

2016 Reevaluation and Re-Specifications Report of the Hospital-Level 30-Day Risk-Standardized Pneumonia Payment Measure

Pneumonia Payment-Version 3.1

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Prepared For:

Centers for Medicare & Medicaid Services (CMS)

March 2016

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Acknowledgements

This work is a collaborative effort and the authors gratefully acknowledge Buccaneer Computer Systems and Service, Inc.; Sharon-Lise Normand from Harvard Medical School, Department of Health Care Policy and Harvard School of Public Health, Department of Biostatistics; Kanchana Bhat, Zhenqiu Lin, Jinghong Gao, and Lori Geary from CORE; Taybah for Healthcare Consulting, Inc.; and Lein Han and Pierre Yong at the Centers for Medicare & Medicaid Services for their contributions to this work.

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1. OVERVIEW

This report describes the revised version of the Centers for Medicare & Medicaid Services' (CMS's) hospital-level risk-standardized payment (RSP) associated with a 30-day episode of care for pneumonia. This revised measure, version 3.1, differs from the measure that is currently publicly reported on [*Hospital Compare*](#). The revision of this measure ensures that it more fully reflects the population of [Medicare fee-for-service](#) (FFS) beneficiaries being treated for pneumonia at hospitals in the United States and that the patients included are comparable across hospitals. In response to clinical research studies and changes in coding practice, the measure inclusion criteria have been broadened to include patients with a principal discharge diagnosis of: 1) aspiration pneumonia and 2) sepsis (not including severe sepsis) with a secondary diagnosis of pneumonia (present on admission [POA]) to maintain a measure [cohort](#) that includes a broad and clinically cohesive cohort of inpatients with pneumonia across the clinical spectrum of disease.

The pneumonia payment measure revision is also intended to keep the pneumonia payment cohort aligned with the revised CMS hospital 30-day, all-cause, risk-standardized mortality rate (RSMR) and hospital 30-day, all-cause, risk-standardized readmission rate (RSRR) following pneumonia hospitalization. The details of this expansion are provided in the 2015 Reevaluation and Re-Specification Report of the Hospital-Level 30-Day Risk-Standardized Measures Following Hospitalization for Pneumonia (Mortality, version 9.2; Readmission, version 8.2) report available in the AMI, HF, PN, COPD and Stroke Readmission Updates folder of the Hospital Quality Initiative Measure Methodology page on [CMS.gov](#).

This report provides a rationale for cohort expansion, an overview of the methodology of the revised measure, assessment and results of the revised measure in current data, and a comparison between the current and revised measure. The analyses presented in this report are similar to the analyses presented in the original Pneumonia Payment Measure Methodology report and in the 2015 Payment Measures Annual Updates and Specifications report.^{1,2} In an effort to ensure transparency in our approach and in the potential impact of these changes on measure results, we present full details of the revised measure including the re-specification of risk variables, model diagnostics, and the impact on hospital-level performance.

The revised pneumonia payment measure specifications are described in these sections:

- **[Section 2](#)** – Rationale for measure revision
- **[Section 3](#)** – Methodology used for measure revision, including a summary of revised specifications for the expanded cohort definition, risk variables, and measure outcome
- **[Section 4](#)** – Revised measure assessment and results using data from July 2011 to June 2014
- **[Section 5](#)** – Comparison of current and revised measures

The appendices contain detailed measure information, including:

- **[Appendix A](#)**: Statistical approach to calculating the RSPs

- **Appendix B:** Measure specifications, including concise tables of the condition codes used for cohort derivation and risk adjustment
- **Appendix C:** Revised Pneumonia Payment Model Candidate Risk-Adjustment Variables

For additional references, the measure methodology reports and prior updates and specifications reports are available in the Measure Methodology and Archived Resources sections under the claims-based payment measures pages of [QualityNet](#):

- Hospital-level, Risk-Standardized Payment Associated with a 30-Day Episode of Care for Pneumonia (Version 1.0)¹
- 2015 Measure Updates and Specifications Report: Hospital-Level, Risk-Standardized Payment Associated with a 30-Day Episode of Care for AMI (Version 4.0), HF (Version 2.0), and Pneumonia (Version 2.0)²
- 2016 Measure Updates and Specifications Report: Hospital-Level, Risk-Standardized Payment Associated with a 30-Day Episode of Care for AMI (Version 5.0), Heart Failure (Version 3.0), and Pneumonia (Version 3.0)³

2. RATIONALE FOR MEASURE REVISION

2.1 Overview

CMS's process for measure reevaluation ensures that the risk-standardized payment measures are continually assessed and remain valid, given possible changes in clinical practice and coding standards over time, and allowing for model refinements and cohort redefinitions. 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 evaluate shifts in clinical practice or billing patterns.

As described in the 2015 Reevaluation and Re-Specification Report of the Hospital-Level 30-Day Risk-Standardized Measures Following Hospitalization for Pneumonia (Mortality, version 9.2; Readmission, version 8.2), made publicly available to support the FY 2016 IPPS final rule, the pneumonia mortality and readmission measures have been re-specified to include patients hospitalized with aspiration pneumonia as a principal discharge diagnosis and patients hospitalized with sepsis as a principal discharge diagnosis who also have a secondary discharge diagnosis of pneumonia, present on admission (POA).⁴ The need to make these changes was underscored by wide variation across hospitals in the use of sepsis codes amongst pneumonia patients and, to a lesser extent, aspiration pneumonia codes, suggesting systematic differences in hospital coding practice that could potentially bias efforts to compare hospital performance for pneumonia hospitalizations.

The reevaluation and re-specification of the pneumonia mortality and readmission measures prompted a parallel expansion of the pneumonia payment measure cohort. Changes to the pneumonia payment measure specifications are needed for consistency with the pneumonia mortality and readmission measures, in order to represent the full clinical spectrum of pneumonia severity among hospitalized Medicare FFS patients, and to respond to changes in coding practices.

2.2 Rationale for Cohort Expansion

Below is a summary of the rationale for the re-specification of the pneumonia mortality and readmission measures which serves as the basis for the reevaluation and re-specification of the pneumonia payment measure. Further rationale can be found in the 2015 Reevaluation and Re-Specification Report of the Hospital-Level 30-Day Risk-Standardized Measures Following Hospitalization for Pneumonia (Mortality, version 9.2; Readmission, version 8.2).⁴

A recent analysis of the Nationwide Inpatient Sample revealed a rapid increase in the use of the principal discharge diagnosis codes for sepsis among patients hospitalized with pneumonia.⁵ Greater recognition and detection of sepsis (resulting from national quality improvement efforts such as the Surviving Sepsis Campaign), as well as efforts by hospitals to maximize reimbursement through clinical documentation improvement programs, might explain this change in coding. Because patients with a principal discharge diagnosis of sepsis have not been included in the current CMS pneumonia

mortality and readmission measures, efforts to track changes over time in the clinical care of pneumonia and their outcomes may be biased. As hospitals increasingly use a principal discharge diagnosis code of sepsis in combination with a secondary discharge diagnosis of pneumonia that is POA, this increases the numbers of “sicker” patients that are excluded from the measures.

In addition to these longitudinal studies, cross sectional analyses have demonstrated wide variation in the use of sepsis codes across hospitals, potentially biasing efforts to compare hospital performance on 30-day mortality, readmission, and payment (resource utilization).⁶ Sepsis codes represent a spectrum of illness severity. Although there is little discretion in the use of severe sepsis codes as a discharge diagnosis, which requires evidence of end-organ failure, there is greater opportunity for variation in the use of codes for sepsis (that is, sepsis diagnosis codes that do not include severe sepsis) as a principal discharge diagnosis. Virtually all patients hospitalized with pneumonia meet criteria for sepsis based on the presence of infection and two or more systemic inflammatory response syndrome (SIRS) criteria, for example, an elevated temperature, heart rate, respiratory rate, or white blood cell count. Therefore, hospitals that disproportionately use these codes may appear to have better outcomes because patients with these alternative codes, who may be “sicker”, are not included in the CMS measures. A recent simulation study that used Medicare claims focusing on 30-day outcomes suggested that the current pneumonia mortality and readmission measures may be susceptible to gaming on the basis of hospital coding patterns related to sepsis and respiratory failure diagnoses.⁷

Given these published studies and additional analyses presented in the 2015 Reevaluation and Re-Specification Report of the Hospital-Level 30-Day Risk-Standardized Measures Following Hospitalization for Pneumonia (Mortality, version 9.2; Readmission, version 8.2), there was both clinical and empirical justification for expanding the measure cohort to include, in addition to patients with a principal discharge diagnosis of pneumonia, patients with a principal discharge diagnosis of aspiration pneumonia, and patients with a principal discharge diagnosis of non-severe sepsis with a secondary discharge diagnosis of pneumonia that was POA.⁴

This approach to expanding the measure cohort will ensure more consistent inclusion of patients admitted across the spectrum of clinical severity of pneumonia across U.S. hospitals. This re-specification was determined to be statistically robust, such that risk-standardization accounted for case-mix differences across hospitals, without being confounded by hospital coding patterns. Finally, this re-specification received support in comments from the public received in response to the FY 2016 IPPS proposed rule.⁸

3. OVERVIEW OF REVISED MEASURE SPECIFICATIONS AND METHODOLOGY

The revised risk-adjusted pneumonia payment measure, version 3.1, uses specifications that align with prior original Methodology Report and Measure Updates and Specifications reports with significant refinements to the measure as listed below.^{1,2} This section provides an overview of the measure methodology as well as the approach to the development, validation, and risk factor selection of the revised measure.

3.1 Expanded Cohort

To ensure that our pneumonia payment measure remains valid, we expanded the cohort for the revised measure to include:

- Patients with a principal discharge diagnosis of pneumonia ([Table B.1.1](#)), including aspiration pneumonia ([Table B.2.1](#))
- Patients with principal discharge diagnoses of sepsis (not including severe sepsis) with a secondary discharge diagnosis of pneumonia ([Table B.3.1](#)) (including aspiration pneumonia and coded as POA) and no secondary discharge diagnosis of severe sepsis

Index Admissions Included in the Revised Pneumonia Payment Measure

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 pneumonia;
 - The pneumonia measure cohort also includes admissions with a principal discharge diagnosis of sepsis (not including severe sepsis) who have a secondary discharge diagnosis of pneumonia coded as POA
- Enrolled in Medicare fee-for-service (FFS) Part A and Part B for the 12 months prior to the date of the admission, and enrolled in Part A and Part B during the index admission;
- Aged 65 or over; and
- Not transferred to another acute care facility.

International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes used to define the cohort for the measure are listed in [Tables B.1.1, B.2.1, and B.3.1](#) in [Appendix B](#). The ICD-10 codes for the cohort are listed in [Tables B.1.2, B.2.2, and B.3.2](#) in [Appendix B](#).

Index Admissions Excluded from the Revised Pneumonia Payment Measure

The exclusion criteria for the revised pneumonia payment measure are the same as those of the current measure. The revised measure excludes 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 admission;
- Transferred to a federal hospital;
- Not matched to an admission in the pneumonia mortality measure; or
- With missing index diagnosis-related group (DRG) weight where the provider received no payment.

For patients with more than one admission in a given year, only one index admission is randomly selected for inclusion in the cohort. Admissions within 30 days of a previous index admission are not considered index admissions and are removed from the cohort.

For the revised cohort, the number of admissions excluded based on each criterion is shown in [Section 4.3](#) in [Figure 2](#).

[Section 5](#) includes comparisons between the current and revised cohort and the effect of the cohort expansion on the measure results. For the July 2011 to June 2014 dataset, the revised cohort included 178,738 admission (13.9%) with aspiration pneumonia as a principal discharge diagnosis and 229,708 admissions (17.8%) with sepsis as a principal discharge diagnosis and a secondary discharge diagnosis of pneumonia or aspiration pneumonia, POA. Overall, the cohort expansion added 386,143 admissions to the revised measure (43% more admissions than the current measure).

3.2 Outcome

The payment [outcome](#) and 30-day timeframe are not affected by the expansion of the pneumonia payment cohort. The outcome definition for the revised measure is identical to that of the current measure.

Payments

Using administrative claims data, we measure RSPs for Medicare patients for an episode of care that begins with an index admission for pneumonia and that ends 30 days after the index admission. The pneumonia payment measure captures 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.⁹ 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 measure assesses payments within a 30-day period from the date of index admission. The measure uses 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 outcomes.

3.3 Revised Measure: Approach to Development, Validation, and Risk Adjustment

Based on the increased number of patients in the revised pneumonia payment measure and the fact that hospital performance may change as a result of this increase, we reselected risk-adjustment variables using the same process used in initial measure development. This required the development and validation of a new risk-adjustment model for the revised measure.

In order to perform comparisons of payments across hospitals, the measure adjusts for variables (e.g., age, comorbid disease, and indicators of patient frailty) that are clinically relevant and have strong relationships with the outcome. The variable selection process and final variables are described in Section 3.4. 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.

Analogous to the current pneumonia payment measure, the revised measure seeks 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.

The pneumonia payment measure does not adjust for patients' admission source. Additionally, the measure does not 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 measure does 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 that groups of patients with varying SES receive. The intent is for the measure 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 payment measures to hospitals caring for low proportions of low-SES patients.¹⁰ Please note that the Office of the Assistant Secretary for Planning and Evaluation (ASPE) is conducting research to examine the impact of socioeconomic status on quality measures, resource use, and other measures under the Medicare program as directed by the IMPACT Act, and will issue an initial report to Congress by October 2016 and a final report to Congress by October 2019. The findings in these reports will be considered in future reevaluation of these measures.

Refer to [Table B.4](#) for the revised pneumonia payment measure list of comorbidity risk-adjustment variables and complications that are excluded from risk adjustment if occurring during the index admission in [Appendix B](#) of this report.

3.3.1 Model Development and Validation Samples of Revised Measure

For model development and validation of the revised measure, we used several samples of data. The model was developed using a full year of data, July 2013-June 2014 (Sample A; N=406,918). To determine variables for inclusion in the model (variable selection), we used a randomly selected 50% sample of the July 2013-June 2014 sample (Sample A1). We used the other half of the full July 2013-June 2014 sample (Sample A2) to assess model validity. [Table 3.1](#) summarizes the different data samples and their purposes. Of note, although the model was developed in one year of data, all final model results presented in [Section 4](#) were produced using three years of data from July 2011 to June 2014.

Table 3.1. 2013-2014 Revised Pneumonia Payment Model Development and Validation Samples

Sample	% of Total Sample	Purpose
Sample A (Full Development and Validation Sample)	100% July 2013-June 2014	Determination of functional form of risk-adjustment model, reliability testing of risk variables and performance of patient-level risk model
Sample A1 (Development)	50% July 2013-June 2014 (randomly selected)	Development (risk variable selection)
Sample A2 (Validation)	50% July 2013-June 2014 (remaining 50%)	Development (validity testing of patient-level risk model)

3.3.2 Risk-Adjustment Model: Determination of Function Form of Revised Measure

As is typical with data for healthcare payments, our dependent variable – total payment for a pneumonia 30-day episode of care – is both right-skewed and leptokurtotic (skewness=2.5;

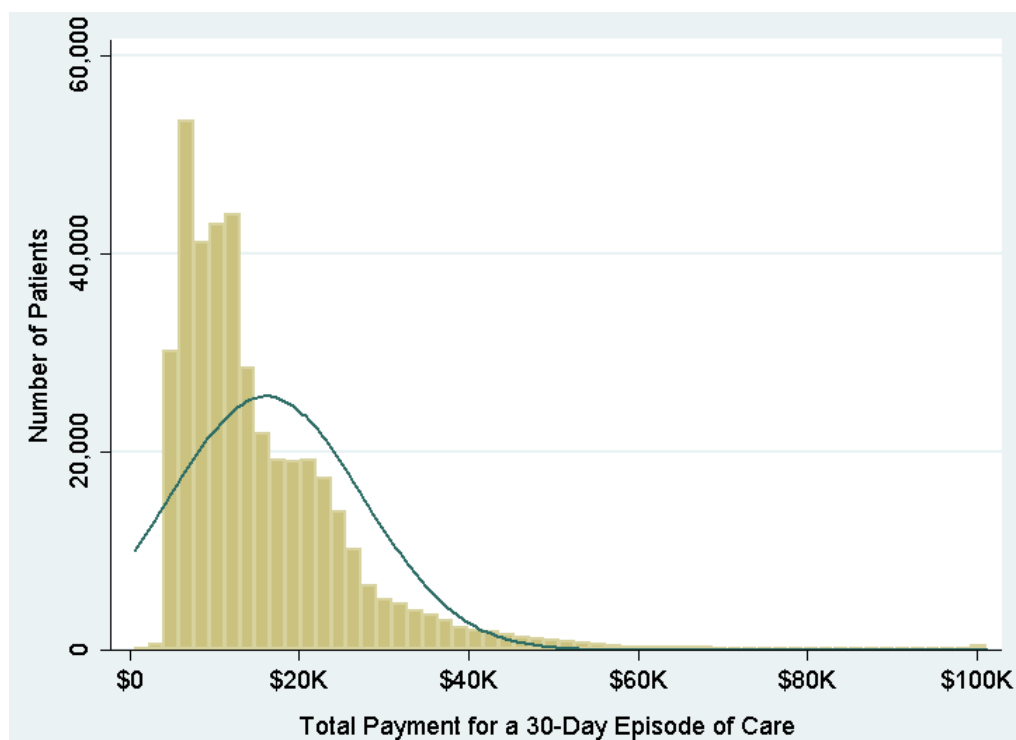
kurtosis=9.8). This is illustrated in [Figure 1](#). To address estimation problems that can arise with non-normally distributed data, we employed the algorithm suggested by Manning & Mullahy and conducted several model diagnostics. Based on these assessments, we chose to estimate a generalized linear model with an identity link and Gamma distribution.¹¹

3.3.3 Risk-Adjustment Model: Candidate Risk-Adjustment Variables

In reselecting variables for the revised pneumonia payment measure, our goal was to develop a parsimonious model that accounted for differences in patient case mix at the time of index admission that were strongly associated with total payment for a pneumonia 30-day episode of care. The candidate variables for the model were derived from secondary diagnoses of the index hospital stay (excluding potential complications), inpatient data, outpatient hospital data, and carrier files for physician, radiology and laboratory services during the 12 months prior to the index hospital stay.

To select candidate variables, we started with the 189 [Condition Categories](#) (CCs). We used the ICD-9-to-CC assignment map, which is maintained by CMS and posted on the [QualityNet](#) website. A team of clinicians reviewed all 189 CCs and excluded those that were not relevant to the Medicare population or not clinically relevant to the pneumonia payment outcome (for example, attention deficit disorder and female infertility). Some of these CCs were combined into clinically coherent groups. The remaining clinically relevant CCs, along with age, were selected as candidate comorbid risk variables. A complete list of candidate variables is presented in [Appendix C](#).

Figure 1. Distribution of Unadjusted Patient-Level Total Payments for a Pneumonia 30-Day Episode of Care (Sample A: July 2013-June 2014; N=406,918)



3.3.4 Risk Adjustment Model: Final Variable Selection

We reselected candidate variables via the same bootstrapping methodology described in our original pneumonia payment technical report. To inform variable selection, we performed a modified approach to stepwise generalized linear model regression. We used Sample A1 to create 1,000 bootstrap samples. For each bootstrap sample, we ran a generalized linear model that included all candidate variables. Specifically, let Y_{ij} denote the outcome (i.e., total payment for a pneumonia 30-day episode of care) for the j^{th} patient admitted to the i^{th} hospital; and \mathbf{Z}_{ij} denotes the candidate risk factors where $\mathbf{Z}_{ij} = (Z_{1ij}, Z_{2ij}, \dots, Z_{pij})$ is a set of p patient-specific variables (e.g., age, comorbid conditions). Let I denote the total number of hospitals and n_i the number of index patient stays in hospital i . We assume the outcome is related linearly to the risk factors via a known link function, $h(\cdot)$, as follows:

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

In our case, $h(\cdot)$ is the identity link, and we assumed a Gamma distribution for the outcome. We estimated these generalized linear models using the SAS software system (SAS 9.3 GENMOD procedure).

The results were summarized to show the percentage of times that each of the candidate variables was significantly associated with pneumonia payment (at the $p < 0.05$ level) in the 1,000 bootstrap samples (for example, 70% would mean that the candidate variable was significant at $p < 0.05$ in 70% of the bootstrap samples).

of the bootstrap samples). We also assessed the direction and magnitude of the regression coefficients.

As during original pneumonia payment measure development, the team reviewed these results and decided to retain all risk-adjustment variables above a 90% cutoff (in other words, to retain variables that were significant at the $p < 0.05$ level in at least 90% of the bootstrap samples). We chose the 90% cutoff because variables above this threshold demonstrated a relatively robust association with pneumonia payment and were clinically relevant. The final pneumonia payment risk-adjustment model for the revised measure included 57 variables ([Table 3.2](#)).

Table 3.2. Sample A1: July 2013-June 2014 Revised Pneumonia Payment Model Final Variables

Category	Variable	CC
Demographics	Age	N/A
Comorbidity	Severe infection	1, 3-5
Comorbidity	Septicemia/shock	2
Comorbidity	Other infectious diseases	6
Comorbidity	Metastatic cancer or acute leukemia	7
Comorbidity	Lung, upper digestive tract, and other severe cancers	8
Comorbidity	Lymphatic, head and neck, brain, and other major cancers	9
Comorbidity	Benign neoplasms of skin, breast, eye	14
Comorbidity	Diabetes (DM) or DM complications	15-19, 119-120
Comorbidity	Protein-calorie malnutrition	21
Comorbidity	Other significant endocrine and metabolic disorders	22
Comorbidity	Liver disease	25-28
Comorbidity	Gallbladder and biliary tract disorders	30
Comorbidity	Appendicitis	35
Comorbidity	Bone/joint/muscle infections/necrosis	37
Comorbidity	Osteoporosis and other bone/cartilage disorders	41
Comorbidity	Severe hematological disorders	44
Comorbidity	Disorders of immunity	45
Comorbidity	Iron deficiency or other unspecified anemias and blood disease	47
Comorbidity	Delirium and encephalopathy	48
Comorbidity	Dementia or other specified brain disorders	49-50
Comorbidity	Drug/alcohol psychosis or dependence	51-52
Comorbidity	Major psychiatric disorders	54-56
Comorbidity	Hemiplegia, paraplegia, paralysis, spinal cord disorders and amputation	67-69, 100-101, 177-178
Comorbidity	Muscular dystrophy and/or polyneuropathy	70-71
Comorbidity	Multiple sclerosis and Parkinson's	72-73
Comorbidity	Seizure disorders and convulsions	74
Comorbidity	Coma, brain compression/anoxic damage	75
Comorbidity	Mononeuropathy, other neurological conditions/injuries	76
Comorbidity	Respiratory arrest/cardiorespiratory failure/respirator dependence	77-79

Category	Variable	CC
Comorbidity	Congestive heart failure	80
Comorbidity	Angina pectoris/old myocardial infarction	83
Comorbidity	Heart infection/inflammation, except rheumatic	85
Comorbidity	Valvular or rheumatic heart disease	86
Comorbidity	Hypertensive heart and renal disease or encephalopathy; hypertensive heart disease	89-90
Comorbidity	Stroke	95-96
Comorbidity	Speech, language, cognitive, perceptual deficits; cerebrovascular disease late effects, unspecified	102-103
Comorbidity	Chronic Obstructive Pulmonary Disease (COPD)	108
Comorbidity	Asthma	110
Comorbidity	Pneumococcal pneumonia, emphysema, lung abscess	112
Comorbidity	Viral and unspecified pneumonia, pleurisy	113
Comorbidity	Pleural effusion/pneumothorax	114
Comorbidity	Other lung disorders	115
Comorbidity	Other eye disorders	124
Comorbidity	Significant ear, nose, and throat disorders	125
Comorbidity	Other ear, nose, throat, and mouth disorders	127
Comorbidity	Dialysis status	130
Comorbidity	Incontinence	134
Comorbidity	Other female genital disorders	139
Comorbidity	Decubitus ulcer or chronic skin ulcer	148-149
Comorbidity	Vertebral fractures	157
Comorbidity	Major fracture, except of Skull, vertebrae, or hip	159
Comorbidity	Internal injuries	160
Comorbidity	Traumatic amputation and other injuries	161-162
Comorbidity	Poisonings and allergic reaction	163
Comorbidity	Major symptoms, abnormalities	166
Comorbidity	Minor symptoms, signs, findings	167

3.4 Data Sources

The data sources used for the revised pneumonia payment measure are identical to those used for the current pneumonia payment measure. The revised pneumonia payment measure includes Medicare administrative claims data and enrollment information for patients with hospitalizations 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 have 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.⁹

3.5 Measure Calculation

The measure calculation for the revised pneumonia payment measure is identical to that used for the current pneumonia payment measure.

The pneumonia payment measure estimates hospital-level 30-day RSP using a hierarchical generalized linear model. 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 measure uses a generalized linear model to model the total 30-day payment using age, selected clinical covariates, and a hospital-specific intercept. The pneumonia RSP is 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.¹¹

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 would 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 ratio lower than 1 indicates a lower-than-expected 30-day payment, and a ratio higher than 1 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 4.1) 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 report.¹

3.6 Categorizing Hospital Performance

The revised pneumonia payment measure categorizes hospital performance the same way as the current pneumonia payment measure.

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.

4. REVISED MEASURE ASSESSMENT AND NATIONAL RESULTS FOR JULY 2011 TO JUNE 2014

4.1 Assessment of Revised Model

The pneumonia payment measure estimates hospital-specific 30-day RSP using a hierarchical generalized linear model. See [Section 3](#) for a summary of the measure methodology and model risk-adjustment variables.

As we do annually for all of the CMS payment measures, we evaluated the performance of the model using the July 2011 to June 2014 data. Before evaluation, all payments were inflation-adjusted to 2013 dollars. 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.¹³ 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.¹³ Specifically, we regressed the total payment on the payment predicted by the patient-level risk factors.

The results of these analyses for the revised pneumonia payment measure are presented in [Section 4.3](#).

4.2 Assessment of Measure Validity

The measure's validity is demonstrated in three ways. The first is clinical and face validity of the cohort revision. As discussed in the early sections of this report, the cohort expansion is based on changes in clinical and coding practices that have led to greater numbers of patients with pneumonia being coded with sepsis or aspiration pneumonia as a principal discharge diagnosis. These are patients that the measure is intended to assess, as they fit within the broad clinical category of pneumonia patients and are often treated by the same groups of physicians and staff, using similar treatment strategies. Moreover, virtually all patients hospitalized with pneumonia meet criteria for sepsis. The revision was also supported by findings in the literature.⁵

Second, for a number of claims-based outcome measures, we validated the administrative model with a medical-record based model. In an earlier study, we demonstrated that the rates calculated using the risk-adjustment model with claims and medical record data were highly correlated.¹⁴ These analyses, though based on different outcome measures, demonstrated that using comorbidity information from administrative claims data is a valid approach to risk adjustment and specifically,

that claims-based risk adjustment adequately assesses the difference in case mix among hospitals as compared to clinical data.^{14,15} The revised pneumonia payment measure utilizes the same approach as the current publicly reported measure.

Finally, as we demonstrated in the 2015 Reevaluation and Re-Specification Report of the Hospital-Level 30-Day Risk-Standardized Measures Following Hospitalization for Pneumonia (Mortality, version 9.2; Readmission, version 8.2), although the revision is adding a large portion of patients currently not included in the measure, the revised version of the measure likely has greater validity in that it has mitigated biases introduced by hospital coding patterns.

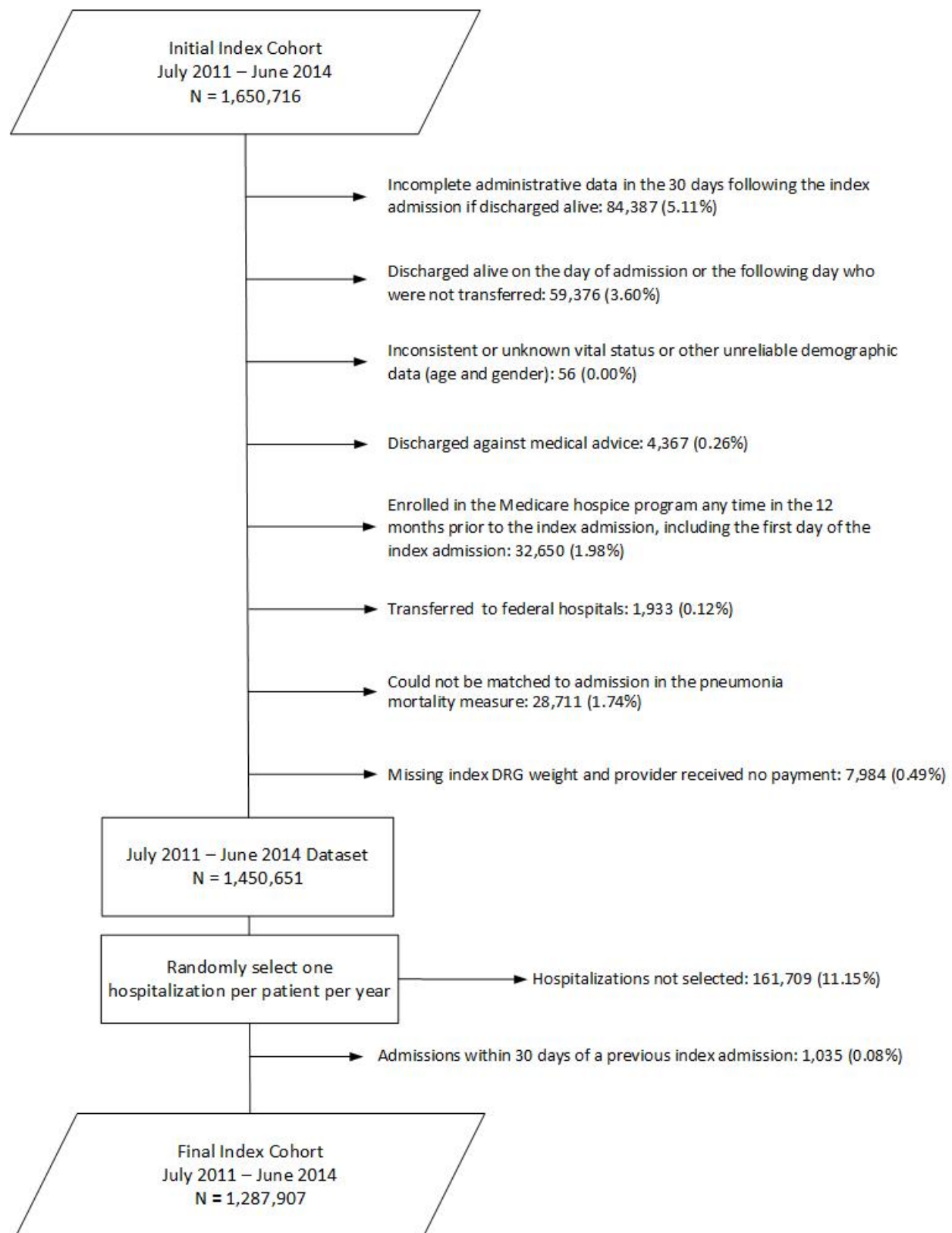
4.3 Results from the Revised Pneumonia Payment Measure Model

4.3.1 Index Cohort Exclusions

The exclusion criteria for the revised pneumonia payment measure are presented in [Section 3.1](#). The percentage of pneumonia patients meeting each exclusion criterion in the July 2011-June 2014 dataset is presented in [Figure 2](#).

Admissions may have been counted in more than one exclusion category because they are not mutually exclusive. The index cohort includes hospitalizations for Medicare FFS patients aged 65 or over with a principal discharge diagnosis of pneumonia, including aspiration pneumonia *or* a principal discharge diagnosis of sepsis (not severe sepsis) with a secondary discharge diagnosis of pneumonia (including aspiration pneumonia) coded as POA; 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 from another acute care facility.

Figure 2. Pneumonia Payment Measure Cohort Exclusions in the July 2011-June 2014 Dataset



4.3.2 Model Parameters and Performance

Table 4.1 shows hierarchical generalized linear model variable coefficients and 95% confidence intervals (CIs) for the revised 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-R² for the pneumonia payment model was 0.10, suggesting that approximately 10% of the variation in payment can be explained by patient-level risk factors. This quasi-R² is in line with R²s from other patient-level risk-adjustment models for healthcare payment.¹⁶ Overall, the variable effect sizes were relatively constant across years (Table 4.2)

4.3.3 Distribution of Hospital Volumes and RSPs

Table 4.3 shows the distribution of hospital admission volumes and Table 4.4 shows the distribution of hospital RSPs. The mean RSP decreased over the three-year period, from \$16,099 between July 2011 and June 2012 to \$16,023 between July 2013 and June 2014. The median hospital RSP in the combined three-year dataset was \$15,988 (IQR \$14,817 - \$17,178). Table 4.5 shows the between-hospital variance by individual year and for the combined three-year dataset. Between-hospital variance in the combined dataset was \$4,156,184 (SE: \$111,691). If there were no systematic differences between hospitals, the between-hospital variance would be \$0.

Figure 3 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 \$4,077 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

Table 4.1. 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	10,461	10,436	10,464	10,530
Age (65 – 74)	-889 (-970, -807)	-863 (-942, -784)	-709 (-793, -626)	-778 (-825, -730)
Age (75 – 84)	-488 (-560, -416)	-470 (-540, -400)	-395 (-469, -320)	-420 (-462, -379)
Age (>=85; reference group)	--	--	--	--
Severe infection (CC 1, 3-5)	2,420 (2,193, 2,648)	2,446 (2,223, 2,668)	2,038 (1,814, 2,262)	2,272 (2,141, 2,402)
Septicemia/shock (CC 2)	441 (298, 584)	378 (240, 516)	179 (40, 318)	312 (231, 393)
Other infectious diseases (CC 6)	431 (363, 498)	355 (290, 421)	259 (190, 328)	330 (290, 369)
Metastatic cancer or acute leukemia (CC 7)	1,026 (854, 1,199)	835 (667, 1,002)	908 (735, 1,080)	899 (800, 998)

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)
Lung, upper digestive tract, and other severe cancers (CC 8)	501 (356, 646)	377 (235, 519)	467 (322, 612)	419 (335, 502)
Lymphatic, head and neck, brain, and other major cancers (CC 9)	705 (563, 847)	617 (481, 754)	482 (341, 622)	572 (491, 653)
Benign neoplasms of skin, breast, eye (CC 14)	-455 (-544, -365)	-387 (-474, -301)	-463 (-553, -373)	-449 (-501, -397)
Diabetes mellitus (DM) or DM complications (CC 15-19, 119-120)	469 (406, 532)	459 (398, 520)	476 (411, 540)	457 (420, 493)
Protein-calorie malnutrition (CC 21)	3,871 (3,760, 3,981)	3,942 (3,835, 4,050)	3,644 (3,533, 3,755)	3,762 (3,699, 3,825)
Other significant endocrine and metabolic disorders (CC 22)	1,220 (1,101, 1,339)	1,208 (1,095, 1,322)	1,286 (1,169, 1,404)	1,211 (1,144, 1,279)
Liver disease (CC 25-28)	820 (585, 1,056)	636 (414, 857)	731 (508, 954)	710 (579, 841)
Gallbladder and biliary tract disorders (CC 30)	813 (628, 997)	625 (445, 805)	714 (525, 903)	710 (603, 817)
Appendicitis (CC 35)	1,417 (554, 2,280)	1,497 (628, 2,366)	1,215 (363, 2,068)	1,366 (867, 1,865)
Bone/joint/muscle infections/necrosis (CC 37)	1,732 (1,469, 1,994)	1,482 (1,227, 1,737)	1,573 (1,310, 1,836)	1,589 (1,438, 1,739)
Osteoporosis and other bone/cartilage disorders (CC 41)	-271 (-343, -200)	-237 (-307, -167)	-296 (-370, -222)	-276 (-318, -234)
Severe hematological disorders (CC 44)	494 (298, 691)	477 (249, 706)	644 (398, 890)	563 (436, 691)
Disorders of immunity (CC 45)	1,009 (829, 1,189)	883 (725, 1,041)	884 (721, 1,046)	880 (784, 976)
Iron deficiency or other unspecified anemias and blood disease (CC 47)	1,341 (1,277, 1,404)	1,277 (1,215, 1,339)	1,192 (1,126, 1,257)	1,248 (1,211, 1,285)
Delirium and encephalopathy (CC 48)	335 (201, 469)	267 (139, 395)	236 (106, 365)	249 (174, 325)
Dementia or other specified brain disorders (CC 49-50)	1,266 (1,192, 1,340)	1,228 (1,157, 1,300)	1,151 (1,076, 1,227)	1,176 (1,133, 1,218)
Drug/alcohol psychosis or dependence (CC 51-52)	1,189 (994, 1,384)	1,153 (967, 1,338)	1,019 (834, 1,204)	1,121 (1,012, 1,230)
Major psychiatric disorders (CC 54-56)	959 (861, 1,057)	895 (801, 990)	818 (719, 916)	863 (807, 919)
Hemiplegia, paraplegia, paralysis, spinal cord disorder and amputation (67-69, 100-101, 177-178)	1,303 (1,162, 1,445)	1,347 (1,208, 1,485)	1,276 (1,133, 1,420)	1,295 (1,213, 1,376)

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)
Muscular dystrophy and/or polyneuropathy (CC 70-71)	666 (563, 769)	626 (528, 725)	581 (480, 681)	610 (551, 668)
Multiple sclerosis and Parkinson's (CC 72-73)	1,344 (1,197, 1,491)	1,473 (1,328, 1,619)	1,380 (1,228, 1,532)	1,369 (1,283, 1,454)
Seizure disorders and convulsions (CC 74)	805 (668, 943)	849 (715, 983)	846 (706, 985)	812 (733, 891)
Coma, brain compression/anoxic damage (CC 75)	1,675 (1,223, 2,128)	1,405 (978, 1,833)	1,602 (1,162, 2,042)	1,519 (1,265, 1,773)
Mononeuropathy, other neurological conditions/injuries (CC 76)	-338 (-425, -251)	-277 (-361, -192)	-175 (-263, -88)	-262 (-312, -212)
Respiratory arrest/cardiorespiratory failure/respirator dependence (CC 77-79)	739 (647, 831)	774 (685, 863)	558 (467, 650)	680 (628, 733)
Congestive heart failure (CC 80)	525 (453, 597)	429 (359, 500)	520 (445, 594)	500 (458, 542)
Angina pectoris/old myocardial infarction (CC 83)	-343 (-427, -260)	-388 (-470, -307)	-430 (-515, -344)	-390 (-438, -341)
Heart infection/inflammation, except rheumatic (CC 85)	1,485 (1,228, 1,742)	1,405 (1,159, 1,652)	1,484 (1,231, 1,738)	1,445 (1,299, 1,592)
Valvular or rheumatic heart disease (CC 86)	368 (292, 444)	460 (386, 533)	464 (386, 541)	406 (363, 450)
Hypertensive heart and renal disease or encephalopathy; hypertensive heart disease (CC 89-90)	709 (635, 782)	680 (609, 751)	691 (617, 765)	667 (624, 709)
Stroke (CC 95-96)	585 (463, 707)	400 (281, 519)	394 (268, 520)	451 (380, 522)
Speech, language, cognitive, perceptual deficits; cerebrovascular disease late effects, unspecified (CC 102-103)	563 (426, 699)	483 (352, 614)	566 (427, 706)	519 (441, 598)
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	496 (433, 559)	566 (505, 627)	418 (354, 483)	489 (452, 525)
Asthma (CC 110)	-901 (-991, -811)	-901 (-988, -814)	-920 (-1,012, -828)	-911 (-963, -859)
Pneumococcal pneumonia, emphysema, lung abscess (CC 112)	-704 (-901, -507)	-595 (-798, -393)	-619 (-834, -404)	-634 (-752, -515)
Viral and unspecified pneumonia, pleurisy (CC 113)	1,152 (1,086, 1,218)	1,245 (1,181, 1,309)	1,428 (1,361, 1,495)	1,259 (1,221, 1,297)

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)
Pleural effusion/pneumothorax (CC 114)	305 (204, 406)	305 (206, 404)	208 (106, 311)	273 (214, 331)
Other lung disorders (CC 115)	-251 (-315, -188)	-203 (-264, -141)	-206 (-271, -140)	-225 (-262, -188)
Other eye disorders (CC 124)	-233 (-305, -162)	-263 (-332, -194)	-267 (-339, -194)	-258 (-299, -217)
Significant ear, nose, and throat disorders (CC 125)	722 (491, 953)	753 (531, 975)	784 (553, 1,014)	739 (607, 871)
Other ear, nose, throat, and mouth disorders (CC 127)	-517 (-579, -455)	-532 (-591, -472)	-457 (-520, -394)	-494 (-530, -458)
Dialysis status (CC 130)	3,177 (2,908, 3,446)	2,849 (2,598, 3,101)	2,557 (2,301, 2,812)	2,810 (2,660, 2,960)
Incontinence (CC 134)	373 (258, 488)	353 (242, 464)	435 (319, 551)	401 (335, 467)
Other female genital disorders (CC 139)	-379 (-510, -249)	-372 (-500, -243)	-409 (-547, -271)	-376 (-453, -300)
Decubitus ulcer or chronic skin ulcer (CC148-149)	992 (882, 1,102)	1,048 (940, 1,156)	1,160 (1,048, 1,273)	1,047 (984, 1,111)
Vertebral fractures (CC 157)	946 (792, 1,100)	872 (722, 1,022)	1,126 (969, 1,282)	966 (877, 1,055)
Major fracture, except of skull, vertebrae, or hip (CC 159)	656 (450, 861)	563 (362, 763)	636 (426, 846)	608 (489, 727)
Internal injuries (CC 160)	1,773 (1,444, 2,102)	1,567 (1,244, 1,889)	1,660 (1,328, 1,992)	1,635 (1,445, 1,825)
Traumatic amputation and other Injuries (CC 161-162)	359 (293, 425)	389 (325, 453)	317 (250, 385)	365 (327, 403)
Poisonings and allergic reaction (CC 163)	-290 (-389, -191)	-302 (-400, -204)	-232 (-336, -128)	-275 (-333, -217)
Major symptoms, abnormalities (CC 166)	673 (596, 750)	685 (611, 759)	620 (540, 699)	644 (599, 688)
Minor symptoms, signs, findings (CC 167)	188 (96, 280)	321 (231, 412)	303 (203, 403)	267 (212, 321)

Table 4.2. 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)	1.06-1.06	1.06-1.06	1.06-1.06	1.06-1.06
Quasi-R ²	0.10	0.10	0.09	0.10

Table 4.3. 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	4,609	4,603	4,562	4,693
Mean number of admissions (SD)	93 (97)	98 (104)	89 (97)	274 (295)
Range (min. – max.)	1 - 963	1 - 1039	1 - 1010	1-3012
25 th percentile	25	25	21	67
50 th percentile	60	61	55	168
75 th percentile	131	137	127	393

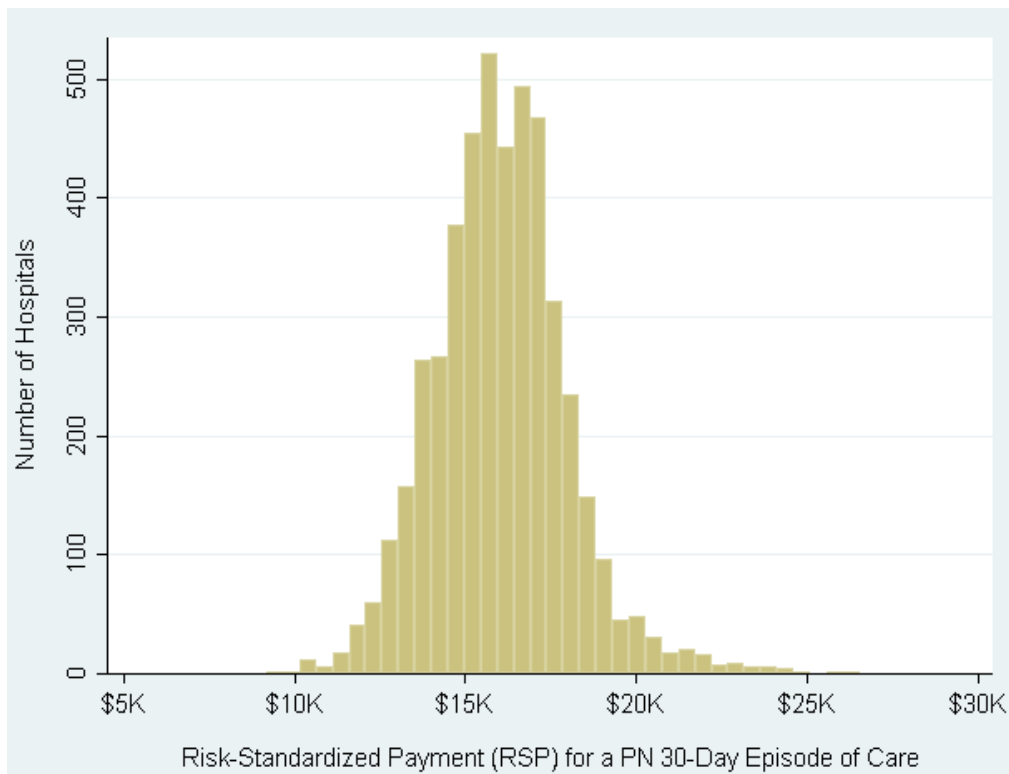
Table 4.4. Distribution of Hospital Pneumonia RSPs Over Different Time Periods (\$2013)

Characteristic	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Number of hospitals	4,609	4,603	4,562	4,693
Mean (SD)	16,099 (1,645)	16,082 (1,654)	16,023 (1,691)	16,056 (1,954)
Range (min. – max.)	9,933 - 25,499	10,175 - 24,870	9,991 - 23,649	9,193 - 26,546
25 th percentile	14,995	15,016	14,927	14,817
50 th percentile	16,081	16,042	16,014	15,988
75 th percentile	17,127	17,130	17,064	17,178

Table 4.5. Between-Hospital Variance for Pneumonia RSPs (\$2013)

	07/2011-06/2012	07/2012-06/2013	07/2013-06/2014	07/2011-06/2014
Between hospital-variance (SE) (\$)	3,613,046 (117,081)	3,671,380 (122,546)	3,897,715 (134,683)	4,156,184 (111,691)

Figure 3. Distribution of Hospital Pneumonia 30-Day Episode-of-Care RSPs between July 2011 and June 2014 (\$2013) (N=4,693)



5. COMPARISON OF CURRENT AND REVISED MEASURES

This revised pneumonia payment measure differs from the measure that is currently publicly reported on *Hospital Compare*. The revision of this measure ensures that it more fully reflects the population of Medicare FFS beneficiaries being treated for pneumonia and that the patients included are comparable across hospitals in the United States. For full transparency, below we compare the current and revised measures and the impact of the revised measure on hospital-level performance.

5.1 Admissions for Current and Revised Pneumonia Payment Measure Cohorts

For the July 2011 to June 2014 dataset, the revised measure cohort included 178,738 admission (13.9%) with aspiration pneumonia as a principal discharge diagnosis, and 229,708 admissions (17.8%) with sepsis as a principal discharge diagnosis and a secondary discharge diagnosis of pneumonia or aspiration pneumonia, POA. Overall, the cohort expansion added 386,143 admissions to the revised measure (43% more admissions than the current measure).

Table 5.1 shows admissions in the July 2011 to June 2014 dataset using the current and revised cohort definitions. Descriptions of the exclusion criteria and rationale for each are included in Appendix B.

Table 5.1 Pneumonia Payment Cohort Exclusions in the July 2011-June 2014 Dataset

		Current Measure Cohort	Revised Measure Cohort
Admissions Meeting Inclusion Criteria		1,099,614	1,650,716
Admissions Removed based on Exclusion Criteria		-121,317	-200,065
Individual exclusion criteria (not mutually exclusive)	1. Incomplete administrative data in the 30 days following the index admission if discharged alive	-39,974 (3.64%)	-84,387 (5.11%)
	2. Discharged alive on the day of admission or the following day who were not transferred	-46,934 (4.27%)	-59,376 (3.60%)
	3. Inconsistent or unknown patient vital status, or other unreliable demographic data (age and gender)	-29 (0.00%)	-56 (0.00%)
	4. Admissions where patients are discharged against medical advice (AMA)	-3,425 (0.31%)	-4,367 (0.26%)
	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	-16,631 (1.51%)	-32,650 (1.98%)
	6. Transferred to federal hospitals	-988 (0.09%)	-1,933 (0.12%)
	7. Could not be matched to admission in the pneumonia mortality measure	-18,836 (1.71%)	-28,711 (1.74%)
	8. Missing index DRG weight and provider received no payment	-5,318 (0.49%)	-7,984 (0.49%)

		Current Measure Cohort	Revised Measure Cohort
Cohort after Exclusion Criteria		978,297	1,450,651
Additional Admissions Removed		-76,533	-162,744
Additional admission removed	Randomly select one hospitalization per patient per year	-76,082 (7.78%)	-161,709 (11.15%)
	Admissions within 30 days of previous index	-451 (0.05%)	-1,035 (0.08%)
Final Cohort		901,764	1,287,907

5.2 Risk Adjustment Variables

The current pneumonia payment risk-adjustment model includes 48 variables. As a result of the variable reselection process described in [Section 3.3.4](#), the revised risk-adjustment model includes 57 variables ([Table B.4](#)). The revised model includes 37 of the same variables that are in the current model as well as 20 additional variables ([Table 5.2](#)). There are 11 variables that are included in the current model not included in the revised model ([Table 5.3](#)).

Table 5.2. Risk-Adjustment Variables in the Revised Pneumonia Payment Model that Are Not Included in the Current Pneumonia Payment Model.

Variable	CC Code
Septicemia/shock	CC 2
Benign neoplasms of skin, breast, eye	CC 14
Liver disease	CC 25-28
Gallbladder and biliary tract disorders	CC 30
Appendicitis	CC 35
Disorders of immunity	CC 45
Seizure disorders and convulsions	CC 74
Mononeuropathy, other neurological conditions/injuries	CC 76
Hypertensive heart and renal disease or encephalopathy; hypertensive heart disease	CC 89-90
Speech, language, cognitive, perceptual deficits; cerebrovascular disease late effects, unspecified	CC 102-103
Pneumococcal pneumonia, emphysema, lung abscess	CC 112
Viral and unspecified pneumonia, pleurisy	CC 113
Other lung disorders	CC 115
Other eye disorders	CC 124
Significant ear, nose, and throat disorders	CC 125
Incontinence	CC 134
Other female genital disorders	CC 139
Traumatic amputation; other injuries	CC 161-162
Poisonings and allergic reaction	CC 163

Variable	CC Code
Minor symptoms, signs, findings	CC 167

Table 5.3. Risk-Adjustment Variables in the Current Pneumonia Payment Model that Are Not Included in the Revised Pneumonia Payment Model.

Variable	CC Code
Other endocrine/metabolic/nutritional disorders	CC 24
Other gastrointestinal disorders	CC 36
Drug/alcohol abuse, without dependence	CC 53
Hypertension	CC 91
Specified arrhythmias and other heart rhythm disorders	CC 92-93
Vascular or circulatory disease	CC 104-106
Fibrosis of lung or other chronic lung disorders	CC 109
Aspiration and specified bacterial pneumonias	CC 111
Renal failure	CC 131
Head injury	CC 154-156
Hip fracture/dislocation	CC 158

5.3 Same-Hospital Change in Predicted/Expected 30-Day Payment for the Current and Revised Pneumonia Payment Measure Cohorts

The observed mean national 30-day payment is \$14,294 for the current pneumonia payment measure cohort and \$16,116 for the revised measure cohort (all payments inflation-adjusted to \$2,013 and Winsorized at 99.9%). This leads to a 12.7% overall increase in RSP, reflecting the inclusion of potentially “sicker” patients with the cohort expansion. To examine the impact on hospitals of expanding the cohort, we assessed the change in a hospital’s predicted payment/expected payment ratio (P/E ratio) in the revised measure by subtracting a hospital’s P/E ratio for the current cohort from its P/E ratio for the revised cohort, dividing by its P/E for the current cohort, and then multiplying by 100 to obtain a percent change.

The numerator of the P/E ratio (predicted payment) for each hospital is the 30-day payment predicted based on the specific hospital and its observed case mix, and the denominator of the P/E ratio (expected payment) is the payment expected based on the nation and the specific hospital’s case mix. This approach 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. A ratio less than 1 indicates a lower-than-expected 30-day payment, and a ratio greater than 1 indicates a higher-than-expected 30-day payment. For further details, please refer to [Section 3.5](#).

[Table 5.4](#) shows the distribution of the P/E ratio percent change $((P/E)_{\text{revised}} - (P/E)_{\text{current}}) / (P/E)_{\text{current}} \times 100$. Overall about 44% of hospitals experienced an increase in their P/E ratio with the expansion of the cohort, while 56% experienced a decrease in their P/E ratio, but the magnitude of change tended to be small in either direction for most hospitals. The median change was -0.68%, roughly equivalent to a decrease of \$100 in a hospital’s 30-day episode-of-care payment. After the cohort expansion, 38 hospitals (0.8%) had a P/E ratio decrease of 10% or more, and 112 hospitals

(2.4%) had a P/E ratio increase of 10% or more (Table 5.5). The vast majority of hospitals (96.8%) had a P/E ratio change between +/- 10%.

Table 5.4. Distribution of the P/E Ratio Percent Change (N=4,685)

Distribution	P/E Ratio Percentage Change
Min	-16.72
1%	-9.8
5%	-7.1
10%	-5.73
25% Q1	-3.42
Median	-0.68
75% Q3	2.32
90%	5.52
95%	7.74
99%	13.11
Max	30.74

Table 5.5. Percent Change in Same-Hospital P/E Ratio Calculated with the Expanded Cohort Compared to the Current Cohort (N=4,685)

% Change in P/E Ratio	Number of Hospitals	% of Hospitals
-10 ⁺	38	0.81
-5 – < (-10)	636	13.58
-3 – < (-5)	649	13.85
-1 – < (-3)	876	18.70
0 – < (-1)	411	8.77
0 – < 1	425	9.07
1 – < 3	683	14.58
3 – < 5	414	8.84
5 – < 10	441	9.41
10 ⁺	112	2.39

5.4 Hospital-Level Reclassification of Outlier Status

Expanding the pneumonia payment measure cohort resulted in an increase in the number of hospitals considered outliers, as well as changes in the outlier status classification of hospitals (Table 5.6). Of the 670 hospitals that were categorized as “Greater than the National Payment” using the current measure cohort definition, 612 hospitals remained in the “Greater than the National Payment”, 58 moved to “No Different than the National Payment” with the adoption of the expanded cohort. Of the 2,852 hospitals that were categorized as “No Different than the National Payment” using the current cohort definition, 390 moved to “Greater than the National Payment,” 2,103 remained “No Different than the National Payment,” and 359 moved to “Less than the National Payment” with adoption of the expanded cohort. Of the 684 hospitals categorized as “Less than the National Payment” using the current cohort

definition, 74 moved to “No Different than the National Payment” and 610 remained “Less than the National Payment” with the adoption of the expanded cohort.

Table 5.6. Hospital-Level Reclassification of Outlier Status for the Current Pneumonia Payment Measure Cohort and the Expanded Pneumonia Payment Measure Cohort

Current Payment Measure Cohort (V 2.0)	Expanded Pneumonia Payment Measure Cohort (V 3.1)			
	Number of Hospitals			
	“Higher than the National Payment”	“No Different than the National Payment”	“Less than the National Payment”	Number of Cases Too Small (fewer than 25)
“Higher than the National Payment”	612	58	0	0
“No Different than the National Payment”	390	2,103	359	0
“Less than the National Payment”	0	74	610	0
Number of Cases Too Small (fewer than 25)	5	69	7	398

GLOSSARY

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

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

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

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

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

Confidence Interval (CI): A confidence interval is a range of values that describes the uncertainty surrounding an estimate. It is indicated by its endpoints; for example, a 95% confidence interval for the **coefficient** associated with protein-calorie malnutrition noted as “3,278, 3,445” would indicate that there is 95% confidence that the **coefficient** lies between 3,278 and 3,445.”

Expected payment: The total payment expected on the basis of an average hospital for a specific hospital’s case mix.

Hierarchical model: A widely accepted statistical method that enables fair evaluation of relative hospital results 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 effects.

Hospital-specific intercept: A measure of the hospital effect on payment calculated through hierarchical generalized linear regression, taking into consideration how many patients were eligible for the cohort, these patients’ risk factors, and these patients’ total payments. The hospital-specific effect is the calculated random effect intercept for each hospital. The hospital-specific effect will be negative for a lower-than-average-payment hospital, positive for a higher-than-average-payment hospital, and close to zero for an average-payment hospital. The hospital-specific effect is used in the numerator to calculate “predicted” payment.

Index admission: Any admission included in the measure calculation as the initial admission for an episode of pneumonia care and evaluated for the outcome.

Interval estimate: Similar to a CI, the interval estimate is a range of probable values for the measure that characterizes the amount of associated uncertainty. For example, a 95% interval estimate for an 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 in which providers receive a fee or payment for each individual service provided directly from Medicare. Only beneficiaries in Medicare FFS, not in managed care (Medicare Advantage), are included in the 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 during the episode of care.

Predicted payment: The total payment during the episode of care predicted based on the hospital's results with its observed case mix, also referred to as "adjusted actual" payment.

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

Variable Coefficients: Represents the change in the predicted value of total payment for a patient with that particular risk factor, holding all other risk factors constant. For example, a coefficient associated with severe infection of 2,420 would indicate that, on average, a patient with severe infection will have a predicted total payment that is \$2,420 higher than a patient without severe infection.

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APPENDICES

Appendix A. Statistical Approach to Risk-Standardized Payments for Pneumonia Measure

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 measure adjusts for variables (for example, age, comorbid disease, and indicators of patient frailty) that are clinically relevant and have strong relationships with the outcome.

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.¹¹ The pneumonia RSP was estimated using an identity link and a Gamma distribution. A generic model is presented here:

$$h(Y_{ij}) = \alpha_i + \beta Z_{ij} \quad (1)$$

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

where i indexes hospitals, j indexes patients within hospitals, α_i represents the hospital-specific intercept, 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.¹⁷ 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, $\hat{\mu}$, $\{\alpha_1, \alpha_2, \dots, \alpha_{ij}\}$, $\hat{\beta}$, 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:

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

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

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

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 $R\widehat{SP}_i$ 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).

Creating Interval Estimates

Because the statistic described in Equation 5, i.e., $R\widehat{SP}_i$, 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

Appendix B. Revised Pneumonia Payment Measure Specifications

Cohort

Inclusion Criteria for Pneumonia Measure

1. Principal discharge diagnosis of pneumonia

Rationale: Pneumonia is the condition targeted for measurement (Tables [B.1.1](#), [B.1.2](#), and [B.2.2](#)).

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 Medicare 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 substantially less expensive

Table B.1.1 – ICD-9-CM Codes that Define Patients with Pneumonia

ICD-9-CM Codes	Description
480.0	Pneumonia due to adenovirus
480.1	Pneumonia due to respiratory syncytial virus
480.2	Pneumonia due to parainfluenza virus
480.3	Pneumonia due to SARS-associated coronavirus
480.8	Pneumonia due to other virus not elsewhere classified
480.9	Viral pneumonia, unspecified
481	Pneumococcal pneumonia (streptococcus pneumoniae pneumonia)
482.0	Pneumonia due to klebsiella pneumoniae
482.1	Pneumonia due to pseudomonas
482.2	Pneumonia due to Hemophilus influenzae (H. influenzae)
482.30	Pneumonia due to streptococcus, unspecified

ICD-9-CM Codes	Description
482.31	Pneumonia due to streptococcus, group A
482.32	Pneumonia due to streptococcus, group B
482.39	Pneumonia due to other streptococcus
482.40	Pneumonia due to staphylococcus, unspecified
482.41	Methicillin susceptible pneumonia due to staphylococcus aureus
482.42	Methicillin resistant pneumonia due to staphylococcus aureus
482.49	Other staphylococcus pneumonia
482.81	Pneumonia due to anaerobes
482.82	Pneumonia due to Escherichia coli (E. coli)
482.83	Pneumonia due to other gram-negative bacteria
482.84	Pneumonia due to Legionnaires' disease
482.89	Pneumonia due to other specified bacteria
482.9	Bacterial pneumonia, unspecified
483.0	Pneumonia due to mycoplasma pneumoniae
483.1	Pneumonia due to chlamydia
483.8	Pneumonia due to other specified organism
485	Bronchopneumonia, organism unspecified
486	Pneumonia, organism unspecified
487.0	Influenza with pneumonia
488.11	Influenza due to identified 2009 H1N1 influenza virus with pneumonia

Table B.1.2 – ICD-10-CM Codes that Define Patients with Pneumonia

ICD-10-CM Codes	Description
A48.1	Legionnaires' disease
J10.08	Influenza due to other identified influenza virus
J11.0	Influenza due to unidentified influenza virus with unspecified type of pneumonia
J12.0	Adenoviral pneumonia
J12.1	Respiratory syncytial virus pneumonia
J12.2	Parainfluenza virus pneumonia
J12.81	Pneumonia due to SARS-associated coronavirus
J12.89	Other viral pneumonia
J12.9	Viral pneumonia, unspecified
J13	Pneumonia due to streptococcus pneumoniae
J14	Pneumonia due to Hemophilus influenzae
J15.0	Pneumonia due to klebsiella pneumoniae
J15.1	Pneumonia due to pseudomonas
J15.20	Pneumonia due to staphylococcus, unspecified
J15.29	Pneumonia due to other staphylococcus
J15.3	Pneumonia due to streptococcus, group B

ICD-10-CM Codes	Description
J15.4	Pneumonia due to other streptococci
J15.5	Pneumonia due to Escherichia coli
J15.6	Pneumonia due to other aerobic gram-negative bacteria
J15.7	Pneumonia due to mycoplasma pneumoniae
J15.8	Pneumonia due to other specified bacteria
J15.9	Unspecified bacterial pneumonia
J16.0	Chlamydial pneumonia
J16.8	Pneumonia due to other specified infectious organisms
J18.0	Bronchopneumonia, unspecified organism
J18.1	Lobar pneumonia, unspecified organism
J18.9	Pneumonia, unspecified organism
J69.0	Pneumonitis due to inhalation of food and vomit
J152.11	Pneumonia due to methicillin susceptible staphylococcus
J152.12	Pneumonia due to methicillin resistant staphylococcus

Table B.2.1 – ICD-9-CM Codes that Define Patients with Aspiration Pneumonia

ICD-9-CM Codes	Description
507.0	Pneumonitis due to inhalation of food or vomitus

Table B.2.2 – ICD-10-CM Codes that Define Patients with Aspiration Pneumonia

ICD-10-CM Codes	Description
J690	Pneumonitis due to inhalation of food and vomit

Table B.3.1– ICD-9-CM Codes that Define Patients with Sepsis (Not Including Severe Sepsis; Cohort Requires Principal Discharge Diagnosis of Sepsis Combined with a Secondary Discharge Diagnosis of Pneumonia or Aspiration Pneumonia [no Secondary Discharge Diagnosis of Severe Sepsis] Coded as POA)

ICD-9-CM Codes	Description
038.0	Streptococcal septicemia
038.10	Staphylococcal septicemia, unspecified
038.11	Methicillin susceptible staphylococcus aureus septicemia
038.12	Methicillin resistant staphylococcus aureus septicemia
038.19	Other staphylococcal septicemia
038.2	Pneumococcal septicemia [streptococcus pneumoniae septicemia]
038.3	Septicemia due to anaerobes
038.40	Septicemia due to gram-negative organism, unspecified
038.41	Septicemia due to Hemophilus influenzae [H. influenzae]
038.42	Septicemia due to Escherichia coli [E. coli]
038.43	Septicemia due to pseudomonas

ICD-9-CM Codes	Description
038.44	Septicemia due to serratia
038.49	Other septicemia due to gram-negative organisms
038.8	Other specified septicemias
038.9	Unspecified septicemia
995.91	Sepsis

Table B.3.2– ICD-10-CM Codes that Define Patients with Sepsis (Not Including Severe Sepsis; Cohort Requires Principal Discharge Diagnosis of Sepsis Combined with a Secondary Discharge Diagnosis of Pneumonia or Aspiration Pneumonia [no Secondary Discharge Diagnosis of Severe Sepsis] Coded as POA)

ICD-10-CM Codes	Description
A40.3	Sepsis due to streptococcus pneumoniae
A40.9	Streptococcal sepsis, unspecified
A41.01	Sepsis due to methicillin susceptible staphylococcus
A41.02	Sepsis due to methicillin resistant staphylococcus
A41.1	Sepsis due to other specified staphylococcus
A41.2	Sepsis due to unspecified staphylococcus
A41.3	Sepsis due to Hemophilus influenzae
A41.4	Sepsis due to anaerobes
A41.50	Gram-negative sepsis, unspecified
A41.51	Sepsis due to Escherichia coli
A41.52	Sepsis due to pseudomonas
A41.53	Sepsis due to serratia
A41.59	Other gram-negative sepsis
A41.89	Other specified sepsis
A41.9	Sepsis, unspecified organism

Risk Adjustment

Table B.4 – Risk-Adjustment Variables for the Revised Pneumonia Payment Measure

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by “X”)
Age	n/a	
Severe infection	CC 1 HIV/AIDS	
	CC 3 Central nervous system infection	
	CC 4 Tuberculosis	
	CC 5 Opportunistic infections	
Septicemia/shock	CC 2 Septicemia/Shock	X
Other infectious diseases	CC 6 Other infectious diseases	X

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by “X”)
Metastatic cancer, acute leukemia and other severe cancers	CC 7 Metastatic cancer or acute leukemia	Not matched to an admission in the pneumonia mortality measure; or
	CC 8 Lung, upper digestive tract, and other severe cancers	
Lymphatic, head and neck, brain, and other major cancers	CC 9 Lymphatic, head and neck, brain, and other major cancers	
Benign neoplasms of skin, breast, eye	CC 14 Benign neoplasms of skin, breast, eye	
Diabetes mellitus (DM) or DM complications	CC 15 Diabetes with renal manifestation	
	CC 16 Diabetes with neurologic or peripheral circulatory manifestation	
	CC 17 Diabetes with acute complications	X
	CC 18 Diabetes with ophthalmologic manifestation	
	CC 19 Diabetes with no or unspecified complications	
	CC 119 Proliferative diabetic retinopathy and vitreous hemorrhage	
	CC 120 Diabetic and other vascular retinopathies	
Protein-calorie malnutrition	CC 21 Protein-calorie malnutrition	
Other significant endocrine and metabolic disorders	CC 22 Other significant endocrine and metabolic disorders	
Liver disease	CC 25 End-stage liver disease	
	CC 26 Cirrhosis of liver	
	CC 27 Chronic hepatitis	
	CC 28 Acute liver failure/disease	X
Gallbladder and biliary tract disorders	CC 30 Gallbladder and biliary tract disorders	
Appendicitis	CC 35 Appendicitis	
Bone/joint/muscle infections/necrosis	CC 37 Bone/joint/muscle infections/necrosis	
Osteoporosis and other bone/cartilage disorders	CC 41 Osteoporosis and other bone/cartilage disorders	
Severe hematological disorders	CC 44 Severe hematological disorders	
Disorders of immunity	CC 45 Disorders of immunity	

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by “X”)
Iron deficiency or other unspecified anemias and blood disease	CC 47 Iron deficiency or other unspecified anemias and blood disease	
Delirium and encephalopathy	CC 48 Delirium and encephalopathy	X
Dementia and other specified brain disorders	CC 49 Dementia	
	CC 50 Senility, nonpsychotic organic brain syndromes/conditions	
Drug/alcohol psychosis or dependence	CC 51 Drug/alcohol psychosis	
	CC 52 Drug/alcohol dependence	
Major psychiatric disorders	CC 54 Schizophrenia	
	CC 55 Major depressive, bipolar, and paranoid disorders	
	CC 56 Reactive and unspecified psychosis	
Hemiplegia, paraplegia, paralysis, spinal cord disorder and amputation	CC 67 Quadriplegia, other extensive paralysis	
	CC 68 Paraplegia	
	CC 69 Spinal cord disorders/injuries	
	CC 100 Hemiplegia/hemiparesis	
	CC 101 Diplegia (upper), monoplegia, and other paralytic syndromes	
	CC 177 Amputation status, lower limb/amputation complications	
	CC 178 Amputation status, upper limb	
Muscular dystrophy and/or polyneuropathy	CC 70 Muscular Dystrophy	
	CC 71 Polyneuropathy	
Multiple sclerosis and Parkinson's	CC 72 Multiple sclerosis	
	CC 73 Parkinson's or Huntington's disease	
Seizure disorders and convulsions	CC 74 Seizure disorders and convulsions	
Coma, brain compression/anoxic damage	CC 75 Coma, brain compression/anoxic damage	X
Mononeuropathy, other neurological conditions/injuries	CC 76 Mononeuropathy, other neurological conditions/injuries	
Respiratory arrest/cardiorespiratory	CC 77 Respirator dependence/tracheostomy status	X
	CC 78 Respiratory arrest	X

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by “X”)
failure/respirator dependence	CC 79 Cardio-respiratory failure and shock	X
Congestive heart failure	CC 80 Congestive heart failure	X
Angina pectoris/old myocardial infarction	CC 83 Angina pectoris/old myocardial infarction	
Heart infection/inflammation, except rheumatic	CC 85 Heart infection/inflammation, except rheumatic	
Valvular or rheumatic heart disease	CC 86 Valvular or rheumatic heart disease	
Hypertensive heart and renal disease or encephalopathy; hypertensive heart disease	CC 89 Hypertensive heart and renal disease or encephalopathy	
	CC 90 Hypertensive heart disease	
Stroke	CC 95 Cerebral hemorrhage	X
	CC 96 Ischemic or unspecified stroke	X
Speech, language, cognitive, perceptual deficits; cerebrovascular disease late effects, unspecified	CC 102 Speech, language, cognitive, perceptual deficits	X
	CC 103 Cerebrovascular disease late effects, unspecified (CC 103)	
Chronic Obstructive Pulmonary Disease (COPD)	CC 108 Chronic Obstructive Pulmonary Disease (COPD)	
Asthma	CC 110 Asthma	
Pneumococcal pneumonia, emphysema, lung abscess	CC 112 Pneumococcal pneumonia, emphysema, lung abscess	X
Viral and unspecified pneumonia, pleurisy	CC 113 Viral and unspecified pneumonia, pleurisy	
Pleural effusion/pneumothorax	CC 114 Pleural effusion/pneumothorax	X
Other lung disorders	CC 115 Other lung disorders	
Other eye disorders	CC 124 Other eye disorders	
Significant ear, nose, and throat disorders	CC 125 Significant ear, nose, and throat disorders	
Other ear, nose, throat, and mouth disorders	CC 127 Other ear, nose, throat, and mouth disorders	
Dialysis status	CC 130 Dialysis status	X
Incontinence	CC 134 Incontinence	
Other female genital disorders	CC 139 Other female genital disorders	
	CC 148 Decubitus ulcer of skin	X

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
Decubitus ulcer or chronic skin ulcer	CC 149 Chronic ulcer of skin, except decubitus	
Vertebral fractures	CC 157 Vertebral fractures	
Major fracture, except of skull, vertebrae, or hip	CC 159 Major fracture, except of skull, vertebrae, or hip	X
Internal injuries	CC 160 Internal injuries	
Traumatic amputation; other injuries	CC 161 Traumatic amputation	
	CC 162 Traumatic amputation; other injuries	
Poisonings and allergic reactions	CC 163 Poisonings and allergic reactions	X
Major symptoms, abnormalities	CC 166 Major symptoms, abnormalities	
Minor symptoms, signs, findings	CC 167 Minor symptoms, signs, findings	

Outcome

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 pneumonia 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 C. Revised Pneumonia Payment Model Candidate Variables

Table C.1. Candidate Variables for Risk-Adjustment Variable Reselection for Revised Pneumonia Payment Model

Category	Variable	CC Code
Demographics	Age	N/A
Comorbidity	Severe infection	1, 3-5
Comorbidity	Septicemia/shock	2
Comorbidity	Other infectious diseases	6
Comorbidity	Metastatic cancer or acute leukemia	7
Comorbidity	Lung, upper digestive tract, and other severe cancers	8
Comorbidity	Lymphatic, head and neck, brain, and other major cancers	9
Comorbidity	Breast, prostate, colorectal and other cancers and tumors	10
Comorbidity	Other respiratory and heart neoplasms	11
Comorbidity	Other digestive and urinary neoplasms	12
Comorbidity	Other neoplasms	13
Comorbidity	Benign neoplasms of skin, breast, eye	14
Comorbidity	Diabetes mellitus (DM) or DM complications	15-19, 119-120
Comorbidity	Protein-calorie malnutrition	21
Comorbidity	Other significant endocrine and metabolic disorders	22
Comorbidity	Disorders of fluid/electrolyte/acid-base	23
Comorbidity	Obesity/disorders of thyroid, cholesterol, lipids	24
Comorbidity	Liver disease	25-28
Comorbidity	Other hepatitis and liver disease	29
Comorbidity	Gallbladder and biliary tract disorders	30
Comorbidity	Intestinal obstruction/perforation	31
Comorbidity	Pancreatic disease	32
Comorbidity	Inflammatory bowel disease	33
Comorbidity	Peptic ulcer, hemorrhage, other specified gastrointestinal disorders	34
Comorbidity	Appendicitis	35
Comorbidity	Other gastrointestinal disorders	36
Comorbidity	Bone/joint/muscle infections/necrosis	37
Comorbidity	Rheumatoid arthritis and inflammatory connective tissue disease	38
Comorbidity	Disorders of the vertebrae and spinal discs	39
Comorbidity	Osteoarthritis of hip or knee	40
Comorbidity	Osteoporosis and other bone/cartilage disorders	41
Comorbidity	Congenital/developmental skeletal and connective tissue disorders; other musculoskeletal and connective tissue disorders	42-43
Comorbidity	Severe hematological disorders	44
Comorbidity	Disorders of immunity	45
Comorbidity	Coagulation defects and other specified hematological disorders	46
Comorbidity	Iron deficiency or other unspecified anemias and blood disease	47
Comorbidity	Delirium and encephalopathy	48

Category	Variable	CC Code
Comorbidity	Dementia or other specified brain disorders	49-50
Comorbidity	Drug/alcohol psychosis or dependence	51-52
Comorbidity	Drug/alcohol abuse, without dependence	53
Comorbidity	Major psychiatric disorders	54-56
Comorbidity	Personality disorders	57
Comorbidity	Depression/anxiety	58-59
Comorbidity	Other psychiatric disorders	60
Comorbidity	Mental retardation or developmental disability	61-65
Comorbidity	Hemiplegia, paraplegia, paralysis, spinal cord disorder and amputation	67-69, 100-101, 177-178
Comorbidity	Muscular dystrophy and/or polyneuropathy	70-71
Comorbidity	Multiple sclerosis and Parkinson's	72-73
Comorbidity	Seizure disorders and convulsions	74
Comorbidity	Coma, brain compression/anoxic damage	75
Comorbidity	Mononeuropathy, other neurological conditions/injuries	76
Comorbidity	Respiratory arrest/cardiorespiratory failure/respirator dependence	77-79
Comorbidity	Congestive heart failure	80
Comorbidity	Acute coronary syndrome	81-82
Comorbidity	Angina pectoris/old myocardial infarction	83
Comorbidity	Coronary atherosclerosis/other chronic ischemic heart disease	84
Comorbidity	Heart infection/inflammation, except rheumatic	85
Comorbidity	Valvular or rheumatic heart disease	86
Comorbidity	Major congenital cardiac/circulatory defect	87-88
Comorbidity	Hypertensive heart and renal disease or encephalopathy; hypertensive heart disease	89-90
Comorbidity	Hypertension	91
Comorbidity	Specified arrhythmias and other heart rhythm disorders	92-93
Comorbidity	Other or unspecified heart disease	94
Comorbidity	Stroke	95-96
Comorbidity	Precerebral arterial occlusion and transient cerebral ischemia	97
Comorbidity	Congenital/developmental skeletal and connective tissue disorders; other musculoskeletal and connective tissue disorders	98-99
Comorbidity	Speech, language, cognitive, perceptual deficits; cerebrovascular disease late effects, unspecified	102-103
Comorbidity	Vascular or circulatory disease	104-106
Comorbidity	Cystic fibrosis	107
Comorbidity	Chronic Obstructive Pulmonary Disease (COPD)	108
Comorbidity	Fibrosis of lung or other chronic lung disorders	109
Comorbidity	Asthma	110
Comorbidity	Aspiration and specified bacterial pneumonias	111
Comorbidity	Pneumococcal pneumonia, emphysema, lung abscess	112
Comorbidity	Viral and unspecified pneumonia, pleurisy	113
Comorbidity	Pleural effusion/pneumothorax	114

Category	Variable	CC Code
Comorbidity	Other lung disorders	115
Comorbidity	Legally blind	116
Comorbidity	Major eye infections/inflammations	117
Comorbidity	Retinal detachment	118
Comorbidity	Retinal disorders, except detachment and vascular retinopathies	121
Comorbidity	Glaucoma	122
Comorbidity	Other eye disorders	124
Comorbidity	Significant ear, nose, and throat disorders	125
Comorbidity	Hearing loss	126
Comorbidity	Other ear, nose, throat, and mouth disorders	127
Comorbidity	Kidney transplant status; major organ transplant status; other organ transplant status	128, 174-175
Comorbidity	Dialysis status	130
Comorbidity	Renal failure	131
Comorbidity	Nephritis	132
Comorbidity	Urinary obstruction and retention	133
Comorbidity	Incontinence	134
Comorbidity	Urinary tract infection	135
Comorbidity	Other urinary tract disorders	136
Comorbidity	Pelvic inflammatory disease	138
Comorbidity	Other female genital disorders	139
Comorbidity	Male genital disorders	140
Comorbidity	Decubitus ulcer or chronic skin ulcer	148-149
Comorbidity	Extensive third-degree burns ; other third-degree and extensive burns	150-151
Comorbidity	Cellulitis, local skin infection and other dermatological disorders	152-153
Comorbidity	Head Injury	154-156
Comorbidity	Vertebral fractures	157
Comorbidity	Hip fracture/dislocation	158
Comorbidity	Internal injuries	160
Comorbidity	Traumatic amputation; other injuries	161-162
Comorbidity	Poisonings and allergic reactions	163
Comorbidity	Major complications of medical care and trauma	164
Comorbidity	Other complications of medical care	165
Comorbidity	Major symptoms, abnormalities	166
Comorbidity	Minor symptoms, signs, findings	167