2017 Condition-Specific Measures Updates and Specifications Report
Hospital-Level 30-Day Risk-Standardized Mortality Measures

Acute Myocardial Infarction – Version 11.0
Chronic Obstructive Pulmonary Disease – Version 6.0
Heart Failure – Version 11.0
Pneumonia – Version 11.0
Stroke – Version 6.0

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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 admissions. This report provides a single source of information about these measures for a wide range of readers. Reports describing other outcome measures can be found on *QualityNet*.

This report provides an overview of the measure methodology, methodology updates for 2017 public reporting, and the national results for 2017 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
  - Outcome
  - Risk-adjustment variables
  - Data sources
  - Mortality rate calculation
  - Categorization of hospitals' performance score
- **Section 3 - 2017 measure updates**
- **Section 4 - 2017 measure results**
- **Section 5 - Glossary**

The Appendices contain detailed measure information, consisting of:

- 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.

The original measure methodology reports and prior updates and specifications reports are available in the 'Measure Methodology' and 'Archived Resources' sections under the claims-based mortality measures page of *QualityNet.*[1-15]

The AMI, COPD, HF, and pneumonia mortality measure methodologies are also described in the peer-reviewed medical literature.[16-19]

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 (YNHHSC/CORE) to update the AMI, COPD, HF, pneumonia, and stroke mortality measures for 2017 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 2017 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.[1-15] 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; however, the hospitals included in the two programs differ slightly. More information about the Hospital VBP program can be found on the CMS website.

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.

The International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) codes used to define the cohort inclusions for each measure for discharges on or after October 1, 2015 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. ICD-9 code lists for discharges prior to October 1, 2015 can be found in the 2016 condition-specific mortality measures updates and specifications report posted on *QualityNet*.

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.

An additional exclusion criterion for the AMI, HF, and pneumonia cohorts is that patients discharged alive on the day of admission or the following calendar 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 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 group. The International Classification of Diseases, 10th Revision, Procedure Coding System (ICD-10-PCS) codes used to identify LVAD and heart transplant procedures in claims for discharges on or after October 1, 2015 are posted on *QualityNet* due to volume. ICD-9 code lists for discharges prior to October 1, 2015 can be found in the 2016 condition-specific mortality measures updates and specifications report also posted on *QualityNet*.

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 2014 or June/July 2015), 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, 2014, readmitted on July 2, 2014,

and subsequently dies on July 15, 2014: if both admissions are randomly selected for inclusion (one for the July 2013-June 2014 time period and the other for the July 2014-June 2015 time period), the measure will exclude the July 2, 2014 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, claims for patients not listed in the Medicare enrollment database, and records 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

The measures consider multiple contiguous hospitalizations as a single acute episode of care. Transfer patients are identified by tracking claims for inpatient short-term acute care hospitalizations over time. To qualify as a transfer, the second inpatient admission must occur on the same day or the next calendar day following discharge from the first inpatient admission at a different short-term acute care hospital. Cases that meet this criterion are considered transfers regardless of whether or not the first institution indicates intent to transfer the patient in the discharge disposition code.

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 transferred to Hospital B, only the Hospital A admission (the index admission) would be included in the cohort, and death within 30 days of the start 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 transferred 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.

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.[20] Death within 30 days of the start of the 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.[21]

In determining whether a death occurred within 30 days of the index admission, the measures use the claim "FROM" date, which is the date the index admission started (that is, the date the patient first received care at that hospital within three days of the admission). Thus, in the case where a patient began their index admission with an ED visit, observation stay, or care received in another outpatient location within the same facility, the case was converted to inpatient admission by that hospital within three days of that outpatient encounter, and the care is combined into one claim, the date the outpatient care started would be used for the 30-day time frame.

2.2.3 Risk-Adjustment Variables

In order to account for differences in case 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. As part of the NQF's endorsement process for these measures, we completed analyses for the two-year Sociodemographic Trial Period. Although univariate analyses found that the patient-level observed (unadjusted) mortality rates are higher for dual-eligible patients (for patients living in lower AHRQ SES Index census block groups) and African-American patients compared with all other patients, analyses in the context of a multivariable model demonstrated that the effect size of these variables was small, and that the c-statistics for the models are similar with and without the addition of these variables.

Refer to Table D.1.2, Table D.2.2, Table D.3.2, 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 only during the index admission, for AMI, COPD, HF, pneumonia, and stroke, respectively. The Condition Categories (CCs) outlined in these tables are used to identify risk variables in claims for discharges on or after October 1, 2015 as well as discharges prior to October 1, 2015. The ICD-10 code lists referenced in the tables that are used to identify certain risk variables (for example, history of PTCA) in discharges on or after October 1, 2015 are posted on *QualityNet* due to volume. For a list of ICD-9 codes used to identify these variables in discharges prior to October 1, 2015, please refer to the 2016 condition-specific mortality measures updates and specifications report posted on *QualityNet*.

Note that CC mappings to ICD-10-CM codes (for discharges on or after October 1, 2015) and ICD-9 codes (for discharges prior to October 1, 2015) are available on the *QualityNet* website.

2.2.4 Data Sources

The data sources for these analyses are Medicare administrative claims and enrollment information for patients with hospitalizations between July 1, 2013 and June 30, 2016. 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. Refer to 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 start 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.3.2, 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 calculate a predicted value. The "expected" number of deaths (the denominator) is obtained in the same manner except 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 attributed to a hospital to calculate an expected value. To assess hospital performance for each reporting period, we re-estimate the model coefficients using the years of data in that period.

Multiplying the predicted over expected ratio by the national observed mortality rate transforms the ratio into a rate that can be compared to the national observed mortality rate. The hierarchical logistic regression 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 2017 PUBLIC REPORTING

3.1 Rationale for Measure Updates

Annual 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. 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 2017 public reporting, we made the following modifications to the measures:

- Revised the measure specifications to accommodate the implementation of ICD-10 coding:
  - Identified the ICD-10 codes used to define each of the measure cohorts for discharges on or after October 1, 2015.
  - Re-specified the risk models, updating the CC-based risk variables to the ICD-10-compatible Hierarchical Condition Categories (HCC) system version 22 and applying ICD-10 codes for certain risk variables (for example, history of PTCA) to the models.

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

- Evaluated and validated model performance for the three years combined (July 2013-June 2016);
- Evaluated the stability of the risk-adjustment model over the three-year measurement period by examining the model variable frequencies, model coefficients, and the performance of the risk-adjustment model in each year (July 2013-June 2014, July 2014-June 2015, and July 2015-June 2016); and,
- Updated the measures' SAS analytic package (SAS pack) and documentation.

3.2 Detailed Discussion of Measure Updates

3.2.1 Updates to ICD-10-Based Measure Specifications

Measure Re-specification

We re-specified the measures to accommodate the implementation of ICD-10 coding. Specifically:

- We expanded the cohort definitions to include ICD-10 codes for use with discharges on or after October 1, 2015. (Previously-specified ICD-9 codes continue to be used for discharges before October 1, 2015.)
- We re-specified the risk models:
  - The CC-based risk variables were updated to the ICD-10-compatible Hierarchical Condition Categories (HCC) system version 22, maintained by RTI International; and,
  - Certain risk variables (for example, history of PTCA) previously defined using ICD-9 codes were re-defined using ICD-10 codes, for use with inpatient, outpatient, and/or physician Medicare administrative claims on or after October 1, 2015.

Rationale for Measure Re-specification

On October 1, 2015, the ICD-9 code sets used to report medical diagnoses and inpatient procedures were replaced by ICD-10 code sets. The Department of Health and Human Services (HHS) has mandated that ICD-10 codes be used by all HIPAA-covered entities for medical coding, effective for October 1, 2015+ discharges. More information on ICD-10 coding can be found on the CMS website.

The condition-specific mortality measures use Medicare FFS claims to define the measure cohorts and identify patient comorbidities for measure risk adjustment. In public reporting years prior to 2017, the measures exclusively used ICD-9 codes from claims. However, the measurement period for 2017 public reporting requires data from claims that include ICD-10 codes in addition to data from claims that include ICD-9 codes. Thus, re-specification of both of the above components was warranted to accommodate ICD-10 coding.

The goal of this re-specification was to maintain the intent and validity of the measures.

The ICD-10 Transition Process

In developing the ICD-10 code lists that define the cohorts for the measures, we created cohort crosswalks using the General Equivalence Mappings (GEMs), a tool created by CMS and the Centers for Disease Control and Prevention (CDC) to assist with the conversion of ICD-9 codes to ICD-10 codes. To validate the cohort crosswalks, we compared cohort sizes using ICD-10 codes in a set of claims submitted between October 2015 and March 2016 with cohort sizes using previously-defined ICD-9 codes in a set of claims submitted between October 2014 and March 2015. We conducted clinical review to identify those codes appropriate for cohort definition.

The risk variables were updated to the ICD-10-compatible HCC version 22 map. The intent was to keep the risk-adjustment model as similar as possible to the model previously defined using HCC version 12. Specifically:

- Experts examined the ICD-9 code-based HCC version 12 and version 22 maps and reviewed shifts that occurred (where an ICD-9 code had moved from one CC to another). Based on these examinations, they recommended new risk variables using version 22 CCs.
- Following re-specification of the risk variables using the HCC version 22 map, we ran risk-adjustment models on several outcome measures, including the COPD mortality measure, to ensure testing of all variables where shifts in the ICD-9 codes included in the CCs had occurred.
- For each tested measure, we used the same claims dataset to calculate and compare two separate sets of measure results using two separate risk-adjustment models: One set using the previously-specified version 12 risk variables, and the other using the newly-specified version 22 risk variables. For this analysis we used the ICD-9-coded data from the 2016 measurement period.
    - We compared the frequencies and model coefficients of the two sets of risk-adjustment variables, to ensure that they were similar.

- We compared the performance of each risk-adjustment model by calculating each model's c-statistic and predictive ability.
- We examined the correlation in the risk-standardized outcome rates produced by the two risk-adjustment models, to ensure that they produced similar measure results.
- We examined the degree to which the models produced similar risk-standardized outcome rates at the hospital level by assessing whether individual hospitals' risk-standardized rates fell into the same quintile in the distribution of risk-standardized rates calculated by each of the two models.
- Based on the results of these analyses, we made minor modifications to the re-specified risk-adjustment variables to ensure that the performance of the risk-adjustment model was as similar as possible to the performance of the previously-specified model, and that the hospital-level results were as similar as possible.

The updated measure specifications can be found in Appendix D.

3.3 Changes to SAS Pack

We revised the measure calculation SAS packs to reflect the re-specifications done to accommodate the implementation of ICD-10 coding. The new SAS packs 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 packs describe 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 packs available to be completely transparent regarding the measure calculation methodology. However, note that even with the SAS packs, 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 2017 PUBLIC REPORTING

4.1 Assessment of Updated Models

The mortality measures estimate hospital-specific 30-day all-cause RSMRs using hierarchical logistic regression models. Refer to Section 2 for a summary of the measure methodology and model risk-adjustment variables. Refer to prior methodology and technical reports for further details.[1-15]

We evaluated the performance of the models, using the July 2013-June 2016 data for the 2017 reporting period. We examined the differences in the frequencies 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). We also computed between-hospital variance for each year of data and for the three-year combined period. If there were no systematic differences between hospitals, the between-hospital variance would be zero.

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

4.2 AMI Mortality 2017 Model Results

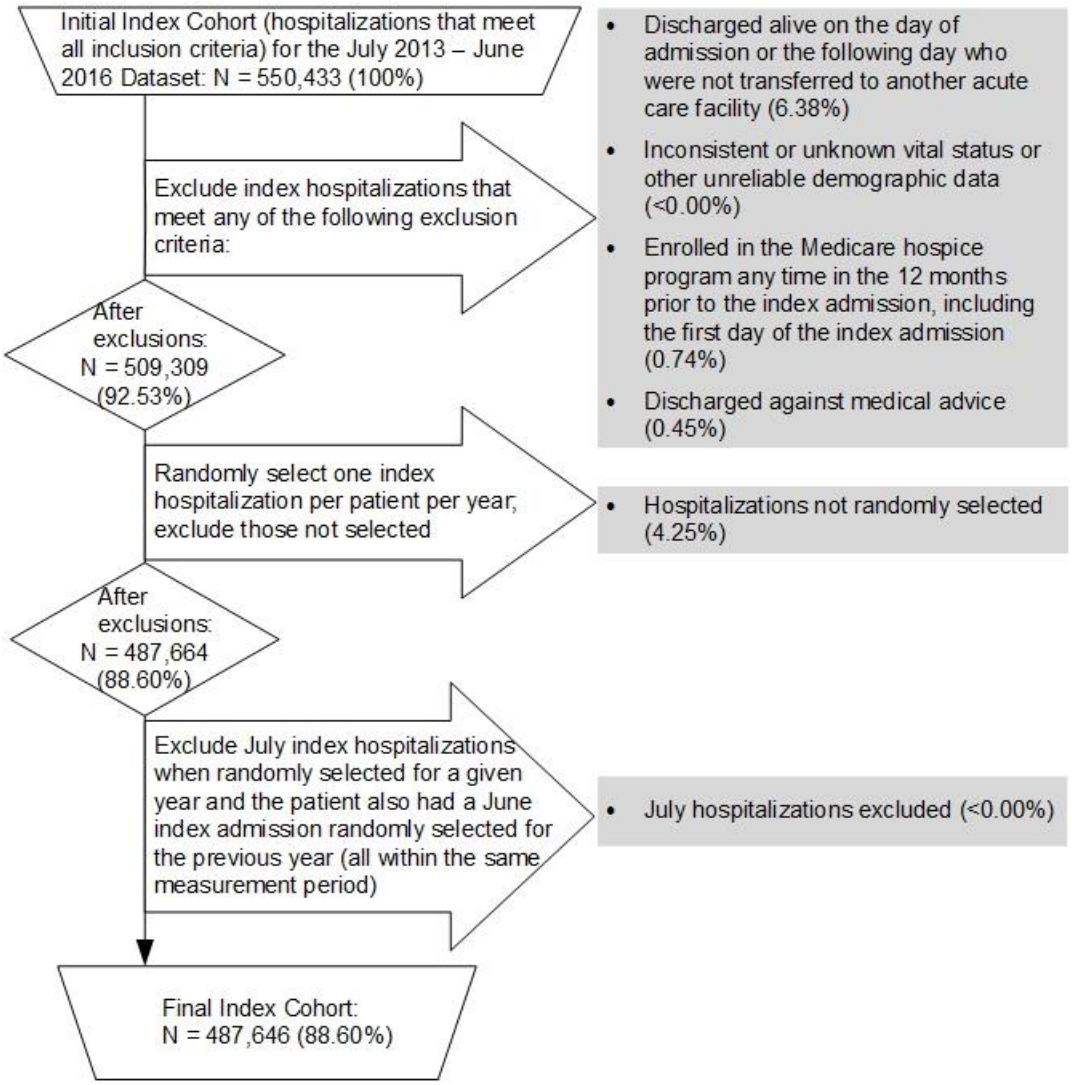
4.2.1 Index Cohort Exclusions

The exclusion criteria for this measure are presented in Section 2.2.1. The percentage of AMI admissions that met each exclusion criterion in the July 2013-June 2016 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 2013-June 2016 Dataset



4.2.2 Frequency of AMI Model Variables

We examined the change in the frequencies of clinical and demographic variables. Frequencies of model variables were stable over the measurement period. The largest changes in the frequencies (those greater than 2% absolute change) include an increase in Other location of myocardial infarction (12.0% to 14.5%).

Refer to Table 4.2.1 for more detail. Note that the increases and decreases in some model variables may reflect not only changes in rates of comorbidities in the Medicare FFS population, but also changes due to ICD-10 code implementation effective with October 1, 2015+ discharges.

4.2.3 AMI Model Parameters and Performance

Table 4.2.2 shows hierarchical logistic regression model variable coefficients by individual year and for the combined three-year dataset. Table 4.2.3 shows the risk-adjusted odds ratio (ORs) and 95% confidence intervals (CIs) for the 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 Mortality Rates for AMI

The national *observed* mortality rate in the combined three-year dataset was 13.6%. Between July 2013-June 2014 and July 2015-June 2016, the *observed* rate decreased from 13.8% to 13.1%.

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 13.8% (between July 2013 and June 2014) to 13.1% (between July 2015 and June 2016). The median hospital RSMR in the combined three-year dataset was 13.6% (interquartile range [IQR]: 13.2% - 14.1%). Table 4.2.7 shows the between-hospital variance by individual year, as well as for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.036 (Standard Error [SE]: 0.003).

Figure 4.2.2 shows the overall distribution of the hospital RSMRs for the combined three-year dataset. The odds of all-cause mortality if a patient is 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 4,310 hospitals in the study cohort, 41 performed "Better than the National Rate," 2,321 performed "No Different from the National Rate," and 22 performed "Worse than the National Rate." 1,926 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	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Total N	161,480	162,795	163,371	487,646
Mean age minus 65 (SD)	13.7 (8.4)	13.7 (8.4)	13.4 (8.4)	13.6 (8.4)
Male (%)	52.2	52.6	53.0	52.6
Anterior myocardial infarction	7.8	7.5	7.5	7.6
Other location of myocardial infarction	12.0	11.6	14.5	12.7
History of coronary artery bypass graft (CABG) surgery	11.8	12.1	13.7	12.5
History of percutaneous transluminal coronary angioplasty (PTCA)	17.5	18.5	19.1	18.4
Metastatic cancer, acute leukemia and other severe cancers (CC 8-9)	4.2	4.2	4.2	4.2
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 17-19, 123)	47.2	47.3	47.7	47.4
Protein-calorie malnutrition (CC 21)	6.4	6.5	6.3	6.4
Chronic liver disease (CC 27-29)	1.5	1.7	1.8	1.7
Dementia or other specified brain disorders (CC 51-53)	19.7	19.5	18.9	19.3
Major psychiatric disorders (CC 57-59)	8.0	8.0	7.1	7.7
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	4.8	4.8	5.0	4.9
Cardio-respiratory failure and shock (CC 84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	10.9	11.3	11.9	11.3
Congestive heart failure (CC 85)	29.2	28.9	28.7	28.9
Acute myocardial infarction (CC 86)	12.8	12.1	13.4	12.7
Unstable angina and other acute ischemic heart disease (CC 87)	13.1	12.9	11.4	12.5
Coronary atherosclerosis or angina (CC 88-89)	84.9	84.9	83.0	84.2
Valvular and rheumatic heart disease (CC 91)	31.6	32.2	32.2	32.0
Hypertension (CC 95)	83.9	84.2	84.8	84.3
Stroke (CC 99-100)	7.1	7.0	6.8	7.0
Cerebrovascular disease (CC 101-102, 105)	21.7	21.2	20.2	21.0
Vascular disease and complications (CC 106-108)	27.4	27.2	27.3	27.3
Chronic obstructive pulmonary disease (COPD) (CC 111)	30.0	29.8	29.3	29.7
Pneumonia (CC 114-116)	22.4	22.6	21.2	22.1
Renal failure (CC 135-140)	38.6	39.4	40.0	39.3
Trauma; other injuries (CC 166-168, 170-174)	31.4	31.8	32.6	31.9

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

Variable	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Intercept	-2.883	-2.850	-3.135	-2.949
Age minus 65 (years above 65, continuous)	0.055	0.054	0.058	0.056
Male	0.111	0.109	0.089	0.103
Anterior myocardial infarction	0.833	0.847	0.961	0.881
Other location of myocardial infarction	0.543	0.508	0.864	0.652
History of coronary artery bypass graft (CABG) surgery	0.070	0.076	0.011	0.049
History of percutaneous transluminal coronary angioplasty (PTCA)	-0.288	-0.276	-0.251	-0.272
Metastatic cancer, acute leukemia and other severe cancers (CC 8-9)	0.647	0.650	0.639	0.649
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 17-19, 123)	0.076	0.104	0.137	0.105
Protein-calorie malnutrition (CC 21)	0.546	0.543	0.555	0.552
Chronic liver disease (CC 27-29)	0.408	0.464	0.434	0.440
Dementia or other specified brain disorders (CC 51-53)	0.373	0.380	0.379	0.377
Major psychiatric disorders (CC 57-59)	0.115	0.032	0.056	0.073
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	0.221	0.285	0.323	0.277
Cardio-respiratory failure and shock (CC 84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	0.197	0.153	0.134	0.158
Congestive heart failure (CC 85)	0.260	0.259	0.199	0.242
Acute myocardial infarction (CC 86)	-0.038	0.035	0.040	0.007
Unstable angina and other acute ischemic heart disease (CC 87)	-0.107	-0.055	-0.113	-0.083
Coronary atherosclerosis or angina (CC 88-89)	-0.462	-0.486	-0.367	-0.433
Valvular and rheumatic heart disease (CC 91)	0.084	0.060	0.101	0.085
Hypertension (CC 95)	-0.259	-0.266	-0.296	-0.275
Stroke (CC 99-100)	0.028	-0.008	-0.022	0.000
Cerebrovascular disease (CC 101-102, 105)	0.016	0.016	0.032	0.022
Vascular disease and complications (CC 106-108)	0.073	0.077	0.085	0.081
Chronic obstructive pulmonary disease (COPD) (CC 111)	0.098	0.100	0.154	0.114
Pneumonia (CC 114-116)	0.426	0.411	0.413	0.418
Renal failure (CC 135-140)	0.263	0.275	0.288	0.275
Trauma; other injuries (CC 166-168, 170-174)	-0.004	0.043	0.000	0.013

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

Variable	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2015-06/2016 OR (95% CI)	07/2013-06/2016 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.06 (1.05 - 1.06)	1.06 (1.05 - 1.06)	1.06 (1.06 - 1.06)	1.06 (1.06 - 1.06)
Male	1.12 (1.08 - 1.15)	1.12 (1.08 - 1.15)	1.09 (1.06 - 1.13)	1.11 (1.09 - 1.13)
Anterior myocardial infarction	2.30 (2.19 - 2.42)	2.33 (2.22 - 2.46)	2.61 (2.48 - 2.76)	2.41 (2.34 - 2.49)
Other location of myocardial infarction	1.72 (1.64 - 1.80)	1.66 (1.59 - 1.74)	2.37 (2.28 - 2.47)	1.92 (1.87 - 1.97)
History of coronary artery bypass graft (CABG) surgery	1.07 (1.02 - 1.12)	1.08 (1.03 - 1.13)	1.01 (0.97 - 1.06)	1.05 (1.02 - 1.08)
History of percutaneous transluminal coronary angioplasty (PTCA)	0.75 (0.72 - 0.79)	0.76 (0.73 - 0.79)	0.78 (0.75 - 0.81)	0.76 (0.74 - 0.78)
Metastatic cancer, acute leukemia and other severe cancers (CC 8-9)	1.91 (1.80 - 2.03)	1.92 (1.80 - 2.04)	1.90 (1.78 - 2.02)	1.91 (1.85 - 1.98)
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 17-19, 123)	1.08 (1.05 - 1.11)	1.11 (1.08 - 1.14)	1.15 (1.11 - 1.18)	1.11 (1.09 - 1.13)
Protein-calorie malnutrition (CC 21)	1.73 (1.64 - 1.81)	1.72 (1.64 - 1.81)	1.74 (1.66 - 1.83)	1.74 (1.69 - 1.79)
Chronic liver disease (CC 27-29)	1.50 (1.35 - 1.67)	1.59 (1.44 - 1.76)	1.54 (1.40 - 1.71)	1.55 (1.47 - 1.65)
Dementia or other specified brain disorders (CC 51-53)	1.45 (1.40 - 1.50)	1.46 (1.41 - 1.52)	1.46 (1.41 - 1.52)	1.46 (1.43 - 1.49)
Major psychiatric disorders (CC 57-59)	1.12 (1.07 - 1.18)	1.03 (0.98 - 1.09)	1.06 (1.00 - 1.12)	1.08 (1.04 - 1.11)
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	1.25 (1.17 - 1.33)	1.33 (1.25 - 1.42)	1.38 (1.30 - 1.47)	1.32 (1.27 - 1.37)
Cardio-respiratory failure and shock (CC 84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	1.22 (1.16 - 1.28)	1.17 (1.11 - 1.22)	1.14 (1.09 - 1.20)	1.17 (1.14 - 1.20)
Congestive heart failure (CC 85)	1.30 (1.25 - 1.35)	1.30 (1.25 - 1.34)	1.22 (1.17 - 1.27)	1.27 (1.25 - 1.30)
Acute myocardial infarction (CC 86)	0.96 (0.92 - 1.01)	1.04 (0.99 - 1.09)	1.04 (0.99 - 1.09)	1.01 (0.98 - 1.04)
Unstable angina and other acute ischemic heart disease (CC 87)	0.90 (0.85 - 0.95)	0.95 (0.90 - 1.00)	0.89 (0.85 - 0.94)	0.92 (0.89 - 0.95)
Coronary atherosclerosis or angina (CC 88-89)	0.63 (0.61 - 0.66)	0.62 (0.59 - 0.64)	0.69 (0.67 - 0.72)	0.65 (0.63 - 0.66)
Valvular and rheumatic heart disease (CC 91)	1.09 (1.05 - 1.12)	1.06 (1.03 - 1.10)	1.11 (1.07 - 1.14)	1.09 (1.07 - 1.11)
Hypertension (CC 95)	0.77 (0.74 - 0.80)	0.77 (0.74 - 0.80)	0.74 (0.71 - 0.78)	0.76 (0.74 - 0.78)
Stroke (CC 99-100)	1.03 (0.97 - 1.09)	0.99 (0.94 - 1.05)	0.98 (0.92 - 1.04)	1.00 (0.97 - 1.03)
Cerebrovascular disease (CC 101-102, 105)	1.02 (0.98 - 1.06)	1.02 (0.98 - 1.06)	1.03 (0.99 - 1.07)	1.02 (1.00 - 1.05)
Vascular disease and complications (CC 106-108)	1.08 (1.04 - 1.11)	1.08 (1.04 - 1.12)	1.09 (1.05 - 1.13)	1.08 (1.06 - 1.11)
Chronic obstructive pulmonary disease (COPD) (CC 111)	1.10 (1.07 - 1.14)	1.11 (1.07 - 1.14)	1.17 (1.13 - 1.21)	1.12 (1.10 - 1.14)
Pneumonia (CC 114-116)	1.53 (1.48 - 1.59)	1.51 (1.46 - 1.56)	1.51 (1.46 - 1.57)	1.52 (1.49 - 1.55)
Renal failure (CC 135-140)	1.30 (1.26 - 1.34)	1.32 (1.27 - 1.36)	1.33 (1.29 - 1.38)	1.32 (1.29 - 1.34)
Trauma; other injuries (CC 166-168, 170-174)	1.00 (0.96 - 1.03)	1.04 (1.01 - 1.08)	1.00 (0.97 - 1.03)	1.01 (0.99 - 1.03)

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

Characteristic	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Predictive ability, % (lowest decile – highest decile)	2.8 - 34.7	3.0 - 34.5	2.5 - 34.9	2.8 - 34.6
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	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Number of hospitals	3,949	3,882	3,794	4,310
Mean number of admissions (SD)	40.9 (54.9)	41.9 (55.9)	43.1 (57.5)	113.1 (162.7)
Range (min. – max.)	1 - 474	1 - 508	1 - 559	1 - 1,541
25th percentile	4	4	4	7
50th percentile	17	18	18	37
75th percentile	60	62	63	165

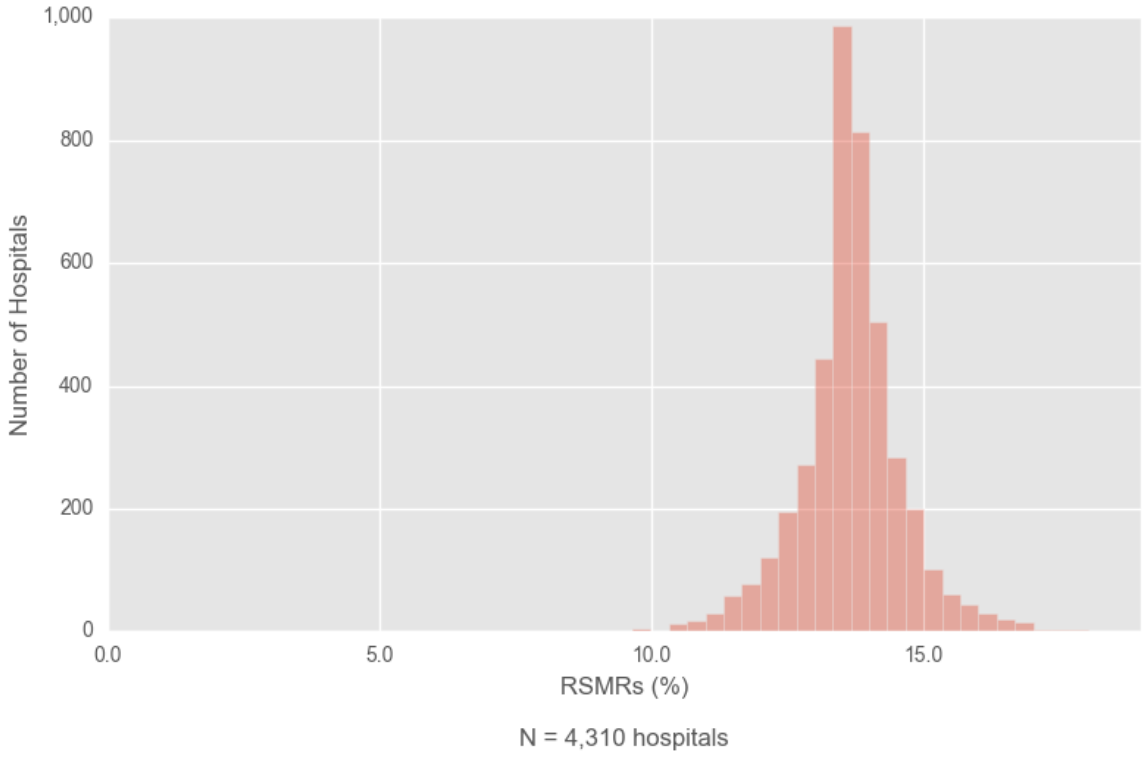
Table 4.2.6 – Distribution of Hospital AMI RSMRs over Different Time Periods

Characteristic	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Number of hospitals	3,949	3,882	3,794	4,310
Mean (SD)	13.8 (0.5)	14.0 (0.7)	13.1 (0.6)	13.7 (0.9)
Range (min. – max.)	11.1 - 17.1	10.5 - 18.5	10.3 - 16.2	9.7 - 18.0
25th percentile	13.6	13.7	12.9	13.2
50th percentile	13.8	13.9	13.1	13.6
75th percentile	14.1	14.3	13.4	14.1

Table 4.2.7 – Between-Hospital Variance for AMI

	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Between-hospital variance (SE)	0.026 (0.005)	0.035 (0.005)	0.030 (0.005)	0.036 (0.003)

Figure 4.2.2 – Distribution of Hospital 30-Day AMI RSMRs between July 2013 and June 2016



4.3 COPD Mortality 2017 Model Results

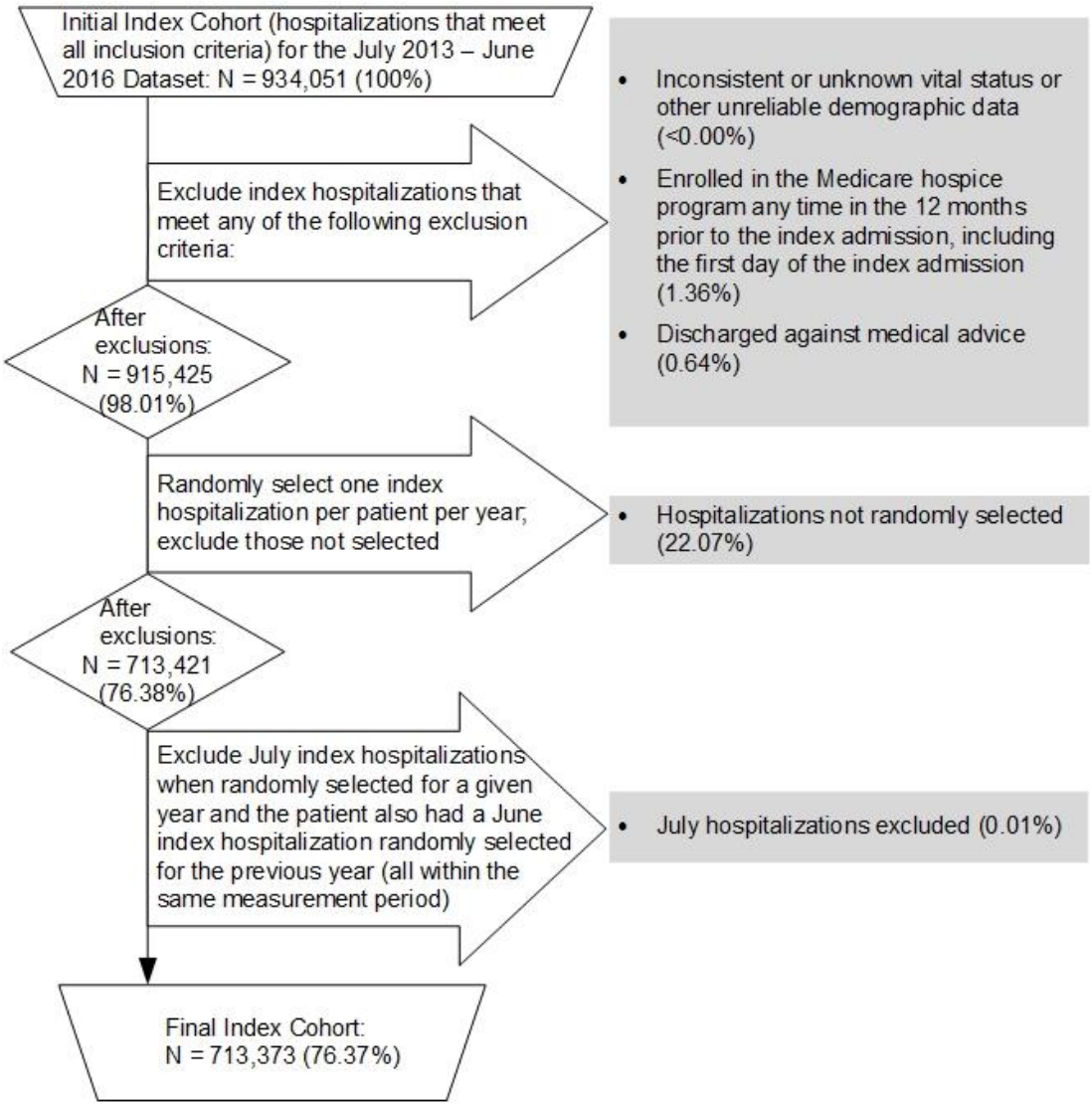
4.3.1 Index Cohort Exclusions

The exclusion criteria for this measure are presented in Section 2.2.1. The percentage of COPD admissions that met each exclusion criterion in the July 2013-June 2016 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 2013-June 2016 Dataset



4.3.2 Frequency of COPD Model Variables

We examined the change in the frequencies of clinical and demographic variables. Frequencies of model variables were stable over the measurement period. The largest changes in the frequencies (those greater than 2% absolute change) include increases in Asthma (16.3% to 23.8%), Cardio-respiratory failure and shock (35.3% to 40.1%), Other psychiatric disorders (30.4% to 33.1%), Other respiratory disorders (56.9% to 64.2%), and Renal failure (32.9% to 35.0%).

Refer to Table 4.3.1 for more detail. Note that the increases and decreases in some model variables may reflect not only changes in rates of comorbidities in the Medicare FFS population, but also changes due to ICD-10 code implementation effective with October 1, 2015+ discharges.

4.3.3 COPD Model Parameters and Performance

Table 4.3.2 shows hierarchical logistic 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 Mortality Rates for COPD

The national *observed* mortality rate in the combined three-year dataset was 8.0%. Between July 2013-June 2014 and July 2015-June 2016, the *observed* rate increased slightly from 8.0% to 8.1%.

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 increased slightly over the three-year period, from 8.0% (between July 2013 and June 2014) to 8.1% (between July 2015 and June 2016). The median hospital RSMR in the combined three-year dataset was 8.0% (IQR: 7.5% - 8.5%). Table 4.3.7 shows the between-hospital variance by individual year, as well as for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.061 (SE: 0.004).

Figure 4.3.2 shows the overall distribution of the hospital RSMRs for the combined three-year dataset. The odds of all-cause mortality if a patient is treated at a hospital one SD above the national rate were 1.64 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 4,619 hospitals in the study cohort, 51 performed “Better than the National Rate,” 3,516 performed “No Different from the National Rate,” and 86 performed “Worse than the National Rate.” 966 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	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Total N	241,604	249,481	222,288	713,373
Mean age minus 65 (SD)	11.8 (7.6)	12.0 (7.7)	11.7 (7.6)	11.9 (7.6)
History of mechanical ventilation	9.1	9.2	9.9	9.4
Metastatic cancer or acute leukemia (CC 8)	2.7	2.7	3.0	2.8
Lung and other severe cancers (CC 9)	7.1	7.0	7.5	7.2
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other cancers and tumors; other respiratory and heart neoplasms (CC 10-13)	13.9	13.8	13.7	13.8
Other digestive and urinary neoplasms (CC 14)	6.6	6.5	6.4	6.5
Diabetes mellitus (DM) or DM complications (CC 17-19, 122-123)	42.7	42.4	42.1	42.4
Protein-calorie malnutrition (CC 21)	10.4	10.3	11.2	10.6
Morbid obesity; other endocrine/metabolic/nutritional disorders (CC 22, 25-26)	81.5	82.3	82.6	82.1
Other significant endocrine and metabolic disorders; disorders of fluid/electrolyte/acid-base balance (CC 23-24)	37.3	36.9	38.3	37.5
Other gastrointestinal disorders (CC 38)	64.4	64.5	65.3	64.7
Osteoarthritis of hip or knee (CC 42)	10.9	11.2	11.6	11.2
Other musculoskeletal and connective tissue disorders (CC 45)	70.7	71.2	70.8	70.9
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	51.3	50.4	50.4	50.7
Dementia or other specified brain disorders (CC 51-53)	18.5	18.2	18.3	18.3
Drug/alcohol abuse, without dependence (CC 56)	32.4	32.5	34.1	33.0
Other psychiatric disorders (CC 63)	30.4	31.4	33.1	31.6
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	4.3	4.3	4.8	4.5
Polyneuropathy, mononeuropathy, and other neurological conditions/injuries (CC 81)	21.1	21.5	22.5	21.7
Respirator dependence/respiratory failure (CC 82-83)	1.2	1.1	1.2	1.2
Cardio-respiratory failure and shock (CC 84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	35.3	36.1	40.1	37.1
Congestive heart failure (CC 85)	42.3	41.8	42.7	42.2
Coronary atherosclerosis or angina (CC 88-89)	51.9	51.4	50.7	51.4
Hypertension and hypertensive disease (CC 94-95)	85.0	85.1	85.4	85.2
Specified arrhythmias and other heart rhythm disorders (CC 96-97)	41.8	41.9	42.1	41.9
Stroke (CC 99-100)	6.1	6.0	5.9	6.0
Vascular or circulatory disease (CC 106-109)	41.9	41.8	42.2	41.9
Fibrosis of lung or other chronic lung disorders (CC 112)	14.7	14.2	13.9	14.3
Asthma (CC 113)	16.3	15.8	23.8	18.5
Pneumonia (CC 114-116)	48.9	47.6	48.3	48.2
Pleural effusion/pneumothorax (CC 117)	14.0	13.9	14.8	14.2
Other respiratory disorders (CC 118)	56.9	56.9	64.2	59.2
Other retinal disorders (CC 125)	11.2	11.6	11.5	11.4
Other eye disorders (CC 128)	20.0	20.4	20.3	20.2
Other ear, nose, throat, and mouth disorders (CC 131)	37.4	37.5	37.1	37.4
Renal failure (CC 135-140)	32.9	33.7	35.0	33.8

Variable	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Decubitus ulcer or chronic skin ulcer (CC 157-161)	8.0	7.9	8.1	8.0
Other dermatological disorders (CC 165)	31.2	31.6	31.7	31.5
Trauma (CC 166-168, 170-173)	10.7	11.0	11.2	11.0
Vertebral fractures without spinal cord injury (CC 169)	4.9	5.0	5.0	4.9
Major complications of medical care and trauma (CC 176-177)	8.9	8.7	8.9	8.8

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

Variable	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Intercept	-2.957	-3.051	-2.912	-2.991
Age minus 65 (years above 65, continuous)	0.034	0.036	0.033	0.035
History of mechanical ventilation	0.189	0.216	0.198	0.203
Metastatic cancer or acute leukemia (CC 8)	0.878	0.916	0.925	0.906
Lung and other severe cancers (CC 9)	0.608	0.563	0.603	0.594
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other cancers and tumors; other respiratory and heart neoplasms (CC 10-13)	0.035	0.042	-0.012	0.024
Other digestive and urinary neoplasms (CC 14)	-0.231	-0.169	-0.229	-0.206
Diabetes mellitus (DM) or DM complications (CC 17-19, 122-123)	-0.050	-0.051	-0.021	-0.039
Protein-calorie malnutrition (CC 21)	0.749	0.773	0.733	0.760
Morbid obesity; other endocrine/metabolic/nutritional disorders (CC 22, 25-26)	-0.167	-0.134	-0.190	-0.161
Other significant endocrine and metabolic disorders; disorders of fluid/electrolyte/acid-base balance (CC 23-24)	0.081	0.084	0.090	0.086
Other gastrointestinal disorders (CC 38)	-0.155	-0.178	-0.158	-0.165
Osteoarthritis of hip or knee (CC 42)	-0.315	-0.308	-0.266	-0.294
Other musculoskeletal and connective tissue disorders (CC 45)	-0.184	-0.195	-0.194	-0.190
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	0.228	0.213	0.258	0.233
Dementia or other specified brain disorders (CC 51-53)	0.177	0.192	0.161	0.181
Drug/alcohol abuse, without dependence (CC 56)	-0.146	-0.106	-0.163	-0.139
Other psychiatric disorders (CC 63)	0.133	0.177	0.133	0.149
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	0.050	0.078	0.058	0.065
Polyneuropathy, mononeuropathy, and other neurological conditions/injuries (CC 81)	-0.104	-0.126	-0.090	-0.109
Respirator dependence/respiratory failure (CC 82-83)	-0.019	-0.301	-0.069	-0.123
Cardio-respiratory failure and shock (CC 84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	0.380	0.372	0.346	0.365
Congestive heart failure (CC 85)	0.223	0.212	0.188	0.209
Coronary atherosclerosis or angina (CC 88-89)	-0.044	-0.038	-0.027	-0.035
Hypertension and hypertensive disease (CC 94-95)	-0.187	-0.137	-0.131	-0.150
Specified arrhythmias and other heart rhythm disorders (CC 96-97)	0.073	0.073	0.098	0.081
Stroke (CC 99-100)	-0.104	-0.013	-0.036	-0.049
Vascular or circulatory disease (CC 106-109)	0.020	-0.004	-0.017	0.002

Variable	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Fibrosis of lung or other chronic lung disorders (CC 112)	0.142	0.133	0.159	0.146
Asthma (CC 113)	-0.376	-0.386	-0.329	-0.356
Pneumonia (CC 114-116)	0.207	0.228	0.204	0.215
Pleural effusion/pneumothorax (CC 117)	0.228	0.161	0.222	0.202
Other respiratory disorders (CC 118)	-0.193	-0.188	-0.283	-0.217
Other retinal disorders (CC 125)	-0.068	-0.087	-0.042	-0.068
Other eye disorders (CC 128)	-0.153	-0.113	-0.087	-0.117
Other ear, nose, throat, and mouth disorders (CC 131)	-0.199	-0.233	-0.240	-0.224
Renal failure (CC 135-140)	0.144	0.154	0.152	0.152
Decubitus ulcer or chronic skin ulcer (CC 157-161)	0.331	0.314	0.262	0.304
Other dermatological disorders (CC 165)	-0.104	-0.114	-0.109	-0.109
Trauma (CC 166-168, 170-173)	-0.005	0.039	0.050	0.027
Vertebral fractures without spinal cord injury (CC 169)	0.219	0.244	0.251	0.236
Major complications of medical care and trauma (CC 176-177)	-0.179	-0.112	-0.128	-0.141

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

Variable	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2015-06/2016 OR (95% CI)	07/2013-06/2016 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.03 (1.03 - 1.04)	1.04 (1.04 - 1.04)	1.03 (1.03 - 1.04)	1.04 (1.03 - 1.04)
History of mechanical ventilation	1.21 (1.15 - 1.27)	1.24 (1.18 - 1.30)	1.22 (1.16 - 1.28)	1.23 (1.19 - 1.26)
Metastatic cancer or acute leukemia (CC 8)	2.41 (2.24 - 2.59)	2.50 (2.32 - 2.69)	2.52 (2.34 - 2.72)	2.47 (2.37 - 2.58)
Lung and other severe cancers (CC 9)	1.84 (1.74 - 1.94)	1.76 (1.67 - 1.85)	1.83 (1.73 - 1.93)	1.81 (1.76 - 1.87)
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other cancers and tumors; other respiratory and heart neoplasms (CC 10-13)	1.04 (0.99 - 1.08)	1.04 (1.00 - 1.09)	0.99 (0.94 - 1.04)	1.02 (1.00 - 1.05)
Other digestive and urinary neoplasms (CC 14)	0.79 (0.74 - 0.85)	0.85 (0.79 - 0.90)	0.80 (0.74 - 0.86)	0.81 (0.78 - 0.85)
Diabetes mellitus (DM) or DM complications (CC 17-19, 122-123)	0.95 (0.92 - 0.98)	0.95 (0.92 - 0.98)	0.98 (0.95 - 1.01)	0.96 (0.94 - 0.98)
Protein-calorie malnutrition (CC 21)	2.12 (2.03 - 2.20)	2.17 (2.08 - 2.25)	2.08 (2.00 - 2.17)	2.14 (2.09 - 2.19)
Morbid obesity; other endocrine/metabolic/nutritional disorders (CC 22, 25-26)	0.85 (0.81 - 0.88)	0.87 (0.84 - 0.91)	0.83 (0.79 - 0.86)	0.85 (0.83 - 0.87)
Other significant endocrine and metabolic disorders; disorders of fluid/electrolyte/acid-base balance (CC 23-24)	1.08 (1.05 - 1.12)	1.09 (1.05 - 1.13)	1.09 (1.05 - 1.14)	1.09 (1.07 - 1.11)
Other gastrointestinal disorders (CC 38)	0.86 (0.83 - 0.89)	0.84 (0.81 - 0.87)	0.85 (0.82 - 0.89)	0.85 (0.83 - 0.87)
Osteoarthritis of hip or knee (CC 42)	0.73 (0.69 - 0.77)	0.74 (0.70 - 0.78)	0.77 (0.72 - 0.81)	0.75 (0.72 - 0.77)
Other musculoskeletal and connective tissue disorders (CC 45)	0.83 (0.80 - 0.86)	0.82 (0.79 - 0.85)	0.82 (0.79 - 0.86)	0.83 (0.81 - 0.85)
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	1.26 (1.21 - 1.30)	1.24 (1.20 - 1.28)	1.30 (1.25 - 1.34)	1.26 (1.24 - 1.29)
Dementia or other specified brain disorders (CC 51-53)	1.19 (1.15 - 1.24)	1.21 (1.17 - 1.26)	1.18 (1.13 - 1.22)	1.20 (1.17 - 1.23)
Drug/alcohol abuse, without dependence (CC 56)	0.86 (0.83 - 0.90)	0.90 (0.87 - 0.93)	0.85 (0.82 - 0.88)	0.87 (0.85 - 0.89)
Other psychiatric disorders (CC 63)	1.14 (1.11 - 1.18)	1.19 (1.16 - 1.23)	1.14 (1.10 - 1.18)	1.16 (1.14 - 1.18)

Variable	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2015-06/2016 OR (95% CI)	07/2013-06/2016 OR (95% CI)
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	1.05 (0.98 - 1.13)	1.08 (1.01 - 1.16)	1.06 (0.99 - 1.14)	1.07 (1.03 - 1.11)
Polyneuropathy, mononeuropathy, and other neurological conditions/injuries (CC 81)	0.90 (0.87 - 0.94)	0.88 (0.85 - 0.92)	0.91 (0.88 - 0.95)	0.90 (0.88 - 0.92)
Respirator dependence/respiratory failure (CC 82-83)	0.98 (0.88 - 1.10)	0.74 (0.65 - 0.84)	0.93 (0.82 - 1.06)	0.88 (0.82 - 0.95)
Cardio-respiratory failure and shock (CC 84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	1.46 (1.41 - 1.52)	1.45 (1.40 - 1.50)	1.41 (1.36 - 1.47)	1.44 (1.41 - 1.47)
Congestive heart failure (CC 85)	1.25 (1.21 - 1.30)	1.24 (1.19 - 1.28)	1.21 (1.16 - 1.25)	1.23 (1.21 - 1.26)
Coronary atherosclerosis or angina (CC 88-89)	0.96 (0.93 - 0.99)	0.96 (0.93 - 1.00)	0.97 (0.94 - 1.01)	0.97 (0.95 - 0.99)
Hypertension and hypertensive disease (CC 94-95)	0.83 (0.80 - 0.87)	0.87 (0.84 - 0.91)	0.88 (0.84 - 0.92)	0.86 (0.84 - 0.88)
Specified arrhythmias and other heart rhythm disorders (CC 96-97)	1.08 (1.04 - 1.11)	1.08 (1.04 - 1.11)	1.10 (1.06 - 1.14)	1.09 (1.06 - 1.11)
Stroke (CC 99-100)	0.90 (0.85 - 0.96)	0.99 (0.93 - 1.05)	0.97 (0.90 - 1.03)	0.95 (0.92 - 0.99)
Vascular or circulatory disease (CC 106-109)	1.02 (0.99 - 1.06)	1.00 (0.96 - 1.03)	0.98 (0.95 - 1.02)	1.00 (0.98 - 1.02)
Fibrosis of lung or other chronic lung disorders (CC 112)	1.15 (1.11 - 1.20)	1.14 (1.10 - 1.19)	1.17 (1.12 - 1.22)	1.16 (1.13 - 1.18)
Asthma (CC 113)	0.69 (0.65 - 0.72)	0.68 (0.65 - 0.71)	0.72 (0.69 - 0.75)	0.70 (0.68 - 0.72)
Pneumonia (CC 114-116)	1.23 (1.19 - 1.27)	1.26 (1.22 - 1.30)	1.23 (1.18 - 1.27)	1.24 (1.22 - 1.26)
Pleural effusion/pneumothorax (CC 117)	1.26 (1.21 - 1.31)	1.18 (1.13 - 1.22)	1.25 (1.20 - 1.30)	1.22 (1.20 - 1.25)
Other respiratory disorders (CC 118)	0.83 (0.80 - 0.85)	0.83 (0.80 - 0.86)	0.75 (0.73 - 0.78)	0.81 (0.79 - 0.82)
Other retinal disorders (CC 125)	0.93 (0.89 - 0.98)	0.92 (0.87 - 0.96)	0.96 (0.91 - 1.01)	0.93 (0.91 - 0.96)
Other eye disorders (CC 128)	0.86 (0.82 - 0.89)	0.89 (0.86 - 0.93)	0.92 (0.88 - 0.96)	0.89 (0.87 - 0.91)
Other ear, nose, throat, and mouth disorders (CC 131)	0.82 (0.79 - 0.85)	0.79 (0.77 - 0.82)	0.79 (0.76 - 0.82)	0.80 (0.78 - 0.82)
Renal failure (CC 135-140)	1.16 (1.12 - 1.20)	1.17 (1.13 - 1.21)	1.16 (1.12 - 1.21)	1.16 (1.14 - 1.19)
Decubitus ulcer or chronic skin ulcer (CC 157-161)	1.39 (1.33 - 1.46)	1.37 (1.30 - 1.44)	1.30 (1.23 - 1.37)	1.36 (1.32 - 1.40)
Other dermatological disorders (CC 165)	0.90 (0.87 - 0.93)	0.89 (0.86 - 0.92)	0.90 (0.87 - 0.93)	0.90 (0.88 - 0.92)
Trauma (CC 166-168, 170-173)	1.00 (0.95 - 1.04)	1.04 (0.99 - 1.09)	1.05 (1.00 - 1.10)	1.03 (1.00 - 1.06)
Vertebral fractures without spinal cord injury (CC 169)	1.25 (1.17 - 1.33)	1.28 (1.20 - 1.36)	1.29 (1.21 - 1.37)	1.27 (1.22 - 1.31)
Major complications of medical care and trauma (CC 176-177)	0.84 (0.79 - 0.88)	0.89 (0.85 - 0.94)	0.88 (0.83 - 0.93)	0.87 (0.84 - 0.90)

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

Characteristic	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Predictive ability, % (lowest decile – highest decile)	1.5 - 22.2	1.5 - 22.1	1.4 - 22.4	1.5 - 22.2
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	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Number of hospitals	4,502	4,469	4,406	4,619
Mean number of admissions (SD)	53.7 (58.9)	55.8 (62.2)	50.5 (56.1)	154.4 (174.9)
Range (min. – max.)	1 - 724	1 - 721	1 - 572	1 - 2,017
25th percentile	12	12	11	31
50th percentile	33	34	31	91
75th percentile	76	80	72	224

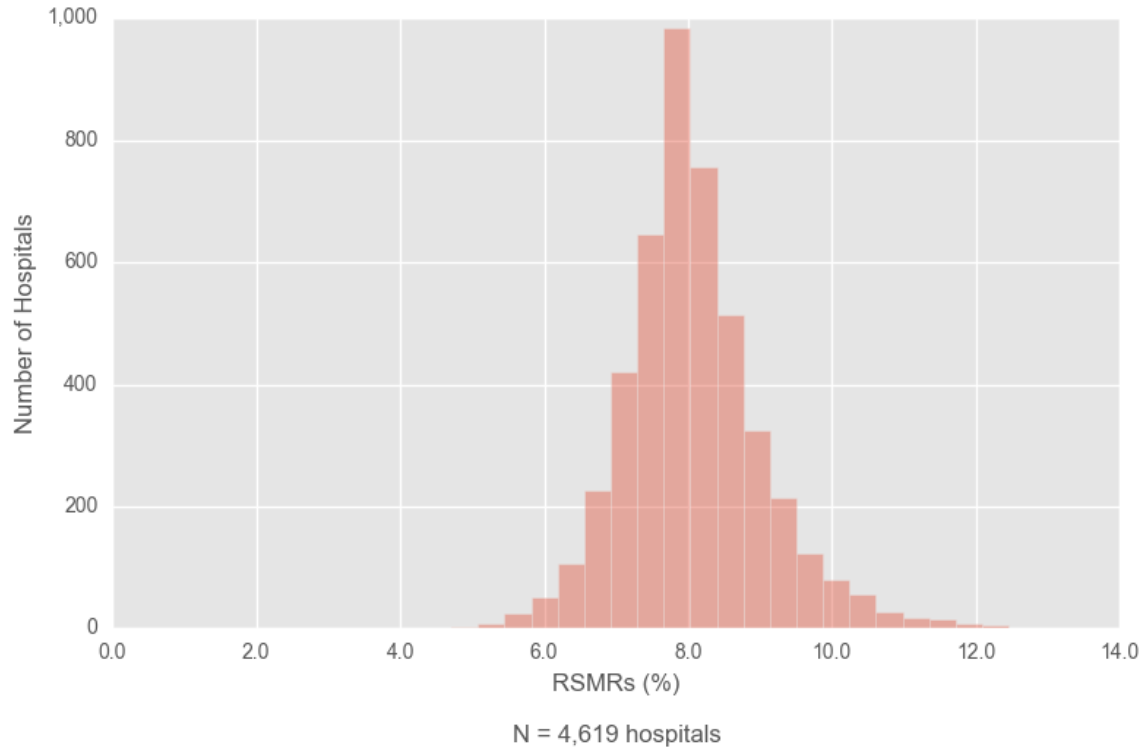
Table 4.3.6 – Distribution of Hospital COPD RSMRs over Different Time Periods

Characteristic	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Number of hospitals	4,502	4,469	4,406	4,619
Mean (SD)	8.0 (0.7)	8.0 (0.8)	8.1 (0.6)	8.1 (1.0)
Range (min. – max.)	5.3 - 12.8	5.3 - 12.2	5.5 - 12.3	4.7 - 13.9
25th percentile	7.6	7.6	7.7	7.5
50th percentile	7.9	7.9	8.0	8.0
75th percentile	8.3	8.4	8.4	8.5

Table 4.3.7 – Between-Hospital Variance for COPD

	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Between-hospital variance (SE)	0.063 (0.006)	0.066 (0.006)	0.056 (0.006)	0.061 (0.004)

Figure 4.3.2 – Distribution of Hospital 30-Day COPD RSMRs between July 2013 and June 2016



4.4 HF Mortality 2017 Model Results

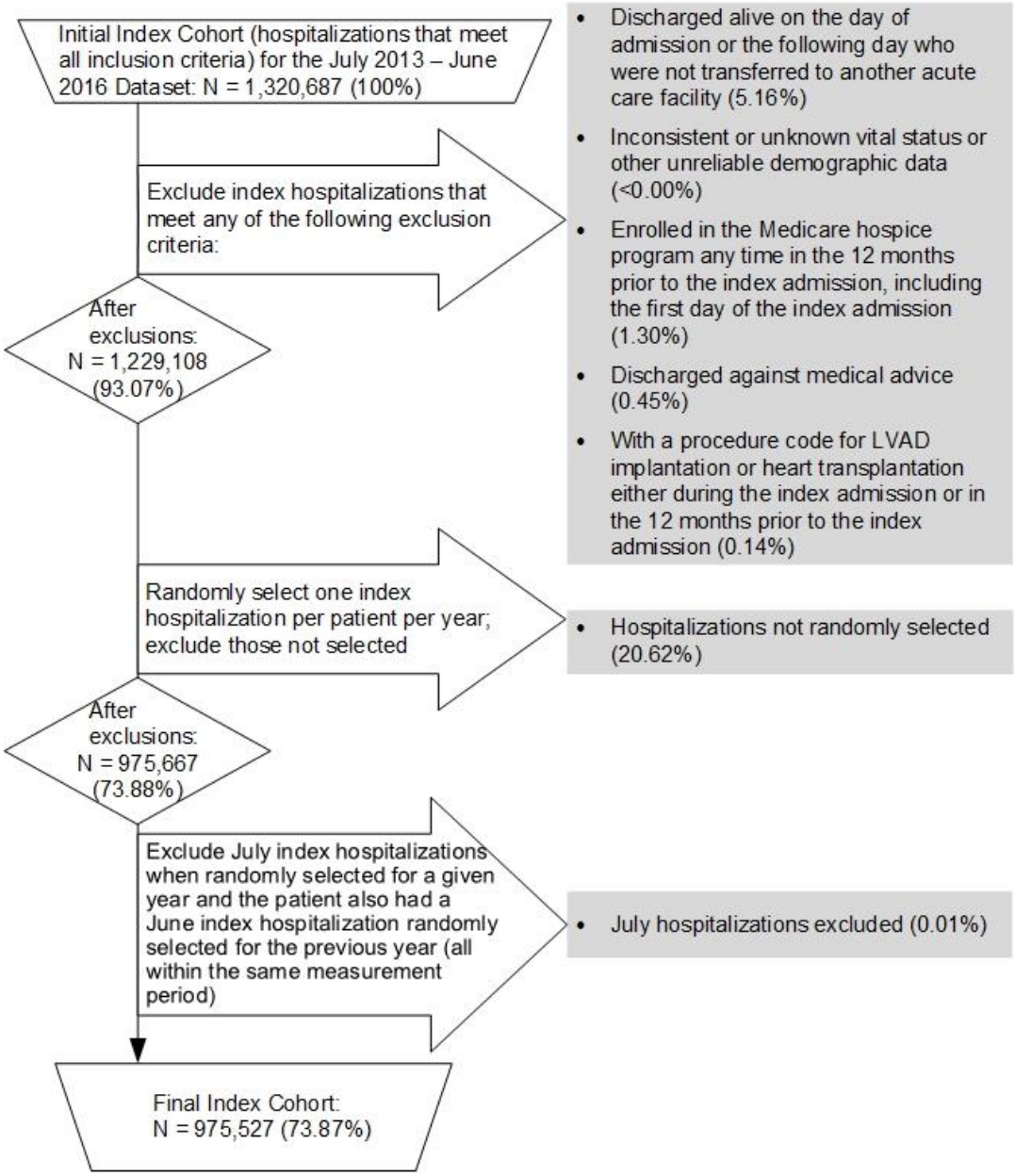
4.4.1 Index Cohort Exclusions

The exclusion criteria for this measure are presented in Section 2.2.1. The percentage of HF admissions that met each exclusion criterion in the July 2013-June 2016 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 2013-June 2016 Dataset



4.4.2 Frequency of HF Model Variables

We examined the change in the frequencies of clinical and demographic variables. Frequencies of model variables were stable over the measurement period. The largest changes in the frequencies (those greater than 2% absolute change) include increases in Renal failure (61.4% to 63.6%), Cardio-respiratory failure and shock (28.0% to 31.5%), and Trauma; other injuries (40.6% to 42.7%).

Refer to Table 4.4.1 for more detail. Note that the increases and decreases in some model variables may reflect not only changes in rates of comorbidities in the Medicare FFS population, but also changes due to ICD-10 code implementation effective with October 1, 2015+ discharges.

4.4.3 HF Model Parameters and Performance

Table 4.4.2 shows hierarchical logistic 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 decreased slightly from 0.69 to 0.68 (Table 4.4.4).

4.4.4 Distribution of Hospital Volumes and Mortality Rates for HF

The national *observed* mortality rate in the combined three-year dataset was 11.9%. Between July 2013-June 2014 and July 2015-June 2016, the *observed* rate decreased from 11.9% to 11.7%.

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 12.0% (between July 2013 and June 2014) to 11.7% (between July 2015 and June 2016). The median hospital RSMR in the combined three-year dataset was 11.9% (IQR: 11.1% - 12.8%). Table 4.4.7 shows the between-hospital variance by individual year, as well as for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.055 (SE: 0.003).

Figure 4.4.2 shows the overall distribution of the hospital RSMRs for the combined three-year dataset. The odds of all-cause mortality if a patient is treated at a hospital one SD above the national rate were 1.60 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 4,599 hospitals in the study cohort, 187 performed “Better than the National Rate,” 3,390 performed “No Different from the National Rate,” and 100 performed “Worse than the National Rate.” 922 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	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Total N	320,366	330,337	324,824	975,527
Mean age minus 65 (SD)	16.1 (8.4)	16.1 (8.4)	16.0 (8.5)	16.1 (8.4)
Male (%)	45.5	45.7	45.8	45.7
History of coronary artery bypass graft (CABG) surgery	18.9	18.6	18.7	18.7
History of percutaneous transluminal coronary angioplasty (PTCA)	14.0	14.5	15.1	14.5
Metastatic cancer, acute leukemia and other severe cancers (CC 8-9)	5.0	5.1	5.4	5.2
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 17-19, 123)	53.9	53.8	54.1	53.9
Protein-calorie malnutrition (CC 21)	10.3	10.3	10.7	10.4
Chronic liver disease (CC 27-29)	3.3	3.5	3.7	3.5
Dementia or other specified brain disorders (CC 51-53)	24.8	24.5	24.4	24.5
Major psychiatric disorders (CC 57-59)	10.8	10.9	9.7	10.5
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	6.3	6.3	6.7	6.4
Cardio-respiratory failure and shock (CC 84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	28.0	29.3	31.5	29.6
Congestive heart failure (CC 85)	73.2	72.8	72.9	73.0
Acute myocardial infarction (CC 86)	9.5	9.4	10.2	9.7
Unstable angina and other acute ischemic heart disease (CC 87)	12.1	12.2	11.3	11.9
Coronary atherosclerosis or angina (CC 88-89)	71.9	70.9	70.3	71.0
Valvular and rheumatic heart disease (CC 91)	53.7	54.1	54.0	53.9
Hypertension (CC 95)	87.2	87.3	88.0	87.5
Stroke (CC 99-100)	9.1	9.1	8.8	9.0
Vascular disease and complications (CC 106-108)	39.2	38.7	39.1	39.0
Chronic obstructive pulmonary disease (COPD) (CC 111)	48.0	47.8	47.7	47.8
Pneumonia (CC 114-116)	45.1	45.2	44.1	44.8
Renal failure (CC 135-140)	61.4	62.2	63.6	62.4
Trauma; other injuries (CC 166-168, 170-174)	40.6	41.2	42.7	41.5

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

Variable	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Intercept	-3.466	-3.485	-3.530	-3.489
Age minus 65 (years above 65, continuous)	0.050	0.050	0.049	0.050
Male	0.224	0.223	0.251	0.231
History of coronary artery bypass graft (CABG) surgery	-0.102	-0.076	-0.067	-0.083
History of percutaneous transluminal coronary angioplasty (PTCA)	-0.270	-0.295	-0.244	-0.269
Metastatic cancer, acute leukemia and other severe cancers (CC 8-9)	0.608	0.554	0.539	0.571
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 17-19, 123)	-0.058	-0.023	-0.027	-0.032
Protein-calorie malnutrition (CC 21)	0.671	0.670	0.675	0.680
Chronic liver disease (CC 27-29)	0.458	0.361	0.437	0.426
Dementia or other specified brain disorders (CC 51-53)	0.316	0.338	0.329	0.331
Major psychiatric disorders (CC 57-59)	0.121	0.081	0.035	0.084

Variable	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	0.123	0.134	0.158	0.139
Cardio-respiratory failure and shock (CC 84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	0.164	0.173	0.189	0.172
Congestive heart failure (CC 85)	0.180	0.176	0.177	0.178
Acute myocardial infarction (CC 86)	0.227	0.236	0.202	0.218
Unstable angina and other acute ischemic heart disease (CC 87)	-0.049	-0.033	-0.050	-0.036
Coronary atherosclerosis or angina (CC 88-89)	-0.035	-0.036	-0.003	-0.019
Valvular and rheumatic heart disease (CC 91)	0.084	0.124	0.083	0.101
Hypertension (CC 95)	-0.336	-0.334	-0.343	-0.338
Stroke (CC 99-100)	-0.061	-0.071	-0.081	-0.068
Vascular disease and complications (CC 106-108)	0.030	0.031	0.052	0.043
Chronic obstructive pulmonary disease (COPD) (CC 111)	0.069	0.094	0.066	0.075
Pneumonia (CC 114-116)	0.276	0.252	0.230	0.255
Renal failure (CC 135-140)	0.283	0.265	0.288	0.282
Trauma; other injuries (CC 166-168, 170-174)	0.093	0.075	0.093	0.084

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

Variable	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2015-06/2016 OR (95% CI)	07/2013-06/2016 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	1.25 (1.22 - 1.28)	1.25 (1.22 - 1.28)	1.29 (1.26 - 1.32)	1.26 (1.24 - 1.28)
History of coronary artery bypass graft (CABG) surgery	0.90 (0.88 - 0.93)	0.93 (0.90 - 0.96)	0.94 (0.91 - 0.96)	0.92 (0.90 - 0.94)
History of percutaneous transluminal coronary angioplasty (PTCA)	0.76 (0.74 - 0.79)	0.74 (0.72 - 0.77)	0.78 (0.76 - 0.81)	0.76 (0.75 - 0.78)
Metastatic cancer, acute leukemia and other severe cancers (CC 8-9)	1.84 (1.76 - 1.92)	1.74 (1.67 - 1.81)	1.71 (1.64 - 1.79)	1.77 (1.73 - 1.81)
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 17-19, 123)	0.94 (0.92 - 0.97)	0.98 (0.96 - 1.00)	0.97 (0.95 - 1.00)	0.97 (0.96 - 0.98)
Protein-calorie malnutrition (CC 21)	1.96 (1.90 - 2.02)	1.95 (1.90 - 2.01)	1.96 (1.91 - 2.02)	1.98 (1.94 - 2.01)
Chronic liver disease (CC 27-29)	1.58 (1.50 - 1.67)	1.43 (1.36 - 1.51)	1.55 (1.47 - 1.63)	1.53 (1.48 - 1.58)
Dementia or other specified brain disorders (CC 51-53)	1.37 (1.34 - 1.41)	1.40 (1.37 - 1.44)	1.39 (1.36 - 1.43)	1.39 (1.37 - 1.41)
Major psychiatric disorders (CC 57-59)	1.13 (1.09 - 1.17)	1.08 (1.05 - 1.12)	1.04 (1.00 - 1.08)	1.09 (1.07 - 1.11)
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	1.13 (1.08 - 1.18)	1.14 (1.10 - 1.19)	1.17 (1.12 - 1.22)	1.15 (1.12 - 1.18)
Cardio-respiratory failure and shock (CC 84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	1.18 (1.15 - 1.21)	1.19 (1.16 - 1.22)	1.21 (1.18 - 1.24)	1.19 (1.17 - 1.21)
Congestive heart failure (CC 85)	1.20 (1.16 - 1.23)	1.19 (1.16 - 1.23)	1.19 (1.16 - 1.23)	1.20 (1.18 - 1.22)
Acute myocardial infarction (CC 86)	1.25 (1.20 - 1.31)	1.27 (1.22 - 1.32)	1.22 (1.18 - 1.27)	1.24 (1.22 - 1.27)
Unstable angina and other acute ischemic heart disease (CC 87)	0.95 (0.92 - 0.99)	0.97 (0.93 - 1.01)	0.95 (0.92 - 0.99)	0.97 (0.94 - 0.99)

Variable	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2015-06/2016 OR (95% CI)	07/2013-06/2016 OR (95% CI)
Coronary atherosclerosis or angina (CC 88-89)	0.97 (0.94 - 0.99)	0.97 (0.94 - 0.99)	1.00 (0.97 - 1.03)	0.98 (0.97 - 1.00)
Valvular and rheumatic heart disease (CC 91)	1.09 (1.06 - 1.11)	1.13 (1.11 - 1.16)	1.09 (1.06 - 1.11)	1.11 (1.09 - 1.12)
Hypertension (CC 95)	0.72 (0.69 - 0.74)	0.72 (0.69 - 0.74)	0.71 (0.69 - 0.73)	0.71 (0.70 - 0.73)
Stroke (CC 99-100)	0.94 (0.91 - 0.98)	0.93 (0.90 - 0.97)	0.92 (0.89 - 0.96)	0.93 (0.91 - 0.96)
Vascular disease and complications (CC 106-108)	1.03 (1.01 - 1.06)	1.03 (1.01 - 1.06)	1.05 (1.03 - 1.08)	1.04 (1.03 - 1.06)
Chronic obstructive pulmonary disease (COPD) (CC 111)	1.07 (1.05 - 1.10)	1.10 (1.07 - 1.12)	1.07 (1.04 - 1.09)	1.08 (1.06 - 1.09)
Pneumonia (CC 114-116)	1.32 (1.29 - 1.35)	1.29 (1.26 - 1.32)	1.26 (1.23 - 1.29)	1.29 (1.27 - 1.31)
Renal failure (CC 135-140)	1.33 (1.29 - 1.36)	1.30 (1.27 - 1.34)	1.33 (1.30 - 1.37)	1.33 (1.31 - 1.35)
Trauma; other injuries (CC 166-168, 170-174)	1.10 (1.07 - 1.12)	1.08 (1.05 - 1.10)	1.10 (1.07 - 1.12)	1.09 (1.07 - 1.10)

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

Characteristic	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Predictive ability, % (lowest decile – highest decile)	3.1 - 26.6	3.1 - 26.5	3.2 - 25.8	3.1 - 26.3
c-statistic	0.69	0.69	0.68	0.69

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

Characteristic	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Number of hospitals	4,488	4,467	4,423	4,599
Mean number of admissions (SD)	71.4 (87.4)	74.0 (91.9)	73.4 (91.9)	212.1 (268.2)
Range (min. – max.)	1 - 978	1 - 1,087	1 - 989	1 - 3,054
25th percentile	12	12	11	32
50th percentile	36	37	36	100
75th percentile	101	105	105	303

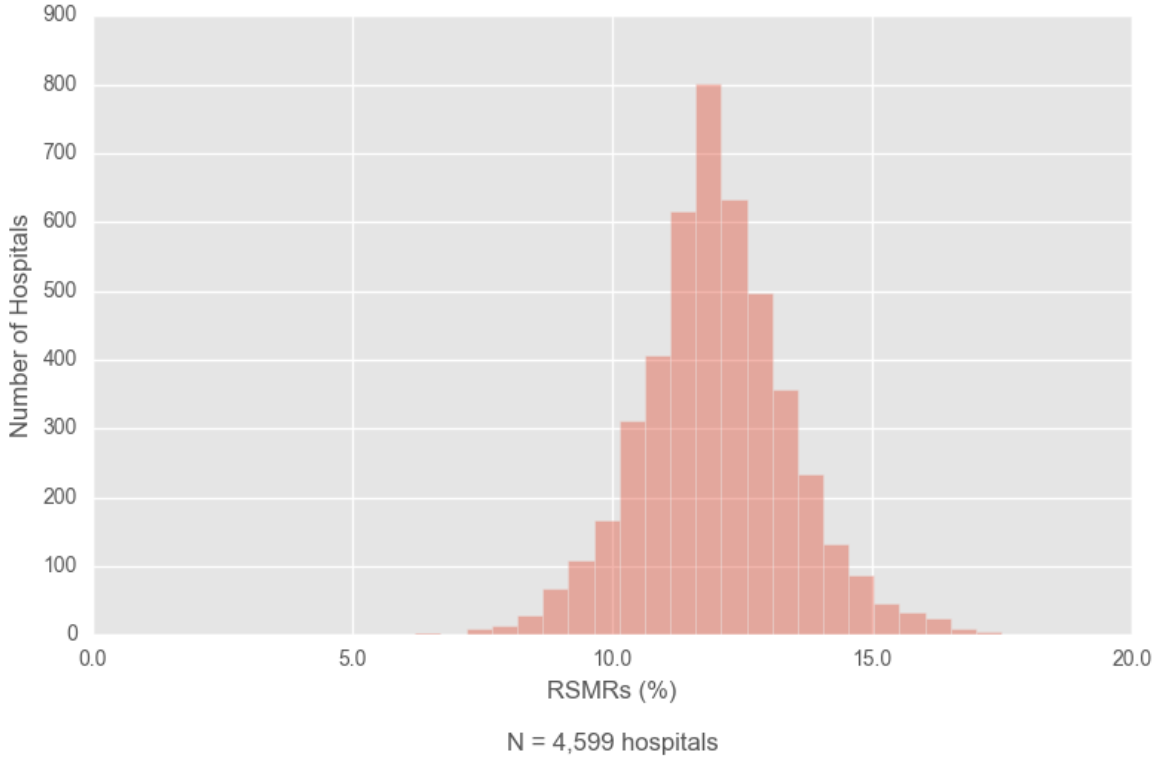
Table 4.4.6 – Distribution of Hospital HF RSMRs over Different Time Periods

Characteristic	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Number of hospitals	4,488	4,467	4,423	4,599
Mean (SD)	12.0 (0.9)	12.2 (1.1)	11.7 (1.1)	12.0 (1.4)
Range (min. – max.)	7.6 - 16.8	7.4 - 17.5	7.3 - 16.9	6.2 - 18.5
25th percentile	11.5	11.6	11.2	11.1
50th percentile	11.9	12.1	11.6	11.9
75th percentile	12.5	12.8	12.2	12.8

Table 4.4.7 – Between-Hospital Variance for HF

	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Between-hospital variance (SE)	0.046 (0.004)	0.054 (0.004)	0.053 (0.004)	0.055 (0.003)

Figure 4.4.2 – Distribution of Hospital 30-Day HF RSMRs between July 2013 and June 2016



4.5 Pneumonia Mortality 2017 Model Results

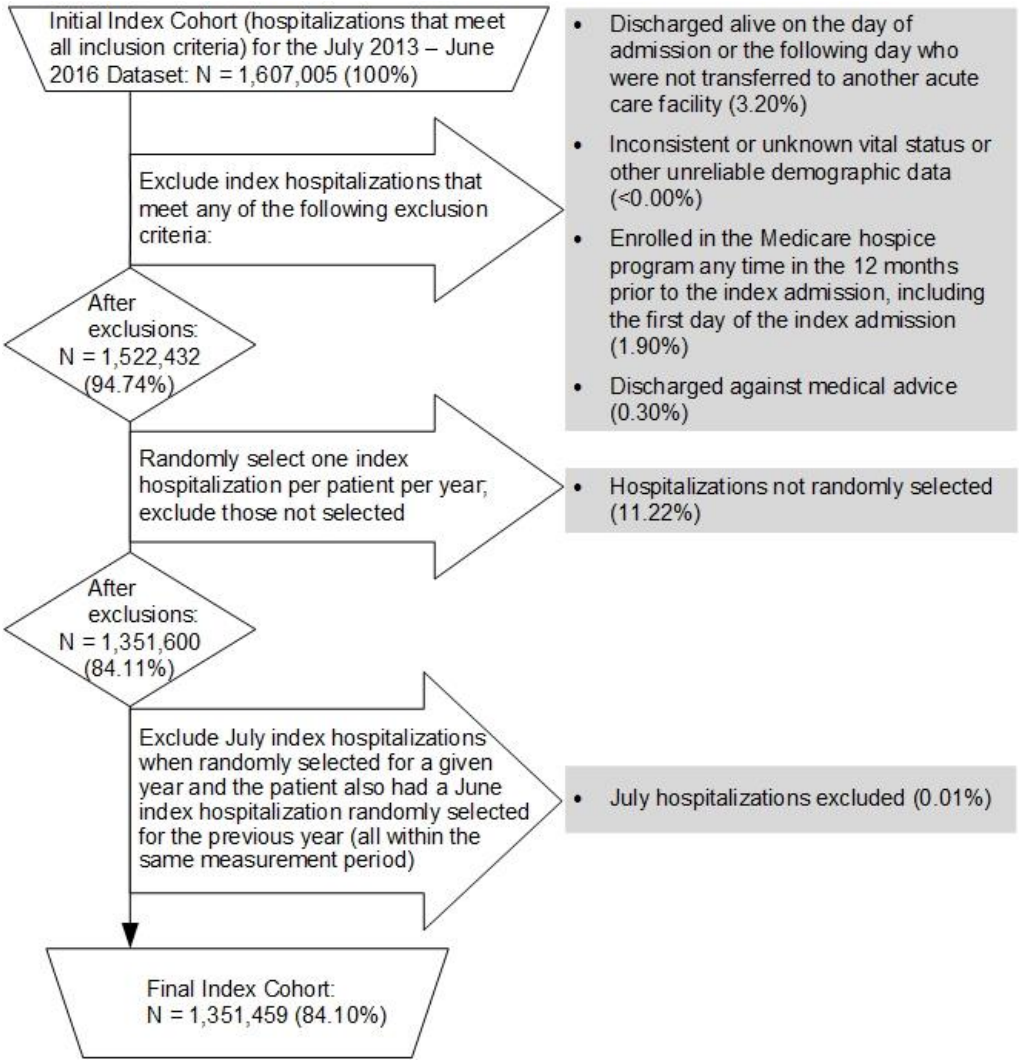
4.5.1 Index Cohort Exclusions

The exclusion criteria for this measure are presented in Section 2.2.1. The percentage of pneumonia admissions that met each exclusion criterion in the July 2013-June 2016 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 2013-June 2016 Dataset



4.5.2 Frequency of Pneumonia Model Variables

We examined the change in the frequencies of clinical and demographic variables. Frequencies of model variables were stable over the measurement period. The largest changes in the frequencies (those greater than 2% absolute change) include:

- Increases in Asthma (10.9% to 14.0%), Respiratory arrest; cardio-respiratory failure and shock (24.3% to 26.5%), and Septicemia, sepsis, systemic inflammatory response syndrome/shock (12.8% to 15.1%)
- Decreases in Iron deficiency or other/unspecified anemias and blood disease (60.5% to 58.4%) and Cerebrovascular disease (25.4% to 23.0%)

Refer to Table 4.5.1 for more detail. Note that the increases and decreases in some model variables may reflect not only changes in rates of comorbidities in the Medicare FFS population, but also changes due to ICD-10 code implementation effective with October 1, 2015+ discharges.

4.5.3 Pneumonia Model Parameters and Performance

Table 4.5.2 shows hierarchical logistic 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 increased slightly from 0.71 to 0.72 (Table 4.5.4).

4.5.4 Distribution of Hospital Volumes and Mortality Rates for Pneumonia

The national *observed* mortality rate in the combined three-year dataset was 15.9%. Between July 2013-June 2014 and July 2015-June 2016, the *observed* rate decreased from 16.3% to 15.6%.

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 16.4% (between July 2013 and June 2014) to 15.7% (between July 2015 and June 2016). The median hospital RSMR in the combined three-year dataset was 15.8% (IQR: 14.9% - 17.1%). Table 4.5.7 shows the between-hospital variance by individual year, as well as for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.047 (SE: 0.002).

Figure 4.5.2 shows the overall distribution of the hospital RSMRs for the combined three-year dataset. The odds of all-cause mortality if a patient is 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]

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

Of 4,657 hospitals in the study cohort, 225 performed “Better than the National Rate,” 3,758 performed “No Different from the National Rate,” and 248 performed “Worse

than the National Rate." 426 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	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Total N	439,493	472,452	439,514	1,351,459
Mean age minus 65 (SD)	15.6 (8.5)	15.8 (8.6)	15.4 (8.6)	15.6 (8.6)
Male (%)	46.6	46.4	46.8	46.6
History of coronary artery bypass graft (CABG) surgery	8.8	8.8	8.7	8.8
History of percutaneous transluminal coronary angioplasty (PTCA)	7.3	7.6	8.0	7.6
Septicemia, sepsis, systemic inflammatory response syndrome/shock (CC 2)	12.8	13.4	15.1	13.8
Metastatic cancer, acute leukemia and other severe cancers (CC 8-9)	10.3	10.0	10.7	10.3
Protein-calorie malnutrition (CC 21)	17.3	16.9	17.6	17.3
Disorders of fluid/electrolyte/acid-base balance (CC 24)	39.2	38.4	38.9	38.8
Chronic liver disease (CC 27-29)	2.4	2.5	2.7	2.5
Severe hematological disorders (CC 46)	2.3	2.1	2.1	2.2
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	60.5	58.8	58.4	59.2
Delirium and encephalopathy (CC 50)	11.3	11.7	12.9	12.0
Dementia or other specified brain disorders (CC 51-53)	36.5	36.1	35.3	36.0
Major psychiatric disorders (CC 57-59)	15.7	15.7	14.3	15.2
Depression (CC 61)	26.1	26.2	26.1	26.1
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	8.8	8.6	9.4	8.9
Parkinson's and Huntington's diseases (CC 78)	5.2	5.1	5.2	5.2
Seizure disorders and convulsions (CC 79)	7.4	7.1	7.1	7.2
Respirator dependence/tracheostomy status (CC 82)	1.3	1.1	1.2	1.2
Respiratory arrest; cardio-respiratory failure and shock (CC 83-84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 83-84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	24.3	24.5	26.5	25.1
Congestive heart failure (CC 85)	38.5	37.8	37.9	38.1
Acute myocardial infarction (CC 86)	4.2	4.0	4.5	4.2
Unstable angina and other acute ischemic heart disease (CC 87)	5.9	5.8	5.6	5.8
Coronary atherosclerosis or angina (CC 88-89)	48.6	47.6	47.4	47.8
Hypertension (CC 95)	83.7	83.5	84.1	83.8
Stroke (CC 99-100)	10.8	10.5	10.2	10.5
Cerebrovascular disease (CC 101-102, 105)	25.4	24.3	23.0	24.2
Vascular disease and complications (CC 106-108)	33.0	32.5	32.9	32.8
Chronic obstructive pulmonary disease (COPD) (CC 111)	51.9	50.6	50.9	51.1
Fibrosis of lung or other chronic lung disorders (CC 112)	13.1	12.4	12.1	12.5
Asthma (CC 113)	10.9	10.9	14.0	11.9
Pneumonia; pleural effusion/pneumothorax (CC 114-117)	45.9	44.0	44.4	44.7
Renal failure (CC 135-140)	39.7	40.1	41.5	40.4
Decubitus ulcer of skin (CC 157-160)	7.9	7.5	7.8	7.7
Trauma; other injuries (CC 166-168, 170-174)	43.3	43.6	44.7	43.8
Vertebral fractures without spinal cord injury (CC 169)	5.5	5.5	5.4	5.5

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

Variable	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Intercept	-3.163	-3.276	-3.259	-3.239
Age minus 65 (years above 65, continuous)	0.046	0.048	0.047	0.047
Male	0.215	0.194	0.217	0.208
History of coronary artery bypass graft (CABG) surgery	-0.111	-0.120	-0.081	-0.105
History of percutaneous transluminal coronary angioplasty (PTCA)	-0.218	-0.279	-0.212	-0.237
Septicemia, sepsis, systemic inflammatory response syndrome/shock (CC 2)	-0.147	-0.137	-0.133	-0.138
Metastatic cancer, acute leukemia and other severe cancers (CC 8-9)	0.951	0.945	0.959	0.955
Protein-calorie malnutrition (CC 21)	0.744	0.764	0.764	0.764
Disorders of fluid/electrolyte/acid-base balance (CC 24)	0.167	0.133	0.130	0.143
Chronic liver disease (CC 27-29)	0.346	0.334	0.369	0.352
Severe hematological disorders (CC 46)	0.162	0.166	0.152	0.165
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	0.088	0.097	0.104	0.099
Delirium and encephalopathy (CC 50)	-0.009	0.012	0.024	0.011
Dementia or other specified brain disorders (CC 51-53)	0.479	0.514	0.507	0.500
Major psychiatric disorders (CC 57-59)	0.083	0.058	0.042	0.064
Depression (CC 61)	-0.042	-0.037	-0.039	-0.039
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	0.190	0.170	0.202	0.188
Parkinson's and Huntington's diseases (CC 78)	0.165	0.142	0.168	0.160
Seizure disorders and convulsions (CC 79)	0.015	0.034	0.010	0.021
Respirator dependence/tracheostomy status (CC 82)	-0.432	-0.380	-0.299	-0.367
Respiratory arrest; cardio-respiratory failure and shock (CC 83-84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 83-84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	0.139	0.173	0.187	0.165
Congestive heart failure (CC 85)	0.167	0.149	0.145	0.155
Acute myocardial infarction (CC 86)	0.180	0.198	0.216	0.197
Unstable angina and other acute ischemic heart disease (CC 87)	-0.046	-0.018	-0.057	-0.036
Coronary atherosclerosis or angina (CC 88-89)	-0.020	-0.008	-0.011	-0.012
Hypertension (CC 95)	-0.182	-0.145	-0.150	-0.160
Stroke (CC 99-100)	0.062	0.080	0.053	0.065
Cerebrovascular disease (CC 101-102, 105)	-0.022	-0.019	-0.017	-0.019
Vascular disease and complications (CC 106-108)	0.008	-0.001	0.008	0.008
Chronic obstructive pulmonary disease (COPD) (CC 111)	-0.078	-0.048	-0.089	-0.073
Fibrosis of lung or other chronic lung disorders (CC 112)	0.097	0.070	0.057	0.078
Asthma (CC 113)	-0.322	-0.359	-0.335	-0.337
Pneumonia; pleural effusion/pneumothorax (CC 114-117)	0.105	0.105	0.092	0.102
Renal failure (CC 135-140)	0.084	0.098	0.091	0.092
Decubitus ulcer of skin (CC 157-160)	0.311	0.294	0.303	0.304
Trauma; other injuries (CC 166-168, 170-174)	0.043	0.056	0.043	0.047
Vertebral fractures without spinal cord injury (CC 169)	0.094	0.083	0.108	0.095

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

Variable	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2015-06/2016 OR (95% CI)	07/2013-06/2016 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)	1.21 (1.19 - 1.24)	1.24 (1.22 - 1.27)	1.23 (1.22 - 1.24)
History of coronary artery bypass graft (CABG) surgery	0.90 (0.87 - 0.92)	0.89 (0.86 - 0.92)	0.92 (0.89 - 0.95)	0.90 (0.88 - 0.92)
History of percutaneous transluminal coronary angioplasty (PTCA)	0.80 (0.78 - 0.83)	0.76 (0.73 - 0.78)	0.81 (0.78 - 0.84)	0.79 (0.77 - 0.81)
Septicemia, sepsis, systemic inflammatory response syndrome/shock (CC 2)	0.86 (0.84 - 0.89)	0.87 (0.85 - 0.89)	0.88 (0.85 - 0.90)	0.87 (0.86 - 0.88)
Metastatic cancer, acute leukemia and other severe cancers (CC 8-9)	2.59 (2.52 - 2.65)	2.57 (2.51 - 2.64)	2.61 (2.55 - 2.68)	2.60 (2.56 - 2.64)
Protein-calorie malnutrition (CC 21)	2.10 (2.06 - 2.15)	2.15 (2.10 - 2.19)	2.15 (2.10 - 2.19)	2.15 (2.12 - 2.17)
Disorders of fluid/electrolyte/acid-base balance (CC 24)	1.18 (1.16 - 1.21)	1.14 (1.12 - 1.16)	1.14 (1.12 - 1.16)	1.15 (1.14 - 1.17)
Chronic liver disease (CC 27-29)	1.41 (1.34 - 1.49)	1.40 (1.33 - 1.47)	1.45 (1.38 - 1.52)	1.42 (1.38 - 1.46)
Severe hematological disorders (CC 46)	1.18 (1.12 - 1.24)	1.18 (1.12 - 1.24)	1.16 (1.10 - 1.23)	1.18 (1.14 - 1.22)
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	1.09 (1.07 - 1.11)	1.10 (1.08 - 1.12)	1.11 (1.09 - 1.13)	1.10 (1.09 - 1.12)
Delirium and encephalopathy (CC 50)	0.99 (0.97 - 1.02)	1.01 (0.99 - 1.04)	1.02 (1.00 - 1.05)	1.01 (1.00 - 1.03)
Dementia or other specified brain disorders (CC 51-53)	1.61 (1.58 - 1.65)	1.67 (1.64 - 1.70)	1.66 (1.63 - 1.69)	1.65 (1.63 - 1.67)
Major psychiatric disorders (CC 57-59)	1.09 (1.06 - 1.11)	1.06 (1.04 - 1.08)	1.04 (1.02 - 1.07)	1.07 (1.05 - 1.08)
Depression (CC 61)	0.96 (0.94 - 0.98)	0.96 (0.95 - 0.98)	0.96 (0.94 - 0.98)	0.96 (0.95 - 0.97)
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	1.21 (1.17 - 1.25)	1.19 (1.15 - 1.22)	1.22 (1.19 - 1.26)	1.21 (1.19 - 1.23)
Parkinson's and Huntington's diseases (CC 78)	1.18 (1.14 - 1.22)	1.15 (1.11 - 1.19)	1.18 (1.14 - 1.23)	1.17 (1.15 - 1.20)
Seizure disorders and convulsions (CC 79)	1.02 (0.98 - 1.05)	1.04 (1.00 - 1.07)	1.01 (0.98 - 1.04)	1.02 (1.00 - 1.04)
Respirator dependence/tracheostomy status (CC 82)	0.65 (0.60 - 0.70)	0.68 (0.63 - 0.74)	0.74 (0.69 - 0.80)	0.69 (0.66 - 0.72)
Respiratory arrest; cardio-respiratory failure and shock (CC 83-84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 83-84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	1.15 (1.12 - 1.18)	1.19 (1.16 - 1.21)	1.21 (1.18 - 1.23)	1.18 (1.16 - 1.20)
Congestive heart failure (CC 85)	1.18 (1.16 - 1.21)	1.16 (1.14 - 1.18)	1.16 (1.13 - 1.18)	1.17 (1.15 - 1.18)
Acute myocardial infarction (CC 86)	1.20 (1.15 - 1.25)	1.22 (1.17 - 1.27)	1.24 (1.19 - 1.29)	1.22 (1.19 - 1.25)
Unstable angina and other acute ischemic heart disease (CC 87)	0.96 (0.92 - 0.99)	0.98 (0.95 - 1.02)	0.95 (0.91 - 0.98)	0.97 (0.94 - 0.99)
Coronary atherosclerosis or angina (CC 88-89)	0.98 (0.96 - 1.00)	0.99 (0.97 - 1.01)	0.99 (0.97 - 1.01)	0.99 (0.98 - 1.00)
Hypertension (CC 95)	0.83 (0.82 - 0.85)	0.87 (0.85 - 0.89)	0.86 (0.84 - 0.88)	0.85 (0.84 - 0.86)
Stroke (CC 99-100)	1.06 (1.04 - 1.10)	1.08 (1.05 - 1.11)	1.05 (1.02 - 1.09)	1.07 (1.05 - 1.09)
Cerebrovascular disease (CC 101-102, 105)	0.98 (0.96 - 1.00)	0.98 (0.96 - 1.00)	0.98 (0.96 - 1.01)	0.98 (0.97 - 0.99)
Vascular disease and complications (CC 106-108)	1.01 (0.99 - 1.03)	1.00 (0.98 - 1.02)	1.01 (0.99 - 1.03)	1.01 (1.00 - 1.02)
Chronic obstructive pulmonary disease (COPD) (CC 111)	0.93 (0.91 - 0.94)	0.95 (0.94 - 0.97)	0.92 (0.90 - 0.93)	0.93 (0.92 - 0.94)

Variable	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2015-06/2016 OR (95% CI)	07/2013-06/2016 OR (95% CI)
Fibrosis of lung or other chronic lung disorders (CC 112)	1.10 (1.08 - 1.13)	1.07 (1.05 - 1.10)	1.06 (1.03 - 1.09)	1.08 (1.07 - 1.10)
Asthma (CC 113)	0.73 (0.70 - 0.75)	0.70 (0.68 - 0.72)	0.72 (0.70 - 0.74)	0.71 (0.70 - 0.73)
Pneumonia; pleural effusion/pneumothorax (CC 114-117)	1.11 (1.09 - 1.13)	1.11 (1.09 - 1.13)	1.10 (1.07 - 1.12)	1.11 (1.10 - 1.12)
Renal failure (CC 135-140)	1.09 (1.07 - 1.11)	1.10 (1.08 - 1.12)	1.10 (1.08 - 1.12)	1.10 (1.09 - 1.11)
Decubitus ulcer of skin (CC 157-160)	1.37 (1.33 - 1.40)	1.34 (1.31 - 1.38)	1.35 (1.32 - 1.39)	1.36 (1.33 - 1.38)
Trauma; other injuries (CC 166-168, 170-174)	1.04 (1.03 - 1.06)	1.06 (1.04 - 1.08)	1.04 (1.03 - 1.06)	1.05 (1.04 - 1.06)
Vertebral fractures without spinal cord injury (CC 169)	1.10 (1.06 - 1.14)	1.09 (1.05 - 1.12)	1.11 (1.08 - 1.15)	1.10 (1.08 - 1.12)

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

Characteristic	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Predictive ability, % (lowest decile – highest decile)	3.0 - 36.4	2.7 - 35.8	2.8 - 36.1	2.8 - 36.1
c-statistic	0.71	0.72	0.72	0.72

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

Characteristic	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Number of hospitals	4,583	4,544	4,520	4,657
Mean number of admissions (SD)	95.9 (103.1)	104.0 (112.8)	97.2 (108.0)	290.2 (320.7)
Range (min. – max.)	1 - 1,047	1 - 1,179	1 - 1,203	1 - 3,373
25th percentile	24	25	22	66
50th percentile	59	64	59	175
75th percentile	136	147	138	413

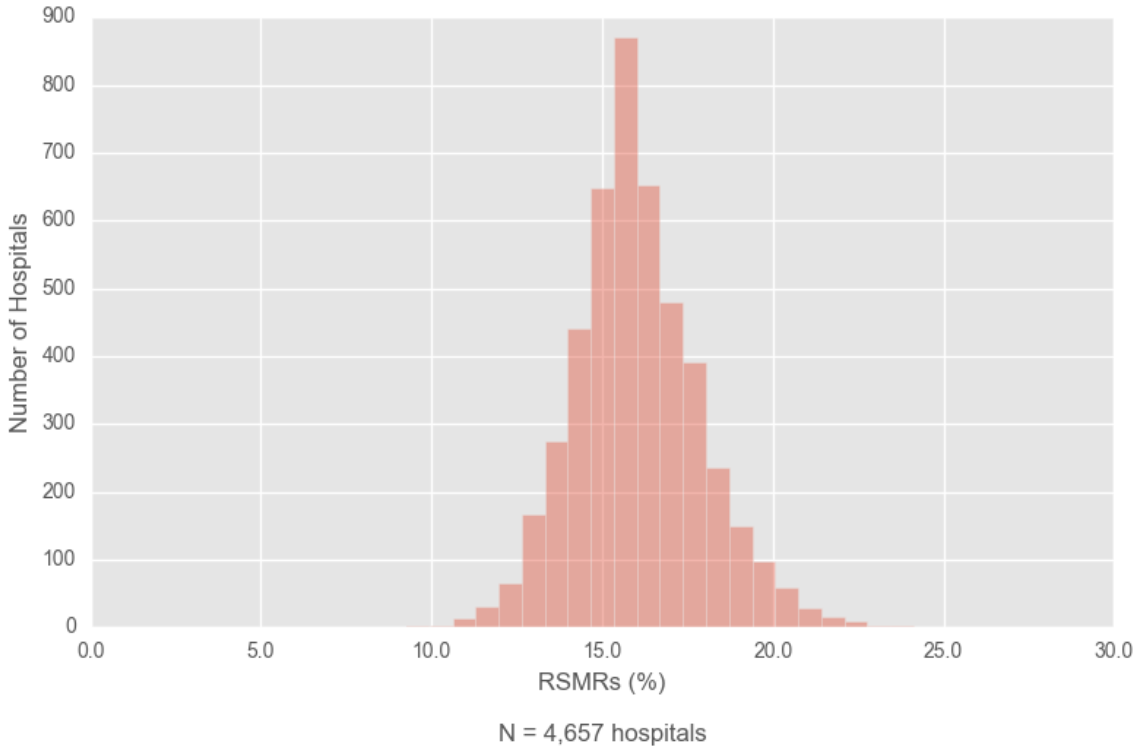
Table 4.5.6 – Distribution of Hospital Pneumonia RSMRs over Different Time Periods

Characteristic	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Number of hospitals	4,583	4,544	4,520	4,657
Mean (SD)	16.4 (1.6)	15.9 (1.5)	15.7 (1.3)	16.0 (1.9)
Range (min. – max.)	10.6 - 24.1	10.7 - 22.4	10.0 - 23.5	9.3 - 26.1
25th percentile	15.4	15.0	14.9	14.9
50th percentile	16.2	15.8	15.5	15.8
75th percentile	17.2	16.7	16.4	17.1

Table 4.5.7 – Between-Hospital Variance for Pneumonia

	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Between-hospital variance (SE)	0.051 (0.003)	0.048 (0.003)	0.045 (0.003)	0.047 (0.002)

Figure 4.5.2 – Distribution of Hospital 30-Day Pneumonia RSMRs between July 2013 and June 2016



4.6 Stroke Mortality 2017 Model Results

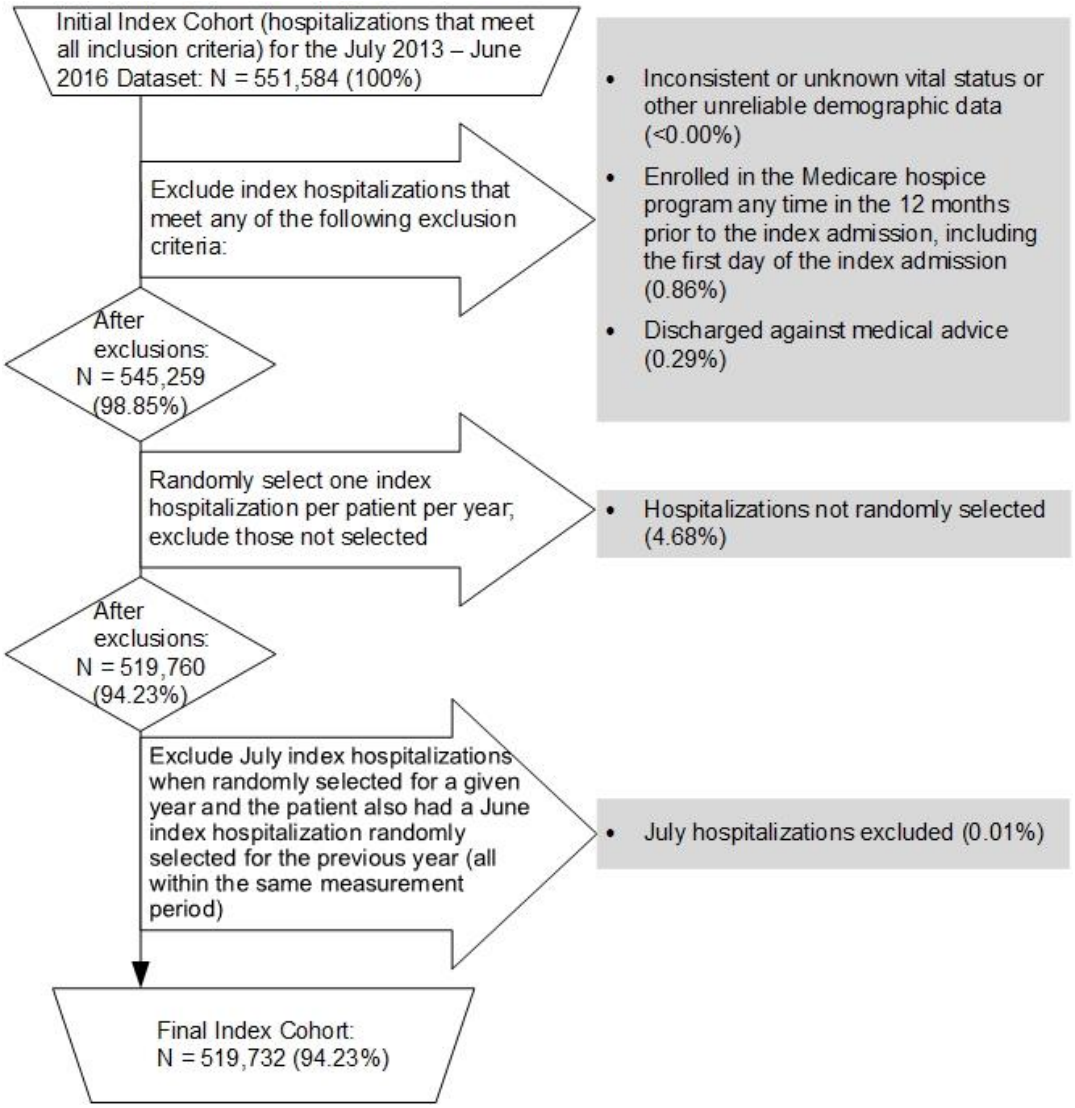
4.6.1 Index Cohort Exclusions

The exclusion criteria for this measure are presented in Section 2.2.1. The percentage of stroke admissions that met each exclusion criterion in the July 2013-June 2016 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 2013-June 2016 Dataset



4.6.2 Frequency of Stroke Model Variables

We examined the change in the frequencies of clinical and demographic variables. Frequencies of model variables were stable over the measurement period. The largest changes in the frequencies (those greater than 2% absolute change) include a decrease in Other musculoskeletal and connective tissue disorders (70.4% - 67.1%).

Refer to Table 4.6.1 for more detail. Note that the increases and decreases in some model variables may reflect not only changes in rates of comorbidities in the Medicare FFS population, but also changes due to ICD-10 code implementation effective with October 1, 2015+ discharges.

4.6.3 Stroke Model Parameters and Performance

Table 4.6.2 shows hierarchical logistic 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 increased slightly from 0.74 to 0.75 (Table 4.6.4).

4.6.4 Distribution of Hospital Volumes and Mortality Rates for Stroke

The national *observed* mortality rate in the combined three-year dataset was 14.6%. Between July 2013-June 2014 and July 2015-June 2016, the *observed* rate decreased from 14.9% to 14.0%.

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 14.9% (between July 2013 and June 2014) to 14.0% (between July 2015 and June 2016). The median hospital RSMR in the combined three-year dataset was 14.5% (IQR: 14.0% - 15.3%). Table 4.6.7 shows the between-hospital variance by individual year, as well as for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.050 (SE: 0.003).

Figure 4.6.2 shows the overall distribution of the hospital RSMRs for the combined three-year dataset. The odds of all-cause mortality if a patient is 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]

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

Of 4,417 hospitals in the cohort, 62 performed “Better than the National Rate,” 2,566 performed “No Different from the National Rate,” and 72 performed “Worse than the National Rate.” 1,718 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	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Total N	172,917	174,268	172,547	519,732
Mean age minus 65 (SD)	15.2 (8.3)	15.2 (8.4)	15.0 (8.4)	15.1 (8.4)
Male (%)	42.2	42.6	42.9	42.6
Transfer from another ED	9.3	10.2	11.2	10.2
Severe infection; other infectious diseases (CC 1, 3-7)	27.6	27.4	27.4	27.5
Metastatic cancer, acute leukemia and other severe cancers (CC 8-9)	4.1	4.1	4.3	4.2
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other major cancers (CC 10-15)	24.0	24.4	24.3	24.2
Protein-calorie malnutrition (CC 21)	6.5	6.5	6.6	6.5
Disorders of fluid/electrolyte/acid-base; other endocrine/metabolic/nutritional disorders (CC 22-26)	87.1	87.5	87.8	87.4
Other gastrointestinal disorders (CC 38)	51.0	51.4	51.6	51.3
Disorders of the vertebrae and spinal discs (CC 41)	20.5	20.8	21.1	20.8
Osteoarthritis of hip or knee (CC 42)	11.8	12.0	12.7	12.2
Other musculoskeletal and connective tissue disorders (CC 45)	70.4	71.1	67.1	69.5
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	37.3	37.1	36.4	36.9
Dementia or other specified brain disorders (CC 51-53)	31.2	31.0	31.3	31.2
Major psychiatric disorders (CC 57-59)	10.7	10.9	9.0	10.2
Quadriplegia, other extensive paralysis; paraplegia; spinal cord disorders/injuries (CC 70-73)	1.6	1.6	1.7	1.6
Cerebral palsy; hemiplegia/hemiparesis (CC 74, 103)	5.3	5.2	5.8	5.4
Multiple sclerosis; mononeuropathy, other neurological conditions/injuries (CC 77, 81)	18.2	18.8	19.4	18.8
Seizure disorders and convulsions (CC 79)	7.7	7.7	7.6	7.6
Congestive heart failure (CC 85)	24.2	23.6	23.5	23.7
Valvular and rheumatic heart disease (CC 91)	25.3	25.5	25.4	25.4
Congenital cardiac/circulatory defects (CC 92-93)	2.5	2.4	2.6	2.5
Hypertensive heart disease (CC 94)	4.7	4.3	4.5	4.5
Hypertension (CC 95)	89.1	89.1	89.4	89.2
Specified heart arrhythmias (CC 96)	30.6	30.3	30.1	30.3
Cerebral hemorrhage (CC 99)	2.1	2.1	2.2	2.1
Ischemic or unspecified stroke (CC 100)	22.7	22.1	21.2	22.0
Precerebral arterial occlusion and transient cerebral ischemia (CC 101)	22.0	21.7	20.9	21.6
Cerebrovascular atherosclerosis, aneurysm, and other disease (CC 102)	14.2	13.7	13.5	13.8
Vascular disease and complications (CC 106-108)	24.3	24.0	24.1	24.1
Chronic obstructive pulmonary disease (COPD) (CC 111)	22.1	21.8	21.5	21.8
Pneumonia (CC 114-116)	15.6	15.1	14.8	15.2
Pleural effusion/pneumothorax (CC 117)	7.5	7.4	7.4	7.4
Other eye disorders (CC 128)	20.5	20.7	21.3	20.8
Other ear, nose, throat, and mouth disorders (CC 131)	28.8	28.5	28.9	28.8
Dialysis status (CC 134)	1.6	1.6	1.7	1.6
Renal failure (CC 135-140)	28.4	29.4	30.4	29.4
Urinary tract infection (CC 144)	21.5	21.3	21.1	21.3
Male genital disorders (CC 149)	14.8	15.0	15.2	15.0

Variable	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Decubitus ulcer of skin (CC 157-160)	2.7	2.6	2.7	2.7
Chronic ulcer of skin, except pressure (CC 161)	5.3	5.2	4.9	5.1
Other dermatological disorders (CC 165)	32.3	32.8	33.2	32.8

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

Variable	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Intercept	-2.878	-2.918	-2.992	-2.932
Age minus 65 (years above 65, continuous)	0.069	0.068	0.066	0.068
Male	-0.007	0.010	0.015	0.004
Transfer from another ED	0.361	0.304	0.415	0.333
Severe infection; other infectious diseases (CC 1, 3-7)	0.098	0.106	0.112	0.110
Metastatic cancer, acute leukemia and other severe cancers (CC 8-9)	0.965	0.923	0.977	0.957
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other major cancers (CC 10-15)	-0.055	-0.037	-0.093	-0.060
Protein-calorie malnutrition (CC 21)	0.549	0.540	0.616	0.572
Disorders of fluid/electrolyte/acid-base; other endocrine/metabolic/nutritional disorders (CC 22-26)	-0.298	-0.322	-0.318	-0.312
Other gastrointestinal disorders (CC 38)	-0.128	-0.098	-0.118	-0.118
Disorders of the vertebrae and spinal discs (CC 41)	-0.127	-0.158	-0.169	-0.151
Osteoarthritis of hip or knee (CC 42)	-0.200	-0.185	-0.164	-0.185
Other musculoskeletal and connective tissue disorders (CC 45)	-0.145	-0.142	-0.097	-0.126
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	0.201	0.212	0.221	0.215
Dementia or other specified brain disorders (CC 51-53)	0.302	0.335	0.322	0.320
Major psychiatric disorders (CC 57-59)	0.048	0.090	0.097	0.081
Quadriplegia, other extensive paralysis; paraplegia; spinal cord disorders/injuries (CC 70-73)	0.302	0.356	0.438	0.374
Cerebral palsy; hemiplegia/hemiparesis (CC 74, 103)	0.270	0.238	0.213	0.240
Multiple sclerosis; mononeuropathy, other neurological conditions/injuries (CC 77, 81)	-0.171	-0.140	-0.177	-0.166
Seizure disorders and convulsions (CC 79)	0.325	0.426	0.384	0.380
Congestive heart failure (CC 85)	0.242	0.251	0.275	0.256
Valvular and rheumatic heart disease (CC 91)	-0.097	-0.118	-0.111	-0.106
Congenital cardiac/circulatory defects (CC 92-93)	-0.267	-0.450	-0.415	-0.380
Hypertensive heart disease (CC 94)	-0.167	-0.160	-0.137	-0.142
Hypertension (CC 95)	-0.136	-0.099	-0.103	-0.113
Specified heart arrhythmias (CC 96)	0.464	0.456	0.463	0.459
Cerebral hemorrhage (CC 99)	0.202	0.153	0.104	0.152
Ischemic or unspecified stroke (CC 100)	-0.110	-0.094	-0.059	-0.087
Precerebral arterial occlusion and transient cerebral ischemia (CC 101)	-0.251	-0.248	-0.257	-0.252
Cerebrovascular atherosclerosis, aneurysm, and other disease (CC 102)	-0.161	-0.233	-0.148	-0.179
Vascular disease and complications (CC 106-108)	0.121	0.103	0.124	0.120
Chronic obstructive pulmonary disease (COPD) (CC 111)	0.098	0.115	0.100	0.103
Pneumonia (CC 114-116)	0.386	0.336	0.347	0.357

Variable	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Pleural effusion/pneumothorax (CC 117)	0.130	0.141	0.116	0.129
Other eye disorders (CC 128)	-0.099	-0.126	-0.101	-0.109
Other ear, nose, throat, and mouth disorders (CC 131)	-0.126	-0.101	-0.149	-0.125
Dialysis status (CC 134)	0.130	0.234	0.117	0.166
Renal failure (CC 135-140)	0.056	0.094	0.053	0.065
Urinary tract infection (CC 144)	0.110	0.060	0.059	0.075
Male genital disorders (CC 149)	-0.198	-0.158	-0.186	-0.178
Decubitus ulcer of skin (CC 157-160)	0.208	0.198	0.168	0.193
Chronic ulcer of skin, except pressure (CC 161)	0.188	0.164	0.158	0.172
Other dermatological disorders (CC 165)	-0.116	-0.134	-0.097	-0.116

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

Variable	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2015-06/2016 OR (95% CI)	07/2013-06/2016 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	0.99 (0.96 - 1.03)	1.01 (0.98 - 1.05)	1.02 (0.98 - 1.05)	1.00 (0.98 - 1.03)
Transfer from another ED	1.43 (1.37 - 1.51)	1.36 (1.29 - 1.42)	1.51 (1.45 - 1.59)	1.40 (1.36 - 1.44)
Severe infection; other infectious diseases (CC 1, 3-7)	1.10 (1.07 - 1.14)	1.11 (1.08 - 1.15)	1.12 (1.08 - 1.16)	1.12 (1.10 - 1.14)
Metastatic cancer, acute leukemia and other severe cancers (CC 8-9)	2.63 (2.47 - 2.79)	2.52 (2.37 - 2.68)	2.66 (2.50 - 2.82)	2.60 (2.51 - 2.70)
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other major cancers (CC 10-15)	0.95 (0.91 - 0.98)	0.96 (0.93 - 1.00)	0.91 (0.88 - 0.95)	0.94 (0.92 - 0.96)
Protein-calorie malnutrition (CC 21)	1.73 (1.65 - 1.82)	1.72 (1.64 - 1.80)	1.85 (1.77 - 1.94)	1.77 (1.72 - 1.82)
Disorders of fluid/electrolyte/acid-base; other endocrine/metabolic/nutritional disorders (CC 22-26)	0.74 (0.71 - 0.77)	0.73 (0.70 - 0.76)	0.73 (0.70 - 0.76)	0.73 (0.71 - 0.75)
Other gastrointestinal disorders (CC 38)	0.88 (0.85 - 0.91)	0.91 (0.88 - 0.94)	0.89 (0.86 - 0.92)	0.89 (0.87 - 0.91)
Disorders of the vertebrae and spinal discs (CC 41)	0.88 (0.85 - 0.91)	0.85 (0.82 - 0.89)	0.85 (0.81 - 0.88)	0.86 (0.84 - 0.88)
Osteoarthritis of hip or knee (CC 42)	0.82 (0.78 - 0.86)	0.83 (0.79 - 0.87)	0.85 (0.81 - 0.89)	0.83 (0.81 - 0.85)
Other musculoskeletal and connective tissue disorders (CC 45)	0.87 (0.84 - 0.90)	0.87 (0.84 - 0.90)	0.91 (0.88 - 0.94)	0.88 (0.87 - 0.90)
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	1.22 (1.18 - 1.26)	1.24 (1.20 - 1.28)	1.25 (1.21 - 1.29)	1.24 (1.22 - 1.26)
Dementia or other specified brain disorders (CC 51-53)	1.35 (1.31 - 1.40)	1.40 (1.36 - 1.44)	1.38 (1.34 - 1.42)	1.38 (1.35 - 1.40)
Major psychiatric disorders (CC 57-59)	1.05 (1.00 - 1.10)	1.10 (1.05 - 1.14)	1.10 (1.05 - 1.16)	1.09 (1.06 - 1.11)
Quadriplegia, other extensive paralysis; paraplegia; spinal cord disorders/injuries (CC 70-73)	1.35 (1.22 - 1.50)	1.43 (1.29 - 1.58)	1.55 (1.41 - 1.71)	1.45 (1.37 - 1.54)
Cerebral palsy; hemiplegia/hemiparesis (CC 74, 103)	1.31 (1.23 - 1.40)	1.27 (1.19 - 1.35)	1.24 (1.16 - 1.32)	1.27 (1.23 - 1.32)
Multiple sclerosis; mononeuropathy, other neurological conditions/injuries (CC 77, 81)	0.84 (0.81 - 0.88)	0.87 (0.84 - 0.90)	0.84 (0.81 - 0.87)	0.85 (0.83 - 0.87)
Seizure disorders and convulsions (CC 79)	1.38 (1.32 - 1.45)	1.53 (1.46 - 1.61)	1.47 (1.40 - 1.54)	1.46 (1.42 - 1.51)

Variable	07/2013-06/2014 OR (95% CI)	07/2014-06/2015 OR (95% CI)	07/2015-06/2016 OR (95% CI)	07/2013-06/2016 OR (95% CI)
Congestive heart failure (CC 85)	1.27 (1.23 - 1.32)	1.29 (1.24 - 1.33)	1.32 (1.27 - 1.37)	1.29 (1.27 - 1.32)
Valvular and rheumatic heart disease (CC 91)	0.91 (0.88 - 0.94)	0.89 (0.86 - 0.92)	0.90 (0.87 - 0.93)	0.90 (0.88 - 0.92)
Congenital cardiac/circulatory defects (CC 92-93)	0.77 (0.69 - 0.85)	0.64 (0.57 - 0.71)	0.66 (0.59 - 0.74)	0.68 (0.64 - 0.73)
Hypertensive heart disease (CC 94)	0.85 (0.79 - 0.91)	0.85 (0.79 - 0.92)	0.87 (0.81 - 0.94)	0.87 (0.83 - 0.90)
Hypertension (CC 95)	0.87 (0.84 - 0.91)	0.91 (0.87 - 0.95)	0.90 (0.86 - 0.95)	0.89 (0.87 - 0.92)
Specified heart arrhythmias (CC 96)	1.59 (1.54 - 1.64)	1.58 (1.53 - 1.63)	1.59 (1.54 - 1.64)	1.58 (1.55 - 1.61)
Cerebral hemorrhage (CC 99)	1.22 (1.12 - 1.34)	1.17 (1.07 - 1.27)	1.11 (1.01 - 1.21)	1.16 (1.11 - 1.23)
Ischemic or unspecified stroke (CC 100)	0.90 (0.86 - 0.93)	0.91 (0.88 - 0.95)	0.94 (0.91 - 0.98)	0.92 (0.90 - 0.94)
Precerebral arterial occlusion and transient cerebral ischemia (CC 101)	0.78 (0.75 - 0.81)	0.78 (0.75 - 0.81)	0.77 (0.74 - 0.81)	0.78 (0.76 - 0.80)
Cerebrovascular atherosclerosis, aneurysm, and other disease (CC 102)	0.85 (0.82 - 0.89)	0.79 (0.76 - 0.83)	0.86 (0.82 - 0.90)	0.84 (0.82 - 0.86)
Vascular disease and complications (CC 106-108)	1.13 (1.09 - 1.17)	1.11 (1.07 - 1.15)	1.13 (1.09 - 1.17)	1.13 (1.11 - 1.15)
Chronic obstructive pulmonary disease (COPD) (CC 111)	1.10 (1.07 - 1.14)	1.12 (1.08 - 1.16)	1.11 (1.07 - 1.15)	1.11 (1.09 - 1.13)
Pneumonia (CC 114-116)	1.47 (1.42 - 1.53)	1.40 (1.35 - 1.45)	1.42 (1.36 - 1.47)	1.43 (1.40 - 1.46)
Pleural effusion/pneumothorax (CC 117)	1.14 (1.09 - 1.20)	1.15 (1.10 - 1.21)	1.12 (1.07 - 1.18)	1.14 (1.11 - 1.17)
Other eye disorders (CC 128)	0.91 (0.87 - 0.94)	0.88 (0.85 - 0.91)	0.90 (0.87 - 0.94)	0.90 (0.88 - 0.92)
Other ear, nose, throat, and mouth disorders (CC 131)	0.88 (0.85 - 0.91)	0.90 (0.88 - 0.93)	0.86 (0.83 - 0.89)	0.88 (0.87 - 0.90)
Dialysis status (CC 134)	1.14 (1.02 - 1.27)	1.26 (1.14 - 1.40)	1.12 (1.01 - 1.25)	1.18 (1.11 - 1.25)
Renal failure (CC 135-140)	1.06 (1.02 - 1.09)	1.10 (1.06 - 1.14)	1.05 (1.02 - 1.09)	1.07 (1.05 - 1.09)
Urinary tract infection (CC 144)	1.12 (1.08 - 1.16)	1.06 (1.03 - 1.10)	1.06 (1.02 - 1.10)	1.08 (1.06 - 1.10)
Male genital disorders (CC 149)	0.82 (0.78 - 0.86)	0.85 (0.81 - 0.90)	0.83 (0.79 - 0.87)	0.84 (0.81 - 0.86)
Decubitus ulcer of skin (CC 157-160)	1.23 (1.14 - 1.33)	1.22 (1.13 - 1.31)	1.18 (1.10 - 1.28)	1.21 (1.16 - 1.27)
Chronic ulcer of skin, except pressure (CC 161)	1.21 (1.14 - 1.28)	1.18 (1.11 - 1.25)	1.17 (1.10 - 1.25)	1.19 (1.15 - 1.23)
Other dermatological disorders (CC 165)	0.89 (0.86 - 0.92)	0.88 (0.85 - 0.90)	0.91 (0.88 - 0.94)	0.89 (0.87 - 0.91)

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

Characteristic	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Predictive ability, % (lowest decile – highest decile)	2.6 - 39.1	2.4 - 38.7	2.3 - 37.7	2.4 - 38.4
c-statistic	0.74	0.74	0.75	0.74

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

Characteristic	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Number of hospitals	4,167	4,118	4,015	4,417
Mean number of admissions (SD)	41.5 (54.6)	42.3 (56.9)	43.0 (58.4)	117.7 (165.7)
Range (min. – max.)	1 - 480	1 - 549	1 - 613	1 - 1,599
25th percentile	5	5	5	11
50th percentile	18	18	18	43
75th percentile	59	59	60	165

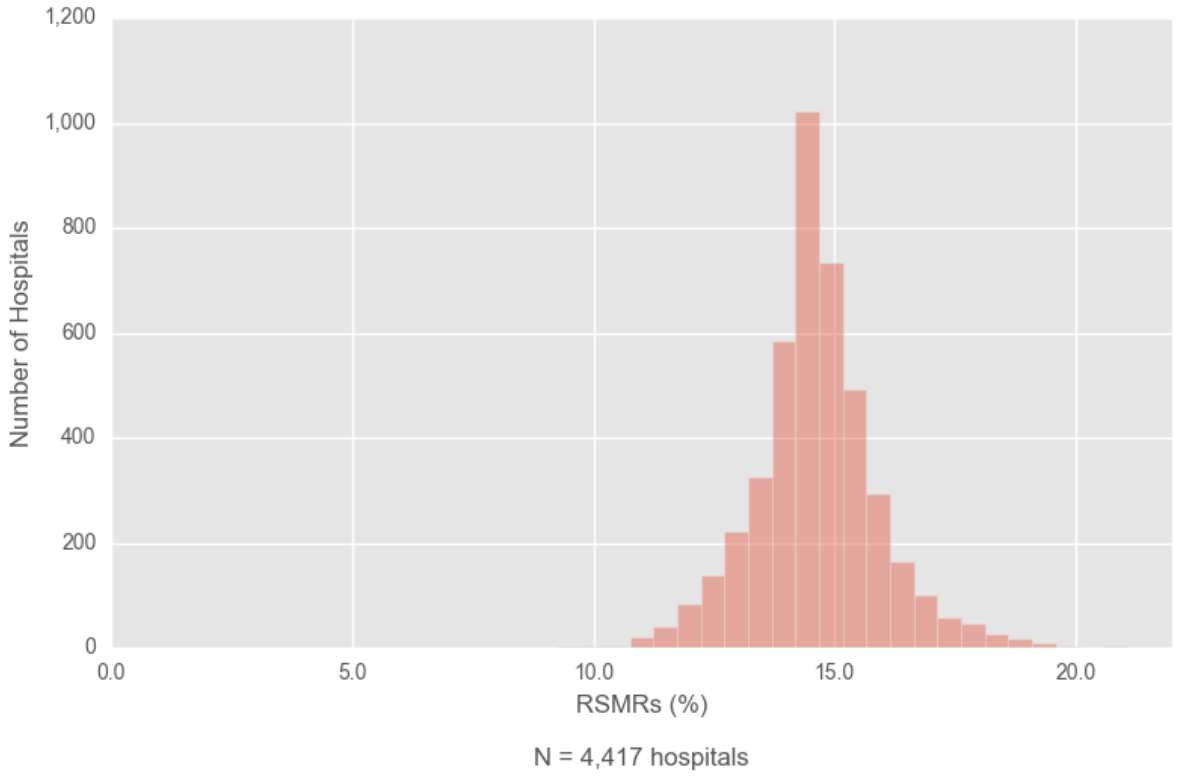
Table 4.6.6 – Distribution of Hospital Stroke RSMRs over Different Time Periods

Characteristic	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Number of hospitals	4,167	4,118	4,015	4,417
Mean (SD)	14.9 (1.0)	14.8 (0.9)	14.0 (0.8)	14.6 (1.3)
Range (min. – max.)	11.1 - 21.1	10.6 - 19.5	9.8 - 20.2	9.3 - 21.5
25th percentile	14.4	14.4	13.6	14.0
50th percentile	14.8	14.7	13.9	14.5
75th percentile	15.4	15.2	14.4	15.3

Table 4.6.7 – Between-Hospital Variance for Stroke

	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Between-hospital variance (SE)	0.050 (0.005)	0.046 (0.005)	0.043 (0.005)	0.050 (0.003)

Figure 4.6.2 – Distribution of Hospital 30-Day Stroke RSMRs between July 2013 and June 2016



5. GLOSSARY

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

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

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

Comorbidities: Medical conditions the patient had in addition to 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/ICD-10-CM diagnosis codes in clinically relevant categories, from the Hierarchical Condition Categories (HCCs) system.[23,24] CMS uses the grouping but not the hierarchical logic of the system to create risk factor variables. Mappings which show the assignment of ICD-9 and ICD-10 codes to the CCs are available on the *QualityNet* website.

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

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

Hierarchical model: A widely accepted statistical method that enables evaluation of relative hospital performance by accounting for patient risk factors. This statistical model accounts for the hierarchical structure of the data (patients clustered within hospitals are assumed to be correlated) and accommodates modeling of the association between outcomes and patient characteristics. Based on the hierarchical model, we can evaluate: (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 there is 95% confidence that the true value of the rate lies between the lower and the upper limit of the interval.

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

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

Odds ratio (OR): The ORs express the relative odds of the outcome for each of the predictor variables. For example, the OR for Protein-calorie malnutrition (CC 21) represents the odds of the outcome for patients with 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 the start of the 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.

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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 case mix and the average hospital-specific effect (that is, the average effect among all hospitals in the national sample). The predicted mortality for each hospital is estimated using the same case mix but an estimated hospital-specific effect for that hospital. 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 obtained by summing the predicted probabilities of mortality for all patients in the hospital. The predicted 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 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.[25] 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 $\hat{y}_{ij}(Z_{ij}) = h^{-1}(\hat{a}_i + \hat{\beta}\boldsymbol{Z}_{ij})$ (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. The estimated regression coefficients of the risk factors, $\hat{\beta}^{(b)}$.
    b. The parameters governing the random effects, hospital adjusted outcomes, distribution, $\hat{\mu}^{(b)}$ and $\hat{\tau}^{2(b)}$.
    c. The set of hospital-specific intercepts and corresponding variances, $\{\hat{\alpha}_i{}^{(b)}, \widehat{var}(\alpha_i{}^{(b)}); i = 1,2,\dots,I\}$

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

Ninety-five percent interval estimates (or alternative interval estimates) for the hospital-standardized outcome can be computed by identifying the 2.5th and 97.5th percentiles of the B estimates (or the percentiles corresponding to the alternative desired intervals[26]).

Appendix B. Data QA

This production year required revision of all SAS packs to account for the ICD-10 code transition. In order to assure the quality of measure output, we utilized a multi-phase approach to QA of the mortality measures.

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 another contractor conducts that work.

Phase I

The first step in this year's QA process started prior to the SAS pack revisions. We tested the conversion of the HCC map from version 12 to version 22 to ensure that the risk variables were well-aligned in both coding schemes. Following risk variable testing, we tested the impact of ICD-10 coding on the cohort inclusion and exclusion criteria, outcomes, and risk factors. We drew comparisons between the first six months of data from the start of the ICD-10 transition and the same six months in the prior year for ICD-9.

In general, we used both manual scan and descriptive analyses to conduct data validity checks, including cross-checking mortality information, distributions of ICD-9/ICD-10 codes, and frequencies of key variables.

Phase II

Using a finalized list of ICD-10 coding changes, we updated the existing SAS packs to accommodate the post-transition data. To assure accuracy in the SAS pack revisions, two to three analysts/programmers independently wrote SAS code for any changes made in calculating the mortality measures: data preparation, cohort construction, hierarchical modeling, and calculation of RSMRs. This process highlighted any programming errors in syntax or logic and checked that new ICD-10 codes had been properly applied. Once this parallel programming process was complete, the analysts cross-checked their codes by analyzing datasets in parallel, checking for consistency of output, and reconciling any discrepancies. Finally, an additional analyst reviewed the finalized SAS code and recommended changes to the coding and readability of the SAS pack, where appropriate.

Phase III

The last phase of QA involved reviewing the year-to-year changes in the risk variable frequencies, beta coefficients, and outcome rates for the measures. This was especially important this year as the final year of the three-year reporting period encompasses a large proportion of ICD-10 claims. This phase served as a final check, to ensure the ICD-10 code-based cohort, risk factor and outcome changes did not have an adverse impact on measure results.

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.

2017

2017 Measures Updates and Specifications Report (Version 11.0 - AMI, HF, and Pneumonia) (Version 6.0 - COPD and Stroke)

1. Revised the measure specifications to accommodate the implementation of ICD-10 coding:
   - Identified the ICD-10 codes used to define each of the measure cohorts for discharges on or after October 1, 2015.
   - Re-specified the risk models, updating the CC-based risk variables to the ICD-10-compatible HCC system version 22 and applying ICD-10 codes for certain risk variables (for example, history of PTCA) to the models.
     - Rationale: The ICD-9 code sets used to report medical diagnoses and inpatient procedures were replaced by ICD-10 code sets on October 1, 2015. HHS mandated that ICD-10 codes be used for medical coding, effective October 1, 2015 discharges. The measurement period for 2017 public reporting required data from claims that include ICD-10 codes in addition to data from claims that include ICD-9 codes. Thus, re-specification was warranted to accommodate ICD-10 coding.

2016

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

2. Updated the pneumonia measure specifications[27]:
   - 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 or aspiration pneumonia. The need to make these changes was further underscored by wide variation across hospitals in the use of sepsis codes and, to a lesser extent, aspiration pneumonia codes. Systematic changes and differences in hospital coding practices potentially bias efforts to compare hospital performance.
   - 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), Respirator 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.

3. 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.[28] These patients represent a clinically distinct group.
4. Added one ischemic stroke code (436 Acute, but ill-defined, cerebrovascular disease) to the stroke measure.
    - 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.[29] 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 fewer 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 against medical advice.
    - Rationale: Providers are unable to deliver full care and prepare the patient for discharge when patients leave against medical advice.
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**
   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. 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-10-CM Codes for AMI Cohort

Table D.1.1 below outlines the ICD-10-CM codes used to define the AMI cohort for discharges on or after October 1, 2015. ICD-9 code lists for discharges prior to October 1, 2015 can be found in the 2016 condition-specific mortality measures updates and specifications report posted on *QualityNet*.

ICD-10-CM Codes	Description
I21.01	ST elevation (STEMI) myocardial infarction involving left main coronary artery
I21.02	ST elevation (STEMI) myocardial infarction involving left anterior descending coronary artery
I21.09	ST elevation (STEMI) myocardial infarction involving other coronary artery of anterior wall
I21.11	ST elevation (STEMI) myocardial infarction involving right coronary artery
I21.19	ST elevation (STEMI) myocardial infarction involving other coronary artery of inferior wall
I21.21	ST elevation (STEMI) myocardial infarction involving left circumflex coronary artery
I21.29	ST elevation (STEMI) myocardial infarction involving other sites
I21.3	ST elevation (STEMI) myocardial infarction of unspecified site
I21.4	Non-ST elevation (NSTEMI) myocardial infarction

Risk Adjustment

Table D.1.2 – Risk Variables for AMI Measure

The CCs outlined in Table D.1.2 below are used to identify risk variables in claims for discharges on or after October 1, 2015 as well as discharges prior to October 1, 2015.

The ICD-10 codes used to identify certain risk variables (for example, history of PTCA) in discharges on or after October 1, 2015 are posted on *QualityNet* due to volume; hyperlinks to these lists are provided in the table. For a list of ICD-9 codes used to identify these variables in discharges prior to October 1, 2015, please refer to the 2016 condition-specific mortality measures updates and specifications report posted on *QualityNet*.

Description of Risk Variable	CCs and/or ICD Codes Included	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	
Anterior myocardial infarction	ICD-10-CM code list	
Other location of myocardial infarction	ICD-10-CM code list	
History of coronary artery bypass graft (CABG) surgery	ICD-10-CM code list and ICD-10-PCS code list	
History of percutaneous transluminal coronary angioplasty (PTCA)	ICD-10-CM code list and ICD-10-PCS code list	
Metastatic cancer, acute leukemia and other severe cancers (CC 8-9)	Metastatic cancer and acute leukemia (CC 8)	
	Lung and other severe cancers (CC 9)	

Description of Risk Variable	CCs and/or ICD Codes Included	Variables Not Used in Risk Adjustment if Occurred Only during Index Admission (indicated by "X")
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 17-19, 123)	Diabetes with acute complications (CC 17)	
	Diabetes with chronic complications (CC 18)	
	Diabetes without complications (CC 19)	
	Diabetic and other vascular retinopathies (CC 123)	
Protein-calorie malnutrition (CC 21)	Protein-calorie malnutrition (CC 21)	
Chronic liver disease (CC 27-29)	End-stage liver disease (CC 27)	
	Cirrhosis of liver (CC 28)	
	Chronic hepatitis (CC 29)	
Dementia or other specified brain disorders (CC 51-53)	Dementia with complications (CC 51)	
	Dementia without complications (CC 52)	
	Nonpsychotic organic brain syndromes/conditions (CC 53)	
Major psychiatric disorders (CC 57-59)	Schizophrenia (CC 57)	
	Major depressive, bipolar, and paranoid disorders (CC 58)	
	Reactive and unspecified psychosis (CC 59)	
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	Quadriplegia (CC 70)	
	Paraplegia (CC 71)	
	Spinal cord disorders/injuries (CC 72)	
	Amyotrophic lateral sclerosis and other motor neuron disease (CC 73)	
	Cerebral palsy (CC 74)	
	Hemiplegia/hemiparesis (CC 103)	X
	Monoplegia, other paralytic syndromes (CC 104)	X
	Amputation status, lower limb/amputation complications (CC 189)	X
	Amputation status, upper limb (CC 190)	X
Cardio-respiratory failure and shock	Cardio-respiratory failure and shock (CC 84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	X
Congestive heart failure (CC 85)	Congestive heart failure (CC 85)	X
Acute myocardial infarction (CC 86)	Acute myocardial infarction (CC 86)	X
Unstable angina and other acute ischemic heart disease (CC 87)	Unstable angina and other acute ischemic heart disease (CC 87)	X
Coronary atherosclerosis or angina (CC 88-89)	Angina pectoris (CC 88)	
	Coronary atherosclerosis/other chronic ischemic heart disease (CC 89)	
Valvular and rheumatic heart disease (CC 91)	Valvular and rheumatic heart disease (CC 91)	
Hypertension (CC 95)	Hypertension (CC 95)	
Stroke (CC 99-100)	Cerebral hemorrhage (CC 99)	X
	Ischemic or unspecified stroke (CC 100)	X
Cerebrovascular disease (CC 101-102, 105)	Precerebral arterial occlusion and transient cerebral ischemia (CC 101)	X

Description of Risk Variable	CCs and/or ICD Codes Included	Variables Not Used in Risk Adjustment if Occurred Only during Index Admission (indicated by "X")
	Cerebrovascular atherosclerosis, aneurysm, and other disease (CC 102)	
	Late effects of cerebrovascular disease, except paralysis (CC 105)	
Vascular disease and complications (CC 106-108)	Atherosclerosis of the extremities with ulceration or gangrene (CC 106)	X
	Vascular disease with complications (CC 107)	X
	Vascular disease (CC 108)	X
Chronic obstructive pulmonary disease (COPD) (CC 111)	Chronic obstructive pulmonary disease (COPD) (CC 111)	
Pneumonia (CC 114-116)	Aspiration and specified bacterial pneumonias (CC 114)	X
	Pneumococcal pneumonia, empyema, lung abscess (CC 115)	X
	Viral and unspecified pneumonia, pleurisy (CC 116)	
Renal failure (CC 135-140)	Acute renal failure (CC 135)	X
	Chronic kidney disease, stage 5 (CC 136)	
	Chronic kidney disease, severe (stage 4) (CC 137)	
	Chronic kidney disease, moderate (stage 3) (CC 138)	
	Chronic kidney disease, mild or unspecified (stages 1-2 or unspecified) (CC 139)	
	Unspecified renal failure (CC 140)	X
Trauma; other injuries (CC 166-168, 170-174)	Severe head injury (CC 166)	X
	Major head injury (CC 167)	X
	Concussion or unspecified head injury (CC 168)	X
	Hip fracture/dislocation (CC 170)	X
	Major fracture, except of skull, vertebrae, or hip (CC 171)	X
	Internal injuries (CC 172)	
	Traumatic amputations and complications (CC 173)	X
	Other injuries (CC 174)	

Outcome

Outcome Criteria for AMI Measure

Death, from any cause, within 30 days of the start of the index admission.
Rationale: From a patient perspective, death is a critical outcome regardless of cause. Outcomes occurring within 30 days of the start of the 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**
   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. 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-10-CM Codes for COPD Cohort

Table D.2.1 below outlines the ICD-10-CM codes used to define the COPD cohort for discharges on or after October 1, 2015. ICD-9 code lists for discharges prior to October 1, 2015 can be found in the 2016 condition-specific mortality measures updates and specifications report posted on *QualityNet*.

ICD-10-CM Codes	Description
J41.8	Mixed simple and mucopurulent chronic bronchitis
J42	Unspecified chronic bronchitis
J43.0	Unilateral pulmonary emphysema [MacLeod's syndrome]
J43.1	Panlobular emphysema
J43.2	Centrilobular emphysema
J43.8	Other emphysema
J43.9	Emphysema, unspecified
J44.0	Chronic obstructive pulmonary disease with acute lower respiratory infection
J44.1	Chronic obstructive pulmonary disease with (acute) exacerbation
J44.9	Chronic obstructive pulmonary disease, unspecified
Principal discharge diagnosis codes included in cohort if combined with a secondary diagnosis of J44.0 or J44.1	
J96.00	Acute respiratory failure, unspecified whether with hypoxia or hypercapnia
J96.01	Acute respiratory failure with hypoxia
J96.02	Acute respiratory failure with hypercapnia
J96.20	Acute and chronic respiratory failure, unspecified whether with hypoxia or hypercapnia
J96.21	Acute and chronic respiratory failure with hypoxia
J96.22	Acute and chronic respiratory failure with hypercapnia
J96.90	Respiratory failure, unspecified, unspecified whether with hypoxia or hypercapnia
J96.91	Respiratory failure, unspecified with hypoxia
J96.92	Respiratory failure, unspecified with hypercapnia
R09.2	Respiratory arrest

Risk Adjustment

Table D.2.2 – Risk Variables for COPD Measure

The CCs outlined in Table D.2.2 below are used to identify risk variables in claims for discharges on or after October 1, 2015 as well as discharges prior to October 1, 2015.

The ICD-10 codes used to identify History of mechanical ventilation in discharges on or after October 1, 2015 are posted on *QualityNet* due to volume; a hyperlink to this list is provided in the table. For a list of ICD-9 codes used to identify this variable in discharges prior to October 1, 2015, please refer to the 2016 condition-specific mortality measures updates and specifications report posted on *QualityNet*.

Description of Risk Variable	CCs and/or ICD Codes Included	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-10-PCS code list	
Metastatic cancer or acute leukemia (CC 8)	Metastatic cancer or acute leukemia (CC 8)	
Lung and other severe cancers (CC 9)	Lung and other severe cancers (CC 9)	
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other cancers and tumors; other respiratory and heart neoplasms (CC 10-13)	Lymphoma and other cancers (CC 10)	
	Colorectal, bladder, and other cancers (CC 11)	
	Breast, prostate, and other cancers and tumors (CC 12)	
	Other respiratory and heart neoplasms (CC 13)	
Other digestive and urinary neoplasms (CC 14)	Other digestive and urinary neoplasms (CC 14)	
Diabetes mellitus (DM) or DM complications (CC 17-19, 122-123)	Diabetes with acute complications (CC 17)	X
	Diabetes with chronic complications (CC 18)	
	Diabetes without complications (CC 19)	
	Proliferative diabetic retinopathy and vitreous hemorrhage (CC 122)	
	Diabetic and other vascular retinopathies (CC 123)	
Protein-calorie malnutrition (CC 21)	Protein-calorie malnutrition (CC 21)	
Morbid obesity; other endocrine/metabolic/nutritional disorders (CC 22, 25-26)	Morbid obesity (CC 22)	
	Disorders of lipoid metabolism (CC 25)	
	Other endocrine/metabolic/nutritional disorders (CC 26)	
Other significant endocrine and metabolic disorders; disorders of fluid/electrolyte/acid-base balance (CC 23-24)	Other significant endocrine and metabolic disorders (CC 23)	
	Disorders of fluid/electrolyte/acid-base balance (CC 24)	X
Other gastrointestinal disorders (CC 38)	Other gastrointestinal disorders (CC 38)	
Osteoarthritis of hip or knee (CC 42)	Osteoarthritis of hip or knee (CC 42)	
Other musculoskeletal and connective tissue disorders (CC 45)	Other musculoskeletal and connective tissue disorders (CC 45)	
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	Iron deficiency or other/unspecified anemias and blood disease (CC 49)	
Dementia or other specified brain disorders (CC 51-53)	Dementia with complications (CC 51)	
	Dementia without complications (CC 52)	
	Nonpsychotic organic brain syndromes/conditions (CC 53)	

Description of Risk Variable	CCs and/or ICD Codes Included	Variables Not Used in Risk Adjustment if Occurred Only during Index Admission (indicated by "X")
Drug/alcohol abuse, without dependence (CC 56)	Drug/alcohol abuse, without dependence (CC 56)	
Other psychiatric disorders (CC 63)	Other psychiatric disorders (CC 63)	
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	Quadriplegia (CC 70)	
	Paraplegia (CC 71)	
	Spinal cord disorders/injuries (CC 72)	
	Amyotrophic lateral sclerosis and other motor neuron disease (CC 73)	
	Cerebral palsy (CC 74)	
	Hemiplegia/hemiparesis (CC 103)	X
	Monoplegia, other paralytic syndromes (CC 104)	X
	Amputation status, lower limb/amputation complications (CC 189)	X
	Amputation status, upper limb (CC 190)	X
Polyneuropathy, mononeuropathy, and other neurological conditions/injuries (CC 81)	Polyneuropathy, mononeuropathy, and other neurological conditions/injuries (CC 81)	
Respirator dependence/respiratory failure (CC 82-83)	Respirator dependence/tracheostomy status (CC 82)	X
	Respiratory arrest (CC 83)	X
Cardio-respiratory failure and shock	Cardio-respiratory failure and shock (CC 84), plus ICD-10-CM codes R09.01 and R09.02 (for discharges on or after October 1, 2015) and ICD-9-CM codes 799.01 and 799.02 (for discharges prior to October 1, 2015)	X
Congestive heart failure (CC 85)	Congestive heart failure (CC 85)	X
Coronary atherosclerosis or angina (CC 88-89)	Angina pectoris (CC 88)	
	Coronary atherosclerosis/other chronic ischemic heart disease (CC 89)	
Hypertension and hypertensive disease (CC 94-95)	Hypertensive heart disease (CC 94)	
	Hypertension (CC 95)	
Specified arrhythmias and other heart rhythm disorders (CC 96-97)	Specified heart arrhythmias (CC 96)	X
	Other heart rhythm and conduction disorders (CC 97)	X
Stroke (CC 99-100)	Cerebral hemorrhage (CC 99)	X
	Ischemic or unspecified stroke (CC 100)	X
Vascular or circulatory disease (CC 106-109)	Atherosclerosis of the extremities with ulceration or gangrene (CC 106)	X
	Vascular disease with complications (CC 107)	X
	Vascular disease (CC 108)	X
	Other circulatory disease (CC 109)	X
Fibrosis of lung or other chronic lung disorders (CC 112)	Fibrosis of lung or other chronic lung disorders (CC 112)	
Asthma (CC 113)	Asthma (CC 113)	
Pneumonia (CC 114-116)	Aspiration and specified bacterial pneumonias (CC 114)	X

Description of Risk Variable	CCs and/or ICD Codes Included	Variables Not Used in Risk Adjustment if Occurred Only during Index Admission (indicated by "X")
	Pneumococcal pneumonia, empyema, lung abscess (CC 115)	X
	Viral and unspecified pneumonia, pleurisy (CC 116)	
Pleural effusion/pneumothorax (CC 117)	Pleural effusion/pneumothorax (CC 117)	X
Other respiratory disorders (CC 118)	Other respiratory disorders (CC 118)	
Other retinal disorders (CC 125)	Other retinal disorders (CC 125)	
Other eye disorders (CC 128)	Other eye disorders (CC 128)	
Other ear, nose, throat, and mouth disorders (CC 131)	Other ear, nose, throat, and mouth disorders (CC 131)	
Renal failure (CC 135-140)	Acute renal failure (CC 135)	X
	Chronic kidney disease, stage 5 (CC 136)	
	Chronic kidney disease, severe (stage 4) (CC 137)	
	Chronic kidney disease, moderate (stage 3) (CC 138)	
	Chronic kidney disease, mild or unspecified (stages 1-2 or unspecified) (CC 139)	
	Unspecified renal failure (CC 140)	X
Decubitus ulcer or chronic skin ulcer (CC 157-161)	Pressure ulcer of skin with necrosis through to muscle, tendon, or bone (CC 157)	X
	Pressure ulcer of skin with full thickness skin loss (CC 158)	X
	Pressure ulcer of skin with partial thickness skin loss (CC 159)	X
	Pressure pre-ulcer skin changes or unspecified stage (CC 160)	X
	Chronic ulcer of skin, except pressure (CC 161)	
Other dermatological disorders (CC 165)	Other dermatological disorders (CC 165)	
Trauma (CC 166-168, 170-173)	Severe head injury (CC 166)	X
	Major head injury (CC 167)	X
	Concussion or unspecified head injury (CC 168)	X
	Hip fracture/dislocation (CC 170)	X
	Major fracture, except of skull, vertebrae, or hip (CC 171)	X
	Internal injuries (CC 172)	
	Traumatic amputations and complications (CC 173)	X
Vertebral fractures without spinal cord injury (CC 169)	Vertebral fractures without spinal cord injury (CC 169)	
Major complications of medical care and trauma (CC 176-177)	Complications of specified implanted device or graft (CC 176)	X
	Other complications of medical care (CC 177)	X

Outcome

Outcome Criteria for COPD Measure

Death, from any cause, within 30 days of the start of the index admission.
Rationale: From a patient perspective, death is a critical outcome regardless of cause. Outcomes occurring within 30 days of the start of the 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**
   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 group (ICD-10-PCS code list).

   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. 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-10-CM Codes for Inclusion in HF Cohort

Table D.3.1 below outlines the ICD-10-CM codes used to define the HF cohort for discharges on or after October 1, 2015. ICD-9 code lists for discharges prior to October 1, 2015 can be found in the 2016 condition-specific mortality measures updates and specifications report posted on *QualityNet*.

ICD-10-CM Codes	Description
I11.0	Hypertensive heart disease with heart failure
I13.0	Hypertensive heart and chronic kidney disease with heart failure and stage 1 through stage 4 chronic kidney disease, or unspecified chronic kidney disease
I13.2	Hypertensive heart and chronic kidney disease with heart failure and with stage 5 chronic kidney disease, or end stage renal disease
I50.1	Left ventricular failure
I50.20	Unspecified systolic (congestive) heart failure
I50.21	Acute systolic (congestive) heart failure
I50.22	Chronic systolic (congestive) heart failure
I50.23	Acute on chronic systolic (congestive) heart failure
I50.30	Unspecified diastolic (congestive) heart failure
I50.31	Acute diastolic (congestive) heart failure
I50.32	Chronic diastolic (congestive) heart failure
I50.33	Acute on chronic diastolic (congestive) heart failure
I50.40	Unspecified combined systolic (congestive) and diastolic (congestive) heart failure
I50.41	Acute combined systolic (congestive) and diastolic (congestive) heart failure
I50.42	Chronic combined systolic (congestive) and diastolic (congestive) heart failure
I50.43	Acute on chronic combined systolic (congestive) and diastolic (congestive) heart failure
I50.9	Heart failure, unspecified

Risk Adjustment

Table D.3.2 – Risk Variables for HF Measure

The CCs outlined in Table D.3.2 below are used to identify risk variables in claims for discharges on or after October 1, 2015 as well as discharges prior to October 1, 2015.

The ICD-10 codes used to identify History of PTCA and History of CABG surgery in discharges on or after October 1, 2015 are posted on *QualityNet* due to volume; hyperlinks to these lists are provided in the table. For a list of ICD-9 codes used to identify these variables in discharges prior to October 1, 2015, please refer to the 2016 condition-specific mortality measures updates and specifications report posted on *QualityNet*.

Description of Risk Variable	CCs and/or ICD Codes Included	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 coronary artery bypass graft (CABG) surgery	ICD-10-CM code list and ICD-10-PCS code list	
History of percutaneous transluminal coronary angioplasty (PTCA)	ICD-10-CM code list and ICD-10-PCS code list	
Metastatic cancer, acute leukemia and other severe cancers (CC 8-9)	Metastatic cancer and acute leukemia (CC 8)	
	Lung and other severe cancers (CC 9)	
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 17-19, 123)	Diabetes with acute complications (CC 17)	X
	Diabetes with chronic complications (CC 18)	
	Diabetes without complications (CC 19)	
	Diabetic and other vascular retinopathies (CC 123)	
Protein-calorie malnutrition (CC 21)	Protein-calorie malnutrition (CC 21)	
Chronic liver disease (CC 27-29)	End-stage liver disease (CC 27)	
	Cirrhosis of liver (CC 28)	
	Chronic hepatitis (CC 29)	
Dementia or other specified brain disorders (CC 51-53)	Dementia with complications (CC 51)	
	Dementia without complications (CC 52)	
	Nonpsychotic organic brain syndromes/conditions (CC 53)	
Major psychiatric disorders (CC 57-59)	Schizophrenia (CC 57)	
	Major depressive, bipolar, and paranoid disorders (CC 58)	
	Reactive and unspecified psychosis (CC 59)	
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	Quadriplegia (CC 70)	
	Paraplegia (CC 71)	
	Spinal cord disorders/injuries (CC 72)	
	Amyotrophic lateral sclerosis and other motor neuron disease (CC 73)	
	Cerebral palsy (CC 74)	
	Hemiplegia/hemiparesis (CC 103)	X
	Monoplegia, other paralytic syndromes (CC 104)	X
	Amputation status, lower limb/amputation complications (CC 189)	X
	Amputation status, upper limb (CC 190)	X
Cardio-respiratory failure and shock	Cardio-respiratory failure and shock (CC 84), plus ICD-10-CM codes R09.01 and R09.02 (for discharges on or after October 1, 2015) and ICD-9-CM codes 799.01 and 799.02 (for discharges prior to October 1, 2015)	X
Congestive heart failure (CC 85)	Congestive heart failure (CC 85)	X
Acute myocardial infarction (CC 86)	Acute myocardial infarction (CC 86)	X
Unstable angina and other acute ischemic heart disease (CC 87)	Unstable angina and other acute ischemic heart disease (CC 87)	X

Description of Risk Variable	CCs and/or ICD Codes Included	Variables Not Used in Risk Adjustment if Occurred Only during Index Admission (indicated by "X")
Coronary atherosclerosis or angina (CC 88-89)	Angina pectoris (CC 88)	
	Coronary atherosclerosis/other chronic ischemic heart disease (CC 89)	
Valvular and rheumatic heart disease (CC 91)	Valvular and rheumatic heart disease (CC 91)	
Hypertension (CC 95)	Hypertension (CC 95)	
Stroke (CC 99-100)	Cerebral hemorrhage (CC 99)	X
	Ischemic or unspecified stroke (CC 100)	X
Vascular disease and complications (CC 106-108)	Atherosclerosis of the extremities with ulceration or gangrene (CC 106)	X
	Vascular disease with complications (CC 107)	X
	Vascular disease (CC 108)	X
Chronic obstructive pulmonary disease (COPD) (CC 111)	Chronic obstructive pulmonary disease (COPD) (CC 111)	
Pneumonia (CC 114-116)	Aspiration and specified bacterial pneumonias (CC 114)	X
	Pneumococcal pneumonia, empyema, lung abscess (CC 115)	X
	Viral and unspecified pneumonia, pleurisy (CC 116)	
Renal failure (CC 135-140)	Acute renal failure (CC 135)	X
	Chronic kidney disease, stage 5 (CC 136)	
	Chronic kidney disease, severe (stage 4) (CC 137)	
	Chronic kidney disease, moderate (stage 3) (CC 138)	
	Chronic kidney disease, mild or unspecified (stages 1-2 or unspecified) (CC 139)	
	Unspecified renal failure (CC 140)	X
Trauma; other injuries (CC 166-168, 170-174)	Severe head injury (CC 166)	X
	Major head injury (CC 167)	X
	Concussion or unspecified head injury (CC 168)	X
	Hip fracture/dislocation (CC 170)	X
	Major fracture, except of skull, vertebrae, or hip (CC 171)	X
	Internal injuries (CC 172)	
	Traumatic amputations and complications (CC 173)	X
	Other injuries (CC 174)	

Outcome

Outcome Criteria for HF Measure

Death, from any cause, within 30 days of the start of the index admission.
Rationale: From a patient perspective, death is a critical outcome regardless of cause. Outcomes occurring within 30 days of the start of the 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**

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. 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-10-CM Codes for Pneumonia Cohort

Table D.4.1 below outlines the ICD-10-CM codes used to define the pneumonia cohort for discharges on or after October 1, 2015. ICD-9 code lists for discharges prior to October 1, 2015 can be found in the 2016 condition-specific mortality measures updates and specifications report posted on *QualityNet*.

ICD-10-CM Codes	Description
A48.1	Legionnaires' disease
J10.00	Influenza due to other identified influenza virus with unspecified type of pneumonia
J10.01	Influenza due to other identified influenza virus with the same other identified influenza virus pneumonia
J10.08	Influenza due to other identified influenza virus with other specified pneumonia
J11.00	Influenza due to unidentified influenza virus with unspecified type of pneumonia
J11.08	Influenza due to unidentified influenza virus with specified pneumonia
J12.0	Adenoviral pneumonia
J12.1	Respiratory syncytial virus pneumonia
J12.2	Parainfluenza virus pneumonia
J12.3	Human metapneumovirus pneumonia
J12.81	Pneumonia due to SARS-associated coronavirus
J12.89	Other viral pneumonia
J12.9	Viral pneumonia, unspecified
J13	Pneumonia due to Streptococcus pneumoniae
J14	Pneumonia due to Hemophilus influenzae
J15.0	Pneumonia due to Klebsiella pneumoniae
J15.1	Pneumonia due to Pseudomonas
J15.20	Pneumonia due to staphylococcus, unspecified
J15.211	Pneumonia due to Methicillin susceptible Staphylococcus aureus
J15.212	Pneumonia due to Methicillin resistant Staphylococcus aureus
J15.29	Pneumonia due to other staphylococcus
J15.3	Pneumonia due to streptococcus, group B
J15.4	Pneumonia due to other streptococci
J15.5	Pneumonia due to Escherichia coli
J15.6	Pneumonia due to other aerobic Gram-negative bacteria
J15.7	Pneumonia due to Mycoplasma pneumoniae
J15.8	Pneumonia due to other specified bacteria
J15.9	Unspecified bacterial pneumonia
J16.0	Chlamydial pneumonia
J16.8	Pneumonia due to other specified infectious organisms

ICD-10-CM Codes	Description
J18.0	Bronchopneumonia, unspecified organism
J18.1	Lobar pneumonia, unspecified organism
J18.8	Other pneumonia, unspecified organism
J18.9	Pneumonia, unspecified organism
J69.0	Pneumonitis due to inhalation of food and vomit
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 (R65.20 Severe sepsis without septic shock or R65.21 Severe sepsis with septic shock) coded as POA is present	
A02.1	Salmonella sepsis
A22.7	Anthrax sepsis
A26.7	Erysipelothrix sepsis
A32.7	Listerial sepsis
A40.0	Sepsis due to streptococcus, group A
A40.1	Sepsis due to streptococcus, group B
A40.3	Sepsis due to Streptococcus pneumoniae
A40.8	Other streptococcal sepsis
A40.9	Streptococcal sepsis, unspecified
A41.01	Sepsis due to Methicillin susceptible Staphylococcus aureus
A41.02	Sepsis due to Methicillin resistant Staphylococcus aureus
A41.1	Sepsis due to other specified staphylococcus
A41.2	Sepsis due to unspecified staphylococcus
A41.3	Sepsis due to Hemophilus influenzae
A41.4	Sepsis due to anaerobes
A41.50	Gram-negative sepsis, unspecified
A41.51	Sepsis due to Escherichia coli [E. coli]
A41.52	Sepsis due to Pseudomonas
A41.53	Sepsis due to Serratia
A41.59	Other Gram-negative sepsis
A41.81	Sepsis due to Enterococcus
A41.89	Other specified sepsis
A41.9	Sepsis, unspecified organism
A42.7	Actinomycotic sepsis
A54.86	Gonococcal sepsis
B37.7	Candidal sepsis

Risk Adjustment

Table D.4.2 – Risk Variables for Pneumonia Measure

The CCs outlined in Table D.4.2 below are used to identify risk variables in claims for discharges on or after October 1, 2015 as well as discharges prior to October 1, 2015.

The ICD-10 codes listed used to identify History of PTCA and History of CABG surgery in discharges on or after October 1, 2015 are posted on *QualityNet* due to volume; hyperlinks to these lists are provided in the table. For a list of ICD-9 codes used to identify these variables in discharges prior to October 1, 2015, please refer to the 2016 condition-specific mortality measures updates and specifications report posted on *QualityNet*.

Description of Risk Variable	CCs and/or ICD Codes Included	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 coronary artery bypass graft (CABG) surgery	ICD-10-CM code list and ICD-10-PCS code list	
History of percutaneous transluminal coronary angioplasty (PTCA)	ICD-10-CM code list and ICD-10-PCS code list	
Septicemia, sepsis, systemic inflammatory response syndrome/shock (CC 2)	Septicemia, sepsis, systemic inflammatory response syndrome/shock (CC 2)	X
Metastatic cancer, acute leukemia and other severe cancers (CC 8-9)	Metastatic cancer or acute leukemia (CC 8)	
	Lung and other severe cancers (CC 9)	
Protein-calorie malnutrition (CC 21)	Protein-calorie malnutrition (CC 21)	
Disorders of fluid/electrolyte/acid-base balance (CC 24)	Disorders of fluid/electrolyte/acid-base balance (CC 24)	X
Chronic liver disease (CC 27-29)	End-stage liver disease (CC 27)	
	Cirrhosis of liver (CC 28)	
	Chronic hepatitis (CC 29)	
Severe hematological disorders (CC 46)	Severe hematological disorders (CC 46)	
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	Iron deficiency or other/unspecified anemias and blood disease (CC 49)	
Delirium and encephalopathy (CC 50)	Delirium and encephalopathy (CC 50)	X
Dementia or other specified brain disorders (CC 51-53)	Dementia with complications (CC 51)	
	Dementia without complications (CC 52)	
	Nonpsychotic organic brain syndromes/conditions (CC 53)	
Major psychiatric disorders (CC 57-59)	Schizophrenia (CC 57)	
	Major depressive, bipolar, and paranoid disorders (CC 58)	
	Reactive and unspecified psychosis (CC 59)	
Depression (CC 61)	Depression (CC 61)	
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	Quadriplegia (CC 70)	
	Paraplegia (CC 71)	
	Spinal cord disorders/injuries (CC 72)	
	Amyotrophic lateral sclerosis and other motor neuron disease (CC 73)	
	Cerebral palsy (CC 74)	
	Hemiplegia/hemiparesis (CC 103)	X
	Monoplegia, other paralytic syndromes (CC 104)	X
	Amputation status, lower limb/amputation complications (CC 189)	X
	Amputation status, upper limb (CC 190)	X
Parkinson's and Huntington's diseases (CC 78)	Parkinson's and Huntington's diseases (CC 78)	
Seizure disorders and convulsions (CC 79)	Seizure disorders and convulsions (CC 79)	
Respirator dependence/tracheostomy status (CC 82)	Respirator dependence/tracheostomy status (CC 82)	X
	Respiratory arrest (CC 83)	X

Description of Risk Variable	CCs and/or ICD Codes Included	Variables Not Used in Risk Adjustment if Occurred Only during Index Admission (indicated by "X")
Respiratory arrest; cardio-respiratory failure and shock	Cardio-respiratory failure and shock (CC 84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	X
Congestive heart failure (CC 85)	Congestive heart failure (CC 85)	X
Acute myocardial infarction (CC 86)	Acute myocardial infarction (CC 86)	X
Unstable angina and other acute ischemic heart disease (CC 87)	Unstable angina and other acute ischemic heart disease (CC 87)	X
Coronary atherosclerosis or angina (CC 88-89)	Angina pectoris (CC 88)	
	Coronary atherosclerosis/other chronic ischemic heart disease (CC 89)	
Hypertension (CC 95)	Hypertension (CC 95)	
Stroke (CC 99-100)	Cerebral hemorrhage (CC 99)	X
	Ischemic or unspecified stroke (CC 100)	X
Cerebrovascular disease (CC 101-102, 105)	Precerebral arterial occlusion and transient cerebral ischemia (CC 101)	X
	Cerebrovascular atherosclerosis, aneurysm, and other disease (CC 102)	
	Late effects of cerebrovascular disease, except paralysis (CC 105)	
Vascular disease and complications (CC 106-108)	Atherosclerosis of the extremities with ulceration or gangrene (CC 106)	X
	Vascular disease with complications (CC 107)	X
	Vascular disease (CC 108)	X
Chronic obstructive pulmonary disease (COPD) (CC 111)	Chronic obstructive pulmonary disease (COPD) (CC 111)	
Fibrosis of lung or other chronic lung disorders (CC 112)	Fibrosis of lung or other chronic lung disorders (CC 112)	
Asthma (CC 113)	Asthma (CC 113)	
Pneumonia; pleural effusion/pneumothorax (CC 114-117)	Aspiration and specified bacterial pneumonias (CC 114)	X
	Pneumococcal pneumonia, empyema, lung abscess (CC 115)	X
	Viral and unspecified pneumonia, pleurisy (CC 116)	X
	Pleural effusion/pneumothorax (CC 117)	X
Renal failure (CC 135-140)	Acute renal failure (CC 135)	X
	Chronic kidney disease, stage 5 (CC 136)	
	Chronic kidney disease, severe (stage 4) (CC 137)	
	Chronic kidney disease, moderate (stage 3) (CC 138)	
	Chronic kidney disease, mild or unspecified (stages 1-2 or unspecified) (CC 139)	
	Unspecified renal failure (CC 140)	X

Description of Risk Variable	CCs and/or ICD Codes Included	Variables Not Used in Risk Adjustment if Occurred Only during Index Admission (indicated by "X")
Decubitus ulcer of skin (CC 157-160)	Pressure ulcer of skin with necrosis through to muscle, tendon, or bone (CC 157)	X
	Pressure ulcer of skin with full thickness skin loss (CC 158)	X
	Pressure ulcer of skin with partial thickness skin loss (CC 159)	X
	Pressure pre-ulcer skin changes or unspecified stage (CC 160)	X
Trauma; other injuries (CC 166-168, 170-174)	Severe head injury (CC 166)	X
	Major head injury (CC 167)	X
	Concussion or unspecified head injury (CC 168)	X
	Hip fracture/dislocation (CC 170)	X
	Major fracture, except of skull, vertebrae, or hip (CC 171)	X
	Internal injuries (CC 172)	
	Traumatic amputations and complications (CC 173)	
	Other injuries (CC 174)	
Vertebral fractures without spinal cord injury (CC 169)	Vertebral fractures without spinal cord injury (CC 169)	

Outcome

Outcome Criteria for Pneumonia Measure

Death, from any cause, within 30 days of the start of the index admission.
Rationale: From a patient perspective, death is a critical outcome regardless of cause. Outcomes occurring within 30 days of the start of the 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**
   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. 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-10-CM Codes for Ischemic Stroke Cohort

Table D.5.1 below outlines the ICD-10-CM codes used to define the ischemic stroke cohort for discharges on or after October 1, 2015. ICD-9 code lists for discharges prior to October 1, 2015 can be found in the 2016 condition-specific mortality measures updates and specifications report posted on *QualityNet*.

ICD-10-CM Codes	Description
I63.00	Cerebral infarction due to thrombosis of unspecified precerebral artery
I63.011	Cerebral infarction due to thrombosis of right vertebral artery
I63.012	Cerebral infarction due to thrombosis of left vertebral artery
I63.019	Cerebral infarction due to thrombosis of unspecified vertebral artery
I63.02	Cerebral infarction due to thrombosis of basilar artery
I63.031	Cerebral infarction due to thrombosis of right carotid artery
I63.032	Cerebral infarction due to thrombosis of left carotid artery
I63.039	Cerebral infarction due to thrombosis of unspecified carotid artery
I63.09	Cerebral infarction due to thrombosis of other precerebral artery
I63.10	Cerebral infarction due to embolism of unspecified precerebral artery
I63.111	Cerebral infarction due to embolism of right vertebral artery
I63.112	Cerebral infarction due to embolism of left vertebral artery
I63.119	Cerebral infarction due to embolism of unspecified vertebral artery
I63.12	Cerebral infarction due to embolism of basilar artery
I63.131	Cerebral infarction due to embolism of right carotid artery
I63.132	Cerebral infarction due to embolism of left carotid artery
I63.139	Cerebral infarction due to embolism of unspecified carotid artery
I63.19	Cerebral infarction due to embolism of other precerebral artery
I63.20	Cerebral infarction due to unspecified occlusion or stenosis of unspecified precerebral arteries
I63.211	Cerebral infarction due to unspecified occlusion or stenosis of right vertebral arteries
I63.212	Cerebral infarction due to unspecified occlusion or stenosis of left vertebral arteries
I63.219	Cerebral infarction due to unspecified occlusion or stenosis of unspecified vertebral arteries
I63.22	Cerebral infarction due to unspecified occlusion or stenosis of basilar arteries
I63.231	Cerebral infarction due to unspecified occlusion or stenosis of right carotid arteries
I63.232	Cerebral infarction due to unspecified occlusion or stenosis of left carotid arteries
I63.239	Cerebral infarction due to unspecified occlusion or stenosis of unspecified carotid arteries
I63.29	Cerebral infarction due to unspecified occlusion or stenosis of other precerebral arteries
I63.30	Cerebral infarction due to thrombosis of unspecified cerebral artery
I63.311	Cerebral infarction due to thrombosis of right middle cerebral artery

ICD-10-CM Codes	Description
I63.312	Cerebral infarction due to thrombosis of left middle cerebral artery
I63.319	Cerebral infarction due to thrombosis of unspecified middle cerebral artery
I63.321	Cerebral infarction due to thrombosis of right anterior cerebral artery
I63.322	Cerebral infarction due to thrombosis of left anterior cerebral artery
I63.329	Cerebral infarction due to thrombosis of unspecified anterior cerebral artery
I63.331	Cerebral infarction due to thrombosis of right posterior cerebral artery
I63.332	Cerebral infarction due to thrombosis of left posterior cerebral artery
I63.339	Cerebral infarction due to thrombosis of unspecified posterior cerebral artery
I63.341	Cerebral infarction due to thrombosis of right cerebellar artery
I63.342	Cerebral infarction due to thrombosis of left cerebellar artery
I63.349	Cerebral infarction due to thrombosis of unspecified cerebellar artery
I63.39	Cerebral infarction due to thrombosis of other cerebral artery
I63.40	Cerebral infarction due to embolism of unspecified cerebral artery
I63.411	Cerebral infarction due to embolism of right middle cerebral artery
I63.412	Cerebral infarction due to embolism of left middle cerebral artery
I63.419	Cerebral infarction due to embolism of unspecified middle cerebral artery
I63.421	Cerebral infarction due to embolism of right anterior cerebral artery
I63.422	Cerebral infarction due to embolism of left anterior cerebral artery
I63.429	Cerebral infarction due to embolism of unspecified anterior cerebral artery
I63.431	Cerebral infarction due to embolism of right posterior cerebral artery
I63.432	Cerebral infarction due to embolism of left posterior cerebral artery
I63.439	Cerebral infarction due to embolism of unspecified posterior cerebral artery
I63.441	Cerebral infarction due to embolism of right cerebellar artery
I63.442	Cerebral infarction due to embolism of left cerebellar artery
I63.449	Cerebral infarction due to embolism of unspecified cerebellar artery
I63.49	Cerebral infarction due to embolism of other cerebral artery
I63.50	Cerebral infarction due to unspecified occlusion or stenosis of unspecified cerebral artery
I63.511	Cerebral infarction due to unspecified occlusion or stenosis of right middle cerebral artery
I63.512	Cerebral infarction due to unspecified occlusion or stenosis of left middle cerebral artery
I63.519	Cerebral infarction due to unspecified occlusion or stenosis of unspecified middle cerebral artery
I63.521	Cerebral infarction due to unspecified occlusion or stenosis of right anterior cerebral artery
I63.522	Cerebral infarction due to unspecified occlusion or stenosis of left anterior cerebral artery
I63.529	Cerebral infarction due to unspecified occlusion or stenosis of unspecified anterior cerebral artery
I63.531	Cerebral infarction due to unspecified occlusion or stenosis of right posterior cerebral artery
I63.532	Cerebral infarction due to unspecified occlusion or stenosis of left posterior cerebral artery
I63.539	Cerebral infarction due to unspecified occlusion or stenosis of unspecified posterior cerebral artery
I63.541	Cerebral infarction due to unspecified occlusion or stenosis of right cerebellar artery
I63.542	Cerebral infarction due to unspecified occlusion or stenosis of left cerebellar artery

ICD-10-CM Codes	Description
I63.549	Cerebral infarction due to unspecified occlusion or stenosis of unspecified cerebellar artery
I63.59	Cerebral infarction due to unspecified occlusion or stenosis of other cerebral artery
I63.6	Cerebral infarction due to cerebral venous thrombosis, nonpyogenic
I63.8	Other cerebral infarction
I63.9	Cerebral infarction, unspecified
I67.89	Other cerebrovascular disease

Risk Adjustment

Table D.5.2 – Risk Variables for Stroke Measure

The CCs outlined in Table D.5.2 below are used to identify risk variables in claims for discharges on or after October 1, 2015 as well as discharges prior to October 1, 2015.

Description of Risk Variable	CCs Included	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	
Severe infection; other infectious diseases (CC 1, 3-7)	HIV/AIDS (CC 1)	
	Bacterial, fungal, and parasitic central nervous system infections (CC 3)	
	Viral and late effects central nervous system infections (CC 4)	
	Tuberculosis (CC 5)	
	Opportunistic infections (CC 6)	
	Other infectious diseases (CC 7)	X
Metastatic cancer, acute leukemia and other severe cancers (CC 8-9)	Metastatic cancer and acute leukemia (CC 8)	
	Lung and other severe cancers (CC 9)	
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other major cancers (CC 10-15)	Lymphoma and other cancers (CC 10)	
	Colorectal, bladder, and other cancers (CC 11)	
	Breast, prostate, and other cancers and tumors (CC 12)	
	Other respiratory and heart neoplasms (CC 13)	
	Other digestive and urinary neoplasms (CC 14)	
	Other neoplasms (CC 15)	
Protein-calorie malnutrition (CC 21)	Protein-calorie malnutrition (CC 21)	
Disorders of fluid/electrolyte/acid-base; other endocrine/metabolic/nutritional disorders (CC 22-26)	Morbid obesity (CC 22)	
	Other significant endocrine and metabolic disorders (CC 23)	
	Disorders of fluid/electrolyte/acid-base balance (CC 24)	X
	Disorders of lipoid metabolism (CC 25)	
	Other endocrine/metabolic/nutritional disorders (CC 26)	

Description of Risk Variable	CCs Included	Variables Not Used in Risk Adjustment if Occurred Only during Index Admission (indicated by "X")
Other gastrointestinal disorders (CC 38)	Other gastrointestinal disorders (CC 38)	
Disorders of the vertebrae and spinal discs (CC 41)	Disorders of the vertebrae and spinal discs (CC 41)	
Osteoarthritis of hip or knee (CC 42)	Osteoarthritis of hip or knee (CC 42)	
Other musculoskeletal and connective tissue disorders (CC 45)	Other musculoskeletal and connective tissue disorders (CC 45)	
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	Iron deficiency or other/unspecified anemias and blood disease (CC 49)	
Dementia or other specified brain disorders (CC 51-53)	Dementia with complications (CC 51)	
	Dementia without complications (CC 52)	
	Nonpsychotic organic brain syndromes/conditions (CC 53)	
Major psychiatric disorders (CC 57-59)	Schizophrenia (CC 57)	
	Major depressive, bipolar, and paranoid disorders (CC 58)	
	Reactive and unspecified psychosis (CC 59)	
Quadriplegia, other extensive paralysis; paraplegia; spinal cord disorders/injuries (CC 70-73)	Quadriplegia (CC 70)	
	Paraplegia (CC 71)	
	Spinal cord disorders/injuries (CC 72)	
	Amyotrophic lateral sclerosis and other motor neuron disease (CC 73)	
Cerebral palsy; hemiplegia/hemiparesis (CC 74, 103)	Cerebral palsy (CC 74)	
	Hemiplegia/hemiparesis (CC 103)	X
Multiple sclerosis; mononeuropathy, other neurological conditions/injuries (CC 77, 81)	Multiple sclerosis (CC 77)	
	Polyneuropathy, mononeuropathy, and other neurological conditions/injuries (CC 81)	
Seizure disorders and convulsions (CC 79)	Seizure disorders and convulsions (CC 79)	
Congestive heart failure (CC 85)	Congestive heart failure (CC 85)	X
Valvular and rheumatic heart disease (CC 91)	Valvular and rheumatic heart disease (CC 91)	
Congenital cardiac/circulatory defects (CC 92-93)	Major congenital cardiac/circulatory defect (CC 92)	
	Other congenital heart/circulatory disease (CC 93)	
Hypertensive heart disease (CC 94)	Hypertensive heart disease (CC 94)	
Hypertension (CC 95)	Hypertension (CC 95)	
Specified heart arrhythmias (CC 96)	Specified heart arrhythmias (CC 96)	X
Cerebral hemorrhage (CC 99)	Cerebral hemorrhage (CC 99)	X
Ischemic or unspecified stroke (CC 100)	Ischemic or unspecified stroke (CC 100)	X
Precerebral arterial occlusion and transient cerebral ischemia (CC 101)	Precerebral arterial occlusion and transient cerebral ischemia (CC 101)	X
Cerebrovascular atherosclerosis, aneurysm, and other disease (CC 102)	Cerebrovascular atherosclerosis, aneurysm, and other disease (CC 102)	
Vascular disease and complications (CC 106-108)	Atherosclerosis of the extremities with ulceration or gangrene (CC 106)	X
	Vascular disease with complications (CC 107)	X
	Vascular disease (CC 108)	X

Description of Risk Variable	CCs Included	Variables Not Used in Risk Adjustment if Occurred Only during Index Admission (indicated by "X")
Chronic obstructive pulmonary disease (COPD) (CC 111)	Chronic obstructive pulmonary disease (COPD) (CC 111)	
Pneumonia (CC 114-116)	Aspiration and specified bacterial pneumonias (CC 114)	X
	Pneumococcal pneumonia, empyema, lung abscess (CC 115)	X
	Viral and unspecified pneumonia, pleurisy (CC 116)	
Pleural effusion/pneumothorax (CC 117)	Pleural effusion/pneumothorax (CC 117)	X
Other eye disorders (CC 128)	Other eye disorders (CC 128)	X
Other ear, nose, throat, and mouth disorders (CC 131)	Other ear, nose, throat, and mouth disorders (CC 131)	
Dialysis status (CC 134)	Dialysis status (CC 134)	X
Renal failure (CC 135-140)	Acute renal failure (CC 135)	X
	Chronic kidney disease, stage 5 (CC 136)	
	Chronic kidney disease, severe (stage 4) (CC 137)	
	Chronic kidney disease, moderate (stage 3) (CC 138)	
	Chronic kidney disease, mild or unspecified (stages 1-2 or unspecified) (CC 139)	
	Unspecified renal failure (CC 140)	X
Urinary tract infection (CC 144)	Urinary tract infection (CC 144)	X
Male genital disorders (CC 149)	Male genital disorders (CC 149)	
Decubitus ulcer of skin (CC 157-160)	Pressure ulcer of skin with necrosis through to muscle, tendon, or bone (CC 157)	X
	Pressure ulcer of skin with full thickness skin loss (CC 158)	X
	Pressure ulcer of skin with partial thickness skin loss (CC 159)	X
	Pressure pre-ulcer skin changes or unspecified stage (CC 160)	X
Chronic ulcer of skin, except pressure (CC 161)	Chronic ulcer of skin, except pressure (CC 161)	
Other dermatological disorders (CC 165)	Other dermatological disorders (CC 165)	

Outcome

Outcome Criteria for Stroke Measure

Death, from any cause, within 30 days of the start of the index admission.
Rationale: From a patient perspective, death is a critical outcome regardless of cause. Outcomes occurring within 30 days of the start of the 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.