2015 Condition-Specific Measures Updates and Specifications Report
Hospital-Level 30-Day Risk-Standardized Mortality Measures

Acute Myocardial Infarction – Version 9.0
Heart Failure – Version 9.0
Pneumonia – Version 9.0
Chronic Obstructive Pulmonary Disease – Version 4.0
Stroke – Version 4.0

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1. HOW TO USE THIS REPORT

This report describes the Centers for Medicare & Medicaid Services' (CMS) 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), heart failure (HF), pneumonia, chronic obstructive pulmonary disease (COPD), and stroke. This report provides a single source of information about these measures for a wide range of readers. Reports describing readmission outcomes for these conditions, hospital-wide readmissions, procedure-specific outcome measures (hip/knee arthroplasty and coronary artery bypass graft [CABG] surgery), and 30-day episode of care payment measures for AMI, HF, and pneumonia can be found on *QualityNet*.

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

Specifically, the report includes

- **Section 2** - An overview of the AMI, HF, pneumonia, COPD 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** - 2015 measure updates:
  - No updates were made to the specifications of the AMI, HF, pneumonia, COPD, and stroke mortality measures for 2015.

- **Section 4** - 2015 measure results:
  - Results from the models that are used for the Hospital Inpatient Quality Reporting program in 2015.

- **Section 5 -** Glossary

The Appendices contain detailed measure information, including

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

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

- Risk-Adjustment Models for AMI and HF 30-Day Mortality Methodology (Version 1.0)[1]
- Risk-Adjustment Methodology for Hospital Monitoring/Surveillance and Public Reporting Supplement #1: 30-Day Mortality Model for Pneumonia (Version 1.0)[2]
- Hospital-level 30-day Mortality Following Admission for an Acute Exacerbation of Chronic Obstructive Pulmonary Disease Measure Methodology Report (Version 1.0)[3]
- 30-Day Mortality Following Acute Ischemic Stroke Hospitalization Measure Methodology Report (Version 1.0)[4]
- 2008-2013 Measure Maintenance Technical Reports: Acute Myocardial Infarction, Heart Failure, and Pneumonia 30-Day Risk-Standardized Mortality Measures (Version 2.0-Version 7.0)[5-10]
- 2013 Measure Updates and Specifications Report: Hospital-level 30-day Mortality Following an Admission for an Acute Exacerbation of Chronic Obstructive Pulmonary Disease (Version 2.0)[11]
- 2013 Measure Updates and Specifications Report: Hospital 30-day Mortality Following an Admission for an Acute Ischemic Stroke (Version 2.0)[12]
- 2014 Measure Updates and Specifications Report Hospital-Level 30-Day Risk-Standardized Mortality Measures: Acute Myocardial Infarction, Heart Failure, Pneumonia, Chronic Obstructive Pulmonary Disease, and Stroke[13]

The AMI, HF, pneumonia, and COPD mortality measure methodologies are also described in the peer-reviewed medical literature.[14-17]

2. BACKGROUND AND OVERVIEW OF MEASURE METHODOLOGY

2.1 Background on Mortality Measures

In June 2007, CMS began publicly reporting hospital 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 2011, CMS and the Veterans Health Administration (VA) collaborated to update the mortality measures to include hospitalizations for patients admitted for AMI, HF, or pneumonia in VA hospitals.

In 2014, CMS began publicly reporting two additional mortality measures: Hospital-level 30-day Mortality Following Admission for an Acute Exacerbation of Chronic Obstructive Pulmonary Disease and 30-Day Mortality Following Acute Ischemic Stroke Hospitalization. These two measures also include admissions to non-federal acute care hospitals and critical access hospitals. However, the COPD and stroke measures do not include admissions to VA hospitals.

The mortality measures complement the 30-day readmission measures that CMS reports for AMI, HF, pneumonia, COPD, and stroke.[18-20] Results for all five of these mortality measures are posted on *Hospital Compare*, which CMS updates annually.

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

2.2 Overview of Measure Methodology

The 2015 risk-adjusted mortality measures use specifications from the initial measure methodology reports with slight refinements to the measures as listed in Appendix C and described in the prior measures updates and specifications reports.[1-13] The National Quality Forum (NQF) endorsed the AMI, HF, pneumonia, and COPD measures. An overview of the methodology is presented in this section.

2.2.1 Cohort

Index Admissions Included in Measures

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

- Having a principal discharge diagnosis of AMI, HF, pneumonia, COPD, or 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
- Enrolled in Medicare fee-for-service (FFS);
- Aged 65 or over;

- Not transferred from another acute care facility; and
- Enrolled in Part A and Part B Medicare for the 12 months prior to the date of the index admission, and enrolled in Part A during the index admission.

VA beneficiaries/hospitalizations are also included in the AMI, HF, and pneumonia mortality measures. Enrollment in Medicare FFS is not required.

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

Index Admissions Excluded from the Measures

The mortality measures exclude index admissions for patients:

- Discharged alive on the day of admission or the following day who were not transferred to another acute care facility. This exclusion applies only to the AMI, HF, and pneumonia measures;
- With inconsistent or unknown vital status or other unreliable demographic (age and gender) data;
- Enrolled in the Medicare hospice program or used VA hospice services any time in the 12 months prior to the index admission, including the first day of the index admission; or
- Discharged against medical advice (AMA).

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

As a part of data processing prior to the measure calculation, records are removed for non-short-term acute care facilities such as psychiatric facilities, rehabilitation facilities, or long-term care hospitals. Additional data cleaning steps include removing claims with stays longer than one year, claims with overlapping dates, and stays for patients not listed in the Medicare enrollment database as well as records for providers with invalid provider IDs.

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

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

Patients Transferred Between Hospitals

The measures include patients who are not transferred from another acute care facility. The measures consider admission to the first hospital as the start of an acute episode of care and deaths for transferred patients are attributed to the hospital that initially admitted the patient. For patients seen in the emergency department, who are then admitted to the hospital or transferred to another hospital, again the measures assign them to the hospital that initially admits them as an inpatient.

2.2.2 Outcome

All-Cause Mortality

There are a number of reasons for counting all deaths in the CMS mortality measures. First, from a patient perspective, a death from any cause is an adverse event. In addition, making inferences about quality issues and accountability based solely on the documented cause of death is difficult. For example, a patient 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. This standard time period is necessary so that the outcome for each patient is measured uniformly. The measures use a 30-day time frame because outcomes occurring within 30 days of admission can be influenced by hospital care and the early transition to the outpatient setting. The use of the 30-day time frame is a clinically meaningful period for hospitals to collaborate with their communities in an effort to reduce mortality.[21]

2.2.3 Risk-Adjustment Variables

In order to perform comparisons of performance between hospitals the measures adjust for variables (e.g., age, comorbid diseases, and indicators of patient frailty) that are clinically relevant and have strong relationships with the outcome. For each patient, risk-adjustment variables are obtained from inpatient, outpatient, and provider Medicare administrative claims data extending 12 months prior to, and including, the index admission. The risk-adjustment variables for the AMI, HF, and pneumonia measures are also obtained from VA administrative data for patients with a VA index admission.

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

All measures except stroke do not adjust for patients' admission source. Additionally, all measures do not adjust for patients' discharge disposition (e.g., skilled nursing facility). These factors are associated with the structure of the healthcare system, not solely patients' clinical comorbidities. Regional differences in the availability of post-acute care providers and practice patterns might exert an undue influence on model results.

The measures also 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 groups of patients with varying SES receive. The intent is for the measures to adjust for patient demographic and clinical characteristics while illuminating important quality differences. Additionally, recent analyses have shown that hospitals caring for high proportions of low SES patients perform similarly on the measures to hospitals caring for low proportions of low SES patients.[22]

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 Table D.1.3, Table D.2.3, Table D.3.3, Table D.4.3, and Table D.5.3 for the list of complications that are excluded from risk adjustment if occurring during the index admission, for AMI, HF, pneumonia, COPD, and stroke, respectively.

2.2.4 Data Sources

The data sources for these analyses are Medicare administrative claims data for all measures; VA administrative data for the AMI, HF, and pneumonia measures; and enrollment information for patients with hospitalizations between July 1, 2011, and June 30, 2014. The datasets also contain associated inpatient, outpatient, and provider Medicare administrative claims for the 12 months prior to the index admission for patients admitted in this time period. See the original methodology reports for further descriptions of these data sources and an explanation of the three-year measurement period.[1-4]

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.[23] At the patient level, it models the log-odds of mortality within 30 days of the index admission using age, sex (in the AMI, HF, pneumonia, and stroke measures), selected clinical covariates, and a hospital-specific intercept. At the hospital level, it models the hospital-specific intercepts as arising from a normal distribution. The hospital intercept represents the underlying risk of mortality at the hospital, after accounting for patient risk. The hospital-specific intercepts are given a distribution to account for the clustering (non-independence) of patients within the same hospital. If there were no differences among hospitals, then after adjusting for patient risk, the hospital intercepts should be identical across all hospitals.

The RSMR is calculated as the ratio of the number of "predicted" deaths to the number of "expected" deaths at a given hospital, multiplied by the national observed mortality rate. For each hospital, the numerator of the ratio is the number of deaths within 30

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

The "predicted" number of deaths (the numerator) is calculated by using the coefficients estimated by regressing the risk factors (Table D.1.2, Table D.2.2, Table D.3.2, Table D.4.2, and Table D.5.2 for the AMI, HF, pneumonia, COPD and stroke measures, respectively) and the hospital-specific intercept on the risk of mortality. The estimated hospital-specific intercept is added to the sum of the estimated regression coefficients multiplied by the patient characteristics. The results are transformed and summed over all patients attributed to a hospital to get a predicted value. The "expected" number of deaths (the denominator) is obtained in the same manner, but a common intercept using all hospitals in our sample is added in place of the hospital-specific intercept. The results are transformed and summed over all patients in the hospital to get an expected value. To assess hospital performance for each reporting period, we re-estimate the model coefficients using the years of data in that period.

This calculation transforms the ratio of predicted over expected into a rate that is compared to the national observed mortality rate. The hierarchical logistic regression models are described fully in Appendix A and in the original methodology 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 U.S. national rate" if the 95% interval estimate surrounding the hospital's rate includes the national observed mortality rate.
- "Worse than U.S. national rate" if the entire 95% interval estimate surrounding the hospital's rate is higher than the national observed mortality rate.
- "Better than U.S. national rate" if the entire 95% interval estimate surrounding the hospital's rate is lower than the national observed mortality rate.

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

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

3. UPDATES TO MEASURES FOR 2015 PUBLIC REPORTING

3.1 Rationale for Measure Updates

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

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

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

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

3.2 Changes to SAS Analytic Package (SAS Pack)

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

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

4. RESULTS FOR 2015 PUBLIC REPORTING

4.1 Assessment of Updated Models

The mortality measures estimate hospital-specific 30-day all-cause RSMRs using hierarchical logistic regression models. See Section 2 for a summary of the measure methodology and model risk-adjustment variables. Refer to prior methodology and technical reports for further details.[1-13]

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

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

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

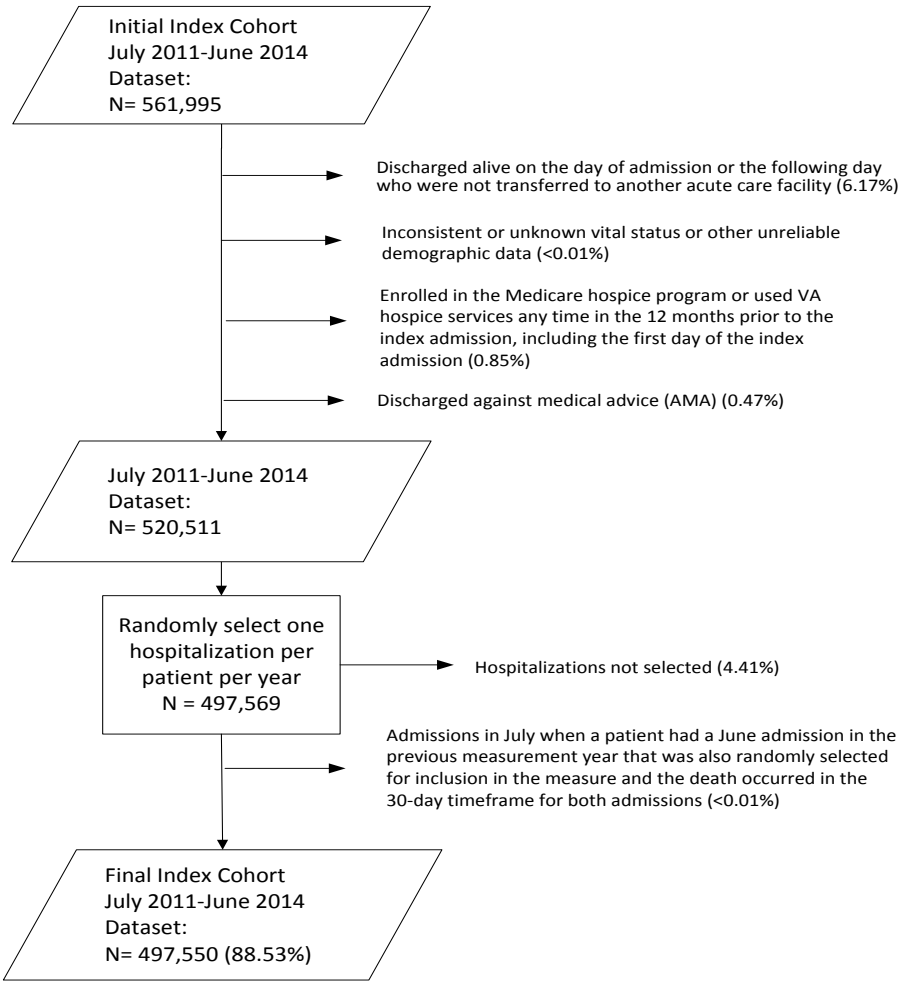
4.2 AMI Mortality 2015 Model Results

4.2.1 Index Cohort Exclusions

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

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

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



4.2.2 Frequency of AMI Model Variables

We examined the change in both observed mortality rates and frequency of clinical and demographic variables (Table 4.2.1). Between July 2011-June 2012 and July 2013-June 2014, the observed mortality rate decreased from 14.8% to 13.3%.

However, the frequency of some model variables increased, which may reflect an increased rate of comorbidity in the FFS population, but is also due, in part, to increased coding opportunities on administrative claims. In the 2012 update to the measures, we increased

the number of diagnosis and procedure codes to align with the version 5010 format changes the Department of Health and Human Services (DHHS) required. Hospitals could begin to submit up to 25 diagnosis and procedure codes starting in 2010. Over time, more hospitals submitted more codes, which translated into increased frequencies for some model variables. Notable decreases occurred in Congestive heart failure (CC 80) (31.0% to 29.3%), Acute myocardial infarction (CC 81) (13.6% to 12.9%), and Anterior myocardial infarction (ICD-9 codes 410.00-410.12) (8.3% to 7.8%), while notable increases occurred in History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 codes V45.82, 00.66, 36.06, and 36.07) (15.9% to 17.5%), Coronary atherosclerosis or angina (CC 83-84) (84.5% to 85.1%), Cardio-respiratory failure or shock (CC 79) (10.4% to 10.8%), and Hypertension (CC 89, 91) (88.9% to 89.3%). Refer to Table 4.2.1 for more detail.

4.2.3 AMI Model Parameters and Performance

Table 4.2.2 shows hierarchical regression model variable coefficients by individual year and for the combined three-year dataset. Table 4.2.3 shows the risk-adjusted odds ratios (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 area under the ROC curve (c-statistic) remained constant at 0.72 (Table 4.2.4).

4.2.4 Distribution of Hospital Volumes and RSMRs for AMI

Table 4.2.5 shows the distribution of hospital admission volumes and Table 4.2.6 shows the distribution of hospital RSMRs. The mean RSMR decreased over the three-year period, from 14.7% between July 2011 and June 2012 to 13.3% between July 2013 and June 2014. The median hospital RSMR in the combined three-year dataset was 14.3% (Interquartile Range [IQR] 13.8% - 14.8%). Table 4.2.7 shows the between-hospital variance by individual year and for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.036 (Standard Error [SE]: 0.003). If there were no systematic differences between hospitals, the between-hospital variance would be 0.

Figure 4.2.2 shows the overall distribution of the hospital RSMRs for the combined dataset. The odds of all-cause mortality if treated at a hospital one standard deviation above the national rate were 1.46 times higher than the odds of all-cause mortality if treated at a hospital one standard deviation below the national rate. If there were no systematic differences between hospitals, the OR would be 1.0.[23]

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

Of 4,490 hospitals in the study cohort, 41 performed "better than the U.S. national rate," 2,474 performed "no different from the U.S. national rate," and 21 performed "worse than the U.S. national rate." 1,954 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	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Total N	167,291	169,885	160,374	497,550
Observed mortality rate (%)	14.8	14.6	13.3	14.2
Mean age minus 65 (SD)	14.1 (8.3)	14.0 (8.4)	13.7 (8.4)	13.9 (8.4)
Male (%)	51.7	52.2	53.3	52.4
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 codes V45.82, 00.66, 36.06, 36.07)	15.9	16.9	17.5	16.7
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 codes V45.81, 36.10-36.16)	11.9	12.3	11.8	12.0
Congestive heart failure (CC 80)	31.0	30.3	29.3	30.2
Acute myocardial infarction (CC 81)	13.6	13.4	12.9	13.3
Other acute/subacute forms of ischemic heart disease (CC 82)	13.5	13.2	13.3	13.3
Anterior myocardial infarction (ICD-9 codes 410.00-410.12)	8.3	8.0	7.8	8.0
Other location of myocardial infarction (ICD-9 codes 410.20-410.62)	12.2	12.0	12.0	12.1
Coronary atherosclerosis or angina (CC 83-84)	84.5	84.7	85.1	84.8
Cardio-respiratory failure or shock (CC 79)	10.4	10.5	10.8	10.6
Valvular or rheumatic heart disease (CC 86)	31.6	31.7	31.2	31.5
Hypertension (CC 89, 91)	88.9	89.3	89.3	89.2
Stroke (CC 95-96)	7.6	7.4	7.2	7.4
Cerebrovascular disease (CC 97-99, 103)	21.0	20.9	20.1	20.7
Renal failure (CC 131)	26.3	26.8	27.3	26.8
Chronic obstructive pulmonary disease (COPD) (CC 108)	31.0	30.8	30.0	30.6
Pneumonia (CC 111-113)	23.7	23.6	22.3	23.2
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 15-20, 120)	46.5	47.0	47.3	46.9
Protein-calorie malnutrition (CC 21)	6.6	6.6	6.3	6.5
Dementia or other specified brain disorders (CC 49-50)	20.8	20.6	19.8	20.4
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	6.5	6.6	6.5	6.5
Vascular disease and complications (CC 104-105)	27.7	27.7	27.2	27.5
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	4.0	3.9	3.9	3.9
Trauma in last year (CC 154-156, 158-162)	31.8	31.6	31.4	31.6
Major psychiatric disorders (CC 54-56)	8.2	8.1	8.1	8.2
Chronic liver disease (CC 25-27)	1.4	1.5	1.6	1.5

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

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Intercept	-2.738	-2.719	-2.843	-2.755
Age minus 65 (years above 65, continuous)	0.059	0.057	0.055	0.057
Male	0.150	0.141	0.122	0.139
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 codes V45.82, 00.66, 36.06, 36.07)	-0.287	-0.286	-0.289	-0.288
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 codes V45.81, 36.10-36.16)	0.045	0.133	0.063	0.080
Congestive heart failure (CC 80)	0.289	0.285	0.261	0.280
Acute myocardial infarction (CC 81)	-0.027	-0.024	-0.045	-0.031
Other acute/subacute forms of ischemic heart disease (CC 82)	-0.062	-0.072	-0.106	-0.077
Anterior myocardial infarction (ICD-9 codes 410.00-410.12)	0.786	0.785	0.828	0.800
Other location of myocardial infarction (ICD-9 codes 410.20-410.62)	0.507	0.494	0.539	0.513
Coronary atherosclerosis or angina (CC 83-84)	-0.512	-0.520	-0.459	-0.495
Cardio-respiratory failure or shock (CC 79)	0.182	0.132	0.200	0.167
Valvular or rheumatic heart disease (CC 86)	0.095	0.054	0.100	0.087
Hypertension (CC 89, 91)	-0.345	-0.319	-0.300	-0.323
Stroke (CC 95-96)	0.009	0.041	0.028	0.027
Cerebrovascular disease (CC 97-99, 103)	-0.035	-0.060	-0.032	-0.043
Renal failure (CC 131)	0.169	0.185	0.201	0.184
Chronic obstructive pulmonary disease (COPD) (CC 108)	0.114	0.137	0.095	0.114
Pneumonia (CC 111-113)	0.429	0.427	0.429	0.428
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 15-20, 120)	0.098	0.093	0.098	0.096
Protein-calorie malnutrition (CC 21)	0.498	0.473	0.536	0.504
Dementia or other specified brain disorders (CC 49-50)	0.355	0.391	0.359	0.368
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	0.213	0.208	0.177	0.199
Vascular disease and complications (CC 104-105)	0.091	0.071	0.085	0.085
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	0.701	0.701	0.688	0.701
Trauma in last year (CC 154-156, 158-162)	-0.035	0.017	0.001	-0.006
Major psychiatric disorders (CC 54-56)	0.091	0.064	0.104	0.086
Chronic liver disease (CC 25-27)	0.419	0.457	0.386	0.424

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

Variable	07/2011-06/2012 OR (95% CI)	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2011-06/2014 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.06 (1.06 - 1.06)	1.06 (1.06 - 1.06)	1.06 (1.06 - 1.06)	1.06 (1.06 - 1.06)
Male	1.16 (1.13 - 1.20)	1.15 (1.12 - 1.19)	1.13 (1.10 - 1.17)	1.15 (1.13 - 1.17)
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 codes V45.82, 00.66, 36.06, 36.07)	0.75 (0.72 - 0.79)	0.75 (0.72 - 0.79)	0.75 (0.72 - 0.78)	0.75 (0.73 - 0.77)
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 codes V45.81, 36.10-36.16)	1.05 (1.00 - 1.10)	1.14 (1.09 - 1.19)	1.07 (1.01 – 1.12)	1.08 (1.06 - 1.11)
Congestive heart failure (CC 80)	1.34 (1.29 - 1.38)	1.33 (1.28 - 1.38)	1.30 (1.25 - 1.35)	1.32 (1.30 - 1.35)

Variable	07/2011-06/2012 OR (95% CI)	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2011-06/2014 OR (95% CI)
Acute myocardial infarction (CC 81)	0.97 (0.93 - 1.02)	0.98 (0.93 - 1.02)	0.96 (0.91 - 1.01)	0.97 (0.94 - 1.00)
Other acute/subacute forms of ischemic heart disease (CC 82)	0.94 (0.90 - 0.99)	0.93 (0.89 - 0.98)	0.90 (0.85 - 0.95)	0.93 (0.90 - 0.95)
Anterior myocardial infarction (ICD-9 codes 410.00-410.12)	2.20 (2.09 - 2.30)	2.19 (2.09 - 2.30)	2.29 (2.18 – 2.41)	2.23 (2.16 - 2.29)
Other location of myocardial infarction (ICD-9 codes 410.20-410.62)	1.66 (1.59 - 1.74)	1.64 (1.57 - 1.71)	1.71 (1.64 - 1.80)	1.67 (1.63 - 1.71)
Coronary atherosclerosis or angina (CC 83-84)	0.60 (0.58 - 0.62)	0.60 (0.57 - 0.62)	0.63 (0.61 - 0.66)	0.61 (0.60 - 0.62)
Cardio-respiratory failure or shock (CC 79)	1.20 (1.15 - 1.26)	1.14 (1.09 - 1.19)	1.22 (1.16 - 1.28)	1.18 (1.15 - 1.21)
Valvular or rheumatic heart disease (CC 86)	1.10 (1.07 - 1.14)	1.06 (1.02 - 1.09)	1.11 (1.07 - 1.14)	1.09 (1.07 - 1.11)
Hypertension (CC 89, 91)	0.71 (0.68 - 0.74)	0.73 (0.69 - 0.76)	0.74 (0.71 - 0.78)	0.72 (0.71 - 0.74)
Stroke (CC 95-96)	1.01 (0.96 - 1.07)	1.04 (0.99 - 1.10)	1.03 (0.97 - 1.09)	1.03 (1.00 - 1.06)
Cerebrovascular disease (CC 97-99, 103)	0.97 (0.93 - 1.00)	0.94 (0.91 - 0.98)	0.97 (0.93 - 1.01)	0.96 (0.94 - 0.98)
Renal failure (CC 131)	1.19 (1.14 - 1.23)	1.20 (1.16 - 1.25)	1.22 (1.18 - 1.27)	1.20 (1.18 - 1.23)
Chronic obstructive pulmonary disease (COPD) (CC 108)	1.12 (1.09 - 1.16)	1.15 (1.11 - 1.18)	1.10 (1.06 - 1.14)	1.12 (1.10 - 1.14)
Pneumonia (CC 111-113)	1.54 (1.48 - 1.59)	1.53 (1.48 - 1.59)	1.54 (1.48 - 1.59)	1.54 (1.51 - 1.57)
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 15-20, 120)	1.10 (1.07 - 1.14)	1.10 (1.07 - 1.13)	1.10 (1.07 - 1.14)	1.10 (1.08 - 1.12)
Protein-calorie malnutrition (CC 21)	1.65 (1.57 - 1.73)	1.61 (1.53 - 1.68)	1.71 (1.62 - 1.80)	1.66 (1.61 - 1.70)
Dementia or other specified brain disorders (CC 49-50)	1.43 (1.38 - 1.48)	1.48 (1.43 - 1.53)	1.43 (1.38 - 1.48)	1.44 (1.42 - 1.47)
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	1.24 (1.17 - 1.31)	1.23 (1.17 - 1.30)	1.19 (1.13 - 1.27)	1.22 (1.18 - 1.26)
Vascular disease and complications (CC 104-105)	1.10 (1.06 - 1.13)	1.07 (1.04 - 1.11)	1.09 (1.05 - 1.13)	1.09 (1.07 - 1.11)
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	2.02 (1.90 - 2.14)	2.02 (1.90 - 2.14)	1.99 (1.87 - 2.12)	2.02 (1.95 - 2.09)
Trauma in last year (CC 154-156, 158-162)	0.97 (0.94 - 1.00)	1.02 (1.00 - 1.05)	1.00 (0.97 - 1.03)	0.99 (0.98 - 1.01)
Major psychiatric disorders (CC 54-56)	1.10 (1.04 - 1.15)	1.07 (1.02 - 1.12)	1.11 (1.05 - 1.17)	1.09 (1.06 - 1.12)
Chronic liver disease (CC 25-27)	1.52 (1.37 - 1.69)	1.58 (1.43 - 1.75)	1.47 (1.32 - 1.64)	1.53 (1.44 - 1.62)

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

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Predictive ability, % (lowest decile – highest decile)	3.1 - 36.3	3.0 - 35.5	2.8 - 33.3	2.9 - 35.1
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	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Number of hospitals	4,166	4,102	3,997	4,490
Mean number of admissions (SD)	40.2 (54.5)	41.4 (56.1)	40.1 (53.9)	110.8 (159.4)
Range (min. – max.)	1 – 456	1 - 510	1 - 470	1 – 1420
25^{th} percentile	4	4	4	8
50^{th} percentile	17	18	17	38
75^{th} percentile	57	59	58	158

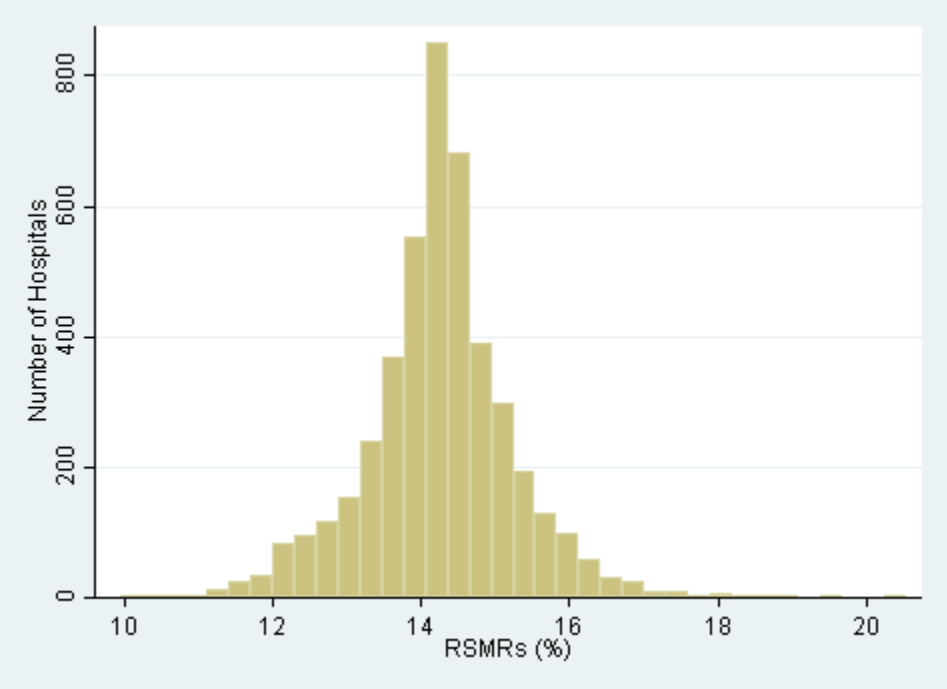
Table 4.2.6 – Distribution of Hospital AMI RSMRs Over Different Time Periods (%)

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Number of hospitals	4,166	4,102	3,997	4,490
Mean (SD)	14.8 (0.7)	14.6 (0.8)	13.3 (0.5)	14.3 (1.0)
Range (min. – max.)	11.2 - 19.4	11.0 - 19.4	10.9 - 16.3	9.9 - 20.6
25th percentile	14.5	14.2	13.1	13.8
50th percentile	14.7	14.5	13.3	14.3
75th percentile	15.1	14.9	13.6	14.8

Table 4.2.7 – Between Hospital Variance for AMI

	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Between hospital variance (SE)	0.034 (0.005)	0.037 (0.005)	0.026 (0.005)	0.036 (0.003)

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



N= 4,490 hospitals

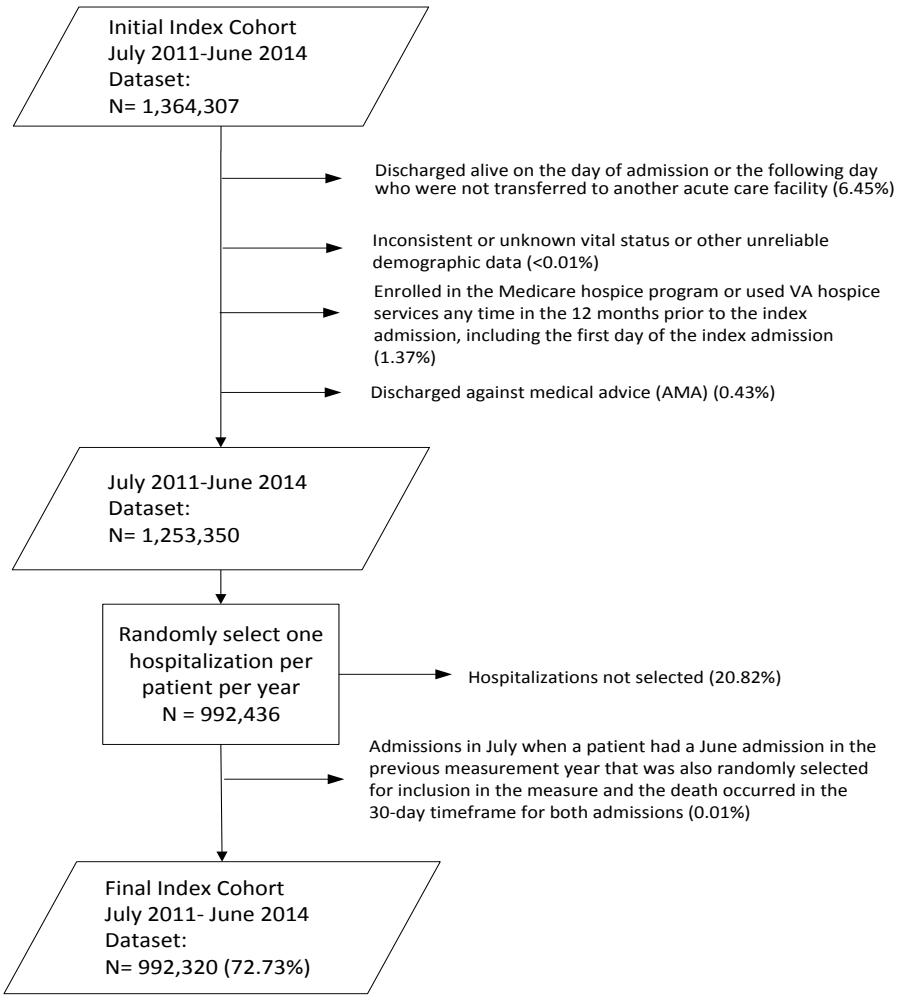
4.3 HF Mortality 2015 Model Results

4.3.1 Index Cohort Exclusions

The exclusion criteria for the measures are presented in Section 2.2.1. The percentage of HF patients meeting each exclusion criterion in the July 2011-June 2014 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 hospitalizations for Medicare FFS patients aged 65 or over with a principal discharge diagnosis of HF; enrolled in Part A and Part B Medicare for the 12 months prior to the date of admission, and enrolled in Part A during the index admission; and who were not transferred from another acute care facility. VA data is only included for the AMI, HF, and pneumonia measures.

Figure 4.3.1 – HF Cohort Exclusions in the July 2011-June 2014 Dataset



4.3.2 Frequency of HF Model Variables

We examined the change in both observed mortality rates and frequency of clinical and demographic variables (Table 4.3.1). Between July 2011-June 2012 and July 2013-June 2014, the observed mortality rate decreased from 11.8% to 11.0%.

However, the frequency of some model variables increased, which may reflect an increased rate of comorbidity in the FFS population, but is also due, in part, to increased coding opportunities on administrative claims. In the 2012 update to the measures, we increased

the number of diagnosis and procedure codes to align with the version 5010 format changes DHHS required. Hospitals could begin to submit up to 25 diagnosis and procedure codes starting in 2010. Over time, more hospitals submitted more codes, which translated into increased frequencies for some model variables. Notable decreases occurred in Coronary atherosclerosis or angina (CC 83-84) (73.5% to 72.0%), Congestive heart failure (CC 80) (74.9% to 73.7%), and Acute myocardial infarction (CC 81) (9.7% to 9.4%), while notable increases occurred in Cardio-respiratory failure or shock (CC 79) (25.7% to 27.9%), History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 codes V45.82, 00.66, 36.06, and 36.07) (12.7% to 13.8%), and Hypertension (CC 89, 91) (93.3% to 93.8%). Refer to Table 4.3.1 for more detail.

4.3.3 HF Model Parameters and Performance

Table 4.3.2 shows hierarchical regression model variable coefficients by individual year and for the combined three-year dataset. Table 4.3.3 shows the risk-adjusted ORs and 95% CIs for the 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 area under the ROC curve (c-statistic) remained constant at 0.68 (Table 4.3.4).

4.3.4 Distribution of Hospital Volumes and RSMRs for HF

Table 4.3.5 shows the distribution of hospital admission volumes and Table 4.3.6 shows the distribution of hospital RSMRs. The mean RSMR decreased over the three-year period, from 11.8% between July 2011 and June 2012 to 11.1% between July 2013 and June 2014. The median hospital RSMR in the combined three-year dataset was 11.7% (IQR 11.0% - 12.5%). Table 4.3.7 shows the between-hospital variance by individual year and for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.049 (SE: 0.002). If there were no systematic differences between hospitals, the between-hospital variance would be 0.

Figure 4.3.2 shows the overall distribution of the hospital RSMRs for the combined dataset. The odds of all-cause mortality if treated at a hospital one standard deviation above the national rate were 1.56 times higher than the odds of all-cause mortality if treated at a hospital one standard deviation below the national rate. If there were no systematic differences between hospitals, the OR would be 1.0.[23]

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

Of 4,771 hospitals in the study cohort, 145 performed “better than the U.S. national rate,” 3,662 performed “no different from the U.S. national rate,” and 93 performed “worse than the U.S. national rate.” 871 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 HF Model Variables Over Different Time Periods

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Total N	333,718	332,946	325,656	992,320

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Observed mortality rate (%)	11.8	12.1	11.0	11.6
Mean age minus 65 (SD)	16.2 (8.2)	16.1 (8.3)	16.0 (8.4)	16.1 (8.3)
Male (%)	45.6	46.3	47.2	46.4
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 codes V45.82, 00.66, 36.06, 36.07)	12.7	13.3	13.8	13.2
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 codes V45.81, 36.10-36.16)	18.8	19.0	18.8	18.9
Congestive heart failure (CC 80)	74.9	74.1	73.7	74.2
Acute myocardial infarction (CC 81)	9.7	9.7	9.4	9.6
Other acute/subacute forms of ischemic heart disease (CC 82)	12.2	12.2	12.2	12.2
Coronary atherosclerosis or angina (CC 83-84)	73.5	72.8	72.0	72.8
Cardio-respiratory failure or shock (CC 79)	25.7	26.6	27.9	26.7
Valvular or rheumatic heart disease (CC 86)	52.6	53.0	52.9	52.9
Hypertension (CC 89, 91)	93.3	93.5	93.8	93.5
Stroke (CC 95-96)	9.7	9.4	9.2	9.5
Renal failure (CC 131)	49.1	49.9	50.8	49.9
Chronic obstructive pulmonary disease (COPD) (CC 108)	48.7	48.7	48.2	48.5
Pneumonia (CC 111-113)	44.9	45.4	44.7	45.0
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 15-20, 120)	53.9	53.7	54.2	53.9
Protein-calorie malnutrition (CC 21)	10.3	10.4	10.2	10.3
Dementia or other specified brain disorders (CC 49-50)	25.5	25.1	24.7	25.1
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	8.7	8.6	8.6	8.7
Vascular disease and complications (CC 104-105)	38.6	38.4	38.4	38.5
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	4.4	4.5	4.5	4.5
Trauma in last year (CC 154-156, 158-162)	40.4	40.5	40.5	40.5
Major psychiatric disorders (CC 54-56)	10.9	10.8	11.0	10.9
Chronic liver disease (CC 25-27)	3.0	3.2	3.4	3.2

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

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Intercept	-3.388	-3.300	-3.412	-3.367
Age minus 65 (years above 65, continuous)	0.053	0.052	0.049	0.051
Male	0.276	0.245	0.238	0.254
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 codes V45.82, 00.66, 36.06, 36.07)	-0.308	-0.265	-0.288	-0.289
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 codes V45.81, 36.10-36.16)	-0.153	-0.105	-0.114	-0.126
Congestive heart failure (CC 80)	0.227	0.185	0.195	0.203
Acute myocardial infarction (CC 81)	0.207	0.249	0.212	0.221
Other acute/subacute forms of ischemic heart disease (CC 82)	-0.035	-0.043	-0.037	-0.033
Coronary atherosclerosis or angina (CC 83-84)	-0.034	-0.050	-0.025	-0.031
Cardio-respiratory failure or shock (CC 79)	0.155	0.166	0.161	0.157
Valvular or rheumatic heart disease (CC 86)	0.068	0.057	0.080	0.070
Hypertension (CC 89, 91)	-0.418	-0.423	-0.395	-0.412

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Stroke (CC 95-96)	-0.019	-0.032	-0.059	-0.034
Renal failure (CC 131)	0.188	0.194	0.203	0.196
Chronic obstructive pulmonary disease (COPD) (CC 108)	0.050	0.076	0.052	0.060
Pneumonia (CC 111-113)	0.300	0.264	0.274	0.280
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 15-20, 120)	-0.013	-0.027	-0.046	-0.025
Protein-calorie malnutrition (CC 21)	0.668	0.658	0.678	0.674
Dementia or other specified brain disorders (CC 49-50)	0.296	0.317	0.318	0.313
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	0.100	0.093	0.098	0.098
Vascular disease and complications (CC 104-105)	-0.004	0.016	0.018	0.015
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	0.590	0.563	0.611	0.591
Trauma in last year (CC 154-156, 158-162)	0.070	0.093	0.079	0.079
Major psychiatric disorders (CC 54-56)	0.110	0.102	0.125	0.113
Chronic liver disease (CC 25-27)	0.430	0.424	0.450	0.441

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

Variable	07/2011-06/2012 OR (95% CI)	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2011-06/2014 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.05 (1.05 - 1.06)	1.05 (1.05 - 1.06)	1.05 (1.05 - 1.05)	1.05 (1.05 - 1.05)
Male	1.32 (1.29 - 1.35)	1.28 (1.25 - 1.31)	1.27 (1.24 - 1.30)	1.29 (1.27 - 1.31)
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 codes V45.82, 00.66, 36.06, 36.07)	0.74 (0.71 - 0.76)	0.77 (0.74 - 0.80)	0.75 (0.72 - 0.78)	0.75 (0.73 - 0.77)
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 codes V45.81, 36.10-36.16)	0.86 (0.83 - 0.89)	0.90 (0.87 - 0.93)	0.89 (0.87 - 0.92)	0.88 (0.87 - 0.90)
Congestive heart failure (CC 80)	1.25 (1.22 - 1.29)	1.20 (1.17 - 1.24)	1.22 (1.18 - 1.25)	1.23 (1.21 - 1.25)
Acute myocardial infarction (CC 81)	1.23 (1.18 - 1.28)	1.28 (1.23 - 1.33)	1.24 (1.19 - 1.29)	1.25 (1.22 - 1.28)
Other acute/subacute forms of ischemic heart disease (CC 82)	0.97 (0.93 - 1.00)	0.96 (0.92 - 1.00)	0.96 (0.93 - 1.00)	0.97 (0.95 - 0.99)
Coronary atherosclerosis or angina (CC 83-84)	0.97 (0.94 - 0.99)	0.95 (0.93 - 0.98)	0.98 (0.95 - 1.00)	0.97 (0.95 - 0.99)
Cardio-respiratory failure or shock (CC 79)	1.17 (1.14 - 1.20)	1.18 (1.15 - 1.21)	1.18 (1.14 - 1.21)	1.17 (1.15 - 1.19)
Valvular or rheumatic heart disease (CC 86)	1.07 (1.05 - 1.10)	1.06 (1.04 - 1.08)	1.08 (1.06 - 1.11)	1.07 (1.06 - 1.09)
Hypertension (CC 89, 91)	0.66 (0.63 - 0.69)	0.66 (0.63 - 0.68)	0.67 (0.65 - 0.71)	0.66 (0.65 - 0.68)
Stroke (CC 95-96)	0.98 (0.95 - 1.02)	0.97 (0.93 - 1.01)	0.94 (0.91 - 0.98)	0.97 (0.95 - 0.99)
Renal failure (CC 131)	1.21 (1.18 - 1.24)	1.21 (1.19 - 1.24)	1.23 (1.20 - 1.26)	1.22 (1.20 - 1.23)
Chronic obstructive pulmonary disease (COPD) (CC 108)	1.05 (1.03 - 1.08)	1.08 (1.06 - 1.10)	1.05 (1.03 - 1.08)	1.06 (1.05 - 1.08)
Pneumonia (CC 111-113)	1.35 (1.32 - 1.38)	1.30 (1.27 - 1.33)	1.32 (1.28 - 1.35)	1.32 (1.31 - 1.34)
Diabetes mellitus (DM) or DM complications except proliferative retinopathy (CC 15-20, 120)	0.99 (0.96 - 1.01)	0.97 (0.95 - 1.00)	0.96 (0.93 - 0.98)	0.98 (0.96 - 0.99)
Protein-calorie malnutrition (CC 21)	1.95 (1.89 - 2.01)	1.93 (1.88 - 1.99)	1.97 (1.91 - 2.03)	1.96 (1.93 - 2.00)
Dementia or other specified brain disorders (CC 49-50)	1.35 (1.31 - 1.38)	1.37 (1.34 - 1.41)	1.37 (1.34 - 1.41)	1.37 (1.35 - 1.39)
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	1.11 (1.06 - 1.15)	1.10 (1.06 - 1.14)	1.10 (1.06 - 1.15)	1.10 (1.08 - 1.13)
Vascular disease and complications (CC 104-105)	1.00 (0.97 - 1.02)	1.02 (0.99 - 1.04)	1.02 (0.99 - 1.04)	1.02 (1.00 - 1.03)
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	1.81 (1.73 - 1.89)	1.76 (1.68 - 1.84)	1.84 (1.76 - 1.93)	1.81 (1.76 - 1.85)
Trauma in last year (CC 154-156, 158-162)	1.07 (1.05 - 1.10)	1.10 (1.07 - 1.12)	1.08 (1.06 - 1.11)	1.08 (1.07 - 1.10)

Variable	07/2011-06/2012 OR (95% CI)	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2011-06/2014 OR (95% CI)
Major psychiatric disorders (CC 54-56)	1.12 (1.08 - 1.15)	1.11 (1.07 - 1.15)	1.13 (1.10 - 1.17)	1.12 (1.10 - 1.14)
Chronic liver disease (CC 25-27)	1.54 (1.45 - 1.63)	1.53 (1.45 - 1.61)	1.57 (1.48 - 1.66)	1.55 (1.51 - 1.61)

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

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Predictive ability, % (lowest decile – highest decile)	3.1 - 26.1	3.3 - 26.4	2.9 - 24.5	3.1 - 25.7
c-statistic	0.68	0.68	0.68	0.68

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

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Number of hospitals	4,670	4,648	4,597	4,771
Mean number of admissions (SD)	71.5 (85.8)	71.6 (86.7)	70.8 (86.5)	208.0 (255.9)
Range (min. – max.)	1 – 946	1 – 959	1 – 971	1 – 2876
25th percentile	13	13	12	36
50th percentile	38	38	36	105
75th percentile	101	102	101	295

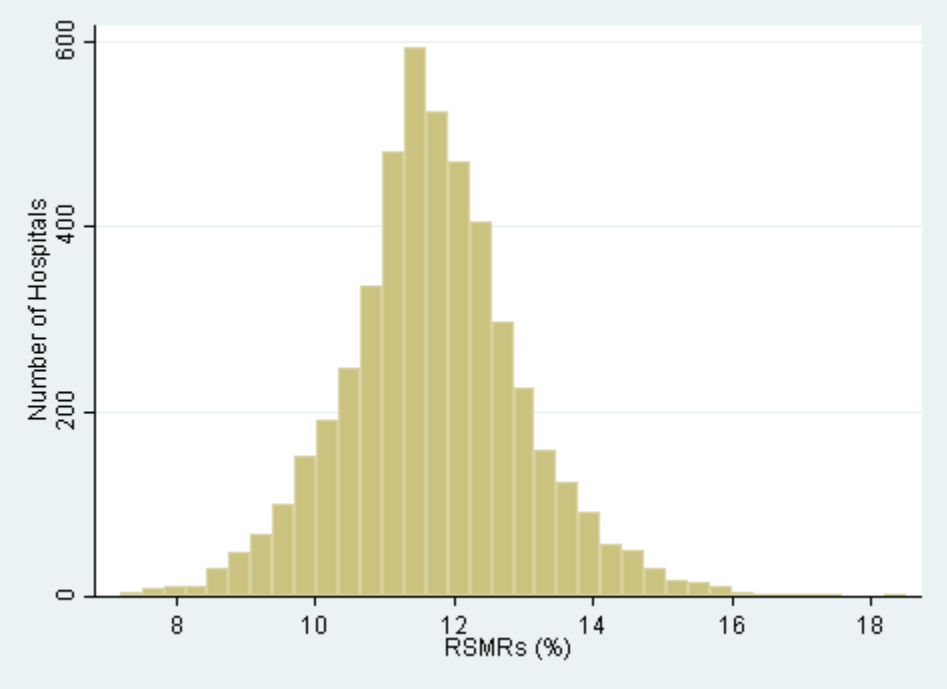
Table 4.3.6 – Distribution of Hospital HF RSMRs Over Different Time Periods

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Number of hospitals	4,670	4,648	4,597	4,771
Mean (SD)	11.8 (1.0)	12.1 (0.9)	11.0 (0.8)	11.7 (1.3)
Range (min. – max.)	8.0 - 17.4	8.4 - 17.6	7.4 - 15.3	7.2 - 18.5
25th percentile	11.2	11.7	10.6	11.0
50th percentile	11.7	12.1	11.0	11.7
75th percentile	12.3	12.6	11.5	12.5

Table 4.3.7 – Between Hospital Variance for HF

	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Between hospital variance (SE)	0.051 (0.004)	0.041 (0.004)	0.043 (0.004)	0.049 (0.002)

Figure 4.3.2 – Distribution of Hospital 30-Day HF RSMRs Between July 2011 and June 2014



N= 4,771 hospitals

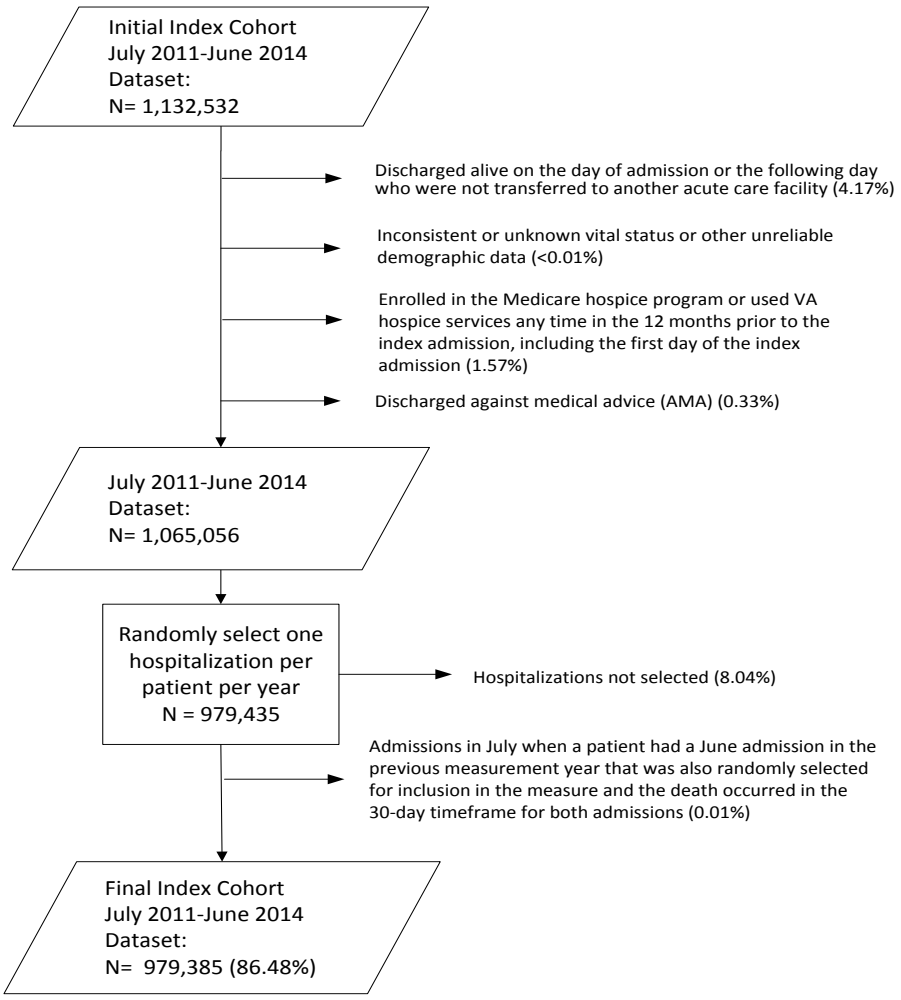
4.4 Pneumonia Mortality 2015 Model Results

4.4.1 Index Cohort Exclusions

The exclusion criteria for the measures are presented in Section 2.2.1. The percentage of pneumonia patients meeting each exclusion criterion in the July 2011-June 2014 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 hospitalizations for Medicare FFS patients aged 65 or over with a principal discharge diagnosis of pneumonia; enrolled in Part A and Part B Medicare for the 12 months prior to the date of admission, and enrolled in Part A during the index admission; and who were not transferred from another acute care facility. VA data is only included for the AMI, HF, and pneumonia measures.

Figure 4.4.1 – Pneumonia Cohort Exclusions in the July 2011-June 2014 Dataset



4.4.2 Frequency of Pneumonia Model Variables

We examined the change in both observed mortality rates and frequency of clinical and demographic variables (Table 4.4.1). Between July 2011-June 2012 and July 2013-June 2014, the observed mortality rate decreased from 11.9% to 10.9%.

However, the frequency of some model variables increased, which may reflect an increased rate of comorbidity in the FFS population, but is also due, in part, to increased coding opportunities on administrative claims. In the 2012 update to the measures, we increased

the number of diagnosis and procedure codes to align with the version 5010 format changes DHHS required. Hospitals could begin to submit up to 25 diagnosis and procedure codes starting in 2010. Over time, more hospitals submitted more codes, which translated into increased frequencies for some model variables. Notable decreases occurred in Pneumonia (CC 111-113) (42.1% to 41.1%), Severe hematological disorders (CC 44) (3.6% to 2.2%), and Fibrosis of lung or other chronic lung disorders (CC 109) (15.9% to 13.9%), while notable increases occurred in Cardio-respiratory failure or shock (CC 79) (21.4% to 23.5%), Renal failure (CC 131) (29.3% to 31.5%), and Depression (CC 58) (24.4% to 25.4%). Refer to Table 4.4.1 for more detail.

4.4.3 Pneumonia Model Parameters and Performance

Table 4.4.2 shows hierarchical regression model variable coefficients by individual year and for the combined three-year dataset. Table 4.4.3 shows the risk-adjusted ORs and 95% CIs for the 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 area under the ROC curve (c-statistic) decreased slightly from 0.72 to 0.71 (Table 4.4.4).

4.4.4 Distribution of Hospital Volumes and RSMRs for Pneumonia

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 11.9% between July 2011 and June 2012 to 10.9% between July 2013 and June 2014. The median hospital RSMR in the combined three-year dataset was 11.5% (IQR 10.6% - 12.5%). Table 4.4.7 shows the between-hospital variance by individual year and for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.064 (SE: 0.003). If there were no systematic differences between hospitals, the between-hospital variance would be 0.

Figure 4.4.2 shows the overall distribution of the hospital RSMRs for the combined dataset. The odds of all-cause mortality if treated at a hospital one standard deviation above the national rate were 1.66 times higher than the odds of all-cause mortality if treated at a hospital one standard deviation below the national rate. If there were no systematic differences between hospitals, the OR would be 1.0.[23]

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

Of 4,812 hospitals in the study cohort, 176 performed “better than the U.S. national rate,” 4,018 performed “no different from the U.S. national rate,” and 177 performed “worse than the U.S. national rate.” 441 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 Pneumonia Model Variables Over Different Time Periods

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Total N	336,407	346,417	296,561	979,385
Observed mortality rate (%)	11.9	11.7	10.9	11.5

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Mean age minus 65 (SD)	15.4 (8.3)	15.5 (8.4)	15.2 (8.5)	15.4 (8.4)
Male (%)	46.3	46.1	46.5	46.3
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 codes V45.82, 00.66, 36.06, 36.07)	7.0	7.4	7.8	7.4
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 codes V45.81, 36.10-36.16)	9.2	9.2	9.2	9.2
Congestive heart failure (CC 80)	39.2	38.1	38.4	38.6
Acute myocardial infarction (CC 81)	3.9	3.9	3.9	3.9
Other acute/subacute forms of ischemic heart disease (CC 82)	5.9	5.8	5.9	5.9
Coronary atherosclerosis or angina (CC 83-84)	50.1	49.2	49.2	49.5
Cardio-respiratory failure or shock (CC 79)	21.4	21.6	23.5	22.1
Hypertension (CC 89, 91)	87.0	87.2	87.7	87.3
Stroke (CC 95-96)	9.3	9.0	8.9	9.1
Cerebrovascular disease (CC 97-99, 103)	22.0	21.6	21.3	21.7
Renal failure (CC 131)	29.3	30.1	31.5	30.2
Chronic obstructive pulmonary disease (COPD) (CC 108)	55.1	54.0	54.6	54.6
Pneumonia (CC 111-113)	42.1	41.3	41.1	41.5
Protein-calorie malnutrition (CC 21)	13.2	13.1	13.2	13.2
Dementia or other specified brain disorders (CC 49-50)	31.5	31.3	30.6	31.2
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	8.9	8.9	8.9	8.9
Vascular disease and complications (CC 104-105)	31.7	31.3	31.6	31.5
Metastatic cancer, acute leukemia, and other severe cancers (CC 7-8)	9.7	9.4	10.0	9.7
Trauma in last year (CC 154-156, 158-162)	40.8	40.6	41.3	40.9
Major psychiatric disorders (CC 54-56)	14.0	14.1	14.3	14.1
Chronic liver disease (CC 25-27)	2.0	2.1	2.3	2.2
Severe hematological disorders (CC 44)	3.6	2.3	2.2	2.7
Iron deficiency or other unspecified anemias and blood disease (CC 47)	58.9	57.7	58.2	58.3
Depression (CC 58)	24.4	24.6	25.4	24.8
Parkinson's or Huntington's diseases (CC 73)	4.1	4.0	3.9	4.0
Seizure disorders and convulsions (CC 74)	5.8	5.7	5.8	5.8
Fibrosis of lung or other chronic lung disorders (CC 109)	15.9	14.1	13.9	14.6
Asthma (CC 110)	11.4	11.5	11.7	11.5
Vertebral fractures (CC 157)	5.1	5.1	5.2	5.1

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

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Intercept	-3.518	-3.601	-3.578	-3.568
Age minus 65 (years above 65, continuous)	0.049	0.048	0.044	0.047
Male	0.185	0.161	0.204	0.182
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 codes V45.82, 00.66, 36.06, 36.07)	-0.251	-0.226	-0.202	-0.225
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 codes V45.81, 36.10-36.16)	-0.131	-0.106	-0.100	-0.112
Congestive heart failure (CC 80)	0.197	0.218	0.230	0.214
Acute myocardial infarction (CC 81)	0.190	0.109	0.193	0.162

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Other acute/subacute forms of ischemic heart disease (CC 82)	-0.085	0.014	-0.051	-0.036
Coronary atherosclerosis or angina (CC 83-84)	-0.010	-0.030	-0.030	-0.021
Cardio-respiratory failure or shock (CC 79)	0.231	0.257	0.209	0.234
Hypertension (CC 89, 91)	-0.156	-0.119	-0.116	-0.132
Stroke (CC 95-96)	0.073	0.040	0.007	0.044
Cerebrovascular disease (CC 97-99, 103)	-0.100	-0.090	-0.067	-0.086
Renal failure (CC 131)	0.108	0.076	0.084	0.090
Chronic obstructive pulmonary disease (COPD) (CC 108)	0.004	0.044	0.004	0.016
Pneumonia (CC 111-113)	0.046	0.039	0.046	0.043
Protein-calorie malnutrition (CC 21)	0.771	0.779	0.762	0.779
Dementia or other specified brain disorders (CC 49-50)	0.402	0.422	0.365	0.398
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	0.174	0.136	0.183	0.163
Vascular disease and complications (CC 104-105)	-0.011	0.051	0.018	0.024
Metastatic cancer, acute leukemia, and other severe cancers (CC 7-8)	1.190	1.139	1.115	1.155
Trauma in last year (CC 154-156, 158-162)	0.059	0.077	0.038	0.058
Major psychiatric disorders (CC 54-56)	0.103	0.108	0.120	0.110
Chronic liver disease (CC 25-27)	0.358	0.359	0.265	0.335
Severe hematological disorders (CC 44)	0.213	0.178	0.238	0.218
Iron deficiency or other unspecified anemias and blood disease (CC 47)	0.145	0.179	0.171	0.168
Depression (CC 58)	-0.025	-0.039	-0.035	-0.033
Parkinson's or Huntington's diseases (CC 73)	0.098	0.141	0.064	0.105
Seizure disorders and convulsions (CC 74)	0.000	0.062	-0.005	0.021
Fibrosis of lung or other chronic lung disorders (CC 109)	0.121	0.139	0.176	0.149
Asthma (CC 110)	-0.363	-0.356	-0.345	-0.351
Vertebral fractures (CC 157)	0.180	0.135	0.148	0.154

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

Variable	07/2011-06/2012 OR (95% CI)	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2011-06/2014 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.05 (1.05 - 1.05)	1.05 (1.05 - 1.05)	1.05 (1.04 - 1.05)	1.05 (1.05 - 1.05)
Male	1.20 (1.18 - 1.23)	1.18 (1.15 - 1.20)	1.23 (1.20 - 1.26)	1.20 (1.18 - 1.22)
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 codes V45.82, 00.66, 36.06, 36.07)	0.78 (0.74 - 0.82)	0.80 (0.76 - 0.84)	0.82 (0.78 - 0.86)	0.80 (0.78 - 0.82)
History of Coronary Artery Bypass Graft (CABG) surgery (ICD-9 codes V45.81, 36.10-36.16)	0.88 (0.84 - 0.92)	0.90 (0.86 - 0.94)	0.91 (0.87 - 0.95)	0.89 (0.87 - 0.92)
Congestive heart failure (CC 80)	1.22 (1.19 - 1.25)	1.24 (1.21 - 1.28)	1.26 (1.22 - 1.29)	1.24 (1.22 - 1.26)
Acute myocardial infarction (CC 81)	1.21 (1.14 - 1.28)	1.12 (1.05 - 1.18)	1.21 (1.14 - 1.29)	1.18 (1.14 - 1.22)
Other acute/subacute forms of ischemic heart disease (CC 82)	0.92 (0.87 - 0.97)	1.01 (0.97 - 1.07)	0.95 (0.90 - 1.01)	0.96 (0.94 - 0.99)
Coronary atherosclerosis or angina (CC 83-84)	0.99 (0.97 - 1.02)	0.97 (0.95 - 1.00)	0.97 (0.94 - 1.00)	0.98 (0.97 - 0.99)
Cardio-respiratory failure or shock (CC 79)	1.26 (1.22 - 1.30)	1.29 (1.26 - 1.33)	1.23 (1.20 - 1.27)	1.26 (1.24 - 1.28)
Hypertension (CC 89, 91)	0.86 (0.83 - 0.89)	0.89 (0.86 - 0.92)	0.89 (0.86 - 0.92)	0.88 (0.86 - 0.89)
Stroke (CC 95-96)	1.08 (1.04 - 1.12)	1.04 (1.00 - 1.08)	1.01 (0.96 - 1.05)	1.05 (1.02 - 1.07)
Cerebrovascular disease (CC 97-99, 103)	0.91 (0.88 - 0.93)	0.91 (0.89 - 0.94)	0.94 (0.91 - 0.97)	0.92 (0.90 - 0.93)

Variable	07/2011-06/2012 OR (95% CI)	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2011-06/2014 OR (95% CI)
Renal failure (CC 131)	1.11 (1.09 - 1.14)	1.08 (1.05 - 1.11)	1.09 (1.06 - 1.12)	1.09 (1.08 - 1.11)
Chronic obstructive pulmonary disease (COPD) (CC 108)	1.00 (0.98 - 1.03)	1.05 (1.02 - 1.07)	1.00 (0.98 - 1.03)	1.02 (1.00 - 1.03)
Pneumonia (CC 111-113)	1.05 (1.02 - 1.07)	1.04 (1.02 - 1.07)	1.05 (1.02 - 1.08)	1.04 (1.03 - 1.06)
Protein-calorie malnutrition (CC 21)	2.16 (2.10 - 2.22)	2.18 (2.12 - 2.24)	2.14 (2.08 - 2.21)	2.18 (2.15 - 2.22)
Dementia or other specified brain disorders (CC 49-50)	1.49 (1.46 - 1.53)	1.53 (1.49 - 1.56)	1.44 (1.40 - 1.48)	1.49 (1.47 - 1.51)
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	1.19 (1.15 - 1.24)	1.15 (1.10 - 1.19)	1.20 (1.15 - 1.25)	1.18 (1.15 - 1.20)
Vascular disease and complications (CC 104-105)	0.99 (0.97 - 1.01)	1.05 (1.03 - 1.08)	1.02 (0.99 - 1.05)	1.02 (1.01 - 1.04)
Metastatic cancer, acute leukemia, and other severe cancers (CC 7-8)	3.29 (3.19 - 3.39)	3.12 (3.03 - 3.22)	3.05 (2.95 - 3.15)	3.17 (3.12 - 3.23)
Trauma in last year (CC 154-156, 158-162)	1.06 (1.04 - 1.09)	1.08 (1.06 - 1.11)	1.04 (1.01 - 1.07)	1.06 (1.05 - 1.08)
Major psychiatric disorders (CC 54-56)	1.11 (1.08 - 1.14)	1.11 (1.08 - 1.15)	1.13 (1.09 - 1.17)	1.12 (1.10 - 1.14)
Chronic liver disease (CC 25-27)	1.43 (1.34 - 1.53)	1.43 (1.34 - 1.53)	1.30 (1.21 - 1.40)	1.40 (1.34 - 1.46)
Severe hematological disorders (CC 44)	1.24 (1.18 - 1.30)	1.19 (1.12 - 1.27)	1.27 (1.18 - 1.36)	1.24 (1.20 - 1.29)
Iron deficiency or other unspecified anemias and blood disease (CC 47)	1.16 (1.13 - 1.19)	1.20 (1.17 - 1.23)	1.19 (1.15 - 1.22)	1.18 (1.17 - 1.20)
Depression (CC 58)	0.98 (0.95 - 1.00)	0.96 (0.94 - 0.99)	0.97 (0.94 - 0.99)	0.97 (0.95 - 0.98)
Parkinson's or Huntington's diseases (CC 73)	1.10 (1.05 - 1.16)	1.15 (1.09 - 1.21)	1.07 (1.01 - 1.13)	1.11 (1.08 - 1.15)
Seizure disorders and convulsions (CC 74)	1.00 (0.96 - 1.05)	1.06 (1.02 - 1.11)	1.00 (0.95 - 1.05)	1.02 (0.99 - 1.05)
Fibrosis of lung or other chronic lung disorders (CC 109)	1.13 (1.10 - 1.16)	1.15 (1.11 - 1.18)	1.19 (1.15 - 1.23)	1.16 (1.14 - 1.18)
Asthma (CC 110)	0.70 (0.67 - 0.72)	0.70 (0.67 - 0.73)	0.71 (0.68 - 0.74)	0.70 (0.687 - 0.72)
Vertebral fractures (CC 157)	1.20 (1.15 - 1.25)	1.14 (1.10 - 1.20)	1.16 (1.11 - 1.22)	1.17 (1.14 - 1.20)

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

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Predictive ability, % (lowest decile – highest decile)	2.1 - 28.7	2.1 - 28.7	2.0 - 26.0	2.1 - 27.8
c-statistic	0.72	0.72	0.71	0.71

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

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Number of hospitals	4,728	4,718	4,670	4,812
Mean number of admissions (SD)	71.2 (69.9)	73.4 (74.4)	63.5 (65.1)	203.5 (206.7)
Range (min. – max.)	1 - 720	1 - 814	1 - 698	1 - 2232
25th percentile	22	22	19	60
50th percentile	49	49	42	137
75th percentile	98	100	87	279

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

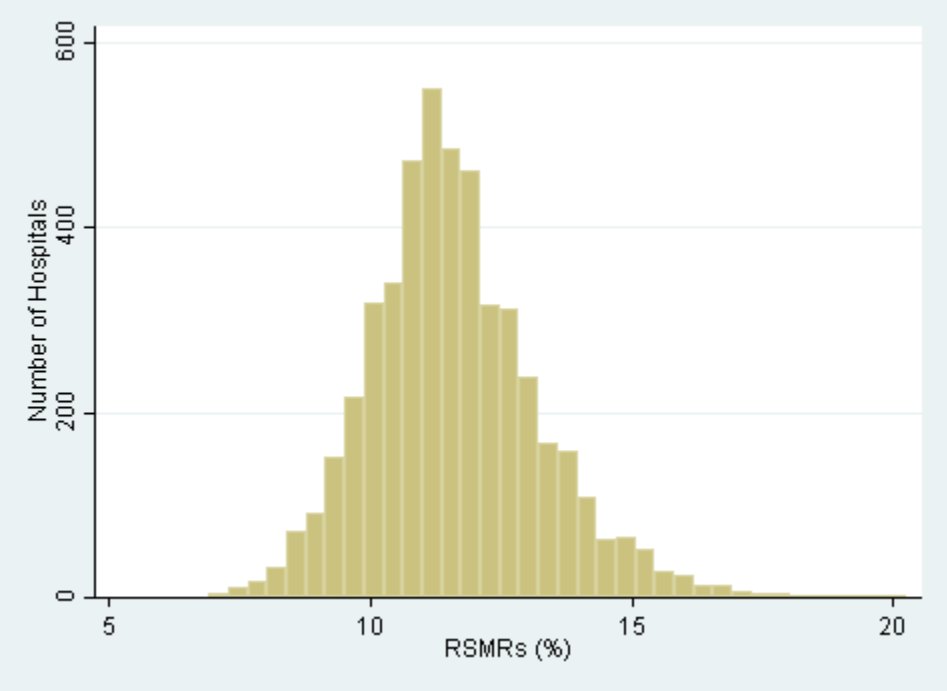
Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Number of hospitals	4,728	4,718	4,670	4,812

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Mean (SD)	11.9 (1.3)	11.8 (1.3)	10.9 (1.1)	11.6 (1.6)
Range (min. – max.)	7.1 - 18.6	7.3 - 20.7	7.3 - 18.0	6.9 - 20.3
25th percentile	11.2	11.0	10.3	10.6
50th percentile	11.8	11.7	10.8	11.5
75th percentile	12.6	12.5	11.5	12.5

Table 4.4.7 – Between Hospital Variance for Pneumonia

	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Between hospital variance (SE)	0.065 (0.005)	0.068 (0.005)	0.061 (0.005)	0.064 (0.003)

Figure 4.4.2 – Distribution of Hospital 30-Day Pneumonia RSMRs Between July 2011 and June 2014



N= 4,812 hospitals

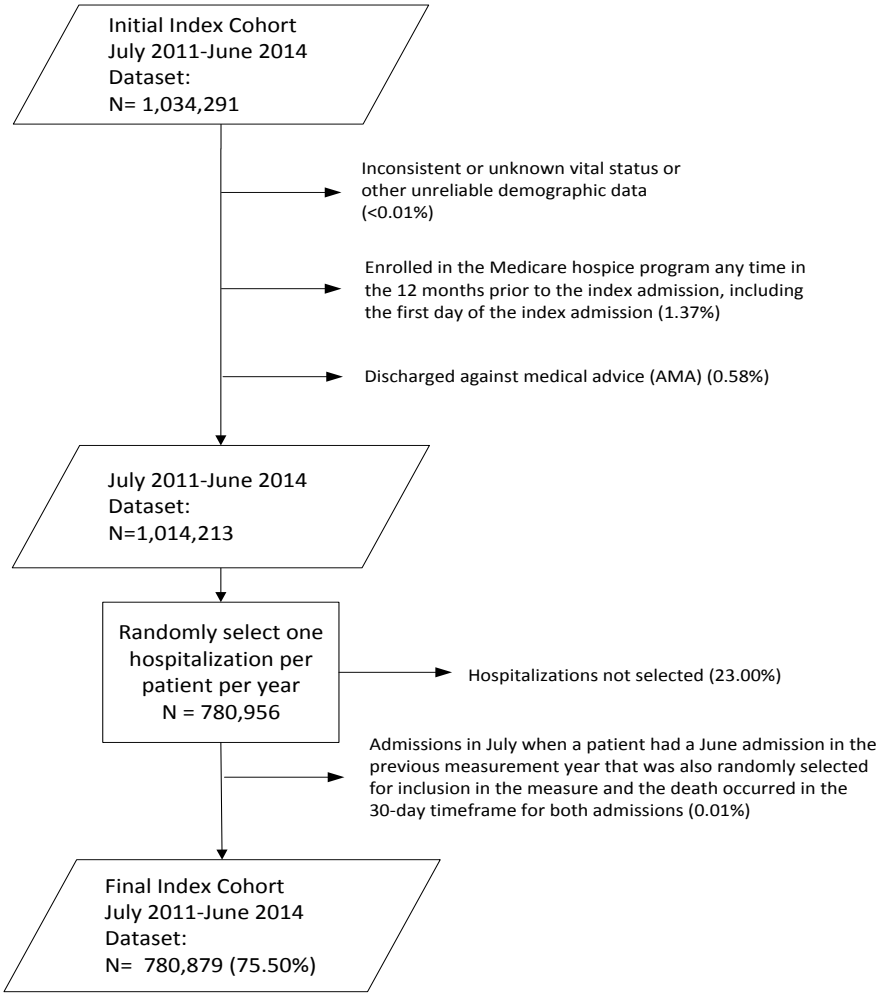
4.5 COPD Mortality 2015 Model Results

4.5.1 Index Cohort Exclusions

The exclusion criteria for the measures are presented in Section 2.2.1. The percentage of COPD patients meeting each exclusion criterion in the July 2011-June 2014 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 hospitalizations for Medicare FFS patients aged 65 or over with a principal discharge diagnosis of COPD or principal diagnosis of respiratory failure with a secondary diagnosis of COPD with exacerbation; enrolled in Part A and Part B Medicare for the 12 months prior to the date of admission, and enrolled in Part A during the index admission; and who were not transferred from another acute care facility.

Figure 4.5.1– COPD Cohort Exclusions in the July 2011-June 2014 Dataset



4.5.2 Frequency of COPD Model Variables

We examined the change in both observed mortality rates and frequency of clinical and demographic variables (Table 4.5.1). Between July 2011-June 2012 and July 2013-June 2014, the observed mortality rate decreased from 7.7% to 7.4%.

However, the frequency of some model variables increased, which may reflect an increased rate of comorbidity in the FFS population, but is also due, in part, to increased coding opportunities on administrative claims. In the 2012 update to the measures, we increased

the number of diagnosis and procedure codes to align with the version 5010 format DHHS required. Hospitals could begin to submit up to 25 diagnosis and procedure codes starting in 2010. Over time, more hospitals submitted more codes, which translated into increased frequencies for some model variables. Notable decreases occurred in Other lung disorders (CC 115) (52.1% to 48.7%), Fibrosis of lung or other chronic lung disorders (CC 109) (17.0% to 14.7%), and Coronary atherosclerosis or angina (CC 83-84) (53.4% to 51.9%), while notable increases occurred in Other psychiatric disorders (CC 60) (25.5% to 31.0%), Cardio-respiratory failure or shock (CC 79) (32.1% to 35.5%), and Sleep apnea (ICD-9 codes 327.20, 327.21, 327.23, 327.27, 327.29, 780.51, 780.53, and 780.57) (16.7% to 19.0%). Refer to Table 4.5.1 for more detail.

4.5.3 COPD Model Parameters and Performance

Table 4.5.2 shows hierarchical regression model variable coefficients by individual year and for the combined three-year dataset. Table 4.5.3 shows the risk-adjusted ORs and 95% CIs for the 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 area under the ROC curve (c-statistic) remained the same at 0.72 (Table 4.5.4).

4.5.4 Distribution of Hospital Volumes and RSMRs for COPD

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 7.7% between July 2011 and June 2012 to 7.4% between July 2013 and June 2014. The median hospital RSMR in the combined three-year dataset was 7.7% (IQR 7.2% -8.2%). Table 4.5.7 shows the between-hospital variance by individual year and for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.060 (SE: 0.003). If there were no systematic differences between hospitals, the between-hospital variance would be 0.

Figure 4.5.2 shows the overall distribution of the hospital RSMRs for the combined dataset. The odds of all-cause mortality if treated at a hospital one standard deviation above the national rate were 1.63 times higher than the odds of all-cause mortality if treated at a hospital one standard deviation below the national rate. If there were no systematic differences between hospitals, the OR would be 1.0.[23]

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

Of 4,658 hospitals in the study cohort, 51 performed “better than the U.S. national rate,” 3,611 performed “no different from the U.S. national rate,” and 89 performed “worse than the U.S. national rate.” 907 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 COPD Model Variables Over Different Time Periods

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Total N	264,721	277,426	238,732	780,879

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Observed mortality rate (%)	7.7	8.0	7.4	7.7
Mean age minus 65 (SD)	12.1 (7.6)	12.1 (7.6)	11.8 (7.6)	12.0 (7.6)
Sleep apnea (ICD-9 codes 327.20, 327.21, 327.23, 327.27, 327.29, 780.51, 780.53, 780.57)	16.7	17.6	19.0	17.7
History of mechanical ventilation (ICD-9 codes 93.90, 96.70, 96.71, 96.72)	8.1	8.1	9.2	8.4
Respirator dependence/respiratory failure (CC 77-78)	1.2	1.1	1.2	1.2
Cardio-respiratory failure or shock (CC 79)	32.1	32.4	35.5	33.2
Congestive heart failure (CC 80)	43.2	41.7	42.4	42.4
Coronary atherosclerosis or angina (CC 83-84)	53.4	52.5	51.9	52.6
Specified arrhythmias and other heart rhythm disorders (CC 92-93)	41.4	41.2	41.9	41.5
Vascular or circulatory disease (CC 104-106)	42.2	41.8	41.9	42.0
Fibrosis of lung or other chronic lung disorders (CC 109)	17.0	15.2	14.7	15.7
Asthma (CC 110)	16.8	16.5	16.4	16.5
Pneumonia (CC 111-113)	49.7	48.5	48.9	49.0
Pleural effusion/pneumothorax (CC 114)	14.0	13.6	14.0	13.9
Other lung disorders (CC 115)	52.1	49.9	48.7	50.3
Metastatic cancer or acute leukemia (CC 7)	2.8	2.8	2.8	2.8
Lung, upper digestive tract, and other severe cancers (CC 8)	6.5	6.4	6.7	6.5
Lymphatic, head and neck, brain, and other major cancers; breast, prostate, colorectal and other cancers and tumors; other respiratory and heart neoplasms (CC 9-11)	14.4	14.1	14.2	14.2
Other digestive and urinary neoplasms (CC 12)	6.9	6.7	6.6	6.7
Diabetes mellitus (DM) or DM complications (CC 15-20, 119-120)	43.2	42.9	42.6	42.9
Protein-calorie malnutrition (CC 21)	9.8	9.9	10.4	10.0
Disorders of fluid/electrolyte/acid-base (CC 22-23)	37.7	37.3	38.4	37.8
Other endocrine/metabolic/nutritional disorders (CC 24)	80.5	81.6	82.7	81.6
Other gastrointestinal disorders (CC 36)	64.1	64.0	64.5	64.2
Osteoarthritis of hip or knee (CC 40)	10.8	10.9	10.9	10.9
Other musculoskeletal and connective tissue disorders (CC 43)	70.4	70.5	70.9	70.6
Iron deficiency or other unspecified anemias and blood disease (CC 47)	50.8	50.2	51.1	50.7
Dementia or other specified brain disorders (CC 49-50)	19.5	19.1	18.6	19.1
Drug/alcohol abuse, without dependence (CC 53)	30.4	31.3	32.4	31.3
Other psychiatric disorders (CC 60)	25.5	28.4	31.0	28.2
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	5.9	5.7	5.8	5.8
Mononeuropathy, other neurological conditions/injuries (CC 76)	15.1	15.5	16.2	15.6

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Hypertension and hypertensive disease (CC 90-91)	84.9	85.0	85.0	85.0
Stroke (CC 95-96)	6.5	6.2	6.1	6.2
Retinal disorders, except detachment and vascular retinopathies (CC 121)	12.2	12.4	12.4	12.3
Other eye disorders (CC 124)	20.0	20.2	20.0	20.1
Other ear, nose, throat and mouth disorders (CC 127)	37.8	37.8	38.1	37.9
Renal failure (CC 131)	25.3	25.7	27.0	26.0
Decubitus ulcer or chronic skin ulcer (CC 148-149)	8.3	8.0	8.1	8.1
Other dermatological disorders (CC 153)	31.0	31.5	31.4	31.3
Trauma (CC 154-156, 158-161)	10.2	10.3	10.4	10.3
Vertebral fractures (CC 157)	4.9	4.7	4.9	4.9
Major complications of medical care and trauma (CC 164)	5.8	5.7	5.6	5.7

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

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Intercept	-3.005	-3.044	-3.015	-3.036
Age minus 65 (years above 65, continuous)	0.035	0.038	0.034	0.036
Sleep apnea (ICD-9 codes 327.20, 327.21, 327.23, 327.27, 327.29, 780.51, 780.53, 780.57)	-0.087	-0.081	-0.085	-0.087
History of mechanical ventilation (ICD-9 codes 93.90, 96.70, 96.71, 96.72)	0.221	0.273	0.227	0.243
Respirator dependence/respiratory failure (CC 77-78)	-0.164	-0.229	-0.037	-0.145
Cardio-respiratory failure or shock (CC 79)	0.389	0.375	0.365	0.373
Congestive heart failure (CC 80)	0.218	0.231	0.237	0.229
Coronary atherosclerosis or angina (CC 83-84)	-0.046	-0.056	-0.030	-0.042
Specified arrhythmias and other heart rhythm disorders (CC 92-93)	0.056	0.078	0.073	0.068
Vascular or circulatory disease (CC 104-106)	0.023	0.047	0.031	0.035
Fibrosis of lung or other chronic lung disorders (CC 109)	0.133	0.120	0.111	0.124
Asthma (CC 110)	-0.378	-0.366	-0.375	-0.370
Pneumonia (CC 111-113)	0.219	0.237	0.205	0.222
Pleural effusion/pneumothorax (CC 114)	0.163	0.133	0.206	0.163
Other lung disorders (CC 115)	-0.161	-0.179	-0.176	-0.171
Metastatic cancer or acute leukemia (CC 7)	0.858	0.863	0.861	0.863
Lung, upper digestive tract, and other severe cancers (CC 8)	0.580	0.618	0.612	0.604
Lymphatic, head and neck, brain, and other major cancers; breast, prostate, colorectal and other cancers and tumors; other respiratory and heart neoplasms (CC 9-11)	0.044	-0.018	0.017	0.014
Other digestive and urinary neoplasms (CC 12)	-0.219	-0.167	-0.235	-0.201
Diabetes mellitus (DM) or DM complications (CC 15-20, 119-120)	-0.041	-0.068	-0.037	-0.046
Protein-calorie malnutrition (CC 21)	0.718	0.788	0.733	0.753
Disorders of fluid/electrolyte/acid-base (CC 22-23)	0.126	0.121	0.124	0.125
Other endocrine/metabolic/nutritional disorders (CC 24)	-0.194	-0.196	-0.191	-0.194

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Other gastrointestinal disorders (CC 36)	-0.188	-0.139	-0.148	-0.158
Osteoarthritis of hip or knee (CC 40)	-0.339	-0.278	-0.310	-0.305
Other musculoskeletal and connective tissue disorders (CC 43)	-0.181	-0.152	-0.184	-0.169
Iron deficiency or other unspecified anemias and blood disease (CC 47)	0.248	0.240	0.237	0.243
Dementia or other specified brain disorders (CC 49-50)	0.153	0.175	0.165	0.169
Drug/alcohol abuse, without dependence (CC 53)	-0.126	-0.119	-0.146	-0.131
Other psychiatric disorders (CC 60)	0.135	0.145	0.134	0.137
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	0.013	0.027	0.046	0.030
Mononeuropathy, other neurological conditions/injuries (CC 76)	-0.149	-0.149	-0.107	-0.137
Hypertension and hypertensive disease (CC 90-91)	-0.178	-0.168	-0.203	-0.179
Stroke (CC 95-96)	-0.032	-0.064	-0.108	-0.065
Retinal disorders, except detachment and vascular retinopathies (CC 121)	-0.074	-0.061	-0.087	-0.075
Other eye disorders (CC 124)	-0.104	-0.108	-0.139	-0.114
Other ear, nose, throat and mouth disorders (CC 127)	-0.225	-0.236	-0.207	-0.224
Renal failure (CC 131)	0.090	0.078	0.053	0.074
Decubitus ulcer or chronic skin ulcer (CC 148-149)	0.280	0.285	0.335	0.300
Other dermatological disorders (CC 153)	-0.087	-0.092	-0.119	-0.098
Trauma (CC 154-156, 158-161)	0.078	0.045	-0.028	0.033
Vertebral fractures (CC 157)	0.295	0.244	0.234	0.254
Major complications of medical care and trauma (CC 164)	-0.194	-0.181	-0.161	-0.180

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

Variable	07/2011-06/2012 OR (95% CI)	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2011-06/2014 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.04 (1.03 - 1.04)	1.04 (1.04 - 1.04)	1.03 (1.03 - 1.04)	1.04 (1.04 - 1.04)
Sleep apnea (ICD-9 codes 327.20, 327.21, 327.23, 327.27, 327.29,780.51, 780.53, 780.57)	0.92 (0.88 - 0.96)	0.92 (0.88 - 0.96)	0.92 (0.88 - 0.96)	0.92 (0.89 - 0.94)
History of mechanical ventilation (ICD-9 codes 93.90, 96.70, 96.71,96.72)	1.25 (1.19 - 1.31)	1.31 (1.25 - 1.38)	1.26 (1.19 - 1.32)	1.28 (1.24 - 1.31)
Respirator dependence/respiratory failure (CC 77-78)	0.85 (0.76 - 0.95)	0.80 (0.71 - 0.89)	0.96 (0.86 - 1.09)	0.87 (0.81 - 0.93)
Cardio-respiratory failure or shock (CC 79)	1.48 (1.42 - 1.53)	1.46 (1.41 - 1.51)	1.44 (1.39 - 1.50)	1.45 (1.42 - 1.48)
Congestive heart failure (CC 80)	1.24 (1.20 - 1.29)	1.26 (1.22 - 1.30)	1.27 (1.22 - 1.32)	1.26 (1.23 - 1.28)
Coronary atherosclerosis or angina (CC 83-84)	0.96 (0.92 - 0.99)	0.95 (0.92 - 0.98)	0.97 (0.94 - 1.01)	0.96 (0.94 - 0.98)
Specified arrhythmias and other heart rhythm disorders (CC 92-93)	1.06 (1.02 - 1.09)	1.08 (1.05 - 1.12)	1.08 (1.04 - 1.12)	1.07 (1.05 - 1.09)
Vascular or circulatory disease (CC 104-106)	1.02 (0.99 - 1.06)	1.05 (1.02 - 1.08)	1.03 (1.00 - 1.07)	1.04 (1.02 - 1.06)
Fibrosis of lung or other chronic lung disorders (CC 109)	1.14 (1.10 - 1.19)	1.13 (1.09 - 1.17)	1.12 (1.07 - 1.17)	1.13 (1.11 - 1.16)
Asthma (CC 110)	0.69 (0.65 - 0.72)	0.69 (0.66 - 0.73)	0.69 (0.65 - 0.72)	0.69 (0.67 - 0.71)
Pneumonia (CC 111-113)	1.24 (1.20 - 1.29)	1.27 (1.23 - 1.31)	1.23 (1.19 - 1.27)	1.25 (1.23 - 1.27)
Pleural effusion/pneumothorax (CC 114)	1.18 (1.13 - 1.23)	1.14 (1.10 - 1.19)	1.23 (1.18 - 1.28)	1.18 (1.15 - 1.21)
Other lung disorders (CC 115)	0.85 (0.82 - 0.88)	0.84 (0.81 - 0.86)	0.84 (0.81 - 0.87)	0.84 (0.83 - 0.86)
Metastatic cancer or acute leukemia (CC 7)	2.36 (2.20 - 2.53)	2.37 (2.21 - 2.54)	2.37 (2.20 - 2.55)	2.37 (2.28 - 2.47)

Variable	07/2011-06/2012 OR (95% CI)	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2011-06/2014 OR (95% CI)
Lung, upper digestive tract, and other severe cancers (CC 8)	1.79 (1.69 - 1.88)	1.86 (1.76 - 1.95)	1.84 (1.75 - 1.95)	1.83 (1.78 - 1.89)
Lymphatic, head and neck, brain, and other major cancers; breast, prostate, colorectal and other cancers and tumors; other respiratory and heart neoplasms (CC 9-11)	1.05 (1.00 - 1.09)	0.98 (0.94 - 1.02)	1.02 (0.97 - 1.07)	1.01 (0.99 - 1.04)
Other digestive and urinary neoplasms (CC 12)	0.80 (0.75 - 0.86)	0.85 (0.80 - 0.90)	0.79 (0.74 - 0.85)	0.82 (0.79 - 0.85)
Diabetes mellitus (DM) or DM complications (CC 15-20, 119-120)	0.96 (0.93 - 0.99)	0.94 (0.91 - 0.96)	0.96 (0.93 - 1.00)	0.96 (0.94 - 0.97)
Protein-calorie malnutrition (CC 21)	2.05 (1.97 - 2.13)	2.20 (2.12 - 2.28)	2.08 (2.00 - 2.17)	2.12 (2.07 - 2.17)
Disorders of fluid/electrolyte/acid-base (CC 22-23)	1.14 (1.10 - 1.18)	1.13 (1.09 - 1.17)	1.13 (1.09 - 1.18)	1.13 (1.11 - 1.16)
Other endocrine/metabolic/nutritional disorders (CC 24)	0.82 (0.79 - 0.86)	0.82 (0.79 - 0.85)	0.83 (0.79 - 0.86)	0.82 (0.81 - 0.84)
Other gastrointestinal disorders (CC 36)	0.83 (0.80 - 0.86)	0.87 (0.84 - 0.90)	0.86 (0.83 - 0.89)	0.85 (0.84 - 0.87)
Osteoarthritis of hip or knee (CC 40)	0.71 (0.67 - 0.75)	0.76 (0.72 - 0.80)	0.73 (0.69 - 0.78)	0.74 (0.71 - 0.76)
Other musculoskeletal and connective tissue disorders (CC 43)	0.84 (0.81 - 0.87)	0.86 (0.83 - 0.89)	0.83 (0.80 - 0.86)	0.84 (0.83 - 0.86)
Iron deficiency or other unspecified anemias and blood disease (CC 47)	1.28 (1.24 - 1.33)	1.27 (1.23 - 1.31)	1.27 (1.22 - 1.31)	1.28 (1.25 - 1.30)
Dementia or other specified brain disorders (CC 49-50)	1.17 (1.12 - 1.21)	1.19 (1.15 - 1.23)	1.18 (1.13 - 1.23)	1.18 (1.16 - 1.21)
Drug/alcohol abuse, without dependence (CC 53)	0.88 (0.85 - 0.91)	0.89 (0.86 - 0.92)	0.86 (0.83 - 0.90)	0.88 (0.86 - 0.90)
Other psychiatric disorders (CC 60)	1.14 (1.11 - 1.18)	1.16 (1.12 - 1.19)	1.14 (1.10 - 1.18)	1.15 (1.13 - 1.17)
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	1.01 (0.95 - 1.08)	1.03 (0.97 - 1.09)	1.05 (0.98 - 1.12)	1.03 (0.99 - 1.07)
Mononeuropathy, other neurological conditions/injuries (CC 76)	0.86 (0.83 - 0.90)	0.86 (0.83 - 0.90)	0.90 (0.86 - 0.94)	0.87 (0.85 - 0.89)
Hypertension and hypertensive disease (CC 90-91)	0.84 (0.80 - 0.87)	0.85 (0.81 - 0.88)	0.82 (0.78 - 0.85)	0.84 (0.82 - 0.86)
Stroke (CC 95-96)	0.97 (0.91 - 1.03)	0.94 (0.88 - 1.00)	0.90 (0.84 - 0.96)	0.94 (0.91 - 0.97)
Retinal disorders, except detachment and vascular retinopathies (CC 121)	0.93 (0.89 - 0.97)	0.94 (0.90 - 0.98)	0.92 (0.87 - 0.96)	0.93 (0.90 - 0.95)
Other eye disorders (CC 124)	0.90 (0.87 - 0.94)	0.90 (0.87 - 0.93)	0.87 (0.84 - 0.91)	0.89 (0.87 - 0.91)
Other ear, nose, throat and mouth disorders (CC 127)	0.80 (0.77 - 0.83)	0.79 (0.77 - 0.82)	0.81 (0.79 - 0.84)	0.80 (0.79 - 0.82)
Renal failure (CC 131)	1.09 (1.06 - 1.13)	1.08 (1.04 - 1.12)	1.05 (1.02 - 1.10)	1.08 (1.06 - 1.10)
Decubitus ulcer or chronic skin ulcer (CC 148-149)	1.32 (1.26 - 1.39)	1.33 (1.27 - 1.39)	1.40 (1.33 - 1.47)	1.35 (1.31 - 1.39)
Other dermatological disorders (CC 153)	0.92 (0.89 - 0.95)	0.91 (0.88 - 0.94)	0.89 (0.86 - 0.92)	0.91 (0.89 - 0.92)
Trauma (CC 154-156, 158-161)	1.08 (1.03 - 1.13)	1.05 (1.00 - 1.09)	0.97 (0.93 - 1.02)	1.03 (1.01 - 1.06)
Vertebral fractures (CC 157)	1.34 (1.27 - 1.42)	1.28 (1.20 - 1.35)	1.26 (1.19 - 1.35)	1.29 (1.25 - 1.34)
Major complications of medical care and trauma (CC 164)	0.82 (0.77 - 0.88)	0.83 (0.79 - 0.89)	0.85 (0.80 - 0.91)	0.84 (0.81 - 0.87)

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

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Predictive ability, % (lowest decile – highest decile)	1.4-20.9	1.5-22.5	1.4-20.7	1.4-21.4
c-statistic	0.72	0.72	0.72	0.72

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

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Number of hospitals	4,538	4,513	4,496	4,658
Mean number of admissions (SD)	58.3 (63.4)	61.5 (67.4)	53.1 (58.6)	167.6 (187.1)
Range (min. – max.)	1-731	1-792	1-719	1-2200
25th percentile	13	14	11	34
50th percentile	36	38	33	100
75th percentile	84	88	76	240

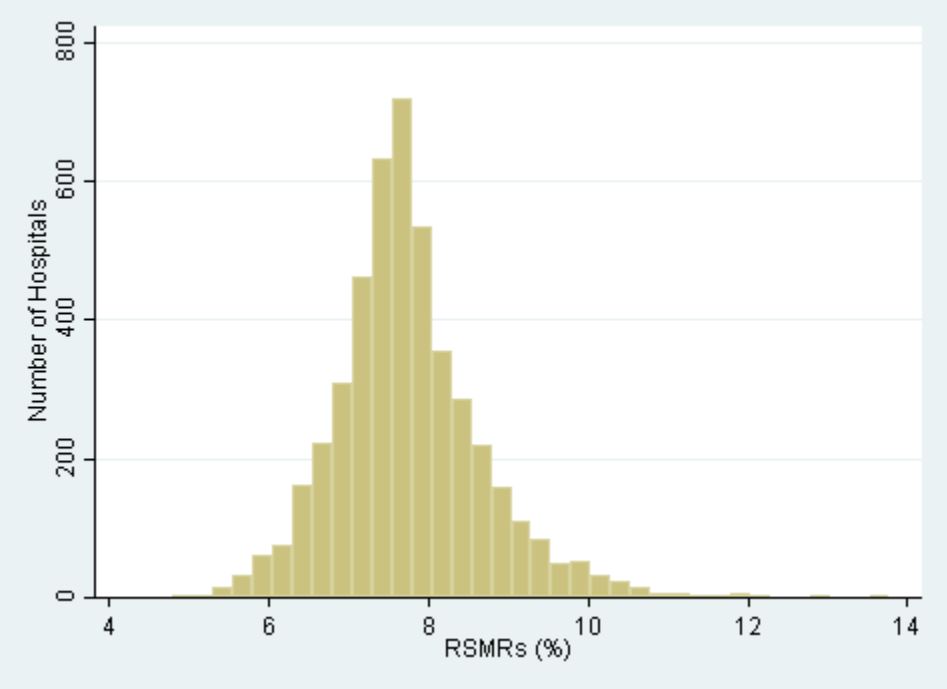
Table 4.5.6 – Distribution of Hospital COPD RSMRs Over Different Time Periods

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Number of hospitals	4,538	4,513	4,496	4,658
Mean (SD)	7.7 (0.7)	8.1 (0.8)	7.4 (0.6)	7.8 (0.9)
Range (min. – max.)	5.5-11.3	5.6-12.1	4.5-12.0	4.8-13.8
25th percentile	7.3	7.6	7.1	7.2
50th percentile	7.6	8.0	7.4	7.7
75th percentile	8.0	8.4	7.7	8.2

Table 4.5.7 – Between Hospital Variance for COPD

	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Between hospital variance (SE)	0.058 (0.006)	0.065 (0.006)	0.061 (0.007)	0.060 (0.003)

Figure 4.5.2 – Distribution of Hospital 30-Day COPD RSMRs Between July 2011 and June 2014



N= 4,658 hospitals

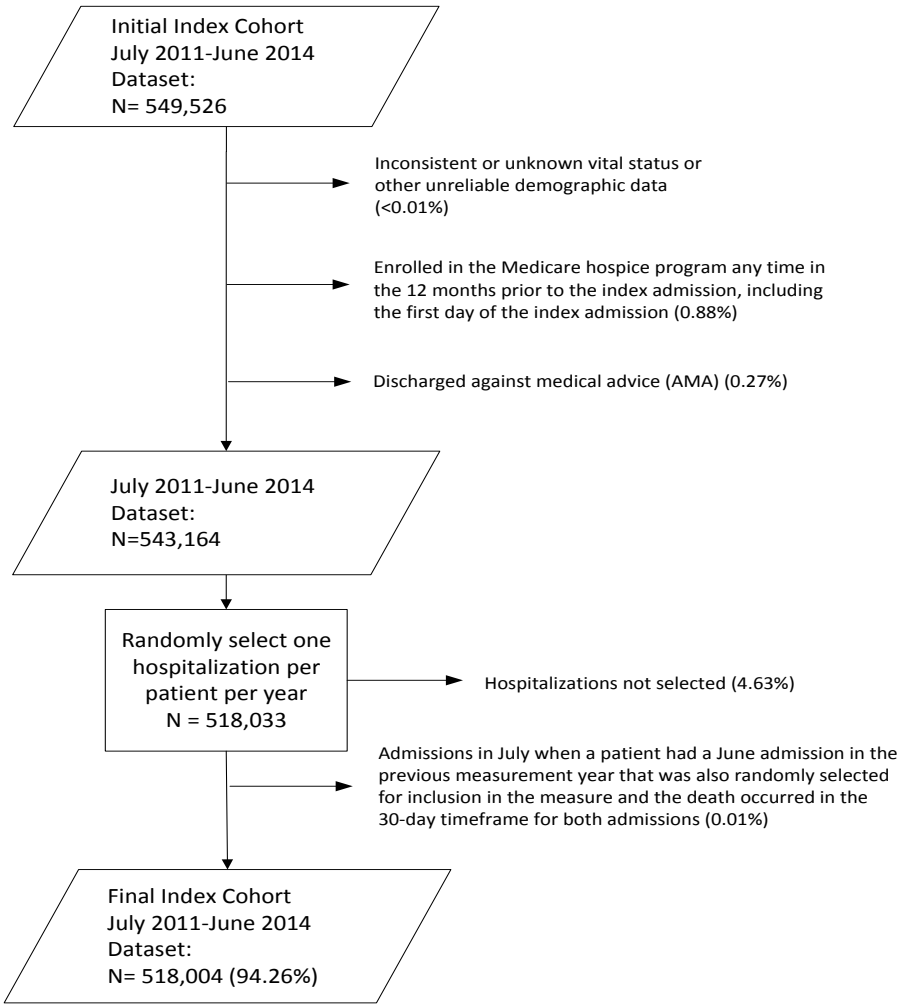
4.6 Stroke Mortality 2015 Model Results

4.6.1 Index Cohort Exclusions

The exclusion criteria for the measures are presented in Section 2.2.1. The percentage of stroke patients meeting each exclusion criterion in the July 2011-June 2014 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 hospitalizations for Medicare FFS patients aged 65 or over with a principal discharge diagnosis of stroke; enrolled in Part A and Part B Medicare for the 12 months prior to the date of admission, and enrolled in Part A during the index admission; and who were not transferred from another acute care facility.

Figure 4.6.1 – Stroke Cohort Exclusions in the July 2011-June 2014 Dataset



4.6.2 Frequency of Stroke Model Variables

We examined the change in both observed mortality rates and frequency of clinical and demographic variables (Table 4.6.1). Between July 2011-June 2012 and July 2013-June 2014, the observed mortality rate decreased from 15.3% to 14.1%.

However, the frequency of some model variables increased, which may reflect an increased rate of comorbidity in the FFS population, but is also due, in part, to increased coding

opportunities on administrative claims. In the 2012 update to the measures, we increased the number of diagnosis and procedure codes to align with the version 5010 format changes DHHS required. Hospitals could begin to submit up to 25 diagnosis and procedure codes starting in 2010. Over time, more hospitals submitted more codes, which translated into increased frequencies for some model variables. Notable decreases occurred in Congestive heart failure (CC 80) (25.3% to 24.2%) and Ischemic or unspecified stroke (CC 96) (23.7% to 22.7%), while notable increases occurred in Other significant endocrine and metabolic disorders (CC 22-24) (85.9% to 87.7%), Other musculoskeletal and connective tissue disorders (CC 43) (69.4% to 70.5%), Renal failure (CC 131) (20.0% to 21.6%), and Transfer from another ED (8.2% to 9.3%). Refer to Table 4.6.1 for more detail.

4.6.3 Stroke Model Parameters and Performance

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

4.6.4 Distribution of Hospital Volumes and RSMRs for Stroke

Table 4.6.5 shows the distribution of hospital admission volumes and Table 4.6.6 shows the distribution of hospital RSMRs. The mean RSMR decreased over the three-year period, from 15.3% between July 2011 and June 2012 to 14.2% between July 2013 and June 2014. The median hospital RSMR in the combined three-year dataset was 14.8% (IQR 14.2% - 15.6%). Table 4.6.7 shows the between-hospital variance by individual year and for the combined three-year dataset. Between-hospital variance in the combined dataset was 0.051 (SE: 0.003). If there were no systematic differences between hospitals, the between-hospital variance would be 0.

Figure 4.6.2 shows the overall distribution of the hospital RSMRs for the combined dataset. The odds of all-cause mortality if treated at a hospital one standard deviation above the national rate were 1.57 times higher than the odds of all-cause mortality if treated at a hospital one standard deviation below the national rate. If there were no systematic differences between hospitals, the OR would be 1.0.[23]

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

Of 4,492 hospitals in the cohort, 42 performed “better than the U.S. national rate,” 2,682 performed “no different from the U.S. national rate,” and 79 performed “worse than the U.S. national rate.” 1,689 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	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Total N	173,817	173,319	170,868	518,004

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Observed mortality rate (%)	15.3	15.1	14.1	14.8
Mean age minus 65 (SD)	15.3 (8.2)	15.3 (8.2)	15.2 (8.3)	15.3 (8.2)
Male (%)	41.4	41.6	42.2	41.8
Transfer from another ED	8.2	8.8	9.3	8.7
Congestive heart failure (CC 80)	25.3	24.6	24.2	24.7
Valvular or rheumatic heart disease (CC 86)	25.5	25.4	25.3	25.4
Congenital cardiac/circulatory defects (CC 87-88)	2.4	2.4	2.5	2.4
Hypertensive heart disease (CC 90)	5.6	5.3	4.7	5.2
Specified arrhythmias (CC 92)	31.3	30.9	30.6	30.9
Cerebral hemorrhage (CC 95)	1.9	2.0	2.1	2.0
Ischemic or unspecified stroke (CC 96)	23.7	23.0	22.7	23.1
Precerebral arterial occlusion and transient cerebral ischemia (CC 97)	22.9	22.6	22.0	22.5
Cerebral atherosclerosis and aneurysm (CC 98)	11.9	11.8	11.7	11.8
Hemiplegia/hemiparesis (CC 100)	5.5	5.3	5.2	5.3
History of infection (CC 1, 3-6)	27.9	27.8	27.7	27.8
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	3.8	3.8	3.9	3.8
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other major cancers (CC 9-13)	24.4	24.4	24.2	24.3
Protein-calorie malnutrition (CC 21)	6.8	6.5	6.5	6.6
Other significant endocrine and metabolic disorders (CC 22-24)	85.9	87.0	87.7	86.9
Other gastrointestinal disorders (CC 36)	50.2	50.7	51.0	50.6
Disorders of the vertebrae and spinal discs (CC 39)	20.2	20.2	20.5	20.3
Osteoarthritis of hip or knee (CC 40)	11.7	11.7	11.9	11.8
Other musculoskeletal and connective tissue disorders (CC 43)	69.4	69.9	70.5	70.0
Iron deficiency or other unspecified anemia and blood disease (CC 47)	37.9	37.4	37.1	37.5
Dementia or other specified brain disorders (CC 49-50)	31.6	31.6	31.3	31.5
Major psychiatric disorders (CC 54-56)	10.4	10.5	10.7	10.5
Quadriplegia, other extensive paralysis (CC 67-69)	1.5	1.5	1.6	1.5
Multiple sclerosis (CC 72, 76)	12.7	13.3	13.6	13.2
Seizure disorders and convulsions (CC 74)	7.5	7.6	7.7	7.6
Hypertension (CC 89, 91)	91.9	92.3	92.4	92.2
Vascular disease and complications (CC 104-105)	24.4	24.1	24.0	24.2
Chronic obstructive pulmonary disease (COPD) (CC 108)	23.0	22.6	22.1	22.6
Pneumonia (CC 111-113)	16.2	16.1	15.6	16.0
Pleural effusion/pneumothorax (CC 114)	7.6	7.4	7.5	7.5
Other eye disorders (CC 124)	20.2	20.3	20.5	20.3
Other ear, nose, throat, and mouth disorders (CC 127)	28.9	28.9	29.3	29.0
Dialysis status (CC 130)	1.6	1.6	1.6	1.6
Renal failure (CC 131)	20.0	20.9	21.6	20.9
Urinary tract infection (CC 135)	21.9	22.0	21.6	21.8
Male genital disorders (CC 140)	14.2	14.5	14.8	14.5
Decubitus ulcer of skin (CC 148)	2.7	2.7	2.7	2.7
Chronic ulcer of skin, except decubitus (CC 149)	5.5	5.2	5.3	5.3
Other dermatological disorders (CC 153)	31.7	32.1	32.6	32.1

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

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Intercept	-2.846	-2.883	-2.850	-2.861
Age minus 65 (years above 65, continuous)	0.069	0.070	0.066	0.068
Male	-0.022	-0.025	-0.010	-0.020
Transfer from another ED	0.390	0.382	0.352	0.348
Congestive heart failure (CC 80)	0.251	0.287	0.230	0.258
Valvular or rheumatic heart disease (CC 86)	-0.067	-0.088	-0.095	-0.082
Congenital cardiac/circulatory defects (CC 87-88)	-0.356	-0.416	-0.288	-0.357
Hypertensive heart disease (CC 90)	-0.223	-0.212	-0.157	-0.185
Specified arrhythmias (CC 92)	0.458	0.459	0.457	0.457
Cerebral hemorrhage (CC 95)	0.108	0.166	0.189	0.154
Ischemic or unspecified stroke (CC 96)	-0.050	-0.100	-0.110	-0.085
Precerebral arterial occlusion and transient cerebral ischemia (CC 97)	-0.237	-0.231	-0.269	-0.244
Cerebral atherosclerosis and aneurysm (CC 98)	-0.211	-0.189	-0.172	-0.189
Hemiplegia/hemiparesis (CC 100)	0.201	0.242	0.264	0.237
History of infection (CC 1, 3-6)	0.083	0.093	0.090	0.094
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	0.960	0.976	0.966	0.970
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other major cancers (CC 9-13)	-0.071	-0.060	-0.065	-0.064
Protein-calorie malnutrition (CC 21)	0.545	0.555	0.527	0.547
Other significant endocrine and metabolic disorders (CC 22-24)	-0.353	-0.347	-0.317	-0.342
Other gastrointestinal disorders (CC 36)	-0.101	-0.111	-0.125	-0.114
Disorders of the vertebrae and spinal discs (CC 39)	-0.110	-0.106	-0.141	-0.117
Osteoarthritis of hip or knee (CC 40)	-0.199	-0.165	-0.194	-0.185
Other musculoskeletal and connective tissue disorders (CC 43)	-0.162	-0.116	-0.147	-0.144
Iron deficiency or other unspecified anemias and blood disease (CC 47)	0.167	0.169	0.203	0.183
Dementia or other specified brain disorders (CC 49-50)	0.302	0.291	0.287	0.295
Major psychiatric disorders (CC 54-56)	0.072	0.023	0.039	0.044
Quadriplegia, other extensive paralysis (CC 67-69)	0.408	0.355	0.422	0.397
Multiple sclerosis (CC 72, 76)	-0.150	-0.161	-0.178	-0.166
Seizure disorders and convulsions (CC 74)	0.361	0.340	0.294	0.333
Hypertension (CC 89, 91)	-0.123	-0.113	-0.151	-0.127
Vascular disease and complications (CC 104-105)	0.074	0.095	0.112	0.098
Chronic obstructive pulmonary disease (COPD) (CC 108)	0.094	0.077	0.105	0.092
Pneumonia (CC 111-113)	0.386	0.384	0.380	0.383
Pleural effusion/pneumothorax (CC 114)	0.121	0.090	0.126	0.111
Other eye disorders (CC 124)	-0.086	-0.100	-0.097	-0.094
Other ear, nose, throat, and mouth disorders (CC 127)	-0.091	-0.140	-0.118	-0.117
Dialysis status (CC 130)	0.226	0.191	0.124	0.189
Renal failure (CC 131)	0.077	0.108	0.096	0.090
Urinary tract infection (CC 135)	0.087	0.099	0.097	0.094
Male genital disorders (CC 140)	-0.201	-0.179	-0.197	-0.191
Decubitus ulcer of skin (CC 148)	0.218	0.209	0.168	0.200
Chronic ulcer of skin, except decubitus (CC 149)	0.184	0.186	0.182	0.186

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Other dermatological disorders (CC 153)	-0.094	-0.109	-0.109	-0.104

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

Variable	07/2011-06/2012 OR (95% CI)	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2011-06/2014 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.07 (1.07 - 1.07)	1.07 (1.07 - 1.07)	1.07 (1.07 - 1.07)	1.07 (1.07 - 1.07)
Male	0.98 (0.95 - 1.01)	0.98 (0.94 - 1.01)	0.99 (0.96 - 1.03)	0.98 (0.96 - 1.00)
Transfer from another ED	1.48 (1.40 - 1.55)	1.46 (1.39 - 1.54)	1.42 (1.35 - 1.50)	1.42 (1.37 - 1.46)
Congestive heart failure (CC 80)	1.29 (1.24 - 1.33)	1.33 (1.29 - 1.38)	1.26 (1.21 - 1.31)	1.29 (1.27 - 1.32)
Valvular or rheumatic heart disease (CC 86)	0.94 (0.91 - 0.97)	0.92 (0.89 - 0.95)	0.91 (0.88 - 0.94)	0.92 (0.90 - 0.94)
Congenital cardiac/circulatory defects (CC 87-88)	0.70 (0.63 - 0.78)	0.66 (0.59 - 0.74)	0.75 (0.67 - 0.84)	0.70 (0.66 - 0.75)
Hypertensive heart disease (CC 90)	0.80 (0.75 - 0.85)	0.81 (0.76 - 0.86)	0.86 (0.80 - 0.92)	0.83 (0.80 - 0.86)
Specified arrhythmias (CC 92)	1.58 (1.53 - 1.63)	1.58 (1.53 - 1.63)	1.58 (1.53 - 1.63)	1.58 (1.55 - 1.61)
Cerebral hemorrhage (CC 95)	1.11 (1.02 - 1.22)	1.18 (1.08 - 1.29)	1.21 (1.10 - 1.32)	1.17 (1.11 - 1.23)
Ischemic or unspecified stroke (CC 96)	0.95 (0.92 - 0.99)	0.91 (0.87 - 0.94)	0.90 (0.86 - 0.93)	0.92 (0.90 - 0.94)
Precerebral arterial occlusion and transient cerebral ischemia (CC 97)	0.79 (0.76 - 0.82)	0.79 (0.77 - 0.83)	0.76 (0.73 - 0.80)	0.78 (0.77 - 0.80)
Cerebral atherosclerosis and aneurysm (CC 98)	0.81 (0.77 - 0.85)	0.83 (0.79 - 0.87)	0.84 (0.80 - 0.88)	0.83 (0.81 - 0.85)
Hemiplegia/hemiparesis (CC 100)	1.22 (1.15 - 1.30)	1.27 (1.20 - 1.36)	1.30 (1.22 - 1.39)	1.27 (1.22 - 1.32)
History of infection (CC 1, 3-6)	1.09 (1.05 - 1.12)	1.10 (1.06 - 1.13)	1.10 (1.06 - 1.13)	1.10 (1.08 - 1.12)
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	2.61 (2.45 - 2.78)	2.66 (2.49 - 2.83)	2.63 (2.47 - 2.80)	2.64 (2.54 - 2.74)
Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other major cancers (CC 9-13)	0.93 (0.90 - 0.97)	0.94 (0.91 - 0.98)	0.94 (0.90 - 0.97)	0.94 (0.92 - 0.96)
Protein-calorie malnutrition (CC 21)	1.73 (1.65 - 1.81)	1.74 (1.66 - 1.83)	1.69 (1.61 - 1.78)	1.73 (1.68 - 1.78)
Other significant endocrine and metabolic disorders (CC 22-24)	0.70 (0.68 - 0.73)	0.71 (0.68 - 0.74)	0.73 (0.70 - 0.76)	0.71 (0.69 - 0.73)
Other gastrointestinal disorders (CC 36)	0.90 (0.88 - 0.93)	0.90 (0.87 - 0.92)	0.88 (0.86 - 0.91)	0.89 (0.88 - 0.91)
Disorders of the vertebrae and spinal discs (CC 39)	0.90 (0.86 - 0.93)	0.90 (0.87 - 0.93)	0.87 (0.84 - 0.90)	0.89 (0.87 - 0.91)
Osteoarthritis of hip or knee (CC 40)	0.82 (0.78 - 0.86)	0.85 (0.81 - 0.89)	0.82 (0.79 - 0.86)	0.83 (0.81 - 0.85)
Other musculoskeletal and connective tissue disorders (CC 43)	0.85 (0.82 - 0.88)	0.89 (0.86 - 0.92)	0.86 (0.83 - 0.89)	0.87 (0.85 - 0.88)
Iron deficiency or other unspecified anemias and blood disease (CC 47)	1.18 (1.15 - 1.22)	1.18 (1.15 - 1.22)	1.23 (1.19 - 1.27)	1.20 (1.18 - 1.22)
Dementia or other specified brain disorders (CC 49-50)	1.35 (1.31 - 1.40)	1.34 (1.30 - 1.38)	1.33 (1.29 - 1.38)	1.34 (1.32 - 1.37)
Major psychiatric disorders (CC 54-56)	1.08 (1.03 - 1.12)	1.02 (0.98 - 1.07)	1.04 (0.99 - 1.09)	1.05 (1.02 - 1.07)
Quadriplegia, other extensive paralysis (CC 67-69)	1.50 (1.36 - 1.67)	1.43 (1.29 - 1.58)	1.53 (1.38 - 1.69)	1.49 (1.40 - 1.58)
Multiple sclerosis (CC 72, 76)	0.86 (0.82 - 0.90)	0.85 (0.81 - 0.89)	0.84 (0.80 - 0.88)	0.85 (0.83 - 0.87)
Seizure disorders and convulsions (CC 74)	1.43 (1.37 - 1.51)	1.41 (1.34 - 1.48)	1.34 (1.28 - 1.41)	1.40 (1.36 - 1.44)
Hypertension (CC 89, 91)	0.88 (0.84 - 0.93)	0.89 (0.85 - 0.94)	0.86 (0.81 - 0.91)	0.88 (0.85 - 0.91)

Variable	07/2011-06/2012 OR (95% CI)	07/2012-06/2013 OR (95% CI)	07/2013-06/2014 OR (95% CI)	07/2011-06/2014 OR (95% CI)
Vascular disease and complications (CC 104-105)	1.08 (1.04 - 1.11)	1.10 (1.06 - 1.14)	1.12 (1.08 - 1.16)	1.10 (1.08 - 1.13)
Chronic obstructive pulmonary disease (COPD) (CC 108)	1.10 (1.06 - 1.14)	1.08 (1.04 - 1.12)	1.11 (1.07 - 1.15)	1.10 (1.07 - 1.12)
Pneumonia (CC 111-113)	1.47 (1.42 - 1.53)	1.47 (1.42 - 1.52)	1.46 (1.41 - 1.52)	1.47 (1.44 - 1.50)
Pleural effusion/pneumothorax (CC 114)	1.13 (1.08 - 1.19)	1.09 (1.04 - 1.15)	1.14 (1.08 - 1.19)	1.12 (1.09 - 1.15)
Other eye disorders (CC 124)	0.92 (0.89 - 0.95)	0.91 (0.87 - 0.94)	0.91 (0.87 - 0.94)	0.91 (0.89 - 0.93)
Other ear, nose, throat, and mouth disorders (CC 127)	0.91 (0.89 - 0.94)	0.87 (0.84 - 0.90)	0.89 (0.86 - 0.92)	0.89 (0.87 - 0.91)
Dialysis status (CC 130)	1.25 (1.13 - 1.39)	1.21 (1.09 - 1.34)	1.13 (1.02 - 1.26)	1.21 (1.14 - 1.28)
Renal failure (CC 131)	1.08 (1.04 - 1.12)	1.11 (1.07 - 1.16)	1.10 (1.06 - 1.14)	1.09 (1.07 - 1.12)
Urinary tract infection (CC 135)	1.09 (1.05 - 1.13)	1.10 (1.07 - 1.14)	1.10 (1.06 - 1.14)	1.10 (1.08 - 1.12)
Male genital disorders (CC 140)	0.82 (0.78 - 0.86)	0.84 (0.80 - 0.88)	0.82 (0.78 - 0.86)	0.83 (0.80 - 0.85)
Decubitus ulcer of skin (CC 148)	1.24 (1.16 - 1.34)	1.23 (1.15 - 1.33)	1.18 (1.10 - 1.28)	1.22 (1.17 - 1.28)
Chronic ulcer of skin, except decubitus (CC 149)	1.20 (1.14 - 1.27)	1.20 (1.14 - 1.28)	1.20 (1.13 - 1.27)	1.20 (1.17 - 1.25)
Other dermatological disorders (CC 153)	0.91 (0.88 - 0.94)	0.90 (0.87 - 0.93)	0.90 (0.87 - 0.93)	0.90 (0.89 - 0.92)

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

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Predictive ability, % (lowest decile – highest decile)	2.6-39.5	2.5-39.3	2.5-36.9	2.6-38.6
c-statistic	0.74	0.74	0.74	0.74

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

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Number of hospitals	4,283	4,199	4,133	4,492
Mean number of admissions (SD)	40.6 (52.1)	41.3 (53.8)	41.3 (54.3)	115.3 (156.6)
Range (min. – max.)	1-449	1-482	1-475	1-1406
25th percentile	6	6	5	13
50th percentile	19	18	18	47
75th percentile	57	58	59	162

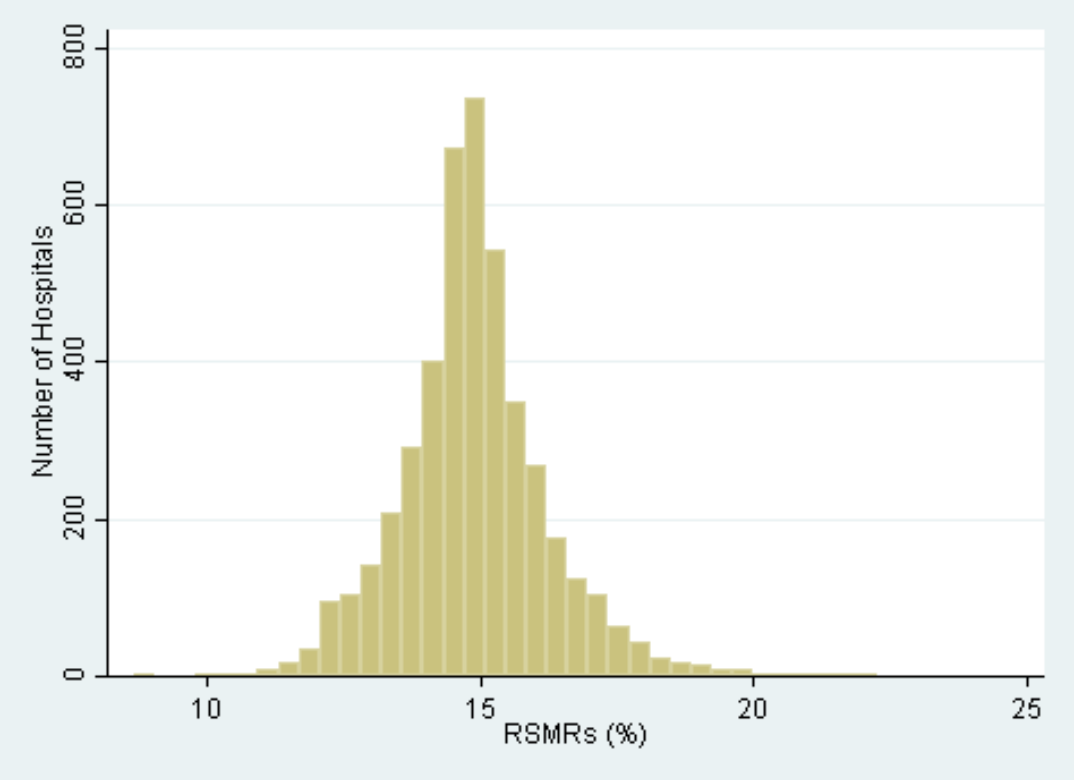
Table 4.6.6 – Distribution of Hospital Stroke RSMRs Over Different Time Periods

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Number of hospitals	4,283	4,199	4,133	4,492
Mean (SD)	15.3 (1.0)	15.2 (1.0)	14.2 (0.9)	14.9 (1.4)
Range (min. – max.)	10.6-21.0	10.8-20.9	10.7-19.8	8.7-22.3
25th percentile	14.8	14.7	13.7	14.2
50th percentile	15.2	15.1	14.1	14.8
75th percentile	15.8	15.6	14.6	15.6

Table 4.6.7 – Between Hospital Variance for Stroke

	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Between hospital variance (SE)	0.048 (0.005)	0.046 (0.005)	0.049 (0.005)	0.051 (0.003)

Figure 4.6.2 – Distribution of Hospital 30-Day Stroke RSMRs Between July 2011 and June 2014



N= 4,492 hospitals

5. GLOSSARY

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

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

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

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

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

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

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

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

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

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

Medicare fee-for-service (FFS): Original Medicare plan in which providers receive a fee or payment for each individual service provided directly from Medicare. All services rendered are unbundled and paid

for separately. Only beneficiaries in Medicare FFS, not in managed care (Medicare Advantage), are included in the measures.

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

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

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

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

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

6. REFERENCES

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7. APPENDICES

Appendix A. Statistical Approach to Risk-Standardized Mortality Rates for AMI, HF, Pneumonia, COPD, 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 risk-standardized mortality rates, which we calculate as the ratio of a hospital's "predicted" mortality to "expected" mortality multiplied by the national observed mortality rate. The expected mortality for each hospital is estimated using its patient mix and the average hospital-specific intercept (i.e., the average intercept among all hospitals in the sample). The predicted mortality for each hospital is estimated given the same patient mix but an estimated hospital-specific intercept. Operationally, the expected mortality for each hospital is obtained by summing the expected probabilities of mortality for all patients in the hospital. The expected probability of mortality for each patient is calculated via the hierarchical model, which applies the estimated regression coefficients to the observed patient characteristics and adds the average of the hospital-specific intercept. The predicted mortality for each hospital is calculated by summing the predicted probabilities for all patients in the hospital. The predicted probability for each patient is calculated through the hierarchical model, which applies the estimated regression coefficients to the patient characteristics observed and adds the hospital-specific intercept.

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

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

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

Where h(.) is a logit link, Y_{ij} is whether the j^{th} patient in the i^{th} hospital died (equal to 1 if death, 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.[24] This model separates within-hospital variation from between-hospital variation. The hierarchical logistic regression models are estimated using the SAS software system (SAS 9.3 GLIMMIX).

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

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

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

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

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

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

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

Creating Interval Estimates

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

Algorithm:

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

1. Sample *I* hospitals with replacement.
2. Fit the hierarchical generalized linear model using all patients within each sampled hospital. If some hospitals are selected more than once in a bootstrapped sample, we treat them as distinct so that we have *I* random effects to estimate the variance components. At the conclusion of Step 2, we have:
    a. $\hat{\beta}^{(b)}$ (the estimated regression coefficients of the risk factors).
    b. The parameters governing the random effects, hospital adjusted outcomes, distribution, $\hat{\mu}^{(b)}$ and $\hat{\tau}^{2(b)}$.
    c. The set of hospital-specific intercepts and corresponding variances, $\{\hat{\alpha}_i{}^{(b)}, \widehat{var}(\alpha_i{}^{(b)}); i = 1,2, \dots, I\}$
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).[25]

Appendix B. Data Quality Assurance (QA)

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

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

Phase I

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

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

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

Phase II

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

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

Figure B.1 – CORE QA Phase I

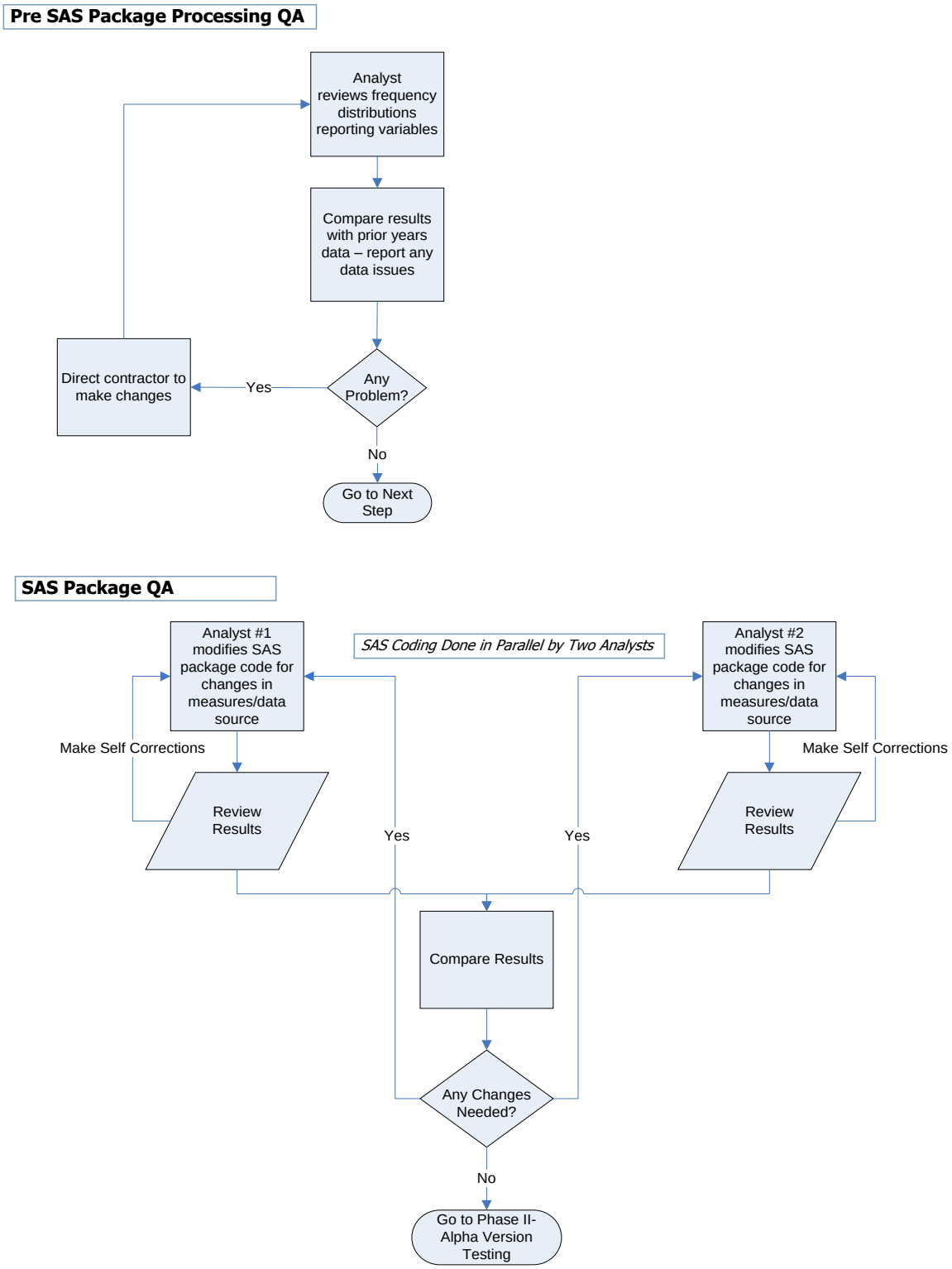
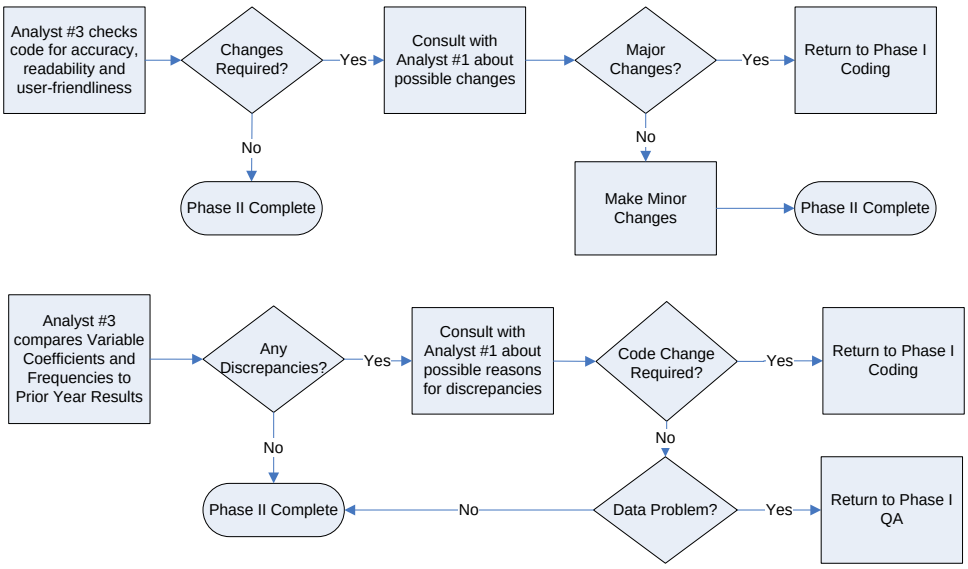


Figure B.2 – CORE QA Phase II

Results Testing – Alpha Version



Appendix C. Annual Updates

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

2015

2015 Measures Updates and Specifications Report (Version 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: 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: The ICD-9-CM CC map is 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: The ICD-9-CM CC map is updated annually to capture all relevant comorbidities coded in patient administrative claims data.
2. Incorporating Risk Adjustment for Emergency Department-transfer Patients
   - Rationale: ED-transfer patients may be at higher risk of mortality.
3. Removed ICD-9-CM code 436 from measure cohort
   - Rationale: ICD-9-CM code 436 is not commonly used to define acute ischemic stroke.

2012

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

1. Included VA one-day stays.
   - Rationale: Stays of less than 24 hours that result in death, discharge against medical advice, or transfer (or that follow a transfer) are not likely to be observation stays because the time frame of the admissions was determined not by clinical necessity but by other factors such as death or transfer. These stays had been previously excluded from the measure.

2. Excluded patients based on enrollment in VA hospice
   - Rationale: VA patients who have a history of VA hospice care in the 12 months prior to the index admission are now excluded.
3. Incorporated Version 5010 format.
   - Rationale: Version 5010 increased the number of diagnoses and procedures hospitals could code on Medicare claims. The inclusion of 15 additional codes for diagnoses and 19 additional codes for procedures allows us to identify additional comorbidities, thereby increasing the accuracy of risk adjustment.
4. Updated CC map.
   - Rationale: The ICD-9-CM CC map is 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: The ICD-9-CM CC map is 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: The ICD-9-CM CC map is updated annually to capture all relevant comorbidities coded in patient administrative claims data.

2009

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

1. Randomly selected one AMI admission per patient per year for inclusion in the cohort
   - Rationale: Three-year data increased the number of multiple AMI admissions, which would be statistically correlated. Randomly selecting one AMI admission per year aligned the measure with HF and PN.
2. Used three years of claims and enrollment data for public reporting.
   - Rationale: Three years of data increased the precision of the hospital RSMR estimates by increasing the number of admissions used to calculate the rates. CMS developed the measures using one year of data.
3. Excluded patients discharged AMA.

- Rationale: Providers are unable to deliver full care and prepare the patient for discharge when patients leave AMA.

4. Updated CC map.
    - Rationale: The ICD-9-CM CC map is 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: The ICD-9-CM CC map is updated annually to capture all relevant comorbidities coded in patient administrative claims data.

Appendix D. Measure Specifications

Appendix D.1 AMI

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 or VA beneficiaries**
   Rationale: Claims data are consistently available only for Medicare FFS and VA beneficiaries.
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: Death is attributed to the hospital where the patient was initially admitted. Transferred patients are still included in the measure cohort, but the "transfer-in" hospitalization is excluded as an index admission.
5. **Enrolled in Part A and Part B Medicare for the 12 months prior to the date of admission, and enrolled in Part A during the index admission**
   Rationale: The 12-month prior enrollment 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. This requirement is dropped for patients with an index admission within a VA hospital.

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 or used VA hospice services any time in the 12 months prior to the index admission, including the first day of the index admission**
   Rationale: These patients are likely continuing to seek comfort measures only, so mortality is not necessarily an adverse outcome or signal of poor quality care.
4. **Discharged against medical advice (AMA)**
   Rationale: Providers did not have the opportunity to deliver full care and prepare the patient for discharge.

   After exclusions #1-4 are applied, the measure randomly selects one index admission per patient per year for inclusion in the cohort so that each episode of care is mutually independent

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

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

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

Risk Adjustment

Table D.1.2 – Risk Variables for AMI Measure

Variable	Description
n/a	Age minus 65 (years above 65, continuous)
n/a	Male
ICD-9 codes V45.82, 00.66, 36.06, 36.07	History of Percutaneous Transluminal Coronary Angioplasty (PTCA)
ICD-9 codes V45.81, 36.10–36.16	History of Coronary Artery Bypass Graft (CABG)
CC 80	Congestive heart failure
CC 81	Acute myocardial infarction
CC 82	Other acute/subacute forms of ischemic heart disease
ICD-9 codes 410.00-410.12	Anterior myocardial infarction
ICD-9 codes 410.20-410.62	Other location of myocardial infarction
CC 83-84	Coronary atherosclerosis or angina
CC 79	Cardio-respiratory failure or shock
CC 86	Valvular or rheumatic heart disease
CC 89, 91	Hypertension
CC 95-96	Stroke
CC 97-99, 103	Cerebrovascular disease
CC 131	Renal failure
CC 108	Chronic obstructive pulmonary disease (COPD)
CC 111-113	Pneumonia
CC 15-20, 120	Diabetes mellitus (DM) or DM complications except proliferative retinopathy
CC 21	Protein-calorie malnutrition
CC 49-50	Dementia or other specified brain disorders
CC 67-69, 100-102, 177-178	Hemiplegia, paraplegia, paralysis, functional disability
CC 104-105	Vascular disease and complications
CC 7-8	Metastatic cancer, acute leukemia and other severe cancers
CC 154-156, 158-162	Trauma in last year
CC 54-56	Major psychiatric disorders
CC 25-27	Chronic liver disease

Table D.1.3 – Complications of Care Variables Not Used in Risk Adjustment If Occurring Only During the Index Admission of AMI Measure

(Includes the subset of risk variables from Table D.1.2 that are not used in risk adjustment if occurring only during the index admission)

Variable	Description
CC 17	Diabetes with acute complications
CC 79	Cardio-respiratory failure or shock
CC 80	Congestive heart failure
CC 81	Acute myocardial infarction
CC 82	Other acute/subacute forms of ischemic heart disease
CC 95	Cerebral hemorrhage
CC 96	Ischemic or unspecified stroke
CC 97	Precerebral arterial occlusion and transient cerebral ischemia
CC 100	Hemiplegia/hemiparesis
CC 101	Diplegia (upper), monoplegia, and other paralytic syndromes
CC 102	Speech, language, cognitive, perceptual
CC 104	Vascular disease with complications
CC 105	Vascular disease
CC 111	Aspiration and specified bacterial pneumonias
CC 112	Pneumococcal pneumonia, emphysema, lung abscess
CC 131	Renal failure
CC 154	Severe head injury
CC 155	Major head injury
CC 156	Concussion or unspecified head injury
CC 158	Hip fracture/dislocation
CC 159	Major fracture, except of skull, vertebrae, or hip
CC 177	Amputation status, lower limb/amputation
CC 178	Amputation status, upper limb

Outcome

Outcome Criteria for AMI Measure

1. **30-day time frame**
   Rationale: Outcomes occurring within 30 days of admission can be influenced by hospital care and early transition to the outpatient setting. The use of the 30-day time frame is a clinically meaningful period for hospitals to collaborate with their communities to reduce mortality.
2. **All-cause mortality**
   Rationale: From a patient perspective, death is the most critical outcome regardless of cause.

Appendix D.2 Heart Failure

Cohort

Inclusion Criteria for HF Measure

1. **Principal discharge diagnosis of HF**
   Rationale: HF is the condition targeted for measurement (Table D.2.1).
2. **Enrolled in Medicare FFS or VA beneficiaries**
   Rationale: Claims data are consistently available only for Medicare FFS and VA beneficiaries.
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: Death is attributed to the hospital where the patient was initially admitted. Transferred patients are still included in the measure cohort, but the "transfer-in" hospitalization is excluded as an index admission.
5. **Enrolled in Part A and Part B Medicare for the 12 months prior to the date of admission, and enrolled in Part A during the index admission**
   Rationale: The 12-month prior enrollment 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. Note: This requirement is dropped for patients with an index admission within a VA hospital.

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 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 or used VA hospice services any time in the 12 months prior to the index admission, including the first day of the index admission**
   Rationale: These patients are likely continuing to seek comfort measures only; thus, mortality is not necessarily an adverse outcome or signal of poor quality care.
4. **Discharged against medical advice (AMA)**
   Rationale: Providers did not have the opportunity to deliver full care and prepare the patient for discharge.

   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. For each patient, the probability of death increases

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

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

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

Risk Adjustment

Table D.2.2 – Risk Variables for HF Measure

Variable	Description
n/a	Age minus 65 (years above 65, continuous)
n/a	Male
ICD-9 codes V45.82, 00.66, 36.06, 36.07	History of Percutaneous Transluminal Coronary Angioplasty (PTCA)
ICD-9 codes V45.81, 36.10–36.16	History of Coronary Artery Bypass Graft (CABG)
CC 80	Congestive heart failure
CC 81	Acute myocardial infarction
CC 82	Other acute/subacute forms of ischemic heart disease
CC 83-84	Coronary atherosclerosis or angina
CC 79	Cardio-respiratory failure or shock
CC 86	Valvular or rheumatic heart disease
CC 89, 91	Hypertension
CC 95-96	Stroke
CC 131	Renal failure
CC 108	Chronic obstructive pulmonary disease (COPD)
CC 111-113	Pneumonia
CC 15-20, 120	Diabetes mellitus (DM) or DM complications except proliferative retinopathy
CC 21	Protein-calorie malnutrition
CC 49-50	Dementia or other specified brain disorders
CC 67-69, 100-102, 177-178	Hemiplegia, paraplegia, paralysis, functional disability
CC 104-105	Vascular disease and complications
CC 7-8	Metastatic cancer, acute leukemia and other severe cancers
CC 154-156, 158-162	Trauma in last year
CC 54-56	Major psychiatric disorders
CC 25-27	Chronic liver disease

Table D.2.3 – Complications of Care Variables Not Used in Risk Adjustment If Occurring Only During the Index Admission of HF Measure

(Includes the subset of risk variables from Table D.2.2 that are not used in risk adjustment if occurring only during the index admission)

Variable	Description
CC 17	Diabetes with acute complications
CC 79	Cardio-respiratory failure or shock
CC 80	Congestive heart failure
CC 81	Acute myocardial infarction

Variable	Description
CC 82	Other acute/subacute forms of ischemic heart disease
CC 95	Cerebral hemorrhage
CC 96	Ischemic or unspecified stroke
CC 100	Hemiplegia/hemiparesis
CC 101	Diplegia (upper), monoplegia, and other paralytic syndromes
CC 102	Speech, language, cognitive, perceptual
CC 104	Vascular disease with complications
CC 105	Vascular disease
CC 111	Aspiration and specified bacterial pneumonias
CC 112	Pneumococcal pneumonia, emphysema, lung abscess
CC 131	Renal failure
CC 154	Severe head injury
CC 155	Major head injury
CC 156	Concussion or unspecified head injury
CC 158	Hip fracture/dislocation
CC 159	Major fracture, except of skull, vertebrae, or hip
CC 177	Amputation status, lower limb/amputation
CC 178	Amputation status, upper limb

Outcome

Outcome Criteria for HF Measure

1. **30-day time frame**
   Rationale: Outcomes occurring within 30 days of admission can be influenced by hospital care and early transition to the outpatient setting. The use of the 30-day time frame is a clinically meaningful period for hospitals to collaborate with their communities to reduce mortality.
2. **All-cause mortality**
   Rationale: From a patient perspective, death is the most critical outcome regardless of cause.

Appendix D.3 Pneumonia

Cohort

Inclusion Criteria for Pneumonia Measure

1. **Principal discharge diagnosis of pneumonia**
   Rationale: Pneumonia is the condition targeted for measurement (Table D.3.1).
2. **Enrolled in Medicare FFS or VA beneficiaries**
   Rationale: Claims data are consistently available only for Medicare FFS and VA beneficiaries.
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: Death is attributed to the hospital where the patient was initially admitted. Transferred patients are still included in the measure cohort, but the "transfer-in" hospitalization is excluded as an index admission.
5. **Enrolled in Part A and Part B Medicare for the 12 months prior to the date of admission, and enrolled in Part A during the index admission**
   Rationale: The 12-month prior enrollment 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. Note: This requirement is dropped for patients with an index admission within a VA hospital.

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 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 or used VA hospice services any time in the 12 months prior to the index admission, including the first day of the index admission**
   Rationale: These patients are likely continuing to seek comfort measures only; thus, mortality is not necessarily an adverse outcome or signal of poor quality care for these patients.
4. **Discharged against medical advice (AMA)**
   Rationale: Providers did not have the opportunity to deliver full care and prepare the patient for discharge.

   After exclusions #1-4 are applied, the measure randomly selects one index admission per patient per year for inclusion in the cohort so that each episode of care is mutually independent with the same probability of the outcome. For each patient, the probability of death increases with each subsequent admission and therefore the episodes of care are not mutually

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

Table D.3.1 – ICD-9-CM Codes for Pneumonia Cohort

ICD-9-CM Codes	Description
480.0	Pneumonia due to adenovirus
480.1	Pneumonia due to respiratory syncytial virus
480.2	Pneumonia due to parainfluenza virus
480.3	Pneumonia due to SARS-associated coronavirus
480.8	Pneumonia due to other virus not elsewhere classified
480.9	Viral pneumonia, unspecified
481	Pneumococcal pneumonia (Streptococcus pneumoniae pneumonia)
482.0	Pneumonia due to Klebsiella pneumoniae
482.1	Pneumonia due to Pseudomonas
482.2	Pneumonia due to Hemophilus influenzae (H. influenzae)
482.30	Pneumonia due to Streptococcus, unspecified
482.31	Pneumonia due to Streptococcus, group A
482.32	Pneumonia due to Streptococcus, group B
482.39	Pneumonia due to other Streptococcus
482.40	Pneumonia due to Staphylococcus, unspecified
482.41	Methicillin susceptible pneumonia due to Staphylococcus aureus
482.42	Methicillin resistant pneumonia due to Staphylococcus aureus
482.49	Other Staphylococcus pneumonia
482.81	Pneumonia due to anaerobes
482.82	Pneumonia due to escherichia coli (E. coli)
482.83	Pneumonia due to other gram-negative bacteria
482.84	Pneumonia due to Legionnaires' disease
482.89	Pneumonia due to other specified bacteria
482.9	Bacterial pneumonia, unspecified
483.0	Pneumonia due to mycoplasma pneumoniae
483.1	Pneumonia due to chlamydia
483.8	Pneumonia due to other specified organism
485	Bronchopneumonia, organism unspecified
486	Pneumonia, organism unspecified
487.0	Influenza with pneumonia
488.11	Influenza due to identified 2009 H1N1 influenza virus with pneumonia

Risk Adjustment

Table D.3.2 – Risk Variables for Pneumonia Measure

Variable	Description
n/a	Age minus 65 (years above 65, continuous)
n/a	Male
ICD-9 codes V45.82, 00.66, 36.06, 36.07	History of Percutaneous Transluminal Coronary Angioplasty (PTCA)
ICD-9 codes V45.81, 36.10–36.16	History of Coronary Artery Bypass Graft (CABG)
CC 80	Congestive heart failure
CC 81	Acute myocardial infarction
CC 82	Other acute/subacute forms of ischemic heart disease
CC 83-84	Coronary atherosclerosis or angina
CC 79	Cardio-respiratory failure or shock
CC 89, 91	Hypertension
CC 95-96	Stroke
CC 97-99, 103	Cerebrovascular disease
CC 131	Renal failure
CC 108	Chronic obstructive pulmonary disease (COPD)
CC 111-113	Pneumonia
CC 21	Protein-calorie malnutrition
CC 49-50	Dementia or other specified brain disorders
CC 67-69, 100-102, 177-178	Hemiplegia, paraplegia, paralysis, functional disability
CC 104-105	Vascular disease and complications
CC 7-8	Metastatic cancer, acute leukemia and other severe cancers
CC 154-156, 158-162	Trauma in last year
CC 54-56	Major psychiatric disorders
CC 25-27	Chronic liver disease
CC 44	Severe hematological disorders
CC 47	Iron deficiency or other unspecified anemias and blood disease
CC 58	Depression
CC 73	Parkinson’s or Huntington’s diseases
CC 74	Seizure disorders and convulsions
CC 109	Fibrosis of lung or other chronic lung disorders
CC 110	Asthma
CC 157	Vertebral fractures

Table D.3.3 – Complications of Care Variables Not Used in Risk Adjustment If Occurring Only During the Index Admission of Pneumonia Measure

(Includes the subset of risk variables from Table D.3.2 that are not used in risk adjustment if occurring only during the index admission)

Variable	Description
CC 79	Cardio-respiratory failure or shock
CC 80	Congestive heart failure
CC 81	Acute myocardial infarction
CC 82	Other acute/subacute forms of ischemic heart disease
CC 95	Cerebral hemorrhage
CC 96	Ischemic or unspecified stroke
CC 97	Precerebral arterial occlusion and transient cerebral ischemia
CC 100	Hemiplegia/hemiparesis
CC 101	Diplegia (upper), monoplegia, and other paralytic syndromes
CC 102	Speech, language, cognitive, perceptual
CC 104	Vascular disease with complications
CC 105	Vascular disease
CC 111	Aspiration and specified bacterial pneumonias
CC 112	Pneumococcal pneumonia, emphysema, lung abscess
CC 131	Renal failure
CC 154	Severe head injury
CC 155	Major head injury
CC 156	Concussion or unspecified head injury
CC 158	Hip fracture/dislocation
CC 159	Major fracture, except of skull, vertebrae, or hip
CC 177	Amputation status, lower limb/amputation
CC 178	Amputation status, upper limb

Outcome

Outcome Criteria for Pneumonia Measure

1. **30-day time frame**
   Rationale: Outcomes occurring within 30 days of admission can be influenced by hospital care and early transition to the outpatient setting. The use of the 30-day time frame is a clinically meaningful period for hospitals to collaborate with their communities to reduce mortality.
2. **All-cause mortality**
   Rationale: From a patient perspective, death is the most critical outcome regardless of cause.

Appendix D.4 COPD

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 patients 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.4.1).
2. **Enrolled in Medicare FFS**
   Rationale: Claims data are consistently available only for Medicare FFS beneficiaries.
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: Death is attributed to the hospital where the patient was initially admitted. Transferred patients are still included in the measure cohort, but the "transfer-in" hospitalization is excluded as an index admission.
5. **Enrolled in Part A and Part B Medicare for the 12 months prior to the date of admission, and enrolled in Part A during the index admission**
   Rationale: The 12-month prior enrollment 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.

Exclusion Criteria for COPD Measure

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

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

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

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

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

Risk Adjustment

Table D.4.2 – Risk Variables for COPD Measure

Variable	Description
N/A	Age minus 65 (years above 65, continuous)
ICD-9 codes 93.90, 96.70, 96.71, 96.72	History of mechanical ventilation
ICD-9 codes 327.20, 327.21, 327.23, 327.27, 327.29, 780.51, 780.53, 780.57	Sleep apnea
CC 77-78	Respirator dependence/respiratory failure
CC 79	Cardio-respiratory failure or shock
CC 80	Congestive heart failure
CC 83-84	Coronary atherosclerosis or angina
CC 92-93	Specified arrhythmias and other heart rhythm disorders
CC 104-106	Vascular or circulatory disease
CC 109	Fibrosis of lung or other chronic lung disorders
CC 110	Asthma
CC 111-113	Pneumonia
CC 114	Pleural effusion/pneumothorax
CC 115	Other lung disorders
CC 7	Metastatic cancer or acute leukemia
CC 8	Lung, upper digestive tract, and other severe cancers
CC 9-11	Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other cancers and tumors; other respiratory and heart neoplasms
CC 12	Other digestive and urinary neoplasms
CC 15-20, 119-120	Diabetes mellitus (DM) or DM complications
CC 21	Protein-calorie malnutrition
CC 22-23	Disorders of fluid/electrolyte/acid-base
CC 24	Other endocrine/metabolic/nutritional disorders
CC 36	Other gastrointestinal disorders
CC 40	Osteoarthritis of hip or knee
CC 43	Other musculoskeletal and connective tissue disorders
CC 47	Iron deficiency or other unspecified anemias and blood disease
CC 49-50	Dementia or other specified brain disorders
CC 53	Drug/alcohol abuse, without dependence
CC 60	Other psychiatric disorders
CC 67-69, 100-102, 177-178	Hemiplegia, paraplegia, paralysis, functional disability
CC 76	Mononeuropathy, other neurological conditions/injuries
CC 90-91	Hypertension and hypertensive disease

Variable	Description
CC 95-96	Stroke
CC 121	Retinal disorders, except detachment and vascular retinopathies
CC 124	Other eye disorders
CC 127	Other ear, nose, throat and mouth disorders
CC 131	Renal failure
CC 148-149	Decubitus ulcer or chronic skin ulcer
CC 153	Other dermatological disorders
CC 154-156, 158-161	Trauma
CC 157	Vertebral fractures
CC 164	Major complications of medical care and trauma

Table D.4.3 – Complications of Care Variables Not Used in Risk Adjustment If Occurring Only During the Index Admission of COPD Measure

(Includes the subset of risk variables from Table D.4.2 that are not used in risk adjustment if occurring only during the index admission)

Variable	Description
CC 17	Diabetes with acute complications
CC 23	Disorders of fluid/electrolyte/acid-base
CC 77	Respirator dependence/tracheostomy status
CC 78	Respiratory arrest
CC 79	Cardio-respiratory failure or shock
CC 80	Congestive heart failure
CC 92	Specified heart arrhythmias
CC 93	Other heart rhythm and conduction disorders
CC 95	Cerebral hemorrhage
CC 96	Ischemic or unspecified stroke
CC 100	Hemiplegia/hemiparesis
CC 101	Diplegia (upper), monoplegia, and other paralytic syndromes
CC 102	Speech, language, cognitive, perceptual
CC 104	Vascular disease with complications
CC 105	Vascular disease
CC 106	Other circulatory disease
CC 111	Aspiration and specified bacterial pneumonias
CC 112	Pneumococcal pneumonia, emphysema, lung abscess
CC 114	Pleural effusion/pneumothorax
CC 131	Renal failure
CC 148	Decubitus ulcer of skin
CC 154	Severe head injury
CC 155	Major head injury

Variable	Description
CC 156	Concussion or unspecified head injury
CC 158	Hip fracture/dislocation
CC 159	Major fracture, except of skull, vertebrae, or hip
CC 164	Major complications of medical care and trauma
CC 177	Amputation status, lower limb/amputation
CC 178	Amputation status, upper limb

Outcome

Outcome Criteria for COPD Measure

1. **30-day time frame**
   Rationale: Outcomes occurring within 30 days of admission can be influenced by hospital care and early transition to the outpatient setting. The use of the 30-day time frame is a clinically meaningful period for hospitals to collaborate with their communities to reduce mortality.
2. **All-cause mortality**
   Rationale: From a patient perspective, death is the most critical outcome regardless of cause.

Appendix D.5 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).
2. **Enrolled in Medicare FFS**
   Rationale: Claims data are consistently available only for Medicare FFS beneficiaries.
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: Death is attributed to the hospital where the patient was initially admitted. Transferred patients are still included in the measure cohort, but the "transfer-in" hospitalization is excluded as an index admission.
5. **Enrolled in Part A and Part B Medicare for the 12 months prior to the date of admission, and enrolled in Part A during the index admission**
   Rationale: The 12-month prior enrollment 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.

Exclusion Criteria for Stroke Measure

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

After exclusions #1-3 are applied, the measure randomly selects one index admission per patient per year for inclusion in the cohort so that each episode of care is mutually independent with the same probability of the outcome. For each patient, the probability of death increases with each subsequent admission and therefore the episodes of care are not mutually independent. Similarly, for the three year combined data, when index admissions occur during the transition between measure reporting periods (June and July of each year) and both are randomly selected for inclusion in the measure, the measure includes only the June admission.

The July admissions are excluded from the measure to avoid assigning a single death to two admissions.

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

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

Risk Adjustment

Table D.5.2 – Risk Variables for Stroke Measure

Variable	Description
n/a	Age minus 65 (years above 65, continuous)
n/a	Male
n/a	Transfer from another ED
CC 80	Congestive heart failure
CC 86	Valvular or rheumatic heart disease
CC 87-88	Congenital cardiac/circulatory defects
CC 90	Hypertensive heart disease
CC 92	Specified arrhythmias
CC 95	Cerebral hemorrhage
CC 96	Ischemic or unspecified stroke
CC 97	Precerebral arterial occlusion and transient cerebral ischemia
CC 98	Cerebral atherosclerosis and aneurysm
CC 100	Hemiplegia/hemiparesis
CC 1, 3-6	History of infection
CC 7-8	Metastatic cancer, acute leukemia and other severe cancers
CC 9-13	Lymphatic, head and neck, brain, and other major cancers; breast, colorectal and other major cancers
CC 21	Protein-calorie malnutrition
CC 22-24	Other significant endocrine and metabolic disorders
CC 36	Other gastrointestinal disorders

Variable	Description
CC 39	Disorders of the vertebrae and spinal discs
CC 40	Osteoarthritis of hip or knee
CC 43	Other musculoskeletal and connective tissue disorders
CC 47	Iron deficiency or other unspecified anemias and blood disease
CC 49-50	Dementia or other specified brain disorders
CC 54-56	Major psychiatric disorders
CC 67-69	Quadriplegia, other extensive paralysis
CC 72, 76	Multiple sclerosis
CC 74	Seizure disorders and convulsions
CC 89, 91	Hypertension
CC 104-105	Vascular disease and complications
CC 108	Chronic obstructive pulmonary disease (COPD)
CC 111-113	Pneumonia
CC 114	Pleural effusion/pneumothorax
CC 124	Other eye disorders
CC 127	Other ear, nose, throat, and mouth disorders
CC 130	Dialysis status
CC 131	Renal failure
CC 135	Urinary tract infection
CC 140	Male genital disorders
CC 148	Decubitus ulcer of skin
CC 149	Chronic ulcer of skin, except decubitus
CC 153	Other dermatological disorders

Table D.5.3 – Complications of Care Variables Not Used in Risk Adjustment If Occurring Only During the Index Admission of Stroke Measure

(Includes the subset of risk variables from Table D.5.2 that are not used in risk adjustment if occurring only during the index admission)

Variable	Description
CC 6	Other infectious diseases
CC 23	Disorders of fluid/electrolyte/acid-base
CC 80	Congestive heart failure
CC 92	Specified arrhythmias
CC 95	Cerebral hemorrhage
CC 96	Ischemic or unspecified stroke
CC 97	Precerebral arterial occlusion and transient cerebral ischemia
CC 100	Hemiplegia/hemiparesis
CC 104	Vascular disease with complications
CC 105	Vascular disease
CC 111	Aspiration and specified bacterial pneumonias

Variable	Description
CC 112	Pneumococcal pneumonia, emphysema, lung abscess
CC 114	Pleural effusion/pneumothorax
CC 124	Other eye disorders
CC 130	Dialysis status
CC 131	Renal failure
CC 135	Urinary tract infection
CC 148	Decubitus ulcer of skin

Outcome

Outcome Criteria for Stroke Measure

1. **30-day time frame**
   Rationale: Outcomes occurring within 30 days of admission can be influenced by hospital care and early transition to the outpatient setting. The use of the 30-day time frame is a clinically meaningful period for hospitals to collaborate with their communities to reduce mortality.
2. **All-cause mortality**
   Rationale: From a patient perspective, death is the most critical outcome regardless of cause.