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

Acute Myocardial Infarction – Version 4.0
Heart Failure – Version 2.0
Pneumonia – Version 2.0

Submitted By:

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1. HOW TO USE THIS REPORT

This report describes the Centers for Medicare & Medicaid Services' (CMS) payment measures publicly reported on *Hospital Compare*, the hospital-level risk-standardized payments (RSPs) associated with a 30-day episode of care for acute myocardial infarction (AMI), heart failure (HF), and pneumonia. This report serves as a single source of information about these measures for a wide range of readers. Reports describing mortality and readmission outcomes for these and other conditions (chronic obstructive pulmonary disease [COPD] and stroke), hospital-wide readmissions, and procedure-specific outcome measures (hip/knee arthroplasty and coronary artery bypass graft [CABG] surgery) 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 concise tables of the condition codes used for cohort derivation, risk adjustment, and a history of annual updates.

Specifically, this report includes:

- **Section 2 –An overview of the AMI, HF, and pneumonia payment measures:**
  - Background
  - Cohort inclusions and exclusions
    - included and excluded hospitalizations
    - how transferred patients are handled
  - Payment outcome
  - Risk-adjustment specifications
  - Data sources
  - Payment calculation
  - Categorization of hospitals' payments

- **Section 3 – 2015 measure updates:**
  - Data source
  - Pneumonia payment model

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

- **Section 5 – Glossary**

The Appendices contain detailed measure information, including:

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

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

- Hospital-level, Risk-Standardized Payment Associated with a 30-Day Episode of Care for Acute Myocardial Infarction (Version 1.0)[1]
- Hospital-level, Risk-Standardized Payment Associated with a 30-Day Episode of Care for Heart Failure (Version 1.0)[2]
- Hospital-level, Risk-Standardized Payment Associated with a 30-Day Episode of Care for Pneumonia (Version 1.0)[3]
- 2014 Measure Updates and Specifications Report: Hospital-Level, Risk-Standardized Payment Associated with a 30-Day Episode of Care for AMI (Version 3.0)[4]

2. BACKGROUND AND OVERVIEW OF MEASURE METHODOLOGY

2.1 Background on Payment Measures

In December 2014, CMS began publicly reporting hospital RSPs associated with a 30-day episode of care for AMI for the nation's non-federal short-term acute care hospitals (including Indian Health Services hospitals) and critical access hospitals. The results for this measure are posted on *Hospital Compare*, which CMS updates annually.

In 2015, CMS will begin publicly reporting two additional payment measures: Hospital-Level RSP Associated with a 30-Day Episode of Care for Heart Failure (HF) and Hospital-Level RSP Associated with a 30-Day Episode of Care for Pneumonia. These measures also include admissions to non-federal short-term acute care and critical access hospitals.

The payment measures are not intended to be interpreted in isolation, but to be considered in the context of existing quality measures such as CMS's 30-day risk-standardized all-cause mortality and readmission measures for AMI, HF, and pneumonia.

CMS contracted with the Yale-New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (CORE) to update the AMI, HF, and pneumonia payment measures for 2015 public reporting through a process of measure reevaluation. The 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 AMI, HF, and pneumonia payment 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 measure updates and specifications reports.[1-4] The National Quality Forum (NQF) has endorsed all three payment measures. An overview of the methodology is provided in this section.

2.2.1 Cohort

Index Admissions Included in Measures

An index admission is the hospitalization that begins the 30-day episode-of-care payment window and includes admissions for patients:

- Having a principal discharge diagnosis of AMI, HF, pneumonia for each respective measure;
- Enrolled in Medicare fee-for-service (FFS);
- Aged 65 years or over;
- Not transferred from another acute care facility (the acute episode is included in the measure, but payment is attributed to the hospital where the patient was initially admitted rather than to the hospital receiving the transferred patient); and,
- Enrolled in Part A and Part B Medicare FFS for the 12 months prior to the date of admission, and enrolled in Part A and Part B during the index admission.

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

Index Admissions Excluded from the Measure

The payment measures exclude index admissions for patients:

- With incomplete administrative data in the 30 days following the index admission if discharged alive;
- Discharged alive on the day of admission or on the following day who were not transferred;
- With inconsistent or unknown vital status or other unreliable demographic data (age and gender);
- Discharged against medical advice (AMA);
- Enrolled in the Medicare hospice program any time in the 12 months prior to the index admission, including on the first day of the index;
- Transferred to a federal hospital;
- Not matched to an admission in the AMI, HF, or pneumonia mortality measure, respectively; or
- With missing index diagnosis-related group (DRG) weight where the provider received no payment.

Additional exclusion criteria for the HF cohort are: (1) patients who receive a heart transplant during the episode of care; (2) patients who have a Left Ventricular Assist Device (LVAD) implanted during the episode of care. These patients are excluded from the cohort because they are clinically distinct, generally very high-payment cases, and not representative of the typical HF patient that this measure aims to capture.

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

Patients Transferred Between Hospitals

The measures consider multiple contiguous hospitalizations as a single acute episode of care. Admissions to a hospital within one day of discharge from another hospital are considered transfers whether or not the first institution indicates intent to transfer the patient in the discharge disposition code.

Payments for transferred patients are attributed to the hospital that admitted the patient for the index hospitalization. Thus, if a patient is admitted to Hospital A and transferred to Hospital B, the 30-day episode of care is considered to be triggered by admission to Hospital A. The total payment includes payments for Hospital A, Hospital B, and other services provided during the 30-day episode of care. This attribution is consistent with CMS's AMI, HF, and pneumonia mortality measures.[5,6]

Medicare reduces payments when patients are transferred to another Inpatient Prospective Payment System (IPPS) hospital and have a length of stay at least one day less than the geometric mean length of stay for the DRG. Under this policy, transferring hospitals are paid a per diem rate. For stays at the transferring hospital that are equal to or greater than the geometric mean length of stay for the DRG, transferring hospitals receive a full DRG payment.[7] The per diem rate or the full DRG rate is assigned to the transferring hospital where applicable and is then added to the payment for the hospital that received the transfer patient to calculate the payment for the index admission.

2.2.2 Outcome

Payments

Using administrative claims data, we measure RSPs for Medicare patients for an episode of care that begins with an index admission for AMI, HF, or pneumonia and that ends 30 days after the index admission. The payment measures capture payments for Medicare patients across multiple care settings, services, and supplies (i.e., inpatient, outpatient, skilled nursing facility [SNF], home health, hospice, physician/clinical laboratory/ambulance services, durable medical equipment, prosthetics/orthotics, and supplies). Payment adjustments unrelated to clinical care decisions are removed.

To isolate payment variation that reflects practice patterns rather than CMS payment adjustments, payments are standardized for each setting using the CMS Standardization Methodology for Allowed Amount.[8] Geographic differences and policy adjustments in payment rates for individual services are removed from the total payment for that service. Where geographic differences in payments cannot be removed, they are averaged across geographic areas. Standardizing the payment allows for a fair comparison across hospitals based solely on payments for decisions related to clinical care.

30-Day Time Frame

The measures assess payments within a 30-day period from the date of index admission. The measures use a 30-day time frame because payments accrued within 30 days of admission can be influenced by hospital care and the early transition to the post-acute setting. Also, the 30-day time frame provides a standardized observation period for each hospital. Lastly, the 30-day time frame is consistent with other CMS measures endorsed by NQF and publicly reported by CMS, which provides stakeholders with a consistent time period for assessing health care value.[9]

2.2.3 Risk-Adjustment Variables

In order to perform comparisons of payment across hospitals, the measures adjust for variables (e.g., age, comorbid disease, and indicators of patient frailty) that are clinically relevant and have strong relationships with the outcome. The AMI payment measure also adjusts for prior percutaneous coronary intervention (PCI)/coronary artery bypass graft (CABG), as these procedures may impact clinical decisions and payments for subsequent AMI care. For each patient, risk-adjustment variables are obtained from

inpatient, outpatient, and physician Medicare administrative claims data extending 12 months prior to, and including, the index admission.

The measures 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.

None of the measures adjust for patients' admission source. Additionally, none of the measures adjust for patients' discharge disposition (e.g., SNF). These factors are associated with the structure of the healthcare system, not solely with 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 care patients with varying SES receive. The intent is for the measures to adjust for patient demographic and clinical characteristics while illuminating important payment 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.[10,11]

Refer to Table D.1.2, Table D.2.2, and Table D.3.2 for the list of comorbidity risk-adjustment variables and Table D.1.3, Table D.2.3, and Table D.3.3 for the list of complications that are excluded from risk adjustment if occurring during the index admission for AMI, HF, and pneumonia, respectively.

2.2.4 Data Sources

The payment measures include Medicare administrative claims data and enrollment information for patients with hospitalizations that occurred between July 1, 2011 and June 30, 2014. Medicare administrative claims data for certain Part A and Part B services in the 12 months prior to and during the index admission are used for risk adjustment. The data also contain price-standardized payments for Medicare patients across multiple care settings, services, and supplies (i.e., inpatient, outpatient, SNF, home health, hospice, physician/clinical laboratory/ambulance services, and durable medical equipment, prosthetics/orthotics, and supplies). The price-standardized payment data element for these analyses has been updated to harmonize across CMS cost and resource use measures. For additional information, please refer to the CMS Standardization Methodology for Allowed Amount - V.3 report for the Medicare Spending per Beneficiary Measure on *QualityNet*.[8] The CMS Standardization Methodology for Allowed Amount methodology for 2006 through 2013 was also applied to the 2014 claims to calculate the 30-day episode-of-care payment measures.

2.2.5 **Measure Calculation**

The measures estimate hospital-level 30-day RSPs for each condition using hierarchical generalized linear models. In brief, the approach simultaneously models data at the patient and hospital levels to account for the variance in patient outcomes within and across hospitals.[12] At the patient level, the measures use a generalized linear model to model the total 30-day payment using age, selected clinical covariates, and a hospital-specific intercept. The AMI RSP was estimated using log link and inverse Gaussian distribution. The HF RSP was estimated using a log link and Gamma distribution. The pneumonia RSP was estimated using an identity link and Gamma distribution. The choice of link function and distribution was based on the algorithm suggested by Manning & Mullahy and several model diagnostics.[13]

At the hospital level, the approach models the hospital-specific intercepts as arising from a normal distribution. The hospital intercept represents the underlying 30-day payment 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.[12] If there were no differences among hospitals, then after adjusting for patient risk, the hospital intercepts should be identical across all hospitals.

The RSP is calculated as the ratio of the "predicted" payment to the "expected" payment at a given hospital, multiplied by the national mean payment. For each hospital, the numerator of the ratio is the payment predicted based on the hospital's payment for its observed case mix, and the denominator is the payment expected based on the nation's payment for 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 payment, given its case mix, to be compared to an average hospital's payment for the same case mix. Thus, a lower ratio indicates a lower-than-expected 30-day payment, and a higher ratio indicates a higher-than-expected 30-day payment.

The "predicted" 30-day payment (the numerator) is calculated using the coefficients estimated by regressing the risk factors (found in Table D.1.2, Table D.2.2, and Table D.3.2 for the AMI, HF, and pneumonia measures, respectively) and the hospital-specific intercept on the payment outcome. The estimated hospital-specific intercept is added to the sum of the estimated regression coefficients multiplied by the patient characteristics. The results are then summed over all patients attributed to a hospital to get a predicted value. The "expected" 30-day payment (the denominator) is obtained in the same manner, but a common intercept using all hospitals in our sample is added in place of the hospital-specific intercept. The results are then summed over all patients in the hospital to get an expected value. To assess hospital payments for each reporting period, we re-estimate the model coefficients using the years of data in that period.

For each hospital, the ratio of "predicted" 30-day payment over "expected" 30-day payment is then multiplied by the national mean payment to get the RSP. This transforms the ratio of predicted over expected into a payment amount that is compared to the national mean payment. The hierarchical generalized linear regression models are described fully in Appendix A and in the original methodology reports.[1-3]

2.2.6 Categorizing Hospital Payments

To categorize hospital payments, CMS estimates each hospital's RSP and the corresponding 95% interval estimate. CMS assigns hospitals to a payment category by comparing each hospital's RSP interval estimate to the national mean payment. Comparative payments for hospitals with 25 or more eligible cases are classified as follows:

- "No different than U.S. national payment" if the 95% interval estimate surrounding the hospital's RSP includes the national mean payment.
- "Higher than U.S. national payment" if the entire 95% interval estimate surrounding the hospital's RSP is higher than the national mean payment.
- "Lower than U.S. national payment" if the entire 95% interval estimate surrounding the hospital's RSP is lower than the national mean payment.

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 estimate the hospital's RSP." If a hospital has fewer than 25 eligible cases, the hospital's RSP and interval estimate will not be publicly reported for the measure.

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

3. UPDATES TO MEASURE FOR 2015 PUBLIC REPORTING

3.1 Rationale for Measure Updates

Measure reevaluation ensures that the RSP 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, we undertook the following measure reevaluation activities for 2015 public reporting:

- Updated the price-standardized payment data element used in calculating the payment measures;
- Updated the model link function and distribution used to calculate the pneumonia payment measure to improve model performance;
- Validated the performance of each payment model and its corresponding risk-adjustment variables in three recent one-year datasets (July 2011-June 2012, July 2012-June 2013, and July 2013-June 2014);
- Evaluated and validated model performance in the three years combined (July 2011-June 2014); and,
- Updated the measures' SAS analytic package and documentation.

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 Detailed Discussion of Measure Updates

3.2.1 Data Source

For 2015 public reporting, the measures will continue to use Medicare administrative claims data as well as enrollment information for patients with hospitalizations. However, instead of calculating price-standardized payments using the Chronic Conditions Warehouse data used in past years, the measures will use price-standardized payments processed via the CMS Standardization Methodology for Allowed Amount for the analytic input files. The use of the CMS Standardization Methodology for Allowed Amount harmonizes the payment calculation methodology across the broader suite of CMS cost and resource use measures. The change in data source does not meaningfully change the underlying methodology for standardizing payments. . For additional information, please review the CMS Standardization Methodology for Allowed Amount – V.3 report for the Medicare Spending per Beneficiary Measure on *QualityNet*.[8]

3.2.2 Pneumonia Payment Model

For 2015 public reporting, the pneumonia payment model for calculating hospital RSPs will be updated to use an identity link function and Gamma distribution, which improves the model's performance. This update is a change from the pneumonia payment measure's original methodology.[3] This choice of link function and distribution was based on several model diagnostics and better prediction of the payment outcome at the extremes of the distribution.

Unlike the AMI and HF payment models, where exponentiated coefficients can be interpreted as "payment ratios," the pneumonia payment model coefficients can be directly interpreted as dollars.

3.3 Changes to SAS Analytic Package (SAS Pack)

We revised the measure calculation SAS analytic package to reflect the measure updates. The new SAS pack and documentation are available upon request by emailing cmsepisodepaymentmeasures@yale.edu. **Do *NOT* submit patient-identifiable information (for example, 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 RSP 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 PUBLIC REPORTING

4.1 Assessment of Updated Model

The payment measures estimate hospital-specific 30-day RSPs using a hierarchical generalized linear model. 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.[1-3]

We evaluated the performance of the models using the July 2011 to June 2014 data for 2015 reporting. We examined differences in the frequency of patient risk factors and the model variable coefficients. Before evaluation, all payments were inflation-adjusted to 2013 dollars.

For each of the three payment measures, we assessed generalized linear model performance in terms of discriminant ability for each year of data and for the three-year combined period. We computed two summary statistics for assessing model performance: predictive ratio and a quasi-R.[2]

A predictive ratio is an estimator's ratio of predicted outcome to observed outcome.[14] A predictive ratio close to 1.0 indicates an accurate prediction. A ratio substantially greater than 1.0 indicates overprediction, and a ratio substantially less than 1.0 indicates underprediction.

For a traditional linear model (i.e., ordinary least squares regression), R^2 is interpreted as the amount of variation in the observed outcome that is explained by the predictor variables (patient-level risk factors). Generalized linear models, however, do not output an R^2 that is akin to the R^2 of a traditional linear model. We produced a "quasi-R^2" by regressing the total payment outcome on the predicted outcome.[14] Specifically, we regressed the total payment on the payment predicted by the patient-level risk factors.

The results of these national analyses for each of the three payment measures are presented in Section 4.2, Section 4.3, and Section 4.4.

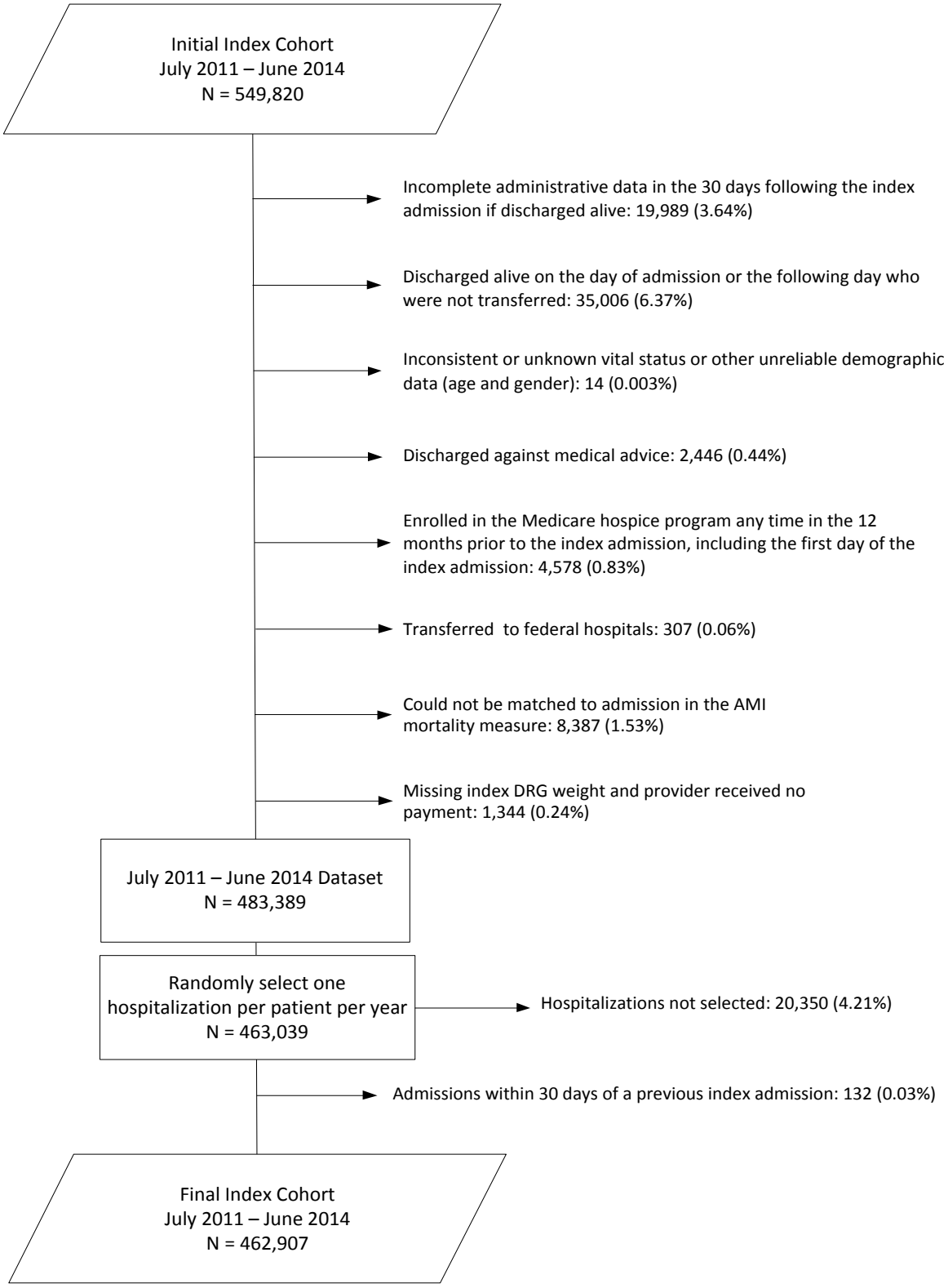
4.2 AMI Payment 2015 Model Results

4.2.1 Index Cohort Exclusions

The exclusion criteria for the measures are presented in Section 2.2.1. The percentage of 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 and Part B during the index admission; and who were not transferred to another acute care facility.

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



4.2.2 Frequency of AMI Payment Model Variables

We examined the change in both observed payments and frequency of clinical and demographic variables shown in Table 4.2.1. Between July 2011-June 2012 and July 2013-June 2014, the national mean payment decreased from $21,816 to $21,555.

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 osteoporosis and other bone/cartilage disorders (17.2% to 15.8%), iron deficiency or other unspecified anemias and blood disease (47.7% to 46.7%), congestive heart failure (30.5% to 28.8%), and other lung disorders (27.0% to 24.9%), while notable increases occurred in history of Percutaneous Transluminal Coronary Angioplasty (PTCA) (16.1% to 17.7%), other endocrine/metabolic/nutritional disorders (85.8% to 87.8%), drug/alcohol abuse/dependence (15.3% to 16.5%), and depression/anxiety (15.9% to 16.9%).

4.2.3 AMI Payment Model Parameters and Performance

Table 4.2.2 Hierarchical Generalized Linear Regression Model Variable Coefficients for AMI Over Different Time Periodsshows the hierarchical generalized linear model variable coefficients by individual year and for the combined three-year dataset. Table 4.2.3 Adjusted PR and 95% CIs for the AMI Hierarchical Generalized Linear Regression Model Over Different Time Periodsshows the risk-adjusted payment ratios (PRs) and 95% confidence intervals (CIs) for the AMI payment model by individual year and for the combined three-year dataset. The quasi-R^2 for the AMI payment model was 0.07, suggesting that approximately 7% of the variation in payment can be explained by patient-level risk factors. This quasi-R^2 is in line with R^2s from other patient-level risk-adjustment models for healthcare payment.[15]

Overall, the variable effect sizes were relatively constant across years. In addition, model performance was stable over the three-year time period; the quasi-R^2 and predictive ratios remained similar to the model used for 2014 public reporting (Table 4.2.4)

4.2.4 Distribution of Hospital Volumes and RSPs for AMI

Table 4.2.5 shows the distribution of hospital admission volumes and Table 4.2.6 shows the distribution of hospital RSPs. The mean RSP decreased over the three-year period, from $21,839 between July 2011 and June 2012 to $21,579 between July 2013 and June 2014. The median hospital RSP in the combined three-year dataset was $21,620 (Interquartile Range [IQR] $20,966 - $22,566). 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 0.010 (Standard Error [SE]: 0.0004). 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 RSPs for the combined dataset. The expected 30-day payment if treated at a hospital one standard deviation above the national average was 1.22 times higher than the expected 30-day payment if treated at a hospital one standard deviation below the national average payment. If there were no systematic differences between hospitals, this ratio would be 1.0.[12]

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

Of the 4,341 hospitals in the study cohort, 368 had a payment "higher than the U.S. national payment," 1,854 had a payment "no different from the U.S. national payment," and 175 had a payment "lower than the U.S. national payment." 1,944 were classified as "number of cases too small" (fewer than 25) to reliably estimate the hospital's RSP.

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	155,601	158,030	149,276	462,907
Observed mean payment ($2013)	21,816	21,894	21,555	21,758
Age (65 – 74)	34.6	35.1	36.7	35.4
Age (75 – 84)	37.5	37.0	36.6	37.0
Age (>=85)	28.0	27.9	26.7	27.6
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 codes V45.82, 00.66, 36.06, 36.07)	16.1	17.1	17.7	17.0
History of Coronary Artery Bypass Graft (CABG) (ICD-9 codes V45.81, 36.10-36.16)	11.8	12.2	11.7	11.9
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	3.8	3.7	3.8	3.8
Diabetes mellitus (DM) or DM complications (CC 15-19, 119-120)	46.3	46.9	47.2	46.8
Protein-calorie malnutrition (CC 21)	6.4	6.4	6.1	6.3
Other significant endocrine and metabolic disorders (CC 22)	9.4	9.7	9.7	9.6
Other endocrine/metabolic/ nutritional disorders (CC 24)	85.8	87.0	87.8	86.9
Other gastrointestinal disorders (CC 36)	53.7	54.5	54.5	54.2
Osteoporosis and other bone/cartilage disorders (CC 41)	17.2	16.6	15.8	16.6
Iron deficiency or other unspecified anemias and blood disease (CC 47)	47.7	47.4	46.7	47.3
Delirium and encephalopathy (CC 48)	4.3	4.5	4.7	4.5

Variable	07/2011-06/2012 (%)	07/2012-06/2013 (%)	07/2013-06/2014 (%)	07/2011-06/2014 (%)
Dementia (CC 49)	18.8	18.6	17.9	18.4
Drug/alcohol psychosis (CC 51)	1.1	1.1	1.1	1.1
Drug/alcohol abuse/dependence (CC 52-53)	15.3	15.9	16.5	15.9
Severe mental illness (CC 54-55)	4.9	4.9	5.0	4.9
Reactive and unspecified psychosis (CC 56)	3.8	3.7	3.6	3.7
Depression/anxiety (CC 58-59)	15.9	16.6	16.9	16.5
Congestive heart failure (CC 80)	30.5	29.8	28.8	29.7
Angina pectoris/old myocardial infarction (CC 83)	26.5	26.6	26.4	26.5
Heart infection/inflammation, except rheumatic (CC 85)	1.9	1.9	1.9	1.9
Valvular or rheumatic heart disease (CC 86)	31.5	31.6	31.2	31.5
Congenital cardiac/circulatory defect (CC 87-88)	1.0	1.0	1.0	1.0
Hypertension and hypertension complications (CC 89-91)	89.3	89.7	89.5	89.5
Precerebral arterial occlusion and transient cerebral ischemia (CC 97)	16.1	15.9	15.3	15.7
Vascular disease and complications (CC 104-105)	27.5	27.5	27.0	27.3
Other lung disorders (CC 115)	27.0	25.8	24.9	25.9
Legally blind (CC 116)	1.2	1.1	1.1	1.2
Dialysis status (CC 130)	3.2	3.4	3.4	3.3
Internal injuries (CC 160)	1.0	1.0	1.0	1.0

Table 4.2.2 Hierarchical Generalized Linear 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	9.763	9.774	9.736	9.750
Age (65 – 74)	0.193	0.182	0.188	0.187
Age (75 – 84)	0.167	0.170	0.176	0.170
Age (>=85) (reference group)	--	--	--	--
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD-9 codes V45.82, 00.66, 36.06, 36.07)	-0.063	-0.057	-0.051	-0.059
History of Coronary Artery Bypass Graft (CABG) (ICD-9 codes V45.81, 36.10-36.16)	-0.190	-0.187	-0.199	-0.191

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Metastatic cancer, acute leukemia and other severe cancers (CC 7-8)	-0.099	-0.092	-0.087	-0.094
Diabetes mellitus (DM) or DM complications (CC 15-19, 119-120)	0.076	0.073	0.088	0.078
Protein-calorie malnutrition (CC 21)	0.215	0.188	0.195	0.198
Other significant endocrine and metabolic disorders (CC 22)	0.055	0.064	0.050	0.055
Other endocrine/metabolic/ nutritional disorders (CC 24)	-0.016	-0.012	-0.019	-0.016
Other gastrointestinal disorders (CC 36)	-0.028	-0.024	-0.026	-0.025
Osteoporosis and other bone/cartilage disorders (CC 41)	-0.047	-0.050	-0.038	-0.044
Iron deficiency or other unspecified anemias and blood disease (CC 47)	0.188	0.201	0.205	0.195
Delirium and encephalopathy (CC 48)	-0.021	-0.045	-0.027	-0.033
Dementia (CC 49)	-0.065	-0.073	-0.080	-0.072
Drug/alcohol psychosis (CC 51)	0.144	0.135	0.115	0.131
Drug/alcohol abuse/dependence (CC 52-53)	0.012	0.012	0.028	0.017
Severe mental illness (CC 54-55)	0.024	0.023	0.012	0.017
Reactive and unspecified psychosis (CC 56)	-0.006	0.007	0.007	0.004
Depression/anxiety (CC 58-59)	-0.023	-0.025	-0.025	-0.023
Congestive heart failure (CC 80)	-0.052	-0.059	-0.049	-0.051
Angina pectoris/old myocardial infarction (CC 83)	-0.037	-0.030	-0.037	-0.034
Heart infection/inflammation, except rheumatic (CC 85)	0.194	0.209	0.189	0.194
Valvular or rheumatic heart disease (CC 86)	0.061	0.074	0.068	0.066
Congenital cardiac/circulatory defect (CC 87-88)	0.132	0.105	0.088	0.107
Hypertension and hypertension complications (CC 89-91)	-0.022	-0.037	-0.024	-0.028
Precerebral arterial occlusion and transient cerebral ischemia (CC 97)	0.015	0.010	0.009	0.011
Vascular disease and complications (CC 104-105)	-0.005	-0.002	-0.003	-0.004
Other dung disorders (CC 115)	0.060	0.055	0.060	0.057
Legally blind (CC 116)	-0.012	-0.053	-0.030	-0.032
Dialysis status (CC 130)	0.118	0.109	0.134	0.120
Internal injuries (CC 160)	0.155	0.134	0.161	0.148

Table 4.2.3 Adjusted PR and 95% CIs for the AMI Hierarchical Generalized Linear Regression Model Over Different Time Periods

Variable	07/2011, 06/2012 PR (95% CI)	07/2012, 06/2013 PR (95% CI)	07/2013, 06/2014 PR (95% CI)	07/2011, 06/2014 PR (95% CI)
Age (65 – 74)	1.21 (1.20, 1.22)	1.20 (1.19, 1.21)	1.21 (1.19, 1.22)	1.21 (1.20, 1.21)
Age (75 – 84)	1.18 (1.17, 1.19)	1.19 (1.18, 1.20)	1.19 (1.18, 1.20)	1.19 (1.18, 1.19)
Age (>=85) (reference group)	1.00 (--)	1.00 (--)	1.00 (--)	1.00 (--)
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD, 9 codes V45.82, 00.66, 36.06, 36.07)	0.94 (0.93, 0.95)	0.94 (0.94, 0.95)	0.95 (0.94, 0.96)	0.94 (0.94, 0.95)
History of Coronary Artery Bypass Graft (CABG) (ICD, 9 codes V45.81, 36.10, 36.16)	0.83 (0.82, 0.84)	0.83 (0.82, 0.84)	0.82 (0.81, 0.83)	0.83 (0.82, 0.83)
Metastatic cancer, acute leukemia and other severe cancers (CC 7, 8)	0.91 (0.89, 0.92)	0.91 (0.90, 0.93)	0.92 (0.90, 0.93)	0.91 (0.90, 0.92)
Diabetes mellitus (DM) or DM complications (CC 15, 19, 119, 120)	1.08 (1.07, 1.09)	1.08 (1.07, 1.08)	1.09 (1.08, 1.10)	1.08 (1.08, 1.09)
Protein, calorie malnutrition (CC 21)	1.24 (1.22, 1.26)	1.21 (1.19, 1.23)	1.22 (1.20, 1.24)	1.22 (1.21, 1.23)
Other significant endocrine and metabolic disorders (CC 22)	1.06 (1.04, 1.07)	1.07 (1.05, 1.08)	1.05 (1.04, 1.07)	1.06 (1.05, 1.07)
Other endocrine/metabolic/ nutritional disorders (CC 24)	0.98 (0.97, 0.99)	0.99 (0.98, 1.00)	0.98 (0.97, 0.99)	0.98 (0.98, 0.99)
Other gastrointestinal disorders (CC 36)	0.97 (0.96, 0.98)	0.98 (0.97, 0.98)	0.97 (0.97, 0.98)	0.97 (0.97, 0.98)
Osteoporosis and other bone/cartilage disorders (CC 41)	0.95 (0.95, 0.96)	0.95 (0.94, 0.96)	0.96 (0.95, 0.97)	0.96 (0.95, 0.96)
Iron deficiency or other unspecified anemias and blood disease (CC 47)	1.21 (1.20, 1.22)	1.22 (1.21, 1.23)	1.23 (1.22, 1.24)	1.22 (1.21, 1.22)
Delirium and encephalopathy (CC 48)	0.98 (0.96, 1.00)	0.96 (0.94, 0.97)	0.97 (0.96, 0.99)	0.97 (0.96, 0.98)
Dementia (CC 49)	0.94 (0.93, 0.95)	0.93 (0.92, 0.94)	0.92 (0.91, 0.93)	0.93 (0.93, 0.94)
Drug/alcohol psychosis (CC 51)	1.16 (1.11, 1.20)	1.14 (1.10, 1.19)	1.12 (1.08, 1.17)	1.14 (1.12, 1.16)
Drug/alcohol abuse/dependence (CC 52, 53)	1.01 (1.00, 1.02)	1.01 (1.00, 1.02)	1.03 (1.02, 1.04)	1.02 (1.01, 1.02)
Severe mental illness (CC 54, 55)	1.02 (1.01, 1.04)	1.02 (1.01, 1.04)	1.01 (0.99, 1.03)	1.02 (1.01, 1.03)
Reactive and unspecified psychosis (CC 56)	0.99 (0.98, 1.01)	1.01 (0.99, 1.03)	1.01 (0.99, 1.03)	1.00 (0.99, 1.02)
Depression/anxiety (CC 58, 59)	0.98 (0.97, 0.99)	0.98 (0.97, 0.98)	0.98 (0.97, 0.99)	0.98 (0.97, 0.98)
Congestive heart failure (CC 80)	0.95 (0.94, 0.96)	0.94 (0.93, 0.95)	0.95 (0.94, 0.96)	0.95 (0.94, 0.95)
Angina pectoris/old myocardial Infarction (CC 83)	0.96 (0.96, 0.97)	0.97 (0.96, 0.98)	0.96 (0.95, 0.97)	0.97 (0.96, 0.97)
Heart infection/inflammation, except rheumatic (CC 85)	1.21 (1.18, 1.25)	1.23 (1.20, 1.27)	1.21 (1.17, 1.25)	1.21 (1.19, 1.23)
Valvular or rheumatic heart disease (CC 86)	1.06 (1.05, 1.07)	1.08 (1.07, 1.09)	1.07 (1.06, 1.08)	1.07 (1.06, 1.07)

Variable	07/2011, 06/2012 PR (95% CI)	07/2012, 06/2013 PR (95% CI)	07/2013, 06/2014 PR (95% CI)	07/2011, 06/2014 PR (95% CI)
Congenital cardiac/circulatory defect (CC 87, 88)	1.14 (1.10, 1.19)	1.11 (1.07, 1.15)	1.09 (1.05, 1.14)	1.11 (1.09, 1.14)
Hypertension and hypertension complications (CC 89, 91)	0.98 (0.97, 0.99)	0.96 (0.95, 0.98)	0.98 (0.96, 0.99)	0.97 (0.97, 0.98)
Precerebral arterial occlusion and transient cerebral ischemia (CC 97)	1.01 (1.00, 1.03)	1.01 (1.00, 1.02)	1.01 (1.00, 1.02)	1.01 (1.00, 1.02)
Vascular disease and complications (CC 104, 105)	0.99 (0.99, 1.00)	1.00 (0.99, 1.01)	1.00 (0.99, 1.01)	1.00 (0.99, 1.00)
Other lung disorders (CC 115)	1.06 (1.05, 1.07)	1.06 (1.05, 1.07)	1.06 (1.05, 1.07)	1.06 (1.05, 1.06)
Legally blind (CC 116)	0.99 (0.96, 1.02)	0.95 (0.92, 0.98)	0.97 (0.94, 1.00)	0.97 (0.95, 0.99)
Dialysis status (CC 130)	1.12 (1.10, 1.16)	1.12 (1.09, 1.15)	1.14 (1.11, 1.17)	1.13 (1.11, 1.14)
Internal injuries (CC 160)	1.17 (1.12, 1.21)	1.14 (1.10, 1.19)	1.18 (1.13, 1.22)	1.16 (1.13, 1.19)

Table 4.2.4 AMI Generalized Linear Model Performance Over Different Time Periods

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Predictive ability, % (lowest decile – highest decile)	0.96-0.94	0.95-0.93	0.95-0.94	0.95-0.93
Quasi-R^2	0.07	0.07	0.08	0.07

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	3,998	3,935	3,838	4,341
Mean number of admissions (SD)	39 (53)	40 (55)	39 (52)	107 (155)
Range (min. – max.)	1-437	1-496	1-459	1-1,382
25th percentile	4	4	3	7
50th percentile	15	17	15	35
75th percentile	56	58	57	153

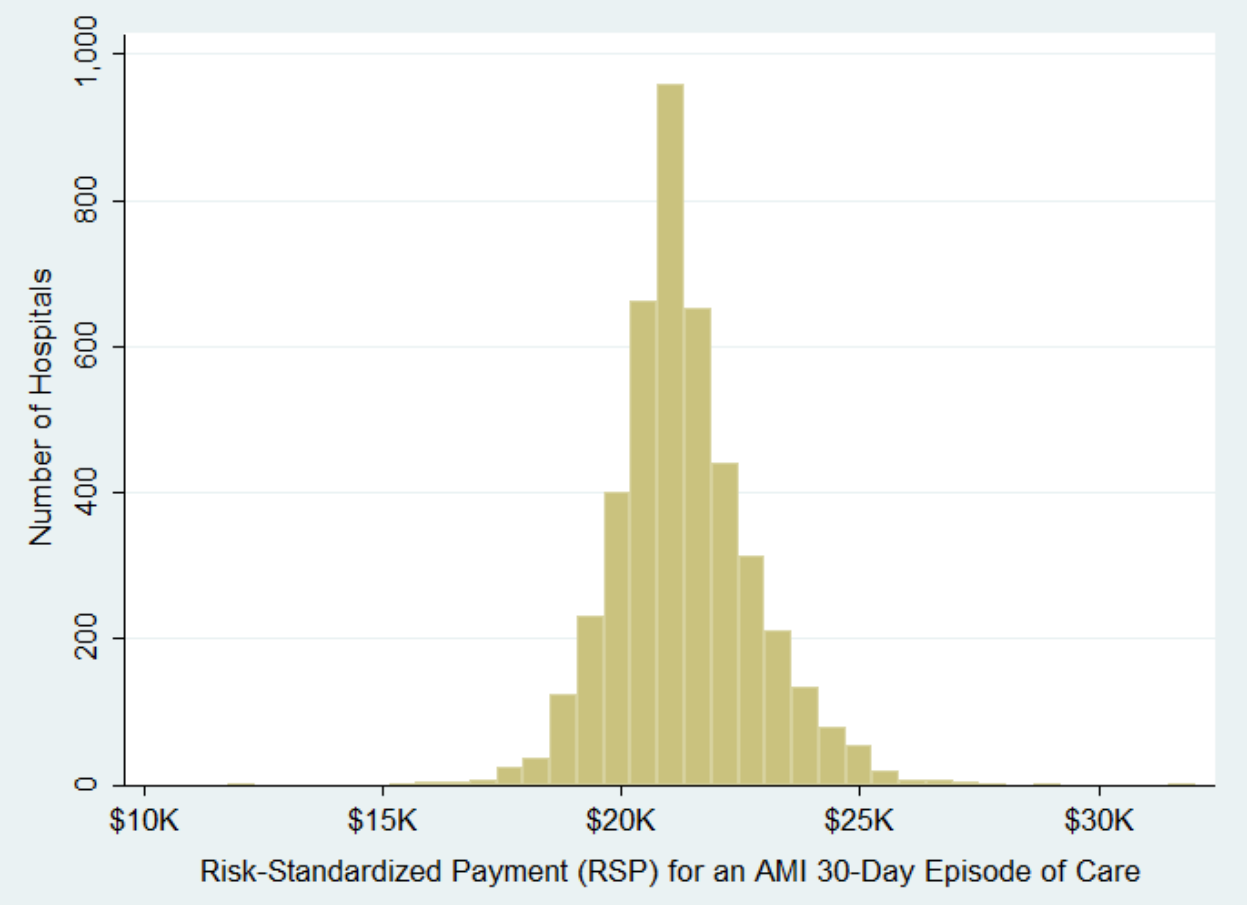
Table 4.2.6 Distribution of Hospital AMI RSPs Over Different Time Periods ($2013)

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Number of hospitals	3,998	3,935	3,838	4,341
Mean (SD)	21,839 (1,018)	21,919 (1,066)	21,579 (1,019)	21,806 (1,459)
Range (min. – max.)	17,495-28,209	14,890-28,050	16,128-27,713	12,862-29,802
25th percentile	21,294	21,370	21,056	20,966
50th percentile	21,698	21,786	21,453	21,620
75th percentile	22,286	22,365	22,067	22,566

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)	0.008 (0.0005)	0.008 (0.0005)	0.008 (0.0005)	0.010 (0.0004)

Figure 4.2.2 Distribution of Hospital AMI 30-Day Episode-of-Care RSPs between July 2011 and June 2014 ($2013)



N= 4,341 hospitals

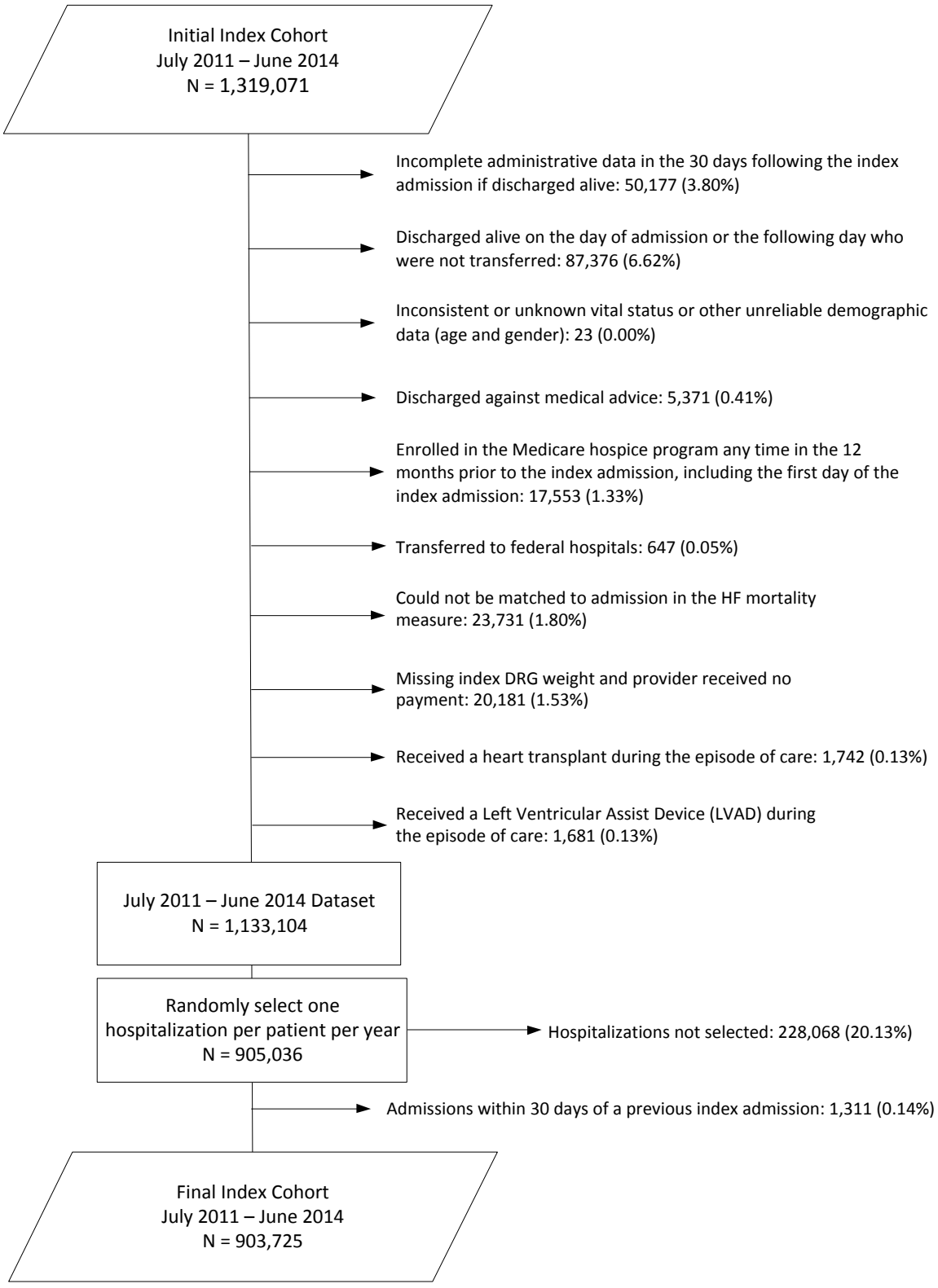
4.3 HF Payment 2015 Model Result

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 older 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 and Part B during the index admission; and who were not transferred to another acute care facility.

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



4.3.2 Frequency of HF Payment Model Variables

We examined the change in both observed payments and frequency of clinical and demographic variables (Table 4.3.1). Between July 2011-June 2012 and July 2013-June 2014, the observed average national payment decreased from $15,313 to $15,034.

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. There were no notable decreases, while notable increases occurred in other endocrine/metabolic/ nutritional disorders (87.3% to 89.5%), other psychiatric disorders (16.9% to 20.8%), respiratory arrest/cardiorespiratory failure/respirator dependence (25.8% to 28.0%), other ear, nose, throat, and mouth disorders (21.9% to 32.6%), and renal failure (48.8% to 50.5%).

4.3.3 HF Payment Model Parameters and Performance

Table 4.3.2 shows hierarchical generalized linear model variable coefficients by individual year and for the combined three-year dataset. Table 4.3.3 shows the risk-adjusted PRs and 95% CIs for the HF payment model by individual year and for the combined three-year dataset. The quasi-R^2 for the HF payment model was 0.04, suggesting that approximately 4% of the variation in payment can be explained by patient-level risk factors. This quasi-R^2 is in line with R^2s from other patient-level risk-adjustment models for healthcare payment.[15] Overall, the variable effect sizes were relatively constant across years. In addition, model performance was stable over the three-year time period; the quasi-R^2 and predictive ratios remained similar to the model used during development (Table 4.3.4).

4.3.4 Distribution of Hospital Volumes and RSPs for HF

Table 4.3.5 shows the distribution of hospital admission volumes and Table 4.3.6 shows the distribution of hospital RSPs. The mean RSP decreased over the three-year period, from $15,353 between July 2011 and June 2012 to $15,065 between July 2013 and June 2014. The median hospital RSP in the combined three-year dataset was $15,139 (IQR $14,312-$16,115). 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 0.013 (SE: 0.0004). 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 RSPs for the combined dataset. The expected 30-day payment if treated at a hospital one standard deviation above the national average was 1.26 times higher than the expected 30-day payment if

treated at a hospital one standard deviation below the national average payment. If there were no systematic differences between hospitals, this ratio would be 1.0.[12]

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

Of the 4,645 hospitals in the study cohort, 731 had a payment "higher than the U.S. national payment," 2,584 had a payment "no different from the U.S. national payment," and 388 had a payment "lower than the U.S. national payment." 942 were classified as "number of cases too small" (fewer than 25) to reliably estimate the hospital's RSP.

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	304,135	302,022	297,568	903,725
Observed mean payment ($2013)	15,313	15,320	15,034	15,223
Age (65 – 74)	24.3	24.7	25.5	24.8
Age (75 – 84)	38.0	37.3	36.9	37.4
Age (>=85)	37.8	38.0	37.6	37.8
History of infection (CC 1, 3-5)	1.7	1.7	1.7	1.7
Other infectious diseases (CC 6)	38.1	38.0	37.6	37.9
Protein-calorie malnutrition (CC 21)	10.1	10.2	10.0	10.1
Other significant endocrine and metabolic disorders (CC 22)	13.7	14.1	14.1	14.0
Other endocrine/metabolic/ nutritional disorders (CC 24)	87.3	88.6	89.5	88.4
Other gastrointestinal disorders (CC 36)	63.2	63.6	63.5	63.4
Bone/joint/muscle infections/necrosis (CC 37)	2.6	2.5	2.6	2.5
Other musculoskeletal and connective tissue disorders (CC 43)	75.5	75.8	75.9	75.8
Delirium and encephalopathy (CC 48)	8.1	8.4	8.9	8.5
Dementia and senility (CC 49, 50)	25.2	24.9	24.4	24.8
Schizophrenia/major depressive/ bipolar disorders (CC 54-55)	6.4	6.4	6.5	6.4
Other psychiatric disorders (CC 60)	16.9	19.5	20.8	19.1
Respiratory arrest/ cardiorespiratory failure/ respirator dependence (CC 77-79)	25.8	26.8	28.0	26.9
Angina pectoris/old myocardial infarction (CC 83)	30.5	30.2	29.8	30.2
Heart infection/inflammation, except rheumatic (CC 85)	3.6	3.6	3.7	3.6
Major congenital cardiac/circulatory defect (CC87)	1.8	1.7	1.7	1.7
Hypertension (CC 91)	87.4	87.3	87.5	87.4
Arrhythmias (CC 92, 93)	66.9	67.2	67.4	67.1

Variable	07/2011-06/2012 (%)	07/2012-06/2013 (%)	07/2013-06/2014 (%)	07/2011-06/2014 (%)
Cerebrovascular disease (CC 97-99)	23.0	22.8	22.1	22.6
Vascular or circulatory disease (CC 104-106)	52.8	52.6	52.3	52.6
History of pneumonia (CC 111-113)	45.1	45.6	44.9	45.2
Other ear, nose, throat, and mouth disorders (CC 127)	31.9	32.4	32.6	32.3
Dialysis status (CC 130)	4.6	4.6	4.3	4.5
Renal failure (CC 131)	48.8	49.7	50.5	49.7
Decubitus ulcer of skin (CC 148)	5.9	5.8	5.7	5.8
Chronic ulcer of skin, except decubitus (CC 149)	11.5	11.4	11.4	11.5
Cellulitis, local skin infection (CC 152)	18.3	18.0	17.8	18.0
Hip fracture/dislocation (CC 158)	3.8	3.7	3.7	3.7
Internal injuries (CC 160)	1.6	1.6	1.7	1.6

Table 4.3.2 Hierarchical Generalized Linear 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	9.467	9.477	9.447	9.455
Age (65 – 74)	0.055	0.051	0.060	0.056
Age (75 – 84)	0.048	0.041	0.047	0.046
Age (>=85) (reference group)	--	--	--	--
History of infection (CC 1, 3-5)	0.057	0.058	0.077	0.062
Other infectious diseases (CC 6)	0.020	0.017	0.023	0.019
Protein-calorie malnutrition (CC 21)	0.152	0.151	0.149	0.149
Other significant endocrine and metabolic disorders (CC 22)	0.069	0.069	0.073	0.069
Other endocrine/metabolic/ nutritional disorders (CC 24)	-0.002	-0.006	0.007	-0.003
Other gastrointestinal disorders (CC 36)	0.004	0.008	0.004	0.006
Bone/joint/muscle infections/necrosis (CC 37)	0.047	0.048	0.036	0.043
Other musculoskeletal and connective tissue disorders (CC 43)	0.008	0.006	0.004	0.006
Delirium and encephalopathy (CC 48)	0.017	0.022	0.012	0.015
Dementia and senility (CC 49, 50)	0.058	0.046	0.055	0.053
Schizophrenia/major depressive/ bipolar disorders (CC 54-55)	0.050	0.051	0.047	0.047
Other psychiatric disorders (CC 60)	0.007	0.013	0.007	0.009
Respiratory arrest/ cardiorespiratory failure/respirator dependence (CC 77-79)	0.025	0.023	0.021	0.023

Variable	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Angina pectoris/old myocardial infarction (CC 83)	-0.016	-0.019	-0.016	-0.017
Heart infection/inflammation, except rheumatic (CC 85)	0.090	0.085	0.071	0.080
Major congenital cardiac/circulatory defect (CC 87)	0.022	0.042	0.054	0.038
Hypertension (CC 91)	-0.053	-0.050	-0.051	-0.050
Arrhythmias (CC 92, 93)	-0.032	-0.028	-0.023	-0.029
Cerebrovascular disease (CC 97-99)	0.011	0.011	0.015	0.011
Vascular or circulatory disease (CC 104-106)	0.011	0.014	0.017	0.013
History of pneumonia (CC 111-113)	0.115	0.116	0.108	0.113
Other ear, nose, throat, and mouth disorders (CC 127)	-0.018	-0.019	-0.018	-0.018
Dialysis status (CC 130)	0.161	0.146	0.152	0.150
Renal failure (CC 131)	0.033	0.031	0.027	0.030
Decubitus ulcer of skin (CC 148)	0.043	0.038	0.034	0.038
Chronic ulcer of skin, except decubitus (CC 149)	0.066	0.066	0.068	0.066
Cellulitis, local skin infection (CC 152)	0.014	0.007	0.008	0.010
Hip fracture/dislocation (CC 158)	0.033	0.037	0.038	0.037
Internal injuries (CC 160)	0.079	0.078	0.066	0.071

Table 4.3.3 Adjusted PR and 95% CIs for the HF Hierarchical Generalized Linear Regression Model Over Different Time Periods

Variable	07/2011, 06/2012 PR (95% CI)	07/2012, 06/2013 PR (95% CI)	07/2013, 06/2014 PR (95% CI)	07/2011, 06/2014 PR (95% CI)
Age (65 – 74)	1.06 (1.05, 1.06)	1.05 (1.04, 1.06)	1.06 (1.05, 1.07)	1.06 (1.05, 1.06)
Age (75 – 84)	1.05 (1.04, 1.06)	1.04 (1.04, 1.05)	1.05 (1.04, 1.05)	1.05 (1.04, 1.05)
Age (>=85) (reference group)	1.00 (--)	1.00 (--)	1.00 (--)	1.00 (--)
History of infection (CC 1, 3, 5)	1.06 (1.04, 1.08)	1.06 (1.04, 1.08)	1.08 (1.06, 1.10)	1.06 (1.05, 1.08)
Other infectious diseases (CC 6)	1.02 (1.01, 1.03)	1.02 (1.01, 1.02)	1.02 (1.02, 1.03)	1.02 (1.02, 1.02)
Protein, calorie malnutrition (CC 21)	1.16 (1.15, 1.17)	1.16 (1.15, 1.17)	1.16 (1.15, 1.17)	1.16 (1.15, 1.17)
Other significant endocrine and metabolic disorders (CC 22)	1.07 (1.06, 1.08)	1.07 (1.06, 1.08)	1.08 (1.07, 1.08)	1.07 (1.07, 1.08)
Other endocrine/metabolic/ nutritional disorders (CC 24)	1.00 (0.99, 1.01)	0.99 (0.99–1.00)	1.01 (1.00, 1.02)	1.00 (0.99, 1.00)
Other gastrointestinal disorders (CC 36)	1.00 (1.00, 1.01)	1.01 (1.00, 1.01)	1.00 (1.00, 1.01)	1.01 (1.00, 1.01)
Bone/joint/muscle infections/necrosis (CC 37)	1.05 (1.03, 1.07)	1.05 (1.03, 1.07)	1.04 (1.02, 1.05)	1.04 (1.03, 1.05)
Other musculoskeletal and connective tissue disorders (CC 43)	1.01 (1.00, 1.01)	1.01 (1.00, 1.01)	1.00 (1.00, 1.01)	1.01 (1.00, 1.01)
Delirium and encephalopathy (CC 48)	1.02 (1.01, 1.03)	1.02 (1.01, 1.03)	1.01 (1.00, 1.02)	1.01 (1.01, 1.02)
Dementia and senility (CC 49, 50)	1.06 (1.05, 1.07)	1.05 (1.04, 1.05)	1.06 (1.05, 1.06)	1.05 (1.05, 1.06)

Variable	07/2011, 06/2012 PR (95% CI)	07/2012, 06/2013 PR (95% CI)	07/2013, 06/2014 PR (95% CI)	07/2011, 06/2014 PR (95% CI)
Schizophrenia/major depressive/ bipolar disorders (CC 54, 55)	1.05 (1.04, 1.06)	1.05 (1.04, 1.06)	1.05 (1.04, 1.06)	1.05 (1.04, 1.05)
Other psychiatric disorders (CC 60)	1.01 (1.00, 1.01)	1.01 (1.01, 1.02)	1.01 (1.00, 1.01)	1.01 (1.00, 1.01)
Respiratory arrest/ cardiorespiratory failure/respirator dependence (CC 77, 79)	1.03 (1.02, 1.03)	1.02 (1.02, 1.03)	1.02 (1.01, 1.03)	1.02 (1.02, 1.03)
Angina pectoris/old myocardial infarction (CC 83)	0.98 (0.98, 0.99)	0.98 (0.98, 0.99)	0.98 (0.98, 0.99)	0.98 (0.98, 0.99)
Heart infection/inflammation, except rheumatic (CC 85)	1.09 (1.08, 1.11)	1.09 (1.07, 1.10)	1.07 (1.06, 1.09)	1.08 (1.07, 1.09)
Major congenital cardiac/circulatory defect (CC 87)	1.02 (1.00, 1.04)	1.04 (1.02, 1.06)	1.06 (1.04, 1.08)	1.04 (1.03, 1.05)
Hypertension (CC 91)	0.95 (0.94, 0.96)	0.95 (0.94, 0.96)	0.95 (0.94, 0.96)	0.95 (0.95, 0.96)
Arrhythmias (CC 92, 93)	0.97 (0.96, 0.97)	0.97 (0.97, 0.98)	0.98 (0.97, 0.98)	0.97 (0.97, 0.97)
Cerebrovascular disease (CC 97, 99)	1.01 (1.00, 1.02)	1.01 (1.00, 1.02)	1.02 (1.01, 1.02)	1.01 (1.01, 1.02)
Vascular or circulatory disease (CC 104, 106)	1.01 (1.01, 1.02)	1.01 (1.01, 1.02)	1.02 (1.01, 1.02)	1.01 (1.01, 1.02)
History of pneumonia (CC 111, 113)	1.12 (1.12, 1.13)	1.12 (1.12, 1.13)	1.11 (1.11, 1.12)	1.12 (1.12, 1.12)
Other ear, nose, throat, and mouth disorders (CC 127)	0.98 (0.98, 0.99)	0.98 (0.98, 0.99)	0.98 (0.98, 0.99)	0.98 (0.98, 0.98)
Dialysis status (CC 130)	1.17 (1.16, 1.19)	1.16 (1.14, 1.17)	1.16 (1.15, 1.18)	1.16 (1.15, 1.17)
Renal failure (CC 131)	1.03 (1.03, 1.04)	1.03 (1.03, 1.04)	1.03 (1.02, 1.03)	1.03 (1.03, 1.03)
Decubitus ulcer of skin (CC 148)	1.04 (1.03, 1.06)	1.04 (1.03, 1.05)	1.03 (1.02, 1.05)	1.04 (1.03, 1.05)
Chronic ulcer of skin, except decubitus (CC 149)	1.07 (1.06, 1.08)	1.07 (1.06, 1.08)	1.07 (1.06, 1.08)	1.07 (1.06, 1.07)
Cellulitis, local skin infection (CC 152)	1.01 (1.01, 1.02)	1.01 (1.00, 1.01)	1.01 (1.00, 1.02)	1.01 (1.01, 1.01)
Hip fracture/dislocation (CC 158)	1.03 (1.02, 1.05)	1.04 (1.02, 1.05)	1.04 (1.02, 1.05)	1.04 (1.03, 1.05)
Internal injuries (CC 160)	1.08 (1.06, 1.10)	1.08 (1.06, 1.10)	1.07 (1.05, 1.09)	1.07 (1.06, 1.09)

Table 4.3.4 HF Generalized Linear Model 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)	1.01-0.99	1.01-0.99	1.01-0.99	1.01-0.99
Quasi-R^2	0.04	0.04	0.04	0.04

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	4,531	4,518	4,474	4,645
Mean number of admissions (SD)	67 (82)	67 (83)	67 (83)	195 (244)
Range (min. – max.)	1-904	1-903	1-932	1-2,739
25^{th} percentile	12	11	11	32
50^{th} percentile	35	34	33	95
75^{th} percentile	94	94	94	275

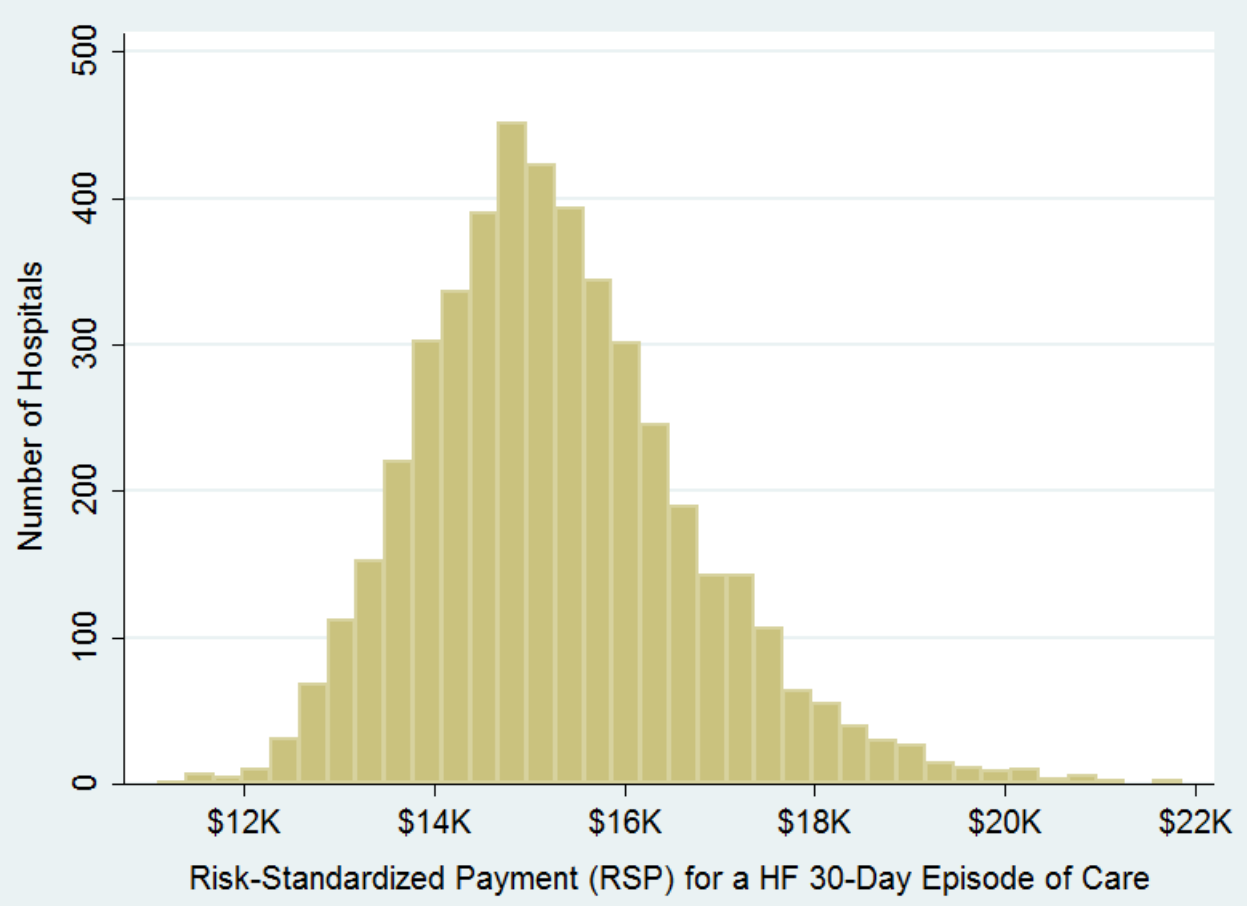
Table 4.3.6 Distribution of Hospital HF RSPs Over Different Time Periods ($2013)

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Number of hospitals	4,531	4,518	4,474	4,645
Mean (SD)	15,353 (1,118)	15,355 (1,053)	15,065 (987)	15,289 (1,432)
Range (min. – max.)	12,000-20,974	12,314-21,637	11,827-20,342	11,086-21,867
25th percentile	146,27	14,685	14,428	14,312
50th percentile	15,185	15,193	14,930	15,139
75th percentile	15,929	15,881	15,584	16,115

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)	0.011 (0.0005)	0.010 (0.0005)	0.010 (0.0005)	0.013 (0.0004)

Figure 4.3.2 Distribution of Hospital HF 30-Day Episode-of-Care RSPs between July 2011 and June 2014 ($2013)



N= 4,645 hospitals

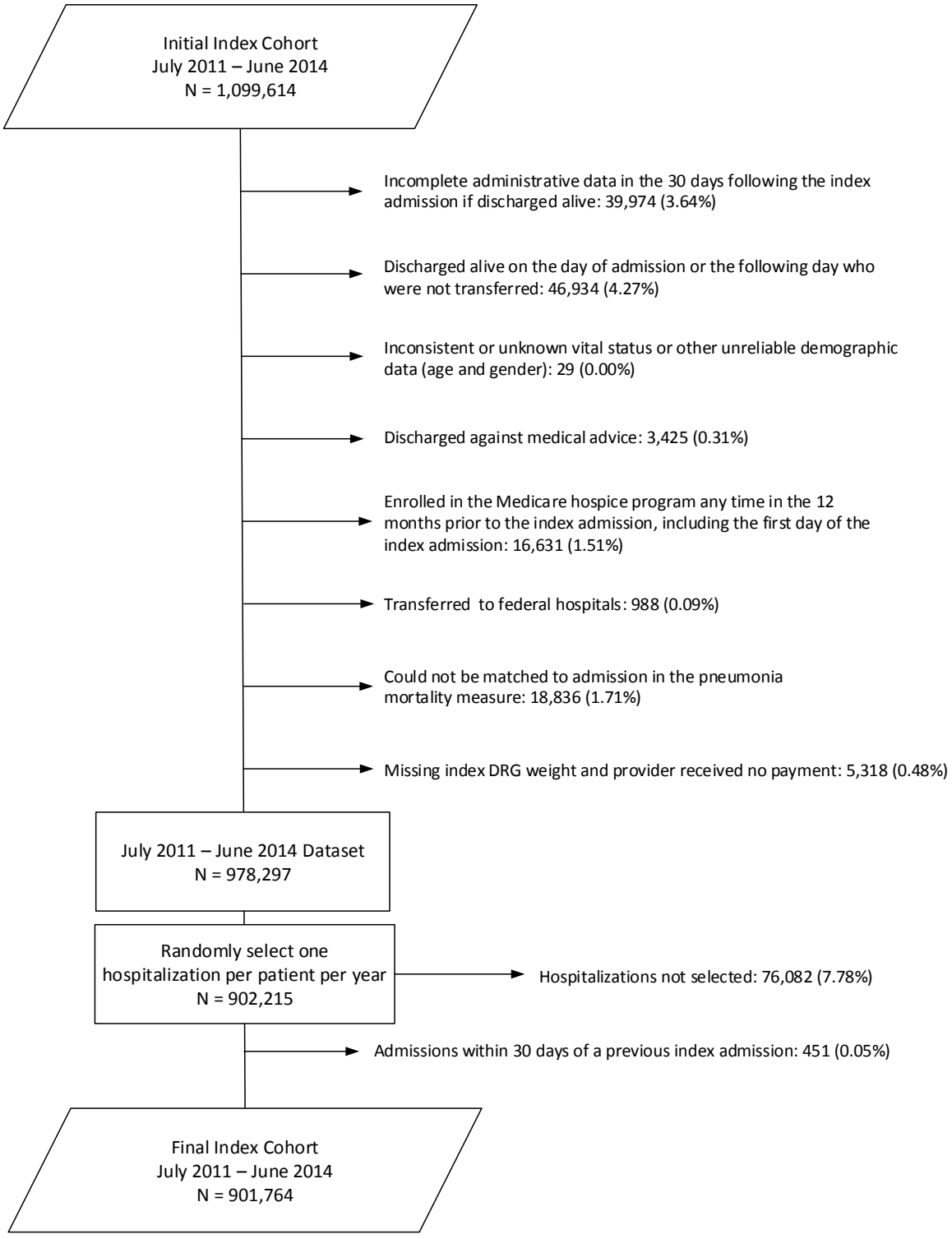
4.4 Pneumonia Payment 2015 Model Results

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 older 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 and Part B during the index admission; and who were not transferred to another acute care facility.

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 payments and frequency of clinical and demographic variables (Table 4.4.1). Between July 2011-June 2012 and July 2013-June 2014, the observed average national payment decreased from $14,341 to $14,177.

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 osteoporosis and other bone/cartilage disorders (25.2% to 23.9%), severe hematological disorders (3.5% to 2.2%), and fibrosis of lung or other chronic lung disorders (15.9% to 13.9%), while notable increases occurred in other significant other endocrine/metabolic/nutritional disorders (80.2% to 83.1%), delirium and encephalopathy (7.8% to 8.8%), drug/alcohol abuse, without dependence (14.0% to 15.1%), muscular dystrophy and/or polyneuropathy (12.2% to 13.5%), respirator dependence/respiratory arrest/cardiorespiratory failure (21.4% to 23.4%), other ear nose, throat, and mouth disorders (37.1% to 38.1%), and renal failure (28.9% to 31.2%).

4.4.3 Pneumonia Payment Model Parameters and Performance

Table 4.4.2 shows hierarchical generalized linear model variable coefficients and 95% CIs for the pneumonia payment model by individual year and for the combined three-year dataset. The pneumonia payment model coefficients can be directly interpreted as dollars. The quasi-R^2 for the pneumonia payment model was 0.09, suggesting that approximately 9% of the variation in payment can be explained by patient-level risk factors. This quasi-R^2 is in line with R^2s from other patient-level risk-adjustment models for healthcare payment.[15] Overall, the variable effect sizes were relatively constant across years. In addition, model performance was stable over the three-year time period; the quasi-R^2 remained similar to the model used during development, while the predictive ratios improved for patients at the extremes of the distribution due to the change in the payment model from a log link function to an identity link function (Table 4.4.3).

4.4.4 Distribution of Hospital Volumes and RSPs for Pneumonia

Table 4.4.4 shows the distribution of hospital admission volumes and Table 4.4.5shows the distribution of hospital RSPs. The mean RSP decreased over the three-year period, from $14,321 between July 2011 and June 2012 to $14,161 between July 2013 and June 2014. The median hospital RSP in the combined three-year dataset was $14,220 (IQR $13,342-$15,097). Table 4.4.6 shows the between-hospital variance by individual year and for the combined three-year dataset. Between-hospital variance in the combined dataset was $2,514,794 (SE: $76,366). 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 RSPs for the combined dataset. The expected 30-day payment if treated at a hospital one standard deviation

above the national average was $3,172 higher than the expected 30-day payment if treated at a hospital one standard deviation below the national average payment. If there were no systematic differences between hospitals, this difference would be $0.[12]

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

Of the 4,685 hospitals in the study cohort, 670 had a payment "higher than the U.S. national payment," 2,852 had a payment "no different from the U.S. national payment," and 684 had a payment "lower than the U.S. national payment." 479 were classified as "number of cases too small" (fewer than 25) to reliably estimate the hospital's RSP.

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	309,742	318,830	273,192	901,764
Observed mean payment ($2013)	14,341	14,348	14,177	14,294
Age (65 – 74)	27.7	27.7	29.3	28.2
Age (75 – 84)	38.5	37.7	37.3	37.9
Age (>=85)	33.8	34.5	33.4	33.9
History of infection (CC 1, 3-5)	2.7	2.6	2.8	2.7
Other Infectious diseases (CC 6)	37.2	37.0	37.1	37.1
Metastatic cancer and acute leukemia (CC 7)	5.1	5.0	5.2	5.1
Lung, upper digestive tract, and other severe cancers (CC 8)	6.9	6.7	7.1	6.9
Lymphatic, head and neck, brain, and other major cancers (CC 9)	6.0	6.0	6.3	6.1
Diabetes mellitus (DM) or DM complications (CC 15-19, 119-120)	42.1	41.9	42.4	42.2
Protein-calorie malnutrition (CC 21)	12.9	12.8	12.8	12.8
Other significant endocrine and metabolic disorders (CC 22)	11.4	11.8	12.3	11.8
Other endocrine/metabolic/ nutritional disorders (CC 24)	80.2	81.6	83.1	81.6
Other gastrointestinal disorders (CC 36)	65.7	65.6	66.4	65.9
Bone/joint/muscle infections/necrosis (CC 37)	2.0	1.9	2.0	2.0
Osteoporosis and other bone/cartilage disorders (CC 41)	25.2	24.3	23.9	24.5
Severe hematological disorders (CC 44)	3.5	2.3	2.2	2.7
Iron deficiency or other unspecified anemias and blood disease (CC 47)	58.8	57.5	58.1	58.2
Delirium and encephalopathy (CC 48)	7.8	8.2	8.8	8.2
Dementia and senility (CC 49-50)	31.1	30.8	30.2	30.7
Drug/alcohol dependence/psychosis (CC 51-52)	3.1	3.2	3.5	3.2

Variable	07/2011-06/2012 (%)	07/2012-06/2013 (%)	07/2013-06/2014 (%)	07/2011-06/2014 (%)
Drug/alcohol abuse, without dependence (CC 53)	14.0	14.4	15.1	14.5
Major psychiatric disorders (CC 54-56)	13.8	13.8	14.0	13.9
Plegia, paralysis, spinal cord disorder and amputation (CC 67-69, 100-101, 177-178)	6.6	6.5	6.5	6.5
Muscular dystrophy and/or polyneuropathy (CC 70-71)	12.2	12.7	13.5	12.7
Multiple sclerosis and Parkinson's (CC 72-73)	4.5	4.4	4.4	4.4
Coma, brain compression/anoxic damage (CC 75)	0.7	0.7	0.7	0.7
Respirator dependence/respiratory arrest/cardiorespiratory failure (CC 77-79)	21.4	21.6	23.4	22.1
Congestive heart failure (CC 80)	39.1	37.9	38.3	38.4
Angina pectoris/old myocardial infarction (CC 83)	17.2	17.0	17.1	17.1
Heart infection/inflammation, except rheumatic (CC 85)	2.1	2.1	2.1	2.1
Valvular or rheumatic heart disease (CC 86)	25.8	25.7	26.1	25.8
Hypertension (CC 91)	83.8	83.9	84.2	84.0
Arrhythmias (CC 92-93)	44.2	44.3	45.1	44.5
Stroke (CC 95-96)	9.2	8.8	8.7	8.9
Vascular or circulatory disease (CC 104-106)	43.1	42.3	43.0	42.8
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	55.0	53.9	54.4	54.4
Fibrosis of lung or other chronic lung disorder (CC 109)	15.9	14.2	13.9	14.7
Asthma (CC 110)	11.7	11.8	12.0	11.8
Aspiration and specified bacterial pneumonias (CC 111)	7.0	6.7	6.9	6.9
Pleural effusion/pneumothorax (CC 114)	16.5	16.1	16.7	16.4
Other ear, nose, throat, and mouth disorders (CC 127)	37.1	37.4	38.1	37.5
Dialysis status (CC 130)	3.2	3.3	3.6	3.4
Renal failure (CC 131)	28.9	29.7	31.2	29.9
Decubitus ulcer or chronic skin ulcer (CC 148-149)	11.5	11.2	11.2	11.3
Head injury (CC 154-156)	8.2	8.4	8.7	8.4
Vertebral fractures (CC 157)	5.2	5.1	5.2	5.2
Hip fracture/dislocation (CC 158)	4.2	4.1	4.1	4.1
Major fracture, except of skull, vertebrae, or hip (CC 159)	2.7	2.6	2.6	2.6
Internal injuries (CC 160)	1.2	1.2	1.2	1.2

Variable	07/2011-06/2012 (%)	07/2012-06/2013 (%)	07/2013-06/2014 (%)	07/2011-06/2014 (%)
Major symptoms, abnormalities (CC 166)	82.7	82.3	82.8	82.6

Table 4.4.2 Hierarchical Generalized Linear Regression Model Variable Coefficients and 95% CIs for Pneumonia Over Different Time Periods

Variable	07/2011-06/2012 $ (95% CI)	07/2012-06/2013 $ (95% CI)	07/2013-06/2014 $ (95% CI)	07/2011-06/2014 $ (95% CI)
Intercept	9,912	10,040	10,028	10,080
Age (65 – 74)	-1,214 (-1,305, -1,123)	-1,207 (-1,296, -1,118)	-1,106 (-1,202, -1,010)	-1,131 (-1,184, -1,077)
Age (75 – 84)	-698 (-779, -617)	-724 (-802, -645)	-675 (-761, -588)	-667 (-714, -620)
Age (>=85; reference group)	--	--	--	--
History of infection (CC 1, 3-5)	2,247 (1,987, 2,507)	2,238 (1,979, 2,498)	1,722 (1,460, 1,984)	2,041 (1,890, 2,191)
Other infectious diseases (CC 6)	467 (392, 543)	394 (320, 468)	341 (262, 420)	380 (335, 424)
Metastatic cancer and acute leukemia (CC 7)	1,437 (1,241, 1,632)	1,167 (977, 1,356)	1,376 (1,174, 1,579)	1,282 (1,168, 1,395)
Lung, upper digestive tract, and other severe cancers (CC 8)	755 (594, 915)	708 (548, 868)	780 (613, 948)	715 (621, 809)
Lymphatic, head and neck, brain, and other major cancers (CC 9)	881 (725, 1,038)	831 (679, 982)	822 (662, 982)	801 (711, 891)
Diabetes mellitus (DM) or DM complications (CC 15-19, 119, 120)	473 (403, 543)	456 (388, 525)	437 (363, 510)	451 (410, 492)
Protein-calorie malnutrition (CC 21)	3,526 (3,390, 3,662)	3,622 (3,488, 3,756)	3,256 (3,115, 3,397)	3,427 (3,347, 3,506)
Other significant endocrine and metabolic disorders (CC 22)	1,173 (1,038, 1,308)	1,134 (1,004, 1,264)	1,198 (1,059, 1,337)	1,140 (1,062, 1,218)
Other endocrine/metabolic/ nutritional disorders (CC 24)	-137 (-219, -55)	-103 (-185, -21)	-107 (-199, -16)	-128 (-177, -78)
Other gastrointestinal disorders (CC 36)	-67 (-137, 3)	-92 (-161, -24)	-160 (-235, -86)	-97 (-138, -56)
Bone/joint/muscle infections/necrosis (CC 37)	910 (611, 1,210)	706 (408, 1,004)	918 (603, 1,233)	850 (673, 1,026)
Osteoporosis and other bone/cartilage disorders (CC 41)	-170 (-249, -91)	-164 (-242, -85)	-193 (-278, -108)	-180 (-227, -133)
Severe hematological disorders (CC 44)	885 (667, 1,102)	950 (690, 1,211)	1,143 (858, 1,429)	981 (837, 1,126)
Iron deficiency or other unspecified anemias and blood disease (CC 47)	1,351 (1,281, 1,422)	1,268 (1,198, 1,337)	1,174 (1,099, 1,249)	1,244 (1,203, 1,286)
Delirium and encephalopathy (CC 48)	393 (230, 556)	383 (227, 539)	287 (126, 447)	326 (233, 418)
Dementia and senility (CC 49-50)	1,272 (1,188, 1,357)	1,288 (1,205, 1,370)	1,229 (1,140, 1,319)	1,234 (1,184, 1,283)
Drug/alcohol dependence/psychosis (CC 51-52)	860 (639, 1,080)	832 (621, 1,043)	735 (518, 952)	826 (700, 951)
Drug/alcohol abuse, without dependence (CC 53)	121 (20, 223)	105 (6, 204)	97 (-8, 202)	116 (57, 175)

Variable	07/2011-06/2012 $ (95% CI)	07/2012-06/2013 $ (95% CI)	07/2013-06/2014 $ (95% CI)	07/2011-06/2014 $ (95% CI)
Major psychiatric disorders (CC 54-56)	1,002 (888, 1,115)	969 (858, 1,079)	964 (846, 1,082)	950 (884, 1,016)
Plegia, paralysis, spinal cord disorder and amputation (CC 67-69, 100-101, 177-178)	1,287 (1,117, 1,457)	1,398 (1,230, 1,567)	1,307 (1,128, 1,485)	1,322 (1,223, 1,422)
Muscular dystrophy and/or polyneuropathy (CC 70-71)	527 (414, 640)	585 (476, 695)	456 (342, 569)	504 (439, 568)
Multiple sclerosis and Parkinson's (CC 72-73)	1,067 (886, 1,248)	1,237 (1,056, 1,417)	1,276 (1,081, 1,471)	1,153 (1,046, 1,261)
Coma, brain compression/anoxic damage (CC 75)	1,307 (732, 1,882)	1,046 (502, 1,590)	1,311 (738, 1,884)	1,154 (829, 1,480)
Respirator dependence/respiratory arrest/cardiorespiratory failure (CC 77-79)	893 (790, 997)	968 (867, 1,069)	795 (690, 901)	871 (811, 930)
Congestive heart failure (CC 80)	702 (620, 785)	637 (555, 719)	753 (664, 841)	702 (653, 751)
Angina pectoris/old myocardial infarction (CC 83)	-310 (-402, -217)	-265 (-357, -174)	-286 (-384, -188)	-285 (-340, -231)
Heart infection/inflammation, except rheumatic (CC 85)	1,487 (1,197, 1,776)	927 (651, 1,204)	1,228 (933, 1,522)	1,202 (1,035, 1,368)
Valvular and rheumatic heart disease (CC 86)	364 (280, 449)	466 (382, 549)	505 (415, 594)	420 (371, 470)
Hypertension (CC 91)	-3 (-90, 84)	-93 (-179, -7)	-46 (-139, 48)	-53 (-105, -2)
Arrhythmias (CC 92-93)	173 (99, 248)	203 (130, 276)	127 (49, 205)	157 (113, 200)
Stroke (CC 95-96)	458 (320, 595)	334 (197, 470)	376 (229, 523)	378 (297, 459)
Vascular or circulatory disease (CC 104-106)	164 (90, 237)	84 (12, 156)	113 (35, 191)	115 (72, 158)
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	791 (721, 862)	899 (830, 969)	771 (696, 846)	811 (769, 853)
Fibrosis of lung or other chronic lung disorder (CC 109)	258 (160, 356)	334 (233, 434)	485 (376, 595)	340 (281, 400)
Asthma (CC 110)	-713 (-810, -615)	-699 (-794, -604)	-820 (-922, -719)	-746 (-803, -689)
Aspiration and specified bacterial pneumonias (CC 111)	479 (310, 648)	415 (247, 584)	187 (11, 364)	351 (252, 450)
Pleural effusion/pneumothorax (CC 114)	520 (406, 635)	483 (370, 596)	488 (368, 607)	496 (429, 562)
Other ear, nose, throat, and mouth disorders (CC 127)	-475 (-542, -408)	-498 (-564, -432)	-400 (-471, -329)	-453 (-492, -413)
Dialysis status (CC 130)	3,365 (3,058, 3,673)	3,227 (2,934, 3,521)	2,983 (2,682, 3,284)	3,145 (2,971, 3,319)
Renal failure (CC 131)	465 (376, 555)	486 (400, 573)	455 (363, 546)	458 (406, 509)
Decubitus ulcer or chronic skin ulcer (CC 148-149)	1,058 (927, 1,189)	1,151 (1,021, 1,281)	1,198 (1,059, 1,337)	1,119 (1,042, 1,196)
Head injury (CC 154-156)	324 (184, 464)	286 (151, 421)	342 (199, 486)	305 (224, 385)
Vertebral fractures (CC 157)	1,009 (833, 1,184)	993 (821, 1,165)	1,124 (940, 1,308)	1,035 (933, 1,138)
Hip fracture/dislocation (CC 158)	754 (555, 953)	430 (235, 625)	576 (366, 787)	611 (495, 728)
Major fracture, except of skull, vertebrae, or hip (CC 159)	702 (467, 936)	747 (515, 979)	701 (454, 947)	727 (589, 864)

Variable	07/2011-06/2012 $ (95% CI)	07/2012-06/2013 $ (95% CI)	07/2013-06/2014 $ (95% CI)	07/2011-06/2014 $ (95% CI)
Internal injuries (CC 160)	1,409 (1,021, 1,797)	1,476 (1,088, 1,864)	1,552 (1,145, 1,959)	1,458 (1,230, 1,686)
Major symptoms, abnormalities (CC 166)	624 (542, 706)	697 (617, 776)	652 (565, 739)	643 (595, 691)

Table 4.4.3 Pneumonia Generalized Linear Model 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)	1.05-1.06	1.05-1.05	1.06-1.05	1.05-1.05
Quasi-R^2	0.09	0.09	0.08	0.09

Table 4.4.4 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	4,597	4,592	4,539	4,685
Mean number of admissions (SD)	67 (67)	69 (71)	60 (63)	192 (198)
Range (min. – max.)	1 - 681	1 - 778	1 - 673	1 - 2,132
25th percentile	21	20	18	56
50th percentile	46	46	40	127
75th percentile	93	95	83	265

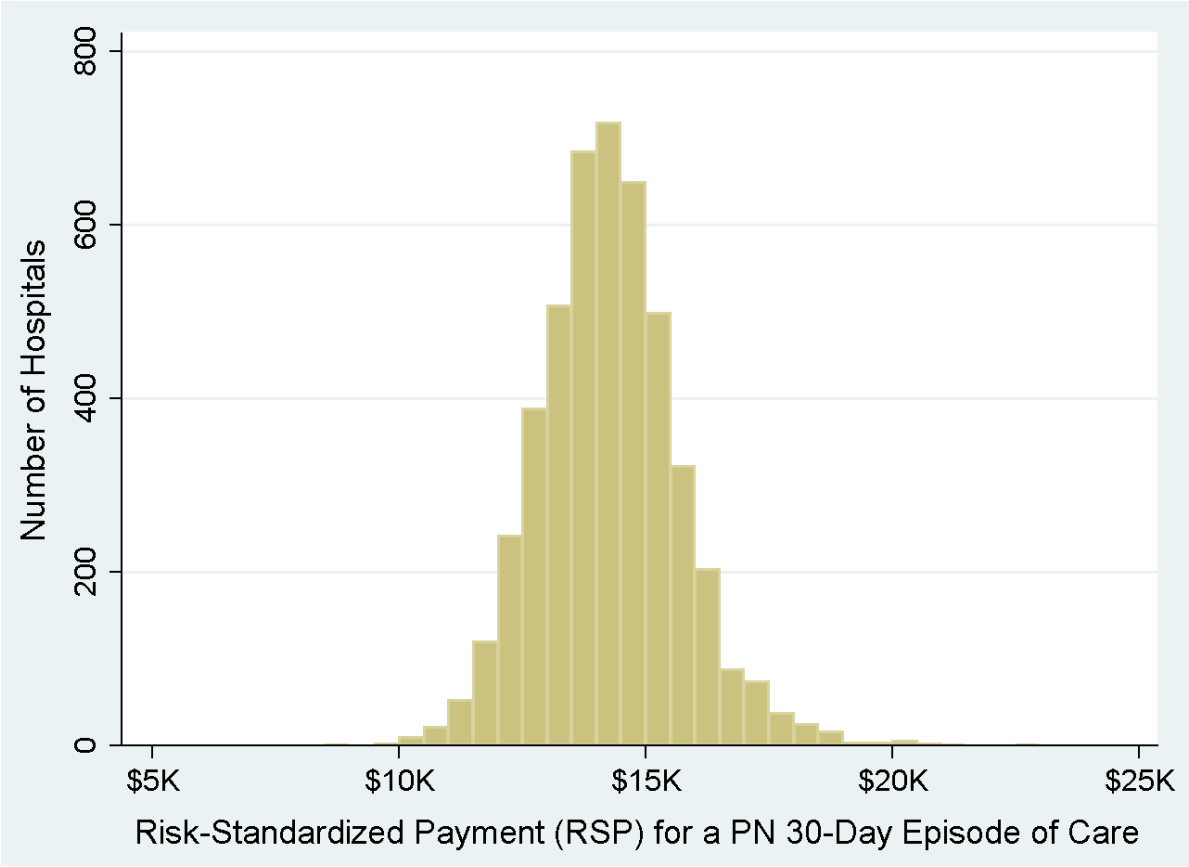
Table 4.4.1 Distribution of Hospital Pneumonia RSPs Over Different Time Periods ($2013)

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Number of hospitals	4,597	4,592	4,539	4,685
Mean (SD)	14,321 (1,117)	14,329 (1,171)	14,161 (1,142)	14,266 (1,428)
Range (min. – max.)	9,639 - 22,283	10,012 - 22,089	10,005 - 19,175	8,977 - 22,999
25th percentile	13,575	13,583	13,419	13,342
50th percentile	14,269	14,270	14,115	14,220
75th percentile	15,024	15,018	14,857	15,097

Table 4.4.2 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) ($)	2,174,094 (88,809)	2,307,485 (94,260)	2,309,193 (100,356)	2,514,794 (76,366)

Figure 4.4.2 Distribution of Hospital Pneumonia 30-Day Episode-of-Care RSPs Between July 2011 and June 2014 ($2013)



N= 4,685 hospitals

5. GLOSSARY

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

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

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

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

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

Expected payment: The total payment expected on the basis of an average hospital's payment for a specific 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 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 payment 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-specific performance.

Hospital-specific intercept: A measure of the hospital payment that is calculated based on the hospital's actual payment, considering how many patients it served, its patients' risk factors, and its patients' total payments. The hospital-specific intercept will be negative for a lower-than-average payment hospital, positive for a greater-than-average payment hospital, and close to zero for an average payment hospital. The hospital-specific intercept is used in the numerator to calculate the "predicted" payment.

Index admission: Any admission included in the measure calculation that begins the 30-day AMI, HF, or pneumonia episode of care.

Interval estimate: Similar to a confidence interval. The interval estimate is a range of probable values for the measure that characterizes the amount of uncertainty associated with the estimate. For example, a 95% interval estimate for the estimated RSP indicates that there is 95% statistical confidence that the true value of the RSP lies between the lower limit and the upper limit of the interval.

Medicare fee-for-service (FFS): Original Medicare plan. Only beneficiaries in Medicare FFS, not in managed care (Medicare Advantage), are included in the measure.

National mean payment: Sum of payments among all included episodes divided by the number of episodes included in the measure.

Outcome: The result of a broad set of healthcare activities that affect patients' well-being. For the payment measure, the outcome is the sum of payments accrued within 30 days of index admission.

Payment ratio (PR): A PR greater than one indicates that total payment for a patient with that particular risk factor is expected to be higher, on average, than for a patient without that risk factor, holding all other risk factors constant. A PR less than one indicates that total payment for a patient with that particular risk factor is expected to be lower, on average, than for a patient without that risk factor, holding all other risk factors constant.

Predicted payment: The total payment within 30 days predicted on the basis of the specific hospital with its observed case mix, also referred to as "adjusted actual" payment.

Risk-adjustment variables: Patient demographics, comorbidities, and relevant prior procedures that are used to adjust for differences in case mix across hospitals.

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Appendix A. Statistical Approach

To calculate a hospital-specific RSP, we estimate a hierarchical generalized linear model using three years of data. This strategy accounts for within-hospital correlation of the observed outcomes and accommodates the assumption that underlying differences in care across hospitals leads to systematic differences in payments. The measures adjust for variables (e.g., age, comorbid disease, and indicators of patient frailty) that are clinically relevant and have strong relationships with the outcome. The AMI measure also adjusts for prior percutaneous coronary intervention (PCI)/coronary artery bypass graft (CABG) as these procedures may impact clinical decisions and payments for subsequent AMI care.

We use the following strategy to calculate the hospital-specific RSPs. We calculate these payments as the ratio of "predicted" payment to "expected" payment, and multiply by the national mean payment. The predicted payment for each hospital is estimated using its case mix and an estimated hospital-specific intercept. The expected payment for each hospital is estimated given the same case mix but the average intercept among all hospitals in the sample.

Operationally, the expected payment for each hospital is obtained by summing the expected payments for all patients in the hospital. The expected payment for each patient is calculated via the hierarchical model by applying the estimated regression coefficients to the observed patient characteristics and adding the average intercept. The predicted payment for each hospital is calculated by summing the predicted payments for all patients in the hospital. The predicted payment for each patient is calculated through the hierarchical model by applying the estimated regression coefficients to the patient characteristics observed and adding the hospital-specific intercept.

More specifically, we use a hierarchical generalized linear model to account for the clustering of observations within hospitals and adjust for the selected risk factors. The model employs a link and error distribution and a hospital-specific random effect, where the link function and error distribution chosen for each measure is based on the algorithm suggested by Manning & Mullahy and several model diagnostics.[13] The AMI RSP was estimated using a log link and an inverse Gaussian distribution. The HF RSP was estimated using a log link and a Gamma distribution. The pneumonia RSP was estimated using an identity link and a Gamma distribution. A generic model is presented here:

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

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

where i indexes hospitals, j indexes patients within hospitals, α_i represents the hospital-specific intercept, $\mathbf{Z}_{ij}$ is defined as the set of risk factors, μ is the average intercept across all hospitals in the sample, and τ^2 is the between-hospital variance component[16].[1717171717] This model separates within-hospital variation from between-hospital variation. The hierarchical generalized linear models are estimated using the SAS software system (SAS 9.3 GLIMMIX procedure).

Hospital Performance Reporting

Using the selected set of risk factors, we fit the hierarchical generalized linear model defined by Equations (1) - (2) and estimate the parameters, $\hat{\mu}$, $\{\alpha_1, \alpha_2, \ldots, \alpha_I\}$, $\hat{\beta}$, and $\hat{\tau}^2$. We calculate a

standardized outcome measure, RSP_i, for each hospital by computing the ratio of the predicted payment to the expected payment, and multiplying by the national mean payment, $\bar{y}$. Specifically, we calculate:

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

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

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

Again, i indexes hospitals, j indexes patients within hospitals, and n_i is the number of patients within hospital i. If "predicted" total payment is higher (or lower) than "expected" total payment for a given hospital, then its $\widehat{RSP}_i$ will be higher (or lower) than the national mean payment. For each hospital, we can compute an interval estimate of RSP_i to characterize the level of uncertainty around the point estimate using bootstrapping simulations. The point estimate and interval estimate can be used to characterize and compare hospital performance (e.g., higher than expected, as expected, or lower than expected). See Figure A.1 for our overall analysis steps.

Creating Interval Estimates

Because the statistic described in Equation 5, i.e., $\widehat{RSP}_i$, 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 (with *b* indexes the *b*th bootstrap sample):

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. $\hat{\beta}^{(b)}$ (estimated regression coefficients of the risk factors)

   b. The parameters governing the random effects, hospital adjusted outcomes, distribution, $\hat{\mu}^{(b)}$ and $\hat{\tau}^{2(b)}$

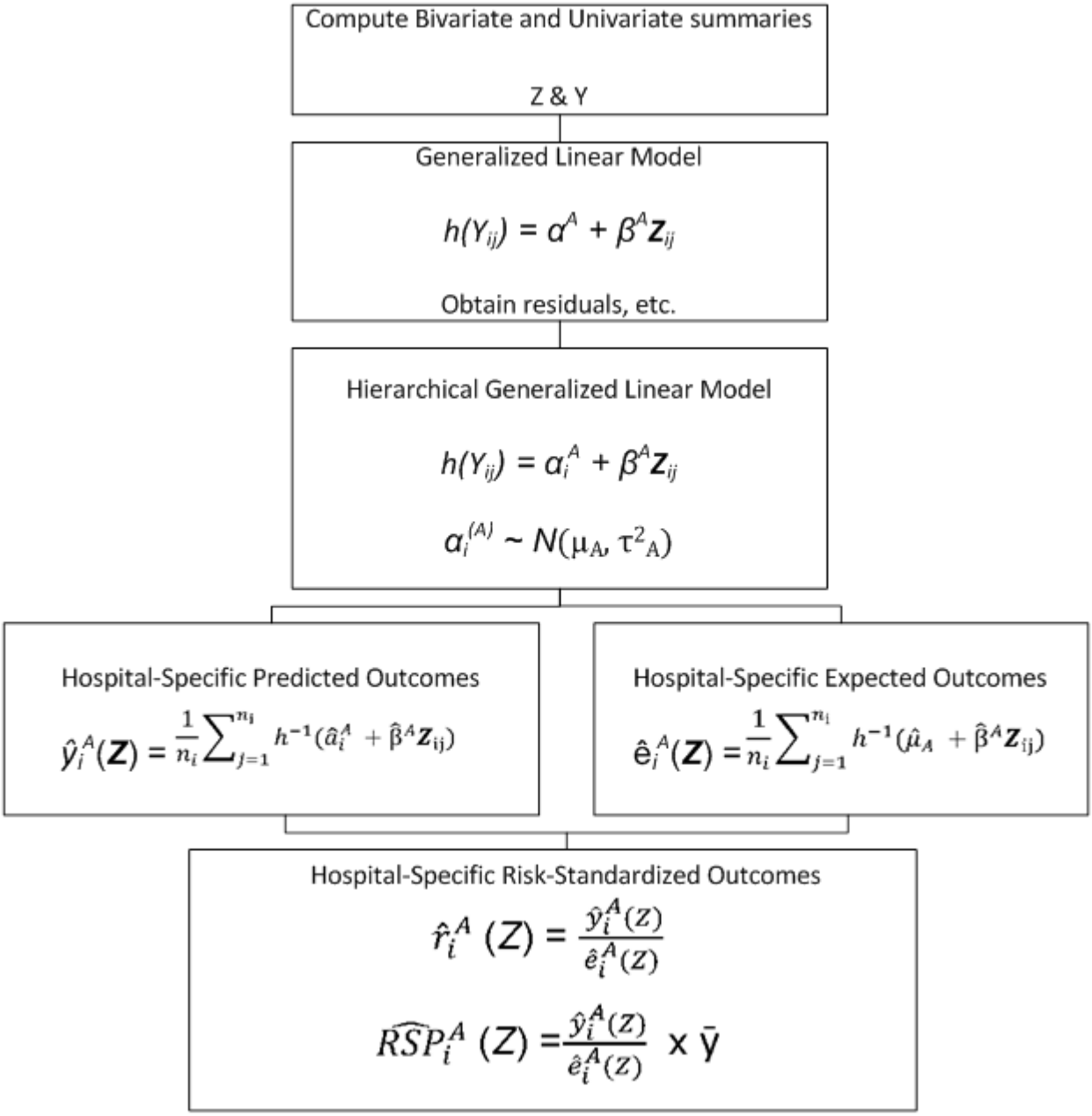
   c. The set of hospital-specific intercepts and corresponding variances, $\{\hat{\alpha}_i^{(b)}, \widehat{var}(\alpha_i^{(b)}); i = 1,2,\dots,I\}$

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 patient *j* in that hospital, we calculate $\hat{y}_{ij}^{(b)}$, $\hat{e}_{ij}^{(b)}$, and $\widehat{RSP}_i(Z)^{(b)}$ 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).[18]

Figure A.1 Analysis Steps



Appendix B. Data Quality Assurance (QA)

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

This section represents QA for the subset of the work CORE conducted to maintain and report these payment 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. Because a new price-standardized payment data element for the analytic input files was used for 2015 public reporting, all data were thoroughly reviewed. The CMS Standardization Methodology for Allowed Amount – V.3 used to process the Medicare administrative claims data was evaluated to ensure that the calculations of associated payments for Medicare patients were consistent with those described in the payment measure methodology reports.[1-3] We also ensured 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 payment 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 codes for any changes made in calculating the payment measures: data preparation, sample selection, hierarchical modeling, and calculation of RSPs. This process highlights any programming errors in syntax or logic. Once the parallel programming process is complete, the analysts cross-check their codes by analyzing datasets in parallel, checking for consistency of output, and reconciling any discrepancies.

Phase II

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

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

Figure B.1 - CORE QA Phase I

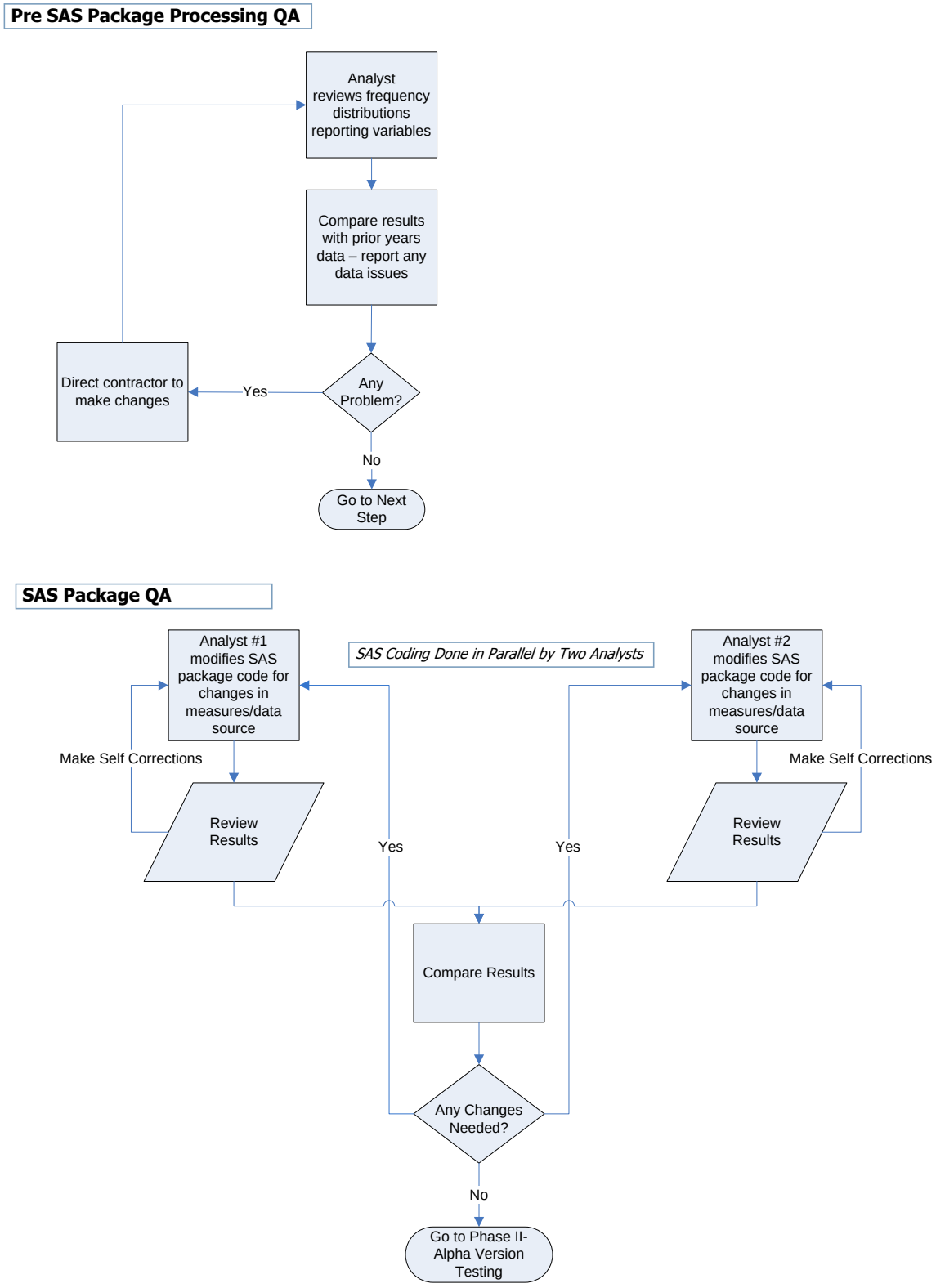
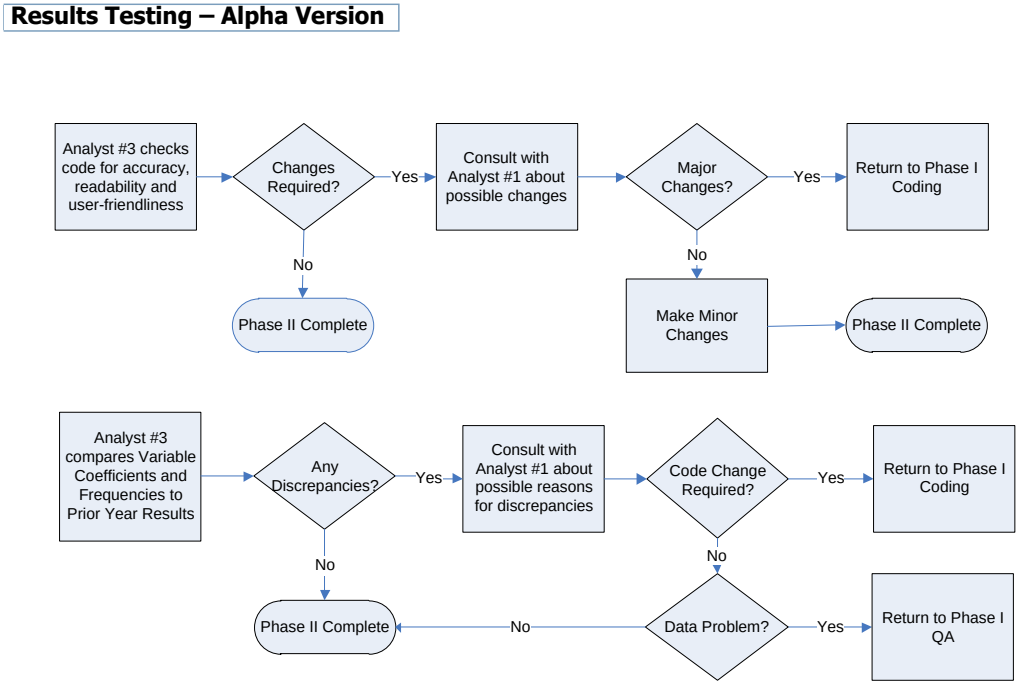


Figure B.2 - CORE QA Phase II



Appendix C. Annual Updates

Prior annual updates for the measure can be found in the annual updates and specifications report 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 Measure Updates and Specifications Report Payment (AMI Version 4.0, HF Version 2.0, Pneumonia Version 2.0)

1. Updated the price-standardized payment data source for the analytic input files to Medicare administrative claims data processed by the CMS Standardization Methodology for Allowed Amount.
    - Rationale: The use of the CMS Standardization Methodology for Allowed Amount harmonizes the payment calculation methodology across the broader suite of CMS cost and resource use measures and creates time efficiencies for the completion of the episode-of-care payment measures.

2. Updated the pneumonia payment model for calculating hospital RSPs to use an identity link function and Gamma distribution.
    - Rationale: This choice of link function and distribution was based on several model diagnostics and better prediction of the payment outcome at the extremes of the distribution.

2014

2014 Measure Updates and Specifications Report AMI Payment (Version 3.0)

1. Updated payment calculation to include a new technology add-on payment.
    - Rationale: New technology payments are meant to ensure that Medicare beneficiaries have access to new technologies that have not been accounted for by the DRG reimbursement rate.
2. Updated payment calculation to include a blood clotting add-on payment.
    - Rationale: Blood clotting add-on payments ensure that inpatient hospitals, inpatient rehabilitation facilities, and long-term care hospitals receive additional reimbursement for blood clotting factor for patients with hemophilia.
3. Updated the payment calculation to include Winsorization of outlier payments.
    - Rationale: Winsorization eliminates extreme values at the upper end of the total payment distribution to improve model prediction and mitigate the impact of possibly erroneous claims without attempting to make corrections or excluding patients.
4. Excluded patients with a missing DRG weight during the index admission if there was also no payment on the claim for the provider.
    - Rationale: With neither DRG weight or payment data, we cannot calculate a payment for the patient's index admission; this would make the entire episode of care appear significantly less expensive.

2013

2013 Measure Updates and Specifications Report AMI Payment (Version 2.0)

1. Updated the inclusion and exclusion criteria to include Maryland and US territories hospitals.
   - Rationale: The original measure did not include AMI admissions from hospitals in Maryland or US Territories because CMS reimburses hospitals in Maryland and US Territories using a different mechanism than hospitals in the other 49 states and the District of Columbia. These hospitals are now included in the measure and treated as if they were paid under CMS's IPPS.
2. Updated the inclusion and exclusion criteria to exclude hospice patients.
   - Rationale: The original AMI payment measure did not exclude patients with any hospice assignment due to a desire to include the full breadth of AMI index admissions that met our criteria. This decision was not aligned with CMS's publicly reported 30-day AMI mortality measure. After discussion with our Technical Expert Panel, we decided to exclude patients with hospice enrollment within one year prior to or on the date of an index admission in order for the AMI payment and mortality measure cohorts to be aligned as closely as possible. Consistent with CMS's 30-day AMI mortality measure, we chose to retain patients with hospice assignments after the date of index admission because the hospice assignment may have been related to care received during the index AMI admission.

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**
   Rationale: FFS is the traditional model for Medicare Payment. The calculation of patient-level total payment relies on FFS claims.
3. **Aged 65 or over**
   Rationale: Medicare patients younger than 65 are not included in the measure because they are considered to be clinically different from patients 65 and over as they often qualify for Medicare at a younger age because of disabilities.
4. **Not transferred from another acute care facility**
   Rationale: Although the acute episode is included in the measure, episode-of-care payments are assigned to the hospital where the patient was initially admitted rather than the hospital receiving the transferred patient.
5. **Enrolled in Part A and Part B Medicare for the 12 months prior to the date of admission, and enrolled in Part A and Part B 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 Medicare Advantage patients are included in the measures. Medicare Part B is required to ensure coverage across all care settings.

Exclusion Criteria for AMI Measure

1. **Incomplete administrative data in the 30 days following the index admission if discharged alive**
   Rationale: This is necessary in order to identify the outcome (payments) in the sample over our analytic period.
2. **Discharged alive on the day of admission or the following day who were not transferred**
   Rationale: These patients likely did not suffer a clinically significant AMI.
3. **Inconsistent or unknown patient vital status, or other unreliable demographic data (age and gender)**
   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, or where the date of death occurs before the date of discharge but the patient was discharged alive.
4. **Admissions where patients are discharged against medical advice (AMA)**
   Rationale: Hospitals had limited opportunity to care for the patient.
5. **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: This exclusion is made in order to harmonize with the AMI mortality measure: these patients are likely continuing to seek comfort measures only, so payment may reflect patient preferences rather than hospital practice patterns.

6. **Transferred to federal hospitals**
   Rationale: We do not have claims data for these hospitals; therefore, including these patients would systematically underestimate payments.
7. **Not matched to admission in the AMI mortality measure**
   Rationale: As part of the current data processing, we match our index AMI admissions to the AMI mortality cohort to obtain the risk-adjustment variables. Patients are excluded if they cannot be matched between the AMI payment and AMI mortality cohorts.
8. **Missing index DRG weight and provider received no payment**
   Rationale: With neither DRG weight or payment data, we cannot calculate a payment for the patient's index admission; this would make the entire episode of care appear significantly less expensive.

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

ICD-9-CM Code	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

Code	Description
n/a	Age (65 – 74)
n/a	Age (75 – 84)
n/a	Age (>=85)
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 7-8	Metastatic cancer, acute leukemia and other severe cancers
CC 15-19, 119-120	Diabetes mellitus (DM) or DM complications
CC 21	Protein-calorie malnutrition
CC 22	Other significant endocrine and metabolic disorders
CC 24	Other endocrine/metabolic/nutritional disorders
CC 36	Other gastrointestinal disorders
CC 41	Osteoporosis and other bone/cartilage disorders
CC 47	Iron deficiency or other specified anemias and blood disease
CC 48	Delirium and encephalopathy
CC 49	Dementia
CC 51	Drug/alcohol psychosis
CC 52-53	Drug/alcohol abuse/dependence
CC 54-55	Severe mental illness
CC 56	Reactive and unspecified psychosis
CC 58-59	Depression/anxiety
CC 80	Congestive heart failure
CC 83	Angina pectoris/old myocardial infarction
CC 85	Heart infection/inflammation, except rheumatic
CC 86	Valvular or rheumatic heart disease
CC 87-88	Congenital cardiac/circulatory defects
CC 89-91	Hypertension and hypertension complications
CC 97	Precerebral arterial occlusion and transient cerebral ischemia
CC 104-105	Vascular disease and complications
CC 115	Other lung disorders
CC 116	Legally blind
CC 130	Dialysis status
CC 160	Internal injuries

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 48	Delirium and encephalopathy
CC 80	Congestive heart failure
CC 97	Precerebral arterial occlusion and transient cerebral ischemia
CC 104	Vascular disease with complications
CC 105	Vascular disease
CC 130	Dialysis status

Outcome Criteria for AMI Measure

1. **All payments**
   Rationale: The specific goal of this task is to sum all payments made for Medicare patients, including index admission and post-discharge payments for: readmission or other post-discharge inpatient care, SNFs, outpatient providers, home health agencies, hospice care, physician/clinical laboratory/ambulance services, supplier Part B items, and durable medical equipment, prosthetics/orthotics, and supplies. This work will be used to better understand differences in the patterns of post-discharge care and associated payments made for Medicare patients across a continuum of care beginning with a hospitalization for AMI and following patients 30 days after hospital admission.

2. **30-day time frame**
   Rationale: First, decisions made at the admitting hospital affect not only hospitalization payments, but payments for care in the immediate post-discharge period. Second, assessing payments for a continuous episode of care may reveal practice variations in the full care of the illness that triggered an index admission. Third, a 30-day preset window provides a standard observation period by which to compare all hospitals. Lastly, when pairing payment measures with quality measures, their measurement periods should be aligned as much as possible. Most publicly reported mortality measures are reported for a 30-day period after admission.

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**
   Rationale: FFS is the traditional model for Medicare Payment. The calculation of patient-level total payment relies on FFS claims.
3. **Aged 65 or over**
   Rationale: Medicare patients younger than 65 are not included in the measure because they are considered to be clinically different from patients 65 and over as they often qualify for Medicare at a younger age because of disabilities.
4. **Not transferred from another acute care facility**
   Rationale: Although the acute episode is included in the measure, episode-of-care payments are assigned to the hospital where the patient was initially admitted rather than the hospital receiving the transferred patient.
5. **Enrolled in Part A and Part B Medicare for the 12 months prior to the date of admission, and enrolled in Part A and Part B 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. Medicare Part B is required to ensure coverage across all care settings.

Exclusion Criteria for HF Measure

1. **Incomplete administrative data in the 30 days following the index admission if discharged alive**
   Rationale: This is necessary in order to identify the outcome (payments) in the sample over our analytic period.
2. **Discharged alive on the day of admission or the following day who were not transferred**
   Rationale: These patients likely did not suffer a clinically significant HF.
3. **Inconsistent or unknown patient vital status, or other unreliable demographic data (age and gender)**
   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, or where the date of death occurs before the date of discharge but the patient was discharged alive.
4. **Admissions where patients are discharged against medical advice (AMA)**
   Rationale: Hospitals had limited opportunity to care for the patient.
5. **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: This exclusion is made in order to harmonize with the HF mortality measure: these patients are likely continuing to seek comfort measures only, so payment may reflect patient preferences rather than hospital practice patterns.
6. **Transferred to federal hospitals**

Rationale: We do not have claims data for these hospitals; therefore, including these patients would systematically underestimate payments.

7. **Could not be matched to admission in the HF mortality measure**
   Rationale: As part of the current data processing, we match our index HF admissions to the HF mortality cohort to obtain the risk-adjustment variables. Patients are excluded if they cannot be matched between the HF payment and HF mortality cohorts.
8. **Missing index DRG weight and provider received no payment**
   Rationale: With neither DRG weight or payment data, we cannot calculate a payment for the patient's index admission; this would make the entire episode of care appear significantly less expensive
9. **Hospitalizations for patients who receive a heart transplant during the episode of care**
   Rationale: These patients are clinically distinct, generally very-high payment cases, and not representative of the typical HF patient that this measure aims to capture.
10. **Hospitalizations for patients who receive a Left Ventricular Assist Device (LVAD) during the episode of care**
    Rationale: These patients are clinically distinct, generally very high-payment cases, and not representative of the typical HF patient that this measure aims to capture.

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

ICD-9-CM	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 or 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 or chronic diastolic heart failure

ICD-9-CM	Description
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 or chronic combined systolic and diastolic heart failure
428.9	Heart failure, unspecified

Risk Adjustment

Table D.2.2 Risk Variables for HF Measure

Code	Description
n/a	Age (65 – 74)
n/a	Age (75 – 84)
n/a	Age (>=85)
CC 1, 3-5	Severe infection
CC 6	Other infectious diseases
CC 21	Protein-calorie malnutrition
CC 22	Other significant endocrine and metabolic disorders
CC 24	Other endocrine/metabolic/nutritional disorders
CC 36	Other gastrointestinal disorders
CC 37	Bone/joint/muscle infections/necrosis
CC 43	Other musculoskeletal and connective tissue disorders
CC 48	Delirium and encephalopathy
CC 49-50	Dementia or other specified brain disorders
CC 54-55	Severe mental illness
CC 60	Other psychiatric disorders
CC 77-79	Respiratory arrest/cardiorespiratory failure/respirator dependence
CC 83	Angina pectoris/old myocardial infarction
CC 85	Heart infection/inflammation, except rheumatic
CC 87	Major congenital cardiac/circulatory defect
CC 91	Hypertension
CC 92-93	Specified arrhythmias and other heart rhythm disorders
CC 97-99	Cerebrovascular disease
CC 104-106	Vascular or circulatory disease
CC 111-113	Pneumonia
CC 127	Other ear, nose, throat, and mouth disorders
CC 130	Dialysis status
CC 131	Renal failure
CC 148	Decubitus ulcer of skin
CC 149	Chronic ulcer of skin, except decubitus
CC 152	Cellulitis, local skin infection
CC 158	Hip fracture/dislocation
CC 160	Internal injuries

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 6	Other infectious diseases
CC 48	Delirium and encephalopathy
CC 77	Respirator dependence/tracheostomy status
CC 78	Respiratory arrest
CC 79	Cardio-respiratory failure or shock
CC 92	Specified heart arrhythmias
CC 93	Other heart rhythm and conduction disorders
CC 97	Precerebral arterial occlusion and transient cerebral ischemia
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 130	Dialysis status
CC 131	Renal failure
CC 148	Decubitus ulcer of skin
CC 152	Cellulitis, local skin infection
CC 158	Hip fracture/dislocation

Outcome Criteria for HF Measure

1. **All payments**
   Rationale: The specific goal of this task is to sum all payments made for Medicare patients, including index admission and post-discharge payments for: readmission or other post-discharge inpatient care, SNFs, outpatient providers, home health agencies, hospice care, physician/clinical laboratory/ambulance services, supplier Part B items, and durable medical equipment, prosthetics/orthotics, and supplies. This work will be used to better understand differences in the patterns of post-discharge care and associated payments made for Medicare patients across a continuum of care beginning with a hospitalization for HF and following patients 30 days after hospital admission.

2. **30-day time frame**
   Rationale: First, decisions made at the admitting hospital affect not only hospitalization payments, but payments for care in the immediate post-discharge period. Second, assessing payments for a continuous episode of care may reveal practice variations in the full care of the illness that triggered an index admission. Third, a 30-day preset window provides a standard observation period by which to compare all hospitals. Lastly, when pairing payment measures

with quality measures, their measurement periods should be aligned as much as possible. Most publicly reported mortality measures are reported for a 30-day period after admission.

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**
   Rationale: FFS is the traditional model for Medicare Payment. The calculation of patient-level total payment relies on FFS claims.
3. **Aged 65 or over**
   Rationale: Medicare patients younger than 65 are not included in the measure because they are considered to be clinically different from patients 65 and over as they often qualify for Medicare at a younger age because of disabilities.
4. **Not transferred from another acute care facility**
   Rationale: Although the acute episode is included in the measure, episode-of-care payments are assigned to the hospital where the patient was initially admitted rather than the hospital receiving the transferred patient.
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. Medicare Part B is required to ensure coverage across all care settings.

Exclusion Criteria for Pneumonia Measure

1. **Incomplete administrative data in the 30 days following the index admission if discharged alive**
   Rationale: This is necessary in order to identify the outcome (payments) in the sample over our analytic period.
2. **Discharged alive on the day of admission or the following day who were not transferred**
   Rationale: These patients likely did not have clinically significant pneumonia.
3. **Inconsistent or unknown patient vital status, or other unreliable demographic data (age and gender)**
   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, or where the date of death occurs before the date of discharge but the patient was discharged alive.
4. **Admissions where patients are discharged against medical advice (AMA)**
   Rationale: Hospitals had limited opportunity to care for the patient.
5. **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: This exclusion is made in order to harmonize with the pneumonia mortality measure: these patients are likely continuing to seek comfort measures only, so payment may reflect patient preferences rather than hospital practice patterns.

6. **Transferred to federal hospitals**
   Rationale: We do not have claims data for these hospitals; therefore, including these patients would systematically underestimate payments.
7. **Could not be matched to admission in the pneumonia mortality measure**
   Rationale: As part of the current data processing, we match our index pneumonia admissions to the pneumonia mortality cohort to obtain the risk-adjustment variables. Patients are excluded if they cannot be matched between the pneumonia payment and pneumonia mortality cohorts.
8. **Missing index DRG weight and provider received no payment**
   Rationale: With neither DRG weight or payment data, we cannot calculate a payment for the patient's index admission; this would make the entire episode of care appear significantly less expensive

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

ICD-9-CM Code	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

ICD-9-CM Code	Description
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

Code	Description
n/a	Age (65 – 74)
n/a	Age (75 – 84)
n/a	Age (>=85)
CC 1, 3-5	Severe infection
CC 6	Other infectious diseases
CC 7	Metastatic cancer or acute leukemia
CC 8	Lung, upper digestive tract, and other severe cancers
CC 9	Lymphatic, head and neck, brain, and other major cancers
CC 15-19, 119-120	Diabetes mellitus (DM) or DM complications
CC 21	Protein-calorie malnutrition
CC 22	Other significant endocrine and metabolic disorders
CC 24	Other endocrine/metabolic/nutritional disorders
CC 36	Other gastrointestinal disorders
CC 37	Bone/joint/muscle infections/necrosis
CC 41	Osteoporosis and other bone/cartilage disorders
CC 44	Severe hematological disorders
CC 47	Iron deficiency or other unspecified anemias and blood disease
CC 48	Delirium and encephalopathy
CC 49-50	Dementia or other specified brain disorders
CC 51-52	Drug/alcohol psychosis or dependence
CC 53	Drug/alcohol abuse, without dependence
CC 54-56	Major psychiatric disorders
CC 67-69, 100-101, 177-178	Plegia, paralysis, spinal cord disorder and amputation
CC 70-71	Muscular dystrophy&/or polyneuropathy
CC 72-73	Multiple sclerosis and Parkinson's
CC 75	Coma, brain compression/anoxic damage
CC 77-79	Respirator dependence/respiratory arrest/cardiorespiratory failure
CC 80	Congestive heart failure
CC 83	Angina pectoris/old myocardial infarction
CC 85	Heart infection/inflammation, except rheumatic
CC 86	Valvular or rheumatic heart disease
CC 91	Hypertension
CC 92-93	Specified arrhythmias and other heart rhythm disorders
CC 95-96	Stroke

Code	Description
CC 104-106	Vascular or circulatory disease
CC 108	Chronic obstructive pulmonary disease (COPD)
CC 109	Fibrosis of lung or other chronic lung disorders
CC 110	Asthma
CC 111	Aspiration and specified bacterial pneumonias
CC 114	Pleural effusion/pneumothorax
CC 127	Other ear, nose, throat, and mouth disorders
CC 130	Dialysis status
CC 131	Renal failure
CC 148-149	Decubitus ulcer or chronic skin ulcer
CC 154-156	Head Injury
CC 157	Vertebral fractures
CC 158	Hip fracture/dislocation
CC 159	Major fracture, except of skull, vertebrae, or hip
CC 160	Internal injuries
CC 166	Major symptoms, abnormalities

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 6	Other infectious diseases
CC 17	Diabetes with acute complications
CC 48	Delirium and encephalopathy
CC 75	Coma, brain compression/anoxic damage
CC 77	Respirator dependence/tracheostomy status
CC 78	Respiratory arrest
CC 79	Cardio-respiratory failure and 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 104	Vascular disease with complications
CC 105	Vascular disease
CC 106	Other circulatory disease
CC 111	Aspiration and specified bacterial pneumonias
CC 114	Pleural effusion/pneumothorax
CC 130	Dialysis status
CC 131	Renal failure
CC 148	Decubitus ulcer of skin
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

Outcome

3. **All payments**
   Rationale: The specific goal of this task is to sum all payments made for Medicare patients, including index admission and post-discharge payments for: readmission or other post-discharge inpatient care, SNFs, outpatient providers, home health agencies, hospice care, physician/clinical laboratory/ambulance services, supplier Part B items, and durable medical equipment, prosthetics/orthotics, and supplies. This work will be used to better understand differences in the patterns of post-discharge care and associated payments made for Medicare patients across a continuum of care beginning with a hospitalization for pneumonia and following patients 30 days after hospital admission.

4. **30-day time frame**
   Rationale: First, decisions made at the admitting hospital affect not only hospitalization payments, but payments for care in the immediate post-discharge period. Second, assessing payments for a continuous episode of care may reveal practice variations in the full care of the illness that triggered an index admission. Third, a 30-day preset window provides a standard observation period by which to compare all hospitals. Lastly, when pairing payment measures with quality measures, their measurement periods should be aligned as much as possible. Most publicly reported mortality measures are reported for a 30-day period after admission.