8	Pneumonia due to other virus not elsewhere classified
480.9	Viral pneumonia, unspecified
481	Pneumococcal pneumonia [Streptococcus pneumoniae pneumonia]
482.0	Pneumonia due to Klebsiella pneumoniae
482.1	Pneumonia due to Pseudomonas
482.2	Pneumonia due to Hemophilus influenzae [H. influenzae]
482.30	Pneumonia due to Streptococcus, unspecified
482.31	Pneumonia due to Streptococcus, group A
482.32	Pneumonia due to Streptococcus, group B
482.39	Pneumonia due to other Streptococcus
482.40	Pneumonia due to Staphylococcus, unspecified
482.41	Methicillin susceptible pneumonia due to Staphylococcus aureus
482.42	Methicillin resistant pneumonia due to Staphylococcus aureus
482.49	Other Staphylococcus pneumonia
482.81	Pneumonia due to anaerobes
482.82	Pneumonia due to escherichia coli [E. coli]
482.83	Pneumonia due to other gram-negative bacteria
482.84	Pneumonia due to Legionnaires' disease
482.89	Pneumonia due to other specified bacteria
482.9	Bacterial pneumonia, unspecified
483.0	Pneumonia due to mycoplasma pneumoniae
483.1	Pneumonia due to chlamydia
483.8	Pneumonia due to other specified organism

ICD-9-CM Diagnosis Codes	Description
485	Bronchopneumonia, organism unspecified
486	Pneumonia, organism unspecified
487.0	Influenza with pneumonia
488.11	Influenza due to identified 2009 H1N1 influenza virus with pneumonia
507.0	Pneumonitis due to inhalation of food or vomitus
Principal discharge diagnosis codes included in cohort if combined with a secondary diagnosis of pneumonia coded as POA AND no secondary diagnosis of severe sepsis (995.92 Severe sepsis or 785.52 Septic shock) coded as POA is present	
038.0	Streptococcal septicemia
038.10	Staphylococcal septicemia, unspecified
038.11	Methicillin susceptible Staphylococcus aureus septicemia
038.12	Methicillin resistant Staphylococcus aureus septicemia
038.19	Other staphylococcal septicemia
038.2	Pneumococcal septicemia [Streptococcus pneumoniae septicemia]
038.3	Septicemia due to anaerobes
038.40	Septicemia due to gram-negative organism, unspecified
038.41	Septicemia due to hemophilus Influenzae [H. influenzae]
038.42	Septicemia due to escherichia coli [E. coli]
038.43	Septicemia due to pseudomonas
038.44	Septicemia due to serratia
038.49	Other septicemia due to gram-negative organisms
038.8	Other specified septicemias
038.9	Unspecified septicemia
995.91	Sepsis

Risk Adjustment

Table D.4.2 – Risk Variables for Pneumonia Measure

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
Age minus 65 (years above 65, continuous)	n/a	
Male	n/a	
History of Percutaneous Transluminal Coronary Angioplasty (PTCA)	ICD-9 diagnosis code V45.82; ICD-9 procedure codes 00.66, 36.06, 36.07	
History of Coronary Artery Bypass Graft (CABG) surgery	ICD-9 diagnosis code V45.81; ICD-9 procedure codes 36.10–36.16	
Septicemia/shock	CC 2 Septicemia/shock	X
Disorders of fluid/electrolyte/acid-base	CC 23 Disorders of fluid/electrolyte/acid-base balance	X
Delirium and encephalopathy	CC 48 Delirium and encephalopathy	X

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
Respiratory dependence/tracheostomy status	CC 77 Respiratory dependence/tracheostomy status	X
Decubitus ulcer of skin	CC 148 Decubitus ulcer of skin	X
Congestive heart failure	CC 80 Congestive heart failure	X
Acute myocardial infarction	CC 81 Acute myocardial infarction	X
Other acute/subacute forms of ischemic heart disease	CC 82 Other acute/subacute forms of ischemic heart disease	X
Coronary atherosclerosis or angina	CC 83 Angina pectoris/old myocardial infarction	
	CC 84 Coronary atherosclerosis/other chronic ischemic heart disease	
Cardio-respiratory failure and shock; respiratory arrest	CC 78 Respiratory arrest	X
	CC 79 Cardio-respiratory failure and shock	X
Hypertension	CC 89 Hypertensive heart and renal disease or encephalopathy	
	CC 91 Hypertension	
Stroke	CC 95 Cerebral hemorrhage	X
	CC 96 Ischemic or unspecified stroke	X
Cerebrovascular disease	CC 97 Precerebral arterial occlusion and transient cerebral ischemia	X
	CC 98 Cerebral atherosclerosis and aneurysm	
	CC 99 Cerebrovascular disease, unspecified	
	CC 103 Cerebrovascular disease late effects, unspecified	
Renal failure	CC 131 Renal failure	X
Chronic Obstructive Pulmonary Disease (COPD)	CC 108 Chronic Obstructive Pulmonary Disease (COPD)	
Pneumonia; pleural effusion/pneumothorax	CC 111 Aspiration and specified bacterial pneumonias	X
	CC 112 Pneumococcal pneumonia, emphysema, lung abscess	X
	CC 113 Viral and unspecified pneumonia, pleurisy	X
	CC 114 Pleural effusion/pneumothorax	X
Protein-calorie malnutrition	CC 21 Protein-calorie malnutrition	
Dementia or other specified brain disorders	CC 49 Dementia	
	CC 50 Senility, nonpsychotic organic brain syndromes/conditions	
Hemiplegia, paraplegia, paralysis, functional disability	CC 67 Quadriplegia, other extensive paralysis	
	CC 68 Paraplegia	
	CC 69 Spinal cord disorders/injuries	
	CC 100 Hemiplegia/hemiparesis	X
	CC 101 Diplegia (upper), monoplegia, and other paralytic syndromes	X

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
	CC 102 Speech, language, cognitive, perceptual deficits	X
	CC 177 Amputation status, lower limb/amputation complications	X
	CC 178 Amputation status, upper limb	X
Vascular disease and complications	CC 104 Vascular disease with complications	X
	CC 105 Vascular disease	X
Metastatic cancer, acute leukemia and other severe cancers	CC 7 Metastatic cancer or acute leukemia	
	CC 8 Lung, upper digestive tract, and other severe cancers	
Trauma in last year	CC 154 Severe head injury	X
	CC 155 Major head injury	X
	CC 156 Concussion or unspecified head injury	X
	CC 158 Hip fracture/dislocation	X
	CC 159 Major fracture, except of skull, vertebrae, or hip	X
	CC 160 Internal injuries	
	CC 161 Traumatic amputation	
	CC 162 Other injuries	
Major psychiatric disorders	CC 54 Schizophrenia	
	CC 55 Major depressive, bipolar, and paranoid disorders	
	CC 56 Reactive and unspecified psychosis	
Chronic liver disease	CC 25 End-stage liver disease	
	CC 26 Cirrhosis of liver	
	CC 27 Chronic hepatitis	
Severe hematological disorders	CC 44 Severe hematological disorders	
Iron deficiency or other unspecified anemias and blood disease	CC 47 Iron deficiency or other unspecified anemias and blood disease	
Depression	CC 58 Depression	
Parkinson's or Huntington's diseases	CC 73 Parkinson's or Huntington's disease	
Seizure disorders and convulsions	CC 74 Seizure disorders and convulsions	
Fibrosis of lung or other chronic lung disorders	CC 109 Fibrosis of lung or other chronic lung disorders	
Asthma	CC 110 Asthma	
Vertebral fractures	CC 157 Vertebral fractures	

Outcome

Outcome Criteria for Pneumonia Measure

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

Appendix D.5 Hospital-Level 30-Day RSMR Following Ischemic Stroke

Cohort

Inclusion Criteria for Stroke Measure

1. **Principal discharge diagnosis of ischemic stroke**
   Rationale: Ischemic stroke is the condition targeted for measurement (Table D.5.1). Hemorrhagic strokes are not included in the cohort. Ischemic strokes are the most common type of stroke, accounting for the vast majority of stroke hospitalizations. Additionally, the causes, prognosis, and treatment of ischemic stroke are quite different than those of hemorrhagic stroke. Combining ischemic and hemorrhagic stroke patients could make it more difficult to account for a hospital's patient case mix.
2. **Enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission**
   Rationale: Claims data are consistently available only for Medicare FFS beneficiaries. The 12-month prior enrollment criterion ensures that patients were Medicare FFS beneficiaries and that their comorbidities are captured from claims for risk adjustment. Medicare Part A is required at the time of admission to ensure no that Medicare Advantage patients are included in the measure
3. **Aged 65 or over**
   Rationale: Medicare patients younger than 65 usually qualify for the program due to severe disability. They are not included in the measure because they are considered to be too clinically distinct from Medicare patients 65 and over.
4. **Not transferred from another acute care facility**
   Rationale: Hospitalizations in which a patient was transferred in from another acute care facility are not included because it is the hospital where the patient was initially admitted that initiates patient management and is responsible for making critical acute care decisions (including the decision to transfer and where to transfer).

Exclusion Criteria for Stroke Measure

1. **Inconsistent or unknown vital status or other unreliable demographic data**
   Rationale: We do not include stays for patients where the age is greater than 115, where the gender is neither male nor female, where the admission date is after the date of death in the Medicare Enrollment Database, or where the date of death occurs before the date of discharge but the patient was discharged alive.
2. **Enrolled in the Medicare hospice program any time in the 12 months prior to the index admission, including the first day of the index admission**
   Rationale: These patients are likely continuing to seek comfort measures only; thus, mortality is not necessarily an adverse outcome or signal of poor quality care for these patients.
3. **Discharged against medical advice (AMA)**
   Rationale: Providers did not have the opportunity to deliver full care and prepare the patient for discharge.

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

For each patient, the probability of death increases with each subsequent admission and therefore the episodes of care are not mutually independent. Similarly, for the three year combined data, when index admissions occur during the transition between measure reporting periods (June and July of each year) and both are randomly selected for inclusion in the measure, the measure includes only the June admission. The July admissions are excluded from the measure to avoid assigning a single death to two admissions.

Table D.5.1 – ICD-9-CM Codes for Ischemic Stroke Cohort

ICD-9-CM Diagnosis Codes	Description
433.01	Occlusion and stenosis of basilar artery with cerebral infarction
433.11	Occlusion and stenosis of carotid artery with cerebral infarction
433.21	Occlusion and stenosis of vertebral artery with cerebral infarction
433.31	Occlusion and stenosis of multiple and bilateral precerebral arteries with cerebral infarction
433.81	Occlusion and stenosis of other specified precerebral artery with cerebral infarction
433.91	Occlusion and stenosis of unspecified precerebral artery with cerebral infarction
434.01	Cerebral thrombosis with cerebral infarction
434.11	Cerebral embolism with cerebral infarction
434.91	Cerebral artery occlusion, unspecified with cerebral infarction
436	Acute, but ill-defined, cerebrovascular disease

Risk Adjustment

Table D.5.2 – Risk Variables for Stroke Measure

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
Age minus 65 (years above 65, continuous)	n/a	
Male	n/a	
Transfer from another ED	n/a	
Congestive heart failure	CC 80 Congestive heart failure	X
Valvular or rheumatic heart disease	CC 86 Valvular or rheumatic heart disease	
Congenital cardiac/circulatory defects	CC 87 Major congenital cardiac/circulatory defect	
	CC 88 Other congenital heart/circulatory disease	
Hypertensive heart disease	CC 90 Hypertensive heart disease	
Specified arrhythmias	CC 92 Specified arrhythmias	X
Cerebral hemorrhage	CC 95 Cerebral hemorrhage	X
Ischemic or unspecified stroke	CC 96 Ischemic or unspecified stroke	X
Precerebral arterial occlusion and transient cerebral ischemia	CC 97 Precerebral arterial occlusion and transient cerebral ischemia	X

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
Cerebral atherosclerosis and aneurysm	CC 98 Cerebral atherosclerosis and aneurysm	
Hemiplegia/hemiparesis	CC 100 Hemiplegia/hemiparesis	X
History of infection	CC 1 HIV/AIDS	
	CC 3 Central nervous system infection	
	CC 4 Tuberculosis	
	CC 5 Opportunistic infections	
	CC 6 Other infectious diseases	X
Metastatic cancer, acute leukemia and other severe cancers	CC 7 Metastatic cancer or acute leukemia	
	CC 8 Lung, upper digestive tract, and other severe cancers	
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other major cancers	CC 9 Lymphatic, head and neck, brain, and other major cancers	
	CC 10 Breast, prostate, colorectal and other cancers and tumors	
	CC 11 Other respiratory and heart neoplasms	
	CC 12 Other digestive and urinary neoplasms	
	CC 13 Other neoplasms	
Protein-calorie malnutrition	CC 21 Protein-calorie malnutrition	
Disorders of fluid/electrolyte/acid-base; other endocrine/metabolic/nutritional disorders	CC 22 Other significant endocrine and metabolic disorders	
	CC 23 Disorders of fluid/electrolyte/acid-base balance	X
	CC 24 Other endocrine/metabolic/nutritional disorders	
Other gastrointestinal disorders	CC 36 Other gastrointestinal disorders	
Disorders of the vertebrae and spinal discs	CC 39 Disorders of the vertebrae and spinal discs	
Osteoarthritis of hip or knee	CC 40 Osteoarthritis of hip or knee	
Other musculoskeletal and connective tissue disorders	CC 43 Other musculoskeletal and connective tissue disorders	
Iron deficiency or other unspecified anemias and blood disease	CC 47 Iron deficiency or other unspecified anemias and blood disease	
Dementia or other specified brain disorders	CC 49 Dementia	
	CC 50 Senility, nonpsychotic organic brain syndromes/conditions	
Major psychiatric disorders	CC 54 Schizophrenia	
	CC 55 Major depressive, bipolar, and paranoid disorders	
	CC 56 Reactive and unspecified psychosis	
Quadriplegia, other extensive paralysis; paraplegia; spinal cord disorders/injuries	CC 67 Quadriplegia, other extensive paralysis	
	CC 68 Paraplegia	
	CC 69 Spinal cord disorders/injuries	
Multiple sclerosis; mononeuropathy, other neurological conditions/injuries	CC 72 Multiple sclerosis	
	CC 76 Mononeuropathy, other neurological conditions/injuries	
Seizure disorders and convulsions	CC 74 Seizure disorders and convulsions	

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
Hypertensive heart and renal disease or encephalopathy; hypertension	CC 89 Hypertensive heart and renal disease or encephalopathy	
	CC 91 Hypertension	
Vascular disease and complications	CC 104 Vascular disease with complications	X
	CC 105 Vascular disease	X
Chronic Obstructive Pulmonary Disease (COPD)	CC 108 Chronic Obstructive Pulmonary Disease (COPD)	
Pneumonia	CC 111 Aspiration and specified bacterial pneumonias	X
	CC 112 Pneumococcal pneumonia, emphysema, lung abscess	X
	CC 113 Viral and unspecified pneumonia, pleurisy	
Pleural effusion/pneumothorax	CC 114 Pleural effusion/pneumothorax	X
Other eye disorders	CC 124 Other eye disorders	X
Other ear, nose, throat, and mouth disorders	CC 127 Other ear, nose, throat, and mouth disorders	
Dialysis status	CC 130 Dialysis status	X
Renal failure	CC 131 Renal failure	X
Urinary tract infection	CC 135 Urinary tract infection	X
Male genital disorders	CC 140 Male genital disorders	
Decubitus ulcer of skin	CC 148 Decubitus ulcer of skin	X
Chronic ulcer of skin, except decubitus	CC 149 Chronic ulcer of skin, except decubitus	
Other dermatological disorders	CC 153 Other dermatological disorders	

Outcome

Outcome Criteria for Stroke Measure

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