Hospital-level 30-day Mortality Following Admission for an Acute Exacerbation of Chronic Obstructive Pulmonary Disease

Measure Methodology Report

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1. INTRODUCTION

1.1 Overview of Measure

Chronic obstructive pulmonary disease (COPD) affects as many as 24 million individuals in the United States and is the nation's fourth leading cause of death. Between 1998 and 2008, the number of patients hospitalized annually for acute exacerbations of COPD increased by approximately 18%.[1-3]

Reported in-hospital mortality rates for patients hospitalized for exacerbations of COPD range from 2-5%.[3-7] Information about 30-day mortality rates following hospitalization for COPD is more limited; however, international studies suggest that rates range from 3 to 9%[8,9], and 90-day mortality rates exceed 15%.[10]

To improve the quality of care for COPD patients, the Centers for Medicare & Medicaid Services (CMS) has contracted with Yale New Haven Health Services Corporation/Center for Outcomes Research and Evaluation (YNHHSC/CORE) to develop hospital outcomes measures of the quality of care delivered to patients who are hospitalized with an acute exacerbation of COPD. In this technical report we describe the development of a hospital-level 30-day measure of mortality after hospitalization for an acute exacerbation of COPD. We have also developed a complementary 30-day readmission measure. The methodology and results of the readmission measure are detailed in a separate technical report.

The overall methodological approach for developing this measure is consistent with that used to develop three prior CMS mortality measures endorsed by the National Quality Forum (NQF) for acute myocardial infarction (AMI), heart failure (HF), and pneumonia, which are now publicly reported by CMS on Hospital Compare (www.hospitalcompare.hhs.gov). The YNHHSC/CORE team developed the measure using Medicare claims and enrollment data. To account for the clustering of observations within hospitals and differences in the number of patient admissions across hospitals, we estimated risk-standardized mortality rates (RSMRs) with hierarchical logistic regression models.

1.2 COPD Mortality as a Measure of Quality

Outcomes measures can focus attention on a broad set of healthcare activities that affect patients' well being. Moreover, improving patient outcomes is the ultimate goal of quality improvement, so outcomes are a direct measure of success in quality improvement. Two statutes direct the Department of Health and Human Services to develop outcomes measures. The Deficit Reduction Act (DRA) of 2005 mandated that the Secretary of Health and Human Services publicly report quality measures that include measures of hospital outcomes and efficiency under the Hospital Inpatient Quality Reporting (IQR) Program (formerly the Reporting Hospital Quality Data for Annual Payment Update Program). In addition, the

Affordable Care Act of 2010 promotes the further development and use of outcomes measures.

Measurement of patient outcomes allows for a more comprehensive view of quality of care, encompassing more than that captured by individual process-of-care measures. Complex and critical aspects of care, such as communication between providers, prevention of and response to complications, patient safety, and coordinated transitions to the outpatient environment, all contribute to patient outcomes but are difficult to measure by individual processes.[11,12] Clinical trials and observational studies suggest that several aspects of care provided to patients hospitalized for exacerbations of COPD can have significant effects on mortality, thus supporting the essential construct of mortality as an appropriate outcome to measure quality.[13-16]

The goal of outcomes measurement is to evaluate patient outcomes after accounting for patients' conditions at the time of hospital admission (hospital case-mix). This mortality measure was developed to identify hospitals whose performance is better or worse than would be expected based on their patient case-mix, and therefore promote hospital quality improvement and better inform consumers about care quality.

1.3 Approach to Measure Development

We developed this measure in accordance with national guidelines for publicly reported outcomes measures, and in consultation with clinical and measurement experts, key stakeholders, and the public. The proposed measure is consistent with the technical approach to outcomes measurement set forth in NQF guidance for outcomes measures,[17] CMS' Measure Management System guidance, and the guidance articulated in the American Heart Association scientific statement, "Standards for Statistical Models Used for Public Reporting of Health Outcomes."[18] Throughout measure development, we obtained expert and stakeholder input via two mechanisms: first, through regular discussions with an advisory working group, and second, through meetings with a national Technical Expert Panel (TEP).

The working group was comprised of three physicians who are board-certified in pulmonary and critical care medicine and a pharmacoepidemiologist with expertise in COPD. All members have expertise in quality measure development. The working group meetings addressed key issues surrounding measure development, including detailed discussions regarding the appropriate cohort for inclusion in the measure. The working group provided a forum for focused expert review and discussion of technical issues during measure development prior to consideration by the broader TEP.

In addition to the working group, and in alignment with the CMS' Measure Management System, we convened a TEP, a group of recognized experts and stakeholders in relevant fields, to provide input and feedback during measure

development. To assemble the TEP, we released a public call for nominations and selected individuals with diverse perspectives and backgrounds, including clinicians, consumers, hospitals, purchasers, and experts in quality improvement. We convened three TEP conference calls during the course of measure development. In contrast to the working group meetings, the TEP meetings followed a more structured format consisting of presentation of key issues, relevant data, and our proposed approach. This presentation was followed by open discussion of these issues with TEP members.

Finally, we publicly posted the measure specifications and a summary of the TEP discussions and made a widely distributed call for public comments. We collected these comments through the Measure Management System Web site (https://www.cms.gov/MMS/17_CallforPublicComment.asp). We summarized the public comments for CMS and posted the verbatim comments on a freely accessible Web site. We took the comments we received into consideration during the final stages of measure development.

2. METHODS

2.1 Overview

We developed a hospital-level mortality measure for patients admitted with an acute exacerbation of COPD to non-federal acute care hospitals in the U.S. (including U.S. Virgin Islands, Puerto Rico, Guam, Northern Mariana Islands, and American Samoa).

To develop the measure, we used Medicare administrative datasets that contain hospitalization data for fee-for-service (FFS) Medicare beneficiaries hospitalized in calendar year 2008 with an acute exacerbation of COPD. The datasets also include administrative data on each patient for the 12 months prior to the index admission and the 30 days following it. An index admission is the hospitalization considered for the outcome.

We used hierarchical logistic regression modeling to adjust for differences in patient case-mix and hospital volume, and to account for the clustering of patients within a hospital. We risk-adjusted for patients' comorbid conditions, as identified in both inpatient and outpatient claims for the 12 months prior to the index hospitalization, as well as those present at admission. The model does not risk-adjust for diagnoses that may have been a complication of the index admission.

2.2 Data Sources

Part A inpatient data - contains final action claims data submitted by inpatient hospital providers for Medicare FFS beneficiaries for reimbursement of facility costs. Information in this file includes diagnoses (ICD-9 codes), procedures (ICD-9 procedure codes), Diagnosis Related Groups (DRGs), dates of service, hospital provider, and beneficiary demographic information.

Part A outpatient data - contains final action claims submitted by inpatient hospital providers for Medicare FFS claims paid for the facility component of surgical or diagnostic procedures, emergency room care, and other non-inpatient services performed in a hospital outpatient department or ambulatory surgical/diagnostic center.

Part B data - contains final action claims for the physician services (regardless of setting) and other outpatient care, services, and supplies for Medicare FFS beneficiaries. For purposes of this project, Part B services included only face-to-face encounters between a care provider and patient. We thus do not include services such as laboratory tests, medical supplies, or other ambulatory services.

Medicare Enrollment Database (EDB) - contains Medicare beneficiary demographic, benefit/coverage, and vital status information.

2.3 Outcome Definition

The outcome for this measure is 30-day all-cause mortality. We define this as death from any cause within 30 days of the admission date for the index hospitalization.

2.3.1 30-Day Timeframe

We chose 30-day mortality because it is an important outcome assessed in a standard period that can be strongly influenced by hospital care and the early transition to the outpatient setting. The 30-day standard period is necessary so that the outcome for each patient is measured consistently. Without a standard period, variation in length of stay would have an undue influence on mortality rates, and institutions would have an incentive to adopt strategies to shift deaths out of the hospital without improving quality. This outcome period is consistent with other NQF-endorsed publicly reported mortality measures (AMI, HF, and pneumonia).

2.3.2 All-Cause Mortality

We measure all-cause mortality rather than COPD-specific mortality for several reasons. First, limiting the measure to COPD-related mortalities may limit the focus of efforts to improve care to a narrow set of approaches (such as processes that will prevent a recurrent exacerbation) as opposed to encouraging broader initiatives aimed at improving the overall in-hospital care. Second, cause of death may be unreliably recorded and it is often not possible to exclude quality issues and accountability based on the documented cause of mortality. For example, a COPD patient who develops a hospital-acquired infection may ultimately die from sepsis. It would be inappropriate to treat this death as unrelated to the care the patient received for COPD. Finally, from a patient perspective death due to any cause is the outcome that matters.

2.4 Cohort Definition

COPD is a group of lung diseases characterized by airway obstruction. Patients hospitalized for an acute exacerbation of COPD (AECOPD) present with varying degrees of severity ranging from a worsening of baseline symptoms (dyspnea, cough, and/or sputum) to respiratory failure. To capture the full spectrum of severity of patients hospitalized for an AECOPD, we included patients with a principal diagnosis of COPD, as well as those with a principal diagnosis of respiratory failure who had a secondary diagnosis of an AECOPD. Requiring

AECOPD as a secondary code helps to identify respiratory failure due to COPD exacerbation versus another condition (e.g., heart failure).

Table 1. Final COPD Measure Cohort

ICD-9 Code	Description
491.21	Obstructive chronic bronchitis; with (acute) exacerbation; acute exacerbation of COPD, decompensated COPD, decompensated COPD with exacerbation.
491.22	Obstructive chronic bronchitis; with acute bronchitis
491.8	Other chronic bronchitis. Chronic: tracheitis, tracheobronchitis.
491.9	Unspecified chronic bronchitis
492.8	Other emphysema; emphysema (lung or pulmonary): NOS, centriacinar, centrilobular, obstructive, panacinar, panlobular, unilateral, vesicular. MacLeod's syndrome; Swyer-James syndrome; unilateral hyperlucent lung
493.20	Chronic obstructive asthma; asthma with COPD, chronic asthmatic bronchitis, unspecified
493.21	Chronic obstructive asthma; asthma with COPD, chronic asthmatic bronchitis, with status asthmaticus
493.22	Chronic obstructive asthma; asthma with COPD, chronic asthmatic bronchitis, with (acute) exacerbation
496	Chronic: nonspecific lung disease, obstructive lung disease, obstructive pulmonary disease (COPD) NOS. NOTE: This code is not to be used with any code from categories 491-493.
518.81*	Other diseases of lung; acute respiratory failure; respiratory failure NOS
518.82*	Other diseases of lung; acute respiratory failure; other pulmonary insufficiency, acute respiratory distress
518.84*	Other diseases of lung; acute respiratory failure; acute and chronic respiratory failure
799.1*	Other ill-defined and unknown causes of morbidity and mortality; respiratory arrest, cardiorespiratory failure
**Principal diagnosis when combined with a secondary diagnosis of AECOPD (491.21, 491.22, 493.21, or 493.22)*	

2.5 Inclusion/Exclusion Criteria

We used all admissions in 2008 Part A inpatient data to identify the cohort for inclusion in the measure. Admissions eligible for inclusion in the measure are those for patients aged 65 or older admitted to acute care hospitals with AECOPD. The flow chart depicting eligible admissions is presented in Figure 2. An index admission is any eligible admission to an acute care hospital assessed in the

measure for the outcome (died within 30 days of the date of the initial admission). Eligible index admissions are identified using the ICD-9 codes listed in Table 1.

Patients may have more than one admission during an acute episode of care for AECOPD. For example, a patient may be admitted to hospital A and then transferred to hospital B. The initial admission to hospital A and the admission to hospital B are considered one acute episode of care, made up of two inpatient admissions. We identified transferred patients as those who are admitted to an acute care hospital on the same day or following day of discharge from an eligible admission.

We excluded the following admissions from the measure:

- Admissions for patients without continuous enrollment in Medicare FFS for one year prior to the date of the index admission
  Rationale: This ensures full data availability for risk adjustment.

- Admissions for patients transferred into the hospital from another acute care hospital
  Rationale: We assign the outcome for the acute episode of care to the first admitting hospital (see Figure 1 below) because the first hospital initiates patient management and is responsible for any decision to transfer the patient. Therefore, the first admission in an acute episode of care (hospital A) is eligible to be an index admission in the measure. The second or subsequent admissions in the same acute episode are excluded from the measure.

- Admissions for patients with inconsistent or unknown mortality status
  Rationale: We cannot be sure of the accuracy of the outcome; this exclusion affects a very small number of admissions.

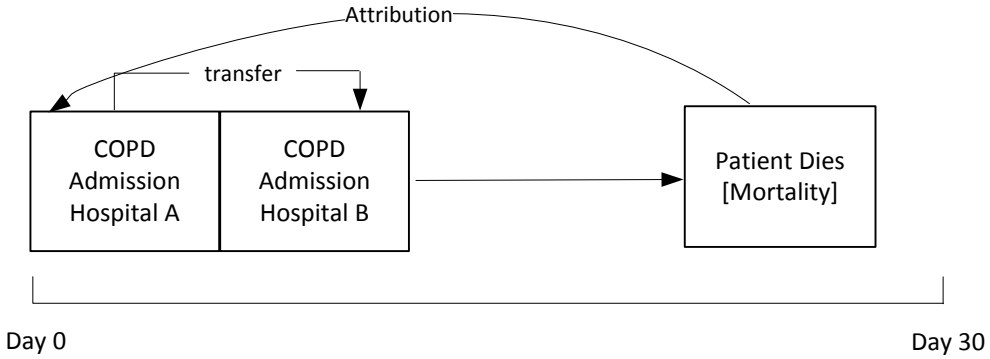
- Admissions for patients enrolled in Medicare Hospice in the 12 months prior to the index hospitalization, up to and including the date of the index admission
  Rationale: It is likely that these patients are continuing to seek comfort measures and their goal may not be survival.

- Admissions for patients who were discharged against medical advice (AMA)
  Rationale: Hospitals and physicians do not have the opportunity to provide the highest quality of care for these patients.

- Admissions with unreliable data (e.g. age > 115)
  Rationale: We cannot be sure of the accuracy of the outcome; this exclusion affects a very small number of admissions.

- After applying the exclusion criteria above, we randomly select one admission per year for patients with multiple index admissions in one year. We therefore exclude the other eligible index admissions in the 12 month period.
  Rationale: Each episode of care must be mutually independent with the same probability of the outcome. The probability of death increases with each subsequent admission and therefore the episodes of care are not mutually independent. We therefore select one admission for inclusion in the measure.

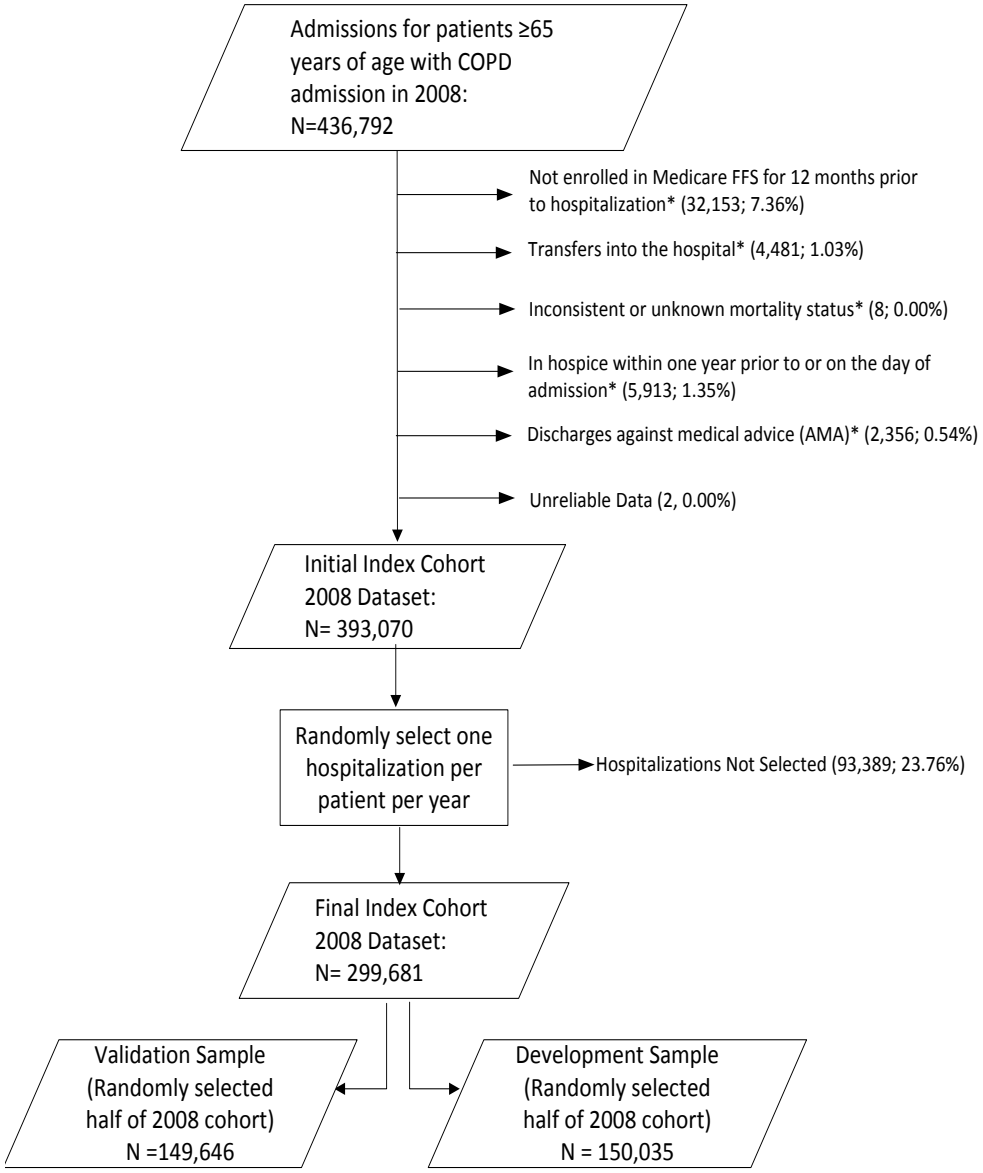
Figure 1. Attribution of Mortality Outcome



2.6 Model Development and Validation Samples

To create the model development and validation samples, we applied the inclusion and exclusion criteria to all 2008 admissions. We randomly selected half of all COPD admissions in 2008 that met the inclusion and exclusion criteria to create a model development sample and used the remaining admissions as our model validation sample.

Figure 2. Model Development and Validation Samples



*Categories are not mutually exclusive

2.7 Approach to Risk Adjustment

The goal of risk adjustment is to account for patient demographic and clinical characteristics in order to illuminate differences in care quality. The model adjusts for case-mix differences based on the clinical status of the patient at the time of admission. Conditions that may represent adverse outcomes due to care received during the index admission are not considered for inclusion in the risk-adjusted model. Although they may increase the risk of mortality, including them as covariates in a risk-adjusted model could attenuate the measure's ability to characterize the quality of care delivered by hospitals. Appendix A lists the conditions not adjusted for if they only appear in the index admission and not in the 12 months prior to admission. This methodology is consistent with NQF guidelines.

The model does not adjust for socioeconomic status (SES), race, ethnicity, or sex. Variation in quality associated with these characteristics may be indicative of disparities in the quality of the care provided to vulnerable populations, and risk adjusting for these factors would obscure these disparities. The model does not adjust for hospital characteristics either (e.g., teaching status) since this would hold different types of hospitals to different quality standards, and because such characteristics may exist on a causal pathway to the outcome, rather than act as confounders. This approach is consistent with NQF guidelines (http://www.qualityforum.org/docs/measure_evaluation_criteria.aspx).

2.8 Candidate and Final Risk-Adjustment Variables

Our goal was to develop a parsimonious model that included clinically relevant variables associated with mortality. The candidate variables for the model were derived from: the index admission, with comorbidities identified from the index admission secondary diagnoses (excluding potential complications), 12-month pre-index inpatient Part A data, outpatient hospital data, and Part B physician data.

For administrative model development, we started with 189 Condition Categories (CCs) which are part of CMS' Hierarchical Condition Categories. The Hierarchical Condition Category (HCC) system groups the ICD-9-CM codes into larger groups that are used in models to predict medical care utilization, spending, mortality or other related measures. CCs are clinically relevant diagnostic groups of the more than 15,000 ICD-9 codes.[19] We used the ICD-9 to CC assignment map, which is maintained by CMS and posted at www.qualitynet.org.

To select candidate variables, a team of clinicians reviewed all 189 CCs and excluded those that were not relevant to the Medicare population (Appendix B) or that were not clinically relevant to the mortality outcome (e.g., attention deficit disorder, female infertility). Clinically relevant CCs were selected as candidate

variables and some of those CCs were then combined into clinically coherent CC groupings. Other candidate variables also included age, history of mechanical ventilation, and sleep apnea, which were selected on the recommendation of clinical experts and identified by ICD-9-CM codes (Table 2).

Table 2. Candidate Model Variables for Risk Adjustment

Category	Variable	CC
Demographics	Age	
Cardiovascular/ Respiratory	History of Mechanical Ventilation	ICD-9 procedure codes: 93.90, 96.70, 96.71, 96.72
	Sleep Apnea	ICD-9 diagnosis codes: 327.20, 327.21, 327.23, 327.27, 327.29, 780.51, 780.53, 780.57
	Respirator Dependence/Respiratory Arrest	CC 77-78
	Cardio-Respiratory Failure and Shock	CC 79
	Congestive Heart Failure	CC 80
	Acute Coronary Syndrome	CC 81-82
	Chronic Atherosclerosis	CC 83-84
	Valvular and Rheumatic Heart Disease	CC 86
	Arrhythmias	CC 92-93
	Other and Unspecified Heart Disease	CC 94
	Vascular or Circulatory Disease	CC 104-106
	Fibrosis of Lung and Other Chronic Lung Disorder	CC 109
	Asthma	CC 110
	Pneumonia	CC 111-113
	Pleural Effusion/Pneumothorax	CC 114
	Other Lung Disorders	CC 115
Comorbidities	History of Infection	CC 1, 3-6
	Septicemia/Shock	CC 2
	Metastatic Cancer and Acute Leukemia	CC 7
	Lung, Upper Digestive Tract, and Other Severe Cancers	CC 8
	Lymphatic, Head and Neck, Brain, and Other Major Cancers; Breast, Colorectal and other Cancers and Tumors; Other Respiratory and Heart Neoplasms	CC 9-11
	Other Digestive and Urinary Neoplasms	CC 12
	Other Neoplasms	CC 13
	Benign Neoplasms of Skin, Breast, Eye	CC 14
	Diabetes and DM Complications	CC 15-20, 119-120
	Protein-Calorie Malnutrition	CC 21
	Disorders of Fluid/Electrolyte/Acid-Base	CC 22-23
	Obesity/Disorders of Thyroid, Cholesterol, Lipids	CC 24
	Liver and Biliary Disease	CC 25-30
	Intestinal Obstruction/Perforation	CC 31
	Pancreatic Disease	CC 32
	Inflammatory Bowel Disease	CC 33
	Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders	CC 34
	Other Gastrointestinal Disorders	CC 36
	Bone/Joint/Muscle Infections/Necrosis	CC 37
	Rheumatoid Arthritis and Inflammatory Connective Tissue Disease	CC 38

Category	Variable	CC
	Disorders of the Vertebrae and Spinal Discs	CC 39
	Osteoarthritis of Hip or Knee	CC 40
	Osteoporosis and Other Bone/Cartilage Disorders	CC 41
	Other Musculoskeletal and Connective Tissue Disorders	CC 43
	Severe Hematological Disorders	CC 44
	Disorders of Immunity	CC 45
	Coagulation Defects and Other Specified Hematological Disorders	CC 46
	Iron Deficiency and Other/Unspecified Anemia and Blood Disease	CC 47
	Delirium and Encephalopathy	CC 48
	Dementia or Senility	CC 49-50
	Drug/Alcohol Induced Dependence/Psychosis	CC 51-52
	Drug/Alcohol Abuse, without Dependence	CC 53
	Major Psychiatric Disorders	CC 54-56
	Depression	CC 58
	Anxiety Disorders	CC 59
	Other Psychiatric Disorders	CC 60
	Hemiplegia, Paraplegia, Paralysis, Functional Disability	CC 67-69, 100-102, 177-178
	Polyneuropathy	CC 71
	Parkinson's and Huntington's Diseases	CC 73
	Seizure Disorders and Convulsions	CC 74
	Mononeuropathy, Other Neurological Conditions/Injuries	CC 76
	Heart Infection/Inflammation, Except Rheumatic	CC 85
	Hypertensive Heart and Renal Disease or Encephalopathy	CC 89
	Hypertension	CC 90-91
	Stroke	CC 95-96
	Cerebrovascular Disease	CC 97-99, 103
	Retinal Disorders, except Detachment and Vascular Retinopathies	CC 121
	Glaucoma	CC 122
	Other Eye Disorders	CC 124
	Significant Ear, Nose, and Throat Disorders	CC 125
	Hearing Loss	CC 126
	Other Ear, Nose, Throat, and Mouth Disorders	CC 127
	End-stage Renal Disease or Dialysis	CC 130
	Renal Failure	CC 131
	Urinary Obstruction and Retention	CC 133
	Incontinence	CC 134
	Urinary Tract Infection	CC 135
	Other Urinary Tract Disorders	CC 136
	Pelvic Inflammatory Disease	CC 138
	Other Female Genital Disorders	CC 139
	Male Genital Disorders	CC 140
	Decubitus Ulcer or Chronic Skin Ulcer	CC 148-149
	Cellulitis, Local Skin Infection	CC 152
	Other Dermatological Disorders	CC 153
	Trauma	CC 154-156, 158-161
	Vertebral Fractures	CC 157
	Other Injuries	CC 162
	Poisoning and Allergic Reactions	CC 163

Category	Variable	CC
	Major Complications of Medical Care and Trauma	CC 164
	Other Complications of Medical Care	CC 165
	Major Symptoms, Abnormalities	CC 166
	Minor Symptoms, Signs, Findings	CC 167

To inform final variable selection, a modified approach to stepwise logistic regression was performed. The development sample was used to create 1,000 "bootstrap" samples. For each sample, we ran a logistic stepwise regression that included the candidate variables. The results were summarized to show the percentage of times that each of the candidate variables was significantly associated with mortality ($p<0.001$) in each of the 1,000 repeated samples (e.g., 90 percent would mean that the candidate variable was selected as significant at $p<0.001$ in 90 percent of the estimations). We also assessed the direction and magnitude of the regression coefficients.

The clinical team reviewed these results and decided to retain risk adjustment variables above a 90% cutoff, because they demonstrated a relatively strong and stable association with risk for death and were clinically relevant. Additionally, specific variables with particular clinical relevance to the risk of death were forced into the model (regardless of % selection) to ensure appropriate risk-adjustment for COPD. These included:

Clinical variables associated with COPD:

- history of mechanical ventilation (ICD-9 procedure codes: 93.90, 96.70, 96.71, 96.72)
- history of sleep apnea (ICD-9 diagnosis codes: 327.20, 327.21, 327.23, 327.27, 327.29, 780.51, 780.53, 780.57)

Markers for end of life/frailty:

- decubitus ulcer or chronic skin ulcer (CC 148-149)
- dementia and senility (CC 49 and CC 50, respectively)
- metastatic cancer and acute leukemia (CC 7)
- protein-calorie malnutrition (CC 21)
- hemiplegia/paraplegia/paralysis/functional disability (CC 67-69, 100-102, 177-178)
- stroke (CC 95-96)

Diagnoses with potential asymmetry among hospitals that would impact the validity of the model:

- lung, upper digestive tract, and other severe cancers (CC 8)
- lymphatic, head and neck, brain, and other major cancers; breast, prostate, colorectal and other cancers and tumors; other respiratory and heart neoplasms (CC 9-11)
- other digestive and urinary neoplasms (CC 12)

Final model variables are listed in Table 3.

Table 3. Final Model Variables

Category	Variable	CC
Demographics	Age	
Cardiovascular/ Respiratory	History of Mechanical Ventilation	ICD-9 codes: 93.90, 96.70, 96.71, 96.72
	Sleep Apnea	ICD-9 codes: 327.20, 327.21, 327.23, 327.27, 327.29, 780.51, 780.53, 780.57
	Respirator Dependence/Respiratory Failure	CC 77-78
	Cardio-Respiratory Failure and Shock	CC 79
	Congestive Heart Failure	CC 80
	Chronic Atherosclerosis	CC 83-84
	Arrhythmias	CC 92-93
	Vascular or Circulatory Disease	CC 104-106
	Fibrosis of Lung and Other Chronic Lung Disorder	CC 109
	Asthma	CC 110
	Pneumonia	CC 111-113
	Pleural Effusion/Pneumothorax	CC 114
	Other Lung Disorders	CC 115
Comorbidities	Metastatic Cancer and Acute Leukemia	CC 7
	Lung, Upper Digestive Tract, and Other Severe Cancers	CC 8
	Lymphatic, Head and Neck, Brain, and Other Major Cancers; Breast, Colorectal and other Cancers and Tumors; Other Respiratory and Heart Neoplasms	CC 9-11
	Other Digestive and Urinary Neoplasms	CC 12
	Diabetes and DM Complications	CC 15-20, 119-120
	Protein-Calorie Malnutrition	CC 21
	Disorders of Fluid/Electrolyte/Acid-Base	CC 22-23
	Other Endocrine/Metabolic/Nutritional Disorders	CC 24
	Other Gastrointestinal Disorders	CC 36
	Osteoarthritis of Hip or Knee	CC 40
	Other Musculoskeletal and Connective Tissue Disorders	CC 43
	Iron Deficiency and Other/Unspecified Anemia and Blood Disease	CC 47
	Dementia or Senility	CC 49-50
	Drug/Alcohol Abuse, without Dependence	CC 53
	Other Psychiatric Disorders	CC 60
	Quadriplegia, Paraplegia, Paralysis, Functional Disability	CC 67-69, 100-102, 177-178
	Mononeuropathy, Other Neurological Conditions/Injuries	CC 76
	Hypertension and Hypertensive Disease	CC 90-91
	Stroke	CC 95-96
	Retinal Disorders, except Detachment and Vascular Retinopathies	CC 121
	Other Eye Disorders	CC 124
	Other Ear, Nose, Throat, and Mouth Disorders	CC 127
	Renal Failure	CC 131
	Decubitus Ulcer or Chronic Skin Ulcer	CC 148-149
	Other Dermatological Disorders	CC 153
	Trauma	CC 154-156, 158-161
	Vertebral Fractures	CC 157
	Major Complications of Medical Care and Trauma	CC 164

2.9 Statistical Approach to Model Development

We used a randomly selected split sample of 2008 admissions for model development and candidate variable selection. We used the remaining half of COPD admissions in 2008 to validate the model. We then selected all qualifying COPD admissions in 2007 and 2009 data to assess model reliability across years of data.

Due to the natural clustering of hospitalizations within hospitals, we used hierarchical logistic regression models to model the log-odds of mortality. Death was modeled as a function of patient-level demographic and clinical characteristics and a random hospital-specific intercept. This strategy accounts for within-hospital correlation of the observed outcomes and models the assumption that underlying differences in quality among the healthcare facilities being evaluated lead to systematic differences in outcomes.

We then calculated hospital risk-standardized mortality rates (RSMRs) using a hierarchical logistic regression model. These rates were calculated as the ratio of the predicted number of deaths to the expected number of deaths, multiplied by the national unadjusted mortality rate. The expected number of deaths for each hospital was estimated using that hospital's patient mix and the average intercept. Specifically, for each patient in the data-set, the estimated regression coefficients were multiplied by the observed characteristics and the average of the hospital-specific intercepts was added to this quantity. Then, the quantity was transformed to the probability scale. For each patient within a hospital, these probabilities were summed. The predicted number of deaths in each hospital employed a similar calculation. The predicted number of deaths for each hospital was calculated by summing the predicted mortality rates for all patients in the hospital. The predicted mortality rate for each patient was calculated through the hierarchical model by applying the estimated regression coefficients to the patient characteristics observed and adding the hospital-specific intercept. In order to assess hospital performance in any specific year (e.g., the validation cohort), we estimated the model coefficients using that year's data.

More specifically, we estimated a logistic regression model and a hierarchical generalized linear model which accounts for the clustering of observations within hospitals. The logistic regression model links the outcome to the patient-level risk factors.[20] Let Y_{ij} denote the outcome (equal to 1 if patient dies, zero if patient lives) for the j^{th} patient who had a COPD admission at the i^{th} hospital; $\mathbf{Z}_{ij}$ denotes a set of risk factors based on the data. 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 covariates via a known linked function, h, where

Logistic regression model: $$h(Y_{ij}) = \alpha + \beta \mathbf{Z}_i \quad (1)$$

and $\mathbf{Z}_{ij} = (Z_{1ij}, Z_{2ij}, ..., Z_{pij})$ is a set of *p* patient-specific covariates. In our case, *h* = the logit link.

To account for the natural clustering of observations within hospitals, we then estimate a hierarchical logistic regression model that links the risk factors to the same outcome and a hospital-specific random effect,

Hierarchical logistic regression model: $h(Y_{ij}) = \alpha_i + \beta \mathbf{Z}_{ij}$ (2)

$\alpha_i = \mu + \omega_i; \quad \omega_i \sim N(0, \tau^2)$ (3)

where α_i represents the hospital-specific intercept, $\mathbf{Z}_{ij}$ is defined as above, μ the adjusted average outcome over all hospitals in the sample, and τ^2 the between-hospital variance component.[21] This model separates within-hospital variation from between-hospital variation. Both hierarchical logistic regression models and logistic regression models are estimated using the SAS software system (GLIMMIX and LOGISTIC procedures, respectively).

We first fit the logistic regression model described in Equation (1) using the logit link. Having identified the covariates that were selected, we next fit the hierarchical logistic regression model described in Equations (2) and (3), again using the logit link function; e.g.,

$$\text{Logit } (P(Y_{ij} = 1)) = \alpha_i + \beta \mathbf{Z}_{ij}$$
$$\alpha_i = \mu + \omega_i, \quad \omega_i \sim N(0, \tau^2)$$

where $\mathbf{Z}_{ij}$ consisted of the covariates retained in the logistic regression model. As before, $Y_{ij} = 1$ if patient *j* treated at hospital *i* had the event; 0 otherwise.

2.10 Hospital Performance Reporting

Using the set of risk factors in the logistic regression model, we fit the hierarchical logistic regression model defined by Equations (2) - (3) and estimate the parameters $\hat{\mu}$, $\{\hat{\alpha}_1, \hat{\alpha}_2, ..., \hat{\alpha}_I\}$, $\hat{\beta}$ and $\hat{\tau}^2$. We calculate a standardized outcome, s_i, for each hospital by computing the ratio of the number of predicted deaths to the number of expected deaths, multiplied by the unadjusted overall mortality rate, $\bar{y}$. Specifically, we calculate

Predicted $\hat{y}_{ij}(Z) = h^{-1}(\hat{\alpha}_i + \hat{\beta} \mathbf{Z}_{ij})$ (4)

Expected $\hat{e}_{ij}(Z) = h^{-1}(\hat{\mu} + \hat{\beta} \mathbf{Z}_{ij})$ (5)

$$\hat{s}_i(Z) = \frac{\sum_{j=1}^{n_i} \hat{y}_{ij}(Z)}{\sum_{j=1}^{n_i} \hat{e}_{ij}(Z)} \times \bar{y} \quad (6)$$

If more (fewer) "predicted" cases than "expected" cases have the outcome in a hospital, then s_i will be higher (lower) than the unadjusted average. For each hospital, we compute an interval estimate of s_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).

2.10.1 Creating Interval Estimates

Because the statistic described in Equation (6) is a complex function of parameter estimates, we use re-sampling and simulation techniques to derive an interval estimate. The bootstrapping simulation has the advantage of avoiding unnecessary distributional assumptions.

2.10.2 Algorithm

Let *I* denote the total number of hospitals in the sample. We repeat steps 1 – 4 below for b = 1,2,…B times:

1. Sample *I* hospitals with replacement.

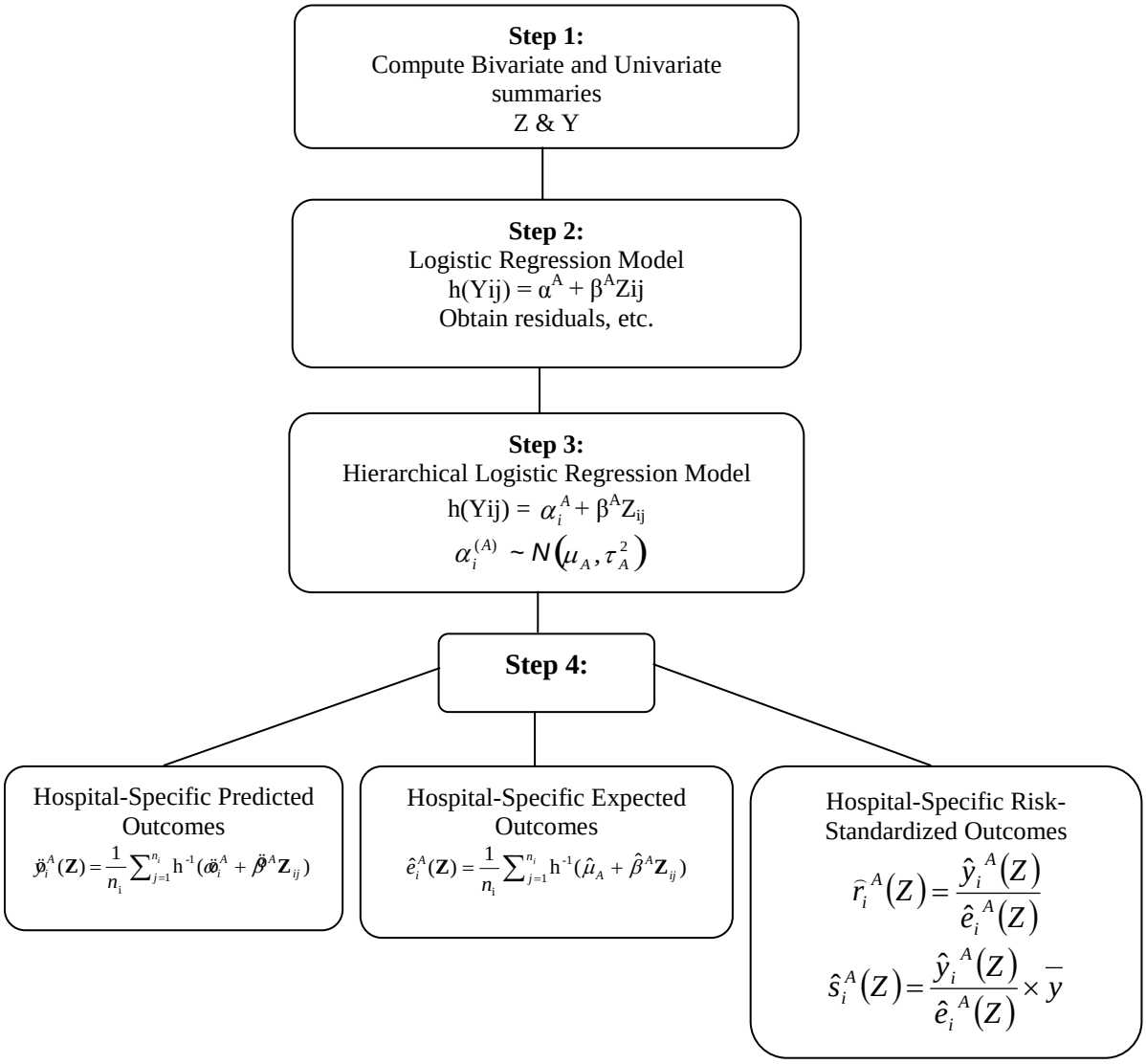
2. Fit the hierarchical logistic regression model using all patients within each sampled hospital. We use as starting values the parameter estimates obtained by fitting the model to all hospitals. If some hospitals are selected more than once in a bootstrapped sample, we treat them as distinct so that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

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 $\alpha_i^{(b*)} \sim N\left(\hat{\alpha}_i^{(b)}, \hat{\text{var}}\left(\hat{\alpha}_i^{(b)}\right)\right)$ for the unique set of hospitals sampled in Step 1.

4. Within each unique hospital *i* sampled in Step 1, and for each case *j* in that hospital, we calculate $\hat{y}_{ij}^{(b)}$, $\hat{e}_{ij}^{(b)}$, and $\hat{s}_i(Z)^{(b)}$ 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 randomly half of the B estimates (or the percentiles corresponding to the alternative desired intervals).[22] (See Figure 3 below for a diagram of the analysis steps).

Figure 3. Analysis Steps



3. RESULTS

3.1 Model Results

3.1.1 Development and Validation Models

The sample for model development included 150,035 admissions from 4,537 hospitals. The model validation sample included 149,646 admissions from 4,535 hospitals. Results tables are presented at the end of Section 3.

Table 4 conveys the risk factor frequencies, parameter estimates, standard errors, odds ratios (OR), and 95% confidence intervals for the model risk factors in the development and validation samples. Variable frequencies and odds ratios are similar in both samples.

3.1.2 Model Validation

We computed several summary statistics for assessing logistic regression (patient-level) model performance, [23] which included over-fitting indices,[a] predictive ability, area under the receiver operating characteristic (ROC) curve, distribution of residuals, and model chi-square.[b] Table 5 conveys results for the development and validation samples. Model performance is similar in the development and validation samples, with strong model discrimination and fit. Predictive ability is also similar in both samples. The C statistic (area under the receiver operator curve) is 0.72 when the model is applied to either the development or validation sample (Table 5).

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[a] Over-fitting (γ_0, γ_1) provides evidence of over-fitting and requires several steps to calculate. Let *b* denote the *estimated vector* of regression coefficients. *Predicted Probabilities* ($\hat{p}$) = 1/(1+exp{-Xb}), and *Z* = *Xb* (e.g., the linear predictor that is a scalar value for everyone). A new logistic regression model that includes only an intercept and a slope by regressing the logits on Z is fitted in the validation sample; e.g., Logit(P(Y=1|Z)) = $\gamma_0 + \gamma_1 Z$. Estimated values of γ_0 far from 0 and estimated values of γ_1 far from 1 provide evidence of over-fitting.

[b] Chi-Square – A test of statistical significance usually employed for categorical data to determine whether there is a good fit between the observed data and expected values; i.e., whether the differences between observed and expected values are attributable to true differences in characteristics or instead the result of chance variation. The formula for computing the chi-square is as follows:

$$\sum \frac{(O-E)^2}{E}$$

where O = observed value
E = expected value, and
degrees of freedom (df) = (rows-1)(columns-1)

3.1.3 Hierarchical Logistic Regression Model

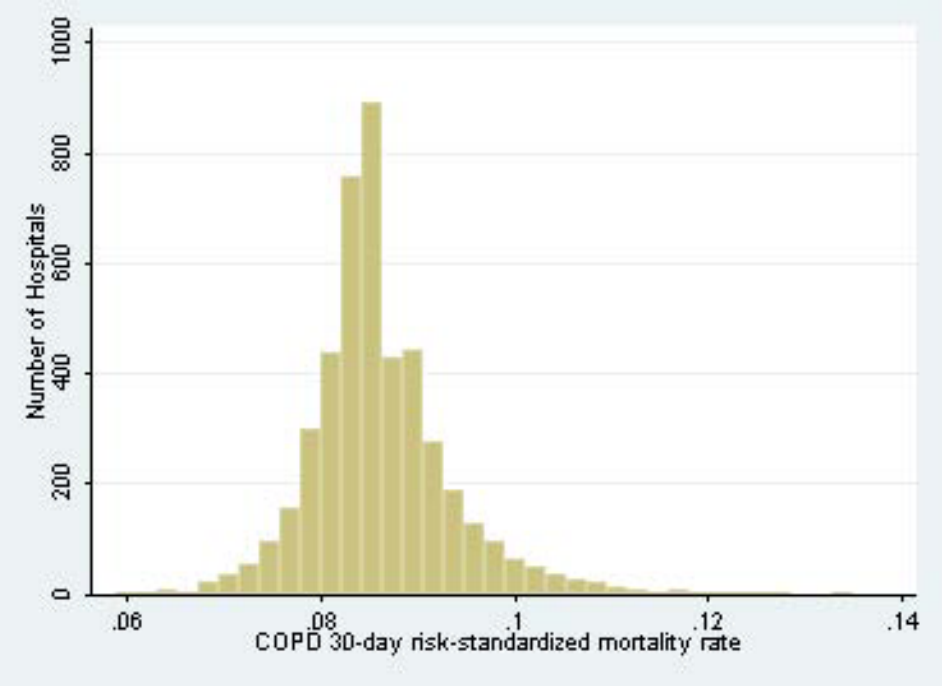
Table 6 conveys the adjusted odds ratios for the development sample calculated via the hierarchical logistic regression model. The odds ratios are nearly identical to those calculated using the logistic regression model (Table 5).

3.1.4 Unadjusted and Adjusted Mortality Rates

The unadjusted mean hospital mortality rate is 8.59% and ranges from 0.00-100%. The median unadjusted mortality rate is 8.33% (data not shown). Figure 4 displays the hospital risk-standardized rates for the development sample, calculated via the hierarchical logistic regression model. The rates are normally distributed with a mean of 8.62%, and range from 5.9%-13.5%. The median risk-standardized rate is 8.51%.

In the hierarchical model, each hospital has its own intercept (random intercept model), which is used to measure the differences in mortality between hospitals while adjusting for case-mix (patient risk factors).

Figure 4. Distribution of Hospital-Level Risk-Standardized Mortality Rates (2008 Development Sample; n=150,035 Admissions from 4,537 Hospitals)



3.2 Model Testing

3.2.1 Reliability of Data Elements

For measure development, we only use data elements in claims that have both face validity and reliability. We do not use fields that are inconsistently coded across providers. We only use fields that are consequential for payment and which are audited. We identify these variables through empiric analyses and our understanding of CMS auditing and billing policies and do not use variables which do not meet this standard. For example, “discharge disposition” is a variable in Medicare claims data that is not consistently coded across hospitals. Thus, we construct an indicator variable as a surrogate for “discharge disposition” to identify patients that are transferred using variables in the claims data with greater reliability, including admit date and discharge date.

In addition, CMS has in place several hospital auditing programs used to assess overall claims code accuracy, ensure appropriate billing, and for overpayment recoupment. CMS routinely conducts data analysis to identify potential problem areas and detect fraud, and audits important data fields used in our measures, including diagnosis and procedure codes, and other elements that are consequential to payment.

The data elements we use are stable over time. We used data from 2007, 2008, and 2009 to assess the data elements over time: 259,911 admissions from 4,636 hospitals in 2007; 299,681 admissions from 4,537 hospitals in 2008; and 279,377 admissions from 4,571 hospitals in 2009. Table 7 conveys the model risk factor frequencies in these samples. Overall, risk factor frequencies changed very little across the three-year period. The percentage of patients with a history of pneumonia (CC 111-113) increased from 45% in 2007 to 50% in 2009. The percentage of patients with a history of diabetes and diabetic complications (CC 15-20, 119-120) increased from 37% in 2007 to 40% in 2009. The percentage of patients diagnosed with other endocrine/metabolic/nutritional disorders (CC 24) increased from 65% in 2007 to 71% in 2009. There were no other notable changes.

Table 8 shows the adjusted odds ratios for the logistic regression (patient-level) model variables and mortality in the 2007, 2008, and 2009 data samples. There are no notable differences in the odds ratios across the samples. The consistency in the rates of the risk adjustment variables and in their relationship to the outcome across the split year sample (development and validation) and the three years of data all demonstrate the reliability of the measure data elements.

3.2.2 Reliability of Model

To test the reliability of the model, we assessed model performance (Table 5) and the effect of the risk adjustment variables on the outcome across the years of data (Table 8). Model performance is similar across years with strong model discrimination and fit. Predictive ability is also similar in both samples. The C statistic (area under the receiver operator curve) is 0.73 for the model in 2007 data and 0.72 for the model in 2009 data (Table 5).

3.2.3 Validity

We have validated six similar NQF-endorsed measures currently used in public reporting (mortality and readmission measures for AMI, heart failure, and pneumonia) against analogous models built with clinical data. We validated the claims-based measures by building comparable models using medical record data for risk adjustment for heart failure patients (National Heart Failure data), AMI patients (Cooperative Cardiovascular Project data) and pneumonia patients (National Pneumonia Project dataset). When the medical record-based models were applied to the corresponding patient population, the hospital risk-standardized rates estimated using the claims-based risk adjustment models had a high level of agreement with the results based on the medical record model, thus supporting the use of the claims-based models for public reporting.

YNHHSC/CORE has also conducted two national, multi-site validation studies for two procedure-based complications measures (primary elective hip/knee arthroplasty and implantable cardioverter defibrillator). Both validation studies demonstrated strong agreement between complications coded in claims and those documented in the medical record. These validation efforts suggest that claims data variables are valid across a variety of conditions and therefore can be used reliably for developing new claims-based outcome measures.

To assess face validity, we surveyed the Technical Expert Panel and asked each member to rate the following statement using a six-point scale (1=Strongly Disagree, 2=Moderately Disagree, 3=Somewhat Disagree, 4=Somewhat Agree, 5=Moderately Agree, and 6=Strongly Agree): “The mortality rates obtained from the mortality measure as specified will provide an accurate reflection of quality.”

Ten of 12 TEP members provided the following responses: Strongly Disagreed (1), Somewhat Agreed (3), Moderately Agreed (4), and Strongly Agreed (2). Hence, of the TEP members who responded, 90%

agreed (60% moderately or strongly agreed) that the measure will provide an accurate reflection of quality.

4. MAIN FINDINGS / SUMMARY

The proposed mortality measure has the potential to significantly improve the quality of care delivered to patients hospitalized with an acute exacerbation of COPD. The cohort for inclusion in the measure is appropriately defined, consisting of patients across the spectrum of COPD. We excluded covariates that are not appropriate for inclusion in a quality measure, including race, gender, socioeconomic status, and physician- and hospital-level variables (e.g., procedural volume). The hierarchical modeling accounts for the clustering of patients within hospitals and differences in sample size across hospitals, thereby allowing for valid comparisons across hospitals. We found variability in the risk-standardized mortality rates across hospitals and these differences remained, even after adjustment for case-mix. Risk-standardized mortality rates can be used for targeted quality improvement efforts by hospitals to decrease rates for death. The risk-standardized model meets recognized standards for outcomes measurement and was developed with extensive input from clinicians and experts in measure development. The model is reliable and valid. In summary, we present a claims-based model of mortality for patients hospitalized for an acute exacerbation of COPD that is suitable for public reporting.

Table 4. Adjusted OR* for Model Risk Factors and Mortality in Development and Validation Samples (Logistic Regression Model)

	Development Sample (n=150,035 admissions at 4,537 hospitals)					Validation Sample (n=149,646 admissions at 4,535 hospitals)				
Variable	**Frequency (%)**	**Estimate**	**SE**	**OR**	**95% CI**	**Frequency (%)**	**Estimate**	**SE**	**OR**	**95% CI**
Demographics										
Age-65 (continuous)	-	0.03	0.001	1.03	(1.03-1.04)	-	0.03	0.001	1.03	(1.03-1.04)
Cardiovascular/Respiratory										
Sleep Apnea (ICD-9 codes: 327.20, 327.21, 327.23, 327.27, 327.29, 780.51, 780.53, 780.57)	9.57	-0.13	0.04	0.87	(0.81-0.94)	9.72	-0.17	0.04	0.84	(0.78-0.91)
History of Mechanical Ventilation (ICD-9 codes: 93.90, 96.70, 96.71, 96.72)	6.00	0.17	0.04	1.19	(1.11-1.28)	6.00	0.15	0.04	1.16	(1.08-1.24)
Respirator Dependence/Respiratory Failure (CC 77-78)	1.15	-0.13	0.08	0.88	(0.76-1.02)	1.20	-0.25	0.08	0.78	(0.67-0.91)
Cardio-Respiratory Failure and Shock (CC 79)	26.35	0.47	0.02	1.60	(1.53-1.68)	26.34	0.47	0.02	1.59	(1.52-1.67)
Congestive Heart Failure (CC 80)	41.50	0.29	0.02	1.33	(1.28-1.40)	41.39	0.27	0.02	1.31	(1.25-1.37)
Chronic Atherosclerosis (CC 83-84)	50.44	-0.14	0.02	0.87	(0.83-0.90)	50.12	-0.10	0.02	0.90	(0.87-0.94)
Arrhythmias (CC 92-93)	37.15	0.16	0.02	1.17	(1.12-1.22)	37.06	0.14	0.02	1.15	(1.10-1.20)
Vascular or Circulatory Disease (CC 104-106)	38.20	0.09	0.02	1.09	(1.05-1.14)	38.09	0.01	0.02	1.02	(0.97-1.06)
Fibrosis of Lung and Other Chronic Lung Disorder (CC 109)	16.96	0.07	0.02	1.08	(1.03-1.13)	17.08	0.11	0.02	1.11	(1.06-1.17)
Asthma (CC 110)	17.05	-0.41	0.03	0.67	(0.63-0.71)	16.90	-0.41	0.03	0.67	(0.63-0.71)
Pneumonia (CC 111-113)	49.46	0.26	0.02	1.29	(1.24-1.35)	49.41	0.24	0.02	1.28	(1.22-1.33)
Pleural Effusion/Pneumothorax (CC 114)	11.78	0.16	0.03	1.17	(1.11-1.23)	11.54	0.17	0.03	1.18	(1.12-1.25)
Other Lung Disorders (CC 115)	53.07	-0.23	0.02	0.80	(0.77-0.83)	53.17	-0.18	0.02	0.83	(0.80-0.87)
Other Comorbid Conditions										
Metastatic Cancer and Acute Leukemia (CC 7)	2.76	0.85	0.05	2.34	(2.13-2.56)	2.79	0.76	0.05	2.15	(1.96-2.35)
Lung, Upper Digestive Tract, and Other Severe Cancers (CC 8)	5.98	0.58	0.04	1.80	(1.67-1.92)	6.02	0.68	0.03	1.98	(1.84-2.11)
Lymphatic, Head and Neck, Brain, and Other Major Cancers; Breast, Prostate, Colorectal and Other Cancers and Tumors; Other Respiratory and Heart Neoplasms (CC 9-11)	14.13	0.02	0.03	1.03	(0.97-1.08)	14.19	0.01	0.03	1.01	(0.96-1.07)
Other Digestive and Urinary Neoplasms(CC 12)	6.91	-0.10	0.04	0.91	(0.84-0.98)	7.05	-0.16	0.04	0.85	(0.79-0.93)

	Development Sample (n=150,035 admissions at 4,537 hospitals)					Validation Sample (n=149,646 admissions at 4,535 hospitals)				
Variable	**Frequency (%)**	**Estimate**	**SE**	**OR**	**95% CI**	**Frequency (%)**	**Estimate**	**SE**	**OR**	**95% CI**
Diabetes and DM Complications (CC 15-20, 119-120)	38.31	-0.10	0.02	0.91	(0.87-0.94)	38.29	-0.10	0.02	0.90	(0.87-0.94)
Protein-calorie Malnutrition (CC 21)	7.40	0.77	0.03	2.17	(2.05-2.29)	7.44	0.73	0.03	2.06	(1.96-2.18)
Disorders of Fluid/Electrolyte/Acid-Base (CC 22-23)	32.05	0.12	0.02	1.13	(1.08-1.18)	32.16	0.21	0.02	1.24	(1.19-1.30)
Other Endocrine/Metabolic/Nutritional Disorders (CC 24)	67.99	-0.29	0.02	0.75	(0.72-0.78)	67.88	-0.27	0.02	0.76	(0.73-0.80)
Other Gastrointestinal Disorders (CC 36)	56.21	-0.21	0.02	0.81	(0.78-0.84)	56.18	-0.25	0.02	0.78	(0.75-0.82)
Osteoarthritis of Hip or Knee (CC 40)	9.32	-0.30	0.04	0.74	(0.69-0.80)	9.33	-0.23	0.04	0.79	(0.74-0.85)
Other Musculoskeletal and Connective Tissue Disorders (CC 43)	64.14	-0.19	0.02	0.83	(0.79-0.86)	64.20	-0.18	0.02	0.83	(0.80-0.87)
Iron Deficiency and Other/Unspecified Anemias and Blood Disease (CC 47)	40.80	0.08	0.02	1.08	(1.04-1.12)	40.72	0.08	0.02	1.09	(1.04-1.13)
Dementia and Senility (CC 49-50)	17.06	0.08	0.02	1.09	(1.04-1.14)	16.97	0.09	0.02	1.09	(1.04-1.15)
Drug/Alcohol Abuse, Without Dependence (CC 53)	23.51	-0.24	0.03	0.79	(0.75-0.83)	23.38	-0.27	0.03	0.76	(0.73-0.80)
Other Psychiatric Disorders (CC 60)	16.49	0.11	0.03	1.12	(1.07-1.18)	16.43	0.11	0.03	1.11	(1.06-1.17)
Quadriplegia, Paraplegia, Functional Disability (CC 67-69, 100-102, 177-178)	4.92	0.03	0.04	1.03	(0.95-1.12)	4.92	0.07	0.04	1.07	(0.99-1.17)
Mononeuropathy, Other Neurological Conditions/Injuries (CC 76)	11.35	-0.16	0.03	0.85	(0.80-0.91)	11.28	-0.13	0.03	0.88	(0.83-0.94)
Hypertension and Hypertensive Disease (CC 90-91)	80.40	-0.25	0.02	0.78	(0.75-0.82)	80.35	-0.24	0.02	0.79	(0.75-0.83)
Stroke (CC 95-96)	6.77	0.002	0.04	1.00	(0.93-1.08)	6.73	-0.03	0.04	0.97	(0.90-1.05)
Retinal Disorders, Except Detachment and Vascular Retinopathies (CC 121)	10.79	-0.14	0.03	0.87	(0.82-0.93)	10.69	-0.10	0.03	0.91	(0.85-0.96)
Other Eye Disorders (CC 124)	19.05	-0.10	0.03	0.90	(0.86-0.95)	19.13	-0.12	0.03	0.89	(0.85-0.94)
Other Ear, Nose, Throat, and Mouth Disorders (CC 127)	35.21	-0.18	0.02	0.83	(0.80-0.87)	35.02	-0.22	0.02	0.80	(0.77-0.84)
Renal Failure (CC 131)	17.92	0.11	0.03	1.12	(1.07-1.18)	18.16	0.12	0.03	1.13	(1.08-1.19)
Decubitus Ulcer or Chronic Skin Ulcer (CC 148-149)	7.42	0.24	0.03	1.27	(1.19-1.35)	7.42	0.29	0.03	1.33	(1.25-1.42)
Other Dermatological Disorders (CC 153)	28.46	-0.10	0.02	0.91	(0.87-0.95)	28.32	-0.11	0.02	0.90	(0.86-0.94)
Trauma (CC 154-156, 158-161)	9.04	0.09	0.03	1.10	(1.03-1.16)	8.99	0.14	0.03	1.15	(1.08-1.22)
Vertebral Fractures (CC 157)	5.01	0.29	0.04	1.33	(1.24-1.44)	4.97	0.26	0.04	1.30	(1.20-1.40)
Major Complications of Medical Care and Trauma (CC 164)	5.47	-0.21	0.04	0.81	(0.75-0.88)	5.55	-0.20	0.04	0.82	(0.76-0.89)

	Development Sample (n=150,035 admissions at 4,537 hospitals)					Validation Sample (n=149,646 admissions at 4,535 hospitals)				
Variable	**Frequency (%)**	**Estimate**	**SE**	**OR**	**95% CI**	**Frequency (%)**	**Estimate**	**SE**	**OR**	**95% CI**

Grey highlighting indicates variable was forced into the model.

SE = Standard Error; OR = Odds Ratio; CI = Confidence Interval

* Each variable in the model is adjusted for the effects of the others

Table 5. Model Performance for Development and Validation Samples (Logistic Regression Model)

Indices	Development Sample	Validation Sample	Data Years	
Year	**2008**	**2008**	**2007**	**2009**
Number of Admissions	150,035	149,646	259,911	279,377
Number of Hospitals	4,537	4,535	4,636	4,571
Mean Risk-Standardized Mortality Rate % (SD)	8.62 (0.94)	8.64 (1.07)	8.97 (1.12)	8.08 (1.09)
Calibration ($\gamma 0$, $\gamma 1$)[3]	(-0.034, 0.985)	(0.009, 1.004)	(0.095, 1.022)	(-0.120, 0.981)
Discrimination -Predictive Ability (lowest decile %, highest decile %)	1.52 - 23.74	1.60 - 23.78	1.54 - 24.64	1.42 - 22.36
Discrimination – Area Under Receiver Operator Curve (C statistic)[4]	0.720	0.723	0.728	0.722
Residuals Lack of Fit (Pearson Residual Fall %)				
<-2	0.00	0.00	0.00	0.00
[-2, 0)	91.14	91.40	91.08	91.93
[0, 2)	1.66	1.70	1.96	1.42
[2+	6.93	6.91	6.96	6.65
Model Wald χ^2 [Number of Covariates] (p-value)	6982.11 [42] (<.0001)	7051.50 [42] (<.0001)	13042.35 [42] (<.0001)	12542.15 [42] (<.0001)
Between-Hospital Variance (τ) (Standard Error)	0.067 (0.008)	0.078 (0.009)	0.067 (0.006)	0.072 (0.006)

[3] Over-Fitting Indices (γ_0, γ_1) provide evidence of over-fitting and require several steps to calculate. Let *b* denote the *estimated vector* of regression coefficients. *Predicted Probabilities* ($\hat{p}$) = 1/(1+exp{-Xb}), and *Z* = *Xb* (e.g., the linear predictor that is a scalar value for everyone). A new logistic regression model that includes only an intercept and a slope by regressing the logits on Z is fitted in the validation sample; e.g., Logit(P(Y=1|Z)) = $\gamma_0 + \gamma_1 Z$. Estimated values of γ_0 far from 0 and estimated values of γ_1 far from 1 provide evidence of over-fitting.

[4] Calculated using logistic regression model

Table 6. Adjusted OR* for Model Risk Factors and Mortality in Development and Validation Sample (Hierarchical Logistic Regression Model)

	Development Sample (150,035 admissions at 4,537 hospitals)					Validation Sample (149,646 admissions at 4,535 hospitals)				
Variable	**Frequency (%)**	**Estimate**	**SE**	**OR**	**95% CI**	**Frequency (%)**	**Estimate**	**SE**	**OR**	**95% CI**
Demographics										
Age-65 (continuous)	-	0.03	0.00	1.03	(1.03-1.04)	-	0.03	0.00	1.03	(1.03-1.04)
Cardiovascular/Respiratory										
Sleep Apnea (ICD-9 codes: 327.20, 327.21, 327.23, 327.27, 327.29, 780.51, 780.53, 780.57)	9.57	-0.14	0.04	0.87	(0.81-0.94)	9.72	-0.17	0.04	0.84	(0.78-0.90)
History of Mechanical Ventilation (ICD-9 codes: 93.90, 96.70, 96.71, 96.72)	6.00	0.17	0.04	1.19	(1.11-1.27)	6.00	0.14	0.04	1.15	(1.08-1.24)
Respirator Dependence/Respiratory Failure (CC 77-78)	1.15	-0.12	0.07	0.89	(0.77-1.02)	1.20	-0.24	0.07	0.78	(0.68-0.91)
Cardio-Respiratory Failure and Shock (CC 79)	26.35	0.47	0.02	1.60	(1.53-1.68)	26.34	0.47	0.02	1.59	(1.52-1.66)
Congestive Heart Failure (CC 80)	41.50	0.29	0.02	1.34	(1.28-1.39)	41.39	0.27	0.02	1.31	(1.25-1.36)
Chronic Atherosclerosis (CC 83-84)	50.44	-0.14	0.02	0.87	(0.83-0.90)	50.12	-0.10	0.02	0.91	(0.87-0.94)
Arrhythmias (CC 92-93)	37.15	0.16	0.02	1.17	(1.12-1.22)	37.06	0.14	0.02	1.15	(1.10-1.20)
Vascular or Circulatory Disease (CC 104-106)	38.20	0.09	0.02	1.09	(1.05-1.14)	38.09	0.02	0.02	1.02	(0.98-1.06)
Fibrosis of Lung and Other Chronic Lung Disorder (CC 109)	16.96	0.07	0.02	1.08	(1.03-1.13)	17.08	0.11	0.02	1.11	(1.06-1.17)
Asthma (CC 110)	17.05	-0.41	0.03	0.67	(0.63-0.70)	16.90	-0.41	0.03	0.67	(0.63-0.70)
Pneumonia (CC 111-113)	49.46	0.26	0.02	1.29	(1.24-1.35)	49.41	0.24	0.02	1.27	(1.22-1.33)
Pleural Effusion/Pneumothorax (CC 114)	11.78	0.16	0.03	1.17	(1.11-1.23)	11.54	0.17	0.03	1.18	(1.12-1.25)
Other Lung Disorders (CC 115)	53.07	-0.23	0.02	0.80	(0.77-0.83)	53.17	-0.18	0.02	0.83	(0.80-0.87)
Other Comorbid Conditions										
Metastatic Cancer and Acute Leukemia (CC 7)	2.76	0.85	0.05	2.34	(2.14-2.56)	2.79	0.77	0.05	2.15	(1.97-2.35)
Lung, Upper Digestive Tract, and Other Severe Cancers (CC 8)	5.98	0.59	0.03	1.80	(1.68-1.92)	6.02	0.68	0.03	1.98	(1.85-2.11)
Lymphatic, Head and Neck, Brain, and Other Major Cancers; Breast, Prostate, Colorectal and Other Cancers and Tumors; Other Respiratory and Heart Neoplasms (CC 9-11)	14.13	0.02	0.03	1.03	(0.97-1.08)	14.19	0.01	0.03	1.01	(0.95-1.06)
Other Digestive and Urinary Neoplasms(CC 12)	6.91	-0.10	0.04	0.91	(0.84-0.98)	7.05	-0.16	0.04	0.85	(0.79-0.92)
Diabetes and DM Complications (CC 15-20, 119-120)	38.31	-0.10	0.02	0.91	(0.87-0.94)	38.29	-0.10	0.02	0.91	(0.87-0.94)
Protein-calorie Malnutrition (CC 21)	7.40	0.78	0.03	2.18	(2.07-2.30)	7.44	0.74	0.03	2.09	(1.98-2.20)
Disorders of Fluid/Electrolyte/Acid-Base (CC 22-23)	32.05	0.12	0.02	1.13	(1.08-1.18)	32.16	0.22	0.02	1.24	(1.19-1.30)
Other Endocrine/Metabolic/Nutritional Disorders (CC 24)	67.99	-0.29	0.02	0.75	(0.72-0.78)	67.88	-0.27	0.02	0.76	(0.73-0.79)
Other Gastrointestinal Disorders (CC 36)	56.21	-0.21	0.02	0.81	(0.78-0.84)	56.18	-0.24	0.02	0.78	(0.75-0.81)
Osteoarthritis of Hip or Knee (CC 40)	9.32	-0.30	0.04	0.74	(0.69-0.79)	9.33	-0.23	0.04	0.80	(0.74-0.85)
Other Musculoskeletal and Connective Tissue Disorders (CC 43)	64.14	-0.19	0.02	0.83	(0.80-0.86)	64.20	-0.18	0.02	0.83	(0.80-0.87)

	Development Sample (150,035 admissions at 4,537 hospitals)					Validation Sample (149,646 admissions at 4,535 hospitals)				
Variable	**Frequency (%)**	**Estimate**	**SE**	**OR**	**95% CI**	**Frequency (%)**	**Estimate**	**SE**	**OR**	**95% CI**
Iron Deficiency and Other/Unspecified Anemias and Blood Disease (CC 47)	40.80	0.08	0.02	1.08	(1.04-1.12)	40.72	0.08	0.02	1.08	(1.04-1.13)
Dementia and Senility (CC 49-50)	17.06	0.08	0.02	1.09	(1.04-1.14)	16.97	0.09	0.02	1.09	(1.04-1.15)
Drug/Alcohol Abuse, Without Dependence (CC 53)	23.51	-0.24	0.02	0.78	(0.75-0.82)	23.38	-0.27	0.02	0.76	(0.72-0.80)
Other Psychiatric Disorders (CC 60)	16.49	0.11	0.02	1.12	(1.07-1.18)	16.43	0.11	0.02	1.12	(1.06-1.17)
Quadriplegia, Paraplegia, Functional Disability (CC 67-69, 100-102, 177-178)	4.92	0.03	0.04	1.03	(0.95-1.12)	4.92	0.07	0.04	1.08	(0.99-1.17)
Mononeuropathy, Other Neurological Conditions/Injuries (CC 76)	11.35	-0.16	0.03	0.85	(0.80-0.91)	11.28	-0.13	0.03	0.88	(0.83-0.93)
Hypertension and Hypertensive Disease (CC 90-91)	80.40	-0.25	0.02	0.78	(0.75-0.82)	80.35	-0.24	0.02	0.79	(0.75-0.83)
Stroke (CC 95-96)	6.77	0.00	0.04	1.00	(0.93-1.08)	6.73	-0.03	0.04	0.98	(0.91-1.05)
Retinal Disorders, Except Detachment and Vascular Retinopathies (CC 121)	10.79	-0.14	0.03	0.87	(0.82-0.93)	10.69	-0.10	0.03	0.90	(0.85-0.96)
Other Eye Disorders (CC 124)	19.05	-0.10	0.02	0.90	(0.86-0.95)	19.13	-0.12	0.02	0.89	(0.85-0.93)
Other Ear, Nose, Throat, and Mouth Disorders (CC 127)	35.21	-0.18	0.02	0.83	(0.80-0.87)	35.02	-0.22	0.02	0.80	(0.77-0.83)
Renal Failure (CC 131)	17.92	0.12	0.02	1.12	(1.07-1.18)	18.16	0.13	0.02	1.13	(1.08-1.19)
Decubitus Ulcer or Chronic Skin Ulcer (CC 148-149)	7.42	0.24	0.03	1.27	(1.19-1.35)	7.42	0.29	0.03	1.33	(1.25-1.42)
Other Dermatological Disorders (CC 153)	28.46	-0.10	0.02	0.90	(0.87-0.94)	28.32	-0.11	0.02	0.89	(0.86-0.93)
Trauma (CC 154-156, 158-161)	9.04	0.09	0.03	1.09	(1.03-1.16)	8.99	0.14	0.03	1.15	(1.08-1.22)
Vertebral Fractures (CC 157)	5.01	0.29	0.04	1.33	(1.24-1.44)	4.97	0.26	0.04	1.29	(1.20-1.39)
Major Complications of Medical Care and Trauma (CC 164)	5.47	-0.21	0.04	0.81	(0.75-0.88)	5.55	-0.20	0.04	0.82	(0.76-0.89)

Grey highlighting indicates variable forced into the model.

* Each variable in the model is adjusted for the effects of the others

Table 7. Risk Factor Frequency (%) in Data Samples

Description	2007 n= 259,911	2008 n= 299,681	2009 n=279,377
Demographics			
Age – 65 (Mean/SD)	-	-	-
Cardiovascular/Respiratory			
Sleep Apnea (ICD-9 codes: 327.20, 327.21, 327.23, 327.27, 327.29, 780.51, 780.53, 780.57)	8.86	9.65	10.87
History of Mechanical Ventilation (ICD-9 codes: 93.90, 96.70, 96.71, 96.72)	6.00	6.00	6.70
Respirator Dependence/Respiratory Failure (CC 77-78)	1.34	1.17	1.17
Cardio-Respiratory Failure and Shock (CC 79)	26.51	26.34	27.76
Congestive Heart Failure (CC 80)	42.79	41.45	42.24
Chronic Atherosclerosis (CC 83-84)	50.20	50.28	50.82
Arrhythmias (CC 92-93)	36.71	37.10	38.11
Vascular or Circulatory Disease (CC 104-106)	37.64	38.15	39.38
Fibrosis of Lung and Other Chronic Lung Disorder (CC 109)	17.87	17.02	17.27
Asthma (CC 110)	18.03	16.98	17.06
Pneumonia (CC 111-113)	45.15	49.44	49.85
Pleural Effusion/Pneumothorax (CC 114)	11.39	11.66	12.49
Other Lung Disorders (CC 115)	51.82	53.12	54.19
Comorbidities			
Metastatic Cancer and Acute Leukemia (CC 7)	2.83	2.78	2.80
Lung, Upper Digestive Tract, and Other Severe Cancers (CC 8)	5.94	6.00	6.22
Lymphatic, Head and Neck, Brain, and Other Major Cancers; Breast, Prostate, Colorectal and Other Cancers and Tumors; Other Respiratory and Heart Neoplasms (CC 9-11)	14.03	14.16	14.22
Other Digestive and Urinary Neoplasms(CC 12)	7.04	6.98	6.81
Diabetes and DM Complications (CC 15-20, 119-120)	37.36	38.30	40.46
Protein-calorie Malnutrition (CC 21)	6.72	7.42	8.21
Disorders of Fluid/Electrolyte/Acid-Base (CC 22-23)	32.51	32.10	33.47
Other Endocrine/Metabolic/Nutritional Disorders (CC 24)	65.10	67.94	70.88
Other Gastrointestinal Disorders (CC 36)	56.37	56.19	56.98
Osteoarthritis of Hip or Knee (CC 40)	9.04	9.32	9.51
Other Musculoskeletal and Connective Tissue Disorders (CC 43)	63.47	64.17	65.28
Iron Deficiency and Other/Unspecified Anemias and Blood Disease (CC 47)	39.41	40.76	42.91
Dementia and Senility (CC 49-50)	16.37	17.01	17.20
Drug/Alcohol Abuse, Without Dependence (CC 53)	23.35	23.45	23.96
Other Psychiatric Disorders (CC 60)	16.63	16.46	17.05
Quadriplegia, paraplegia, functional disability (CC 67-69, 100-102, 177-178)	4.66	4.92	5.23
Mononeuropathy, Other Neurological Conditions/Injuries (CC 76)	11.04	11.31	11.78
Hypertension and Hypertensive Disease (CC 90-91)	79.36	80.37	81.53
Stroke (CC 95-96)	6.87	6.75	6.69
Retinal Disorders, Except Detachment and Vascular Retinopathies (CC 121)	10.36	10.74	11.04
Other Eye Disorders (CC 124)	18.95	19.09	19.19
Other Ear, Nose, Throat, and Mouth Disorders (CC 127)	34.58	35.12	35.52
Renal Failure (CC 131)	16.88	18.04	19.92
Decubitus ulcer or chronic skin ulcer (CC 148-149)	7.04	7.42	7.58
Other Dermatological Disorders (CC 153)	27.80	28.39	28.85
Trauma (CC 154-156, 158-161)	8.54	9.01	9.40
Vertebral Fractures (CC 157)	5.16	4.99	5.04
Major Complications of Medical Care and Trauma (CC 164)	5.45	5.51	5.72

Table 8. Temporal Trend in Adjusted OR* for Model Risk Factors and Mortality in Development and Validation Samples (Logistic Regression Model)

Description	2007 n= 259,911		2008 n= 299,681		2009 n=279,377	
	OR	95% CI	OR	95% CI	OR	95% CI
Demographics						
Age-65 (continuous)	1.03	(1.03-1.04)	1.03	(1.03-1.04)	1.03	(1.03-1.03)
Cardiovascular/Respiratory						
Sleep Apnea (ICD-9 codes: 327.20, 327.21, 327.23, 327.27, 327.29, 780.51, 780.53, 780.57)	0.87	(0.82-0.92)	0.86	(0.82-0.90)	0.84	(0.80-0.89)
History of Mechanical Ventilation (ICD-9 codes: 93.90, 96.70, 96.71, 96.72)	1.20	(1.14-1.27)	1.17	(1.12-1.23)	1.29	(1.22-1.35)
Respirator Dependence/Respiratory Failure (CC 77-78)	0.87	(0.78-0.96)	0.83	(0.74-0.92)	0.81	(0.73-0.91)
Cardio-Respiratory Failure and Shock (CC 79)	1.55	(1.50-1.60)	1.60	(1.55-1.65)	1.53	(1.48-1.58)
Congestive Heart Failure (CC 80)	1.29	(1.25-1.33)	1.32	(1.28-1.36)	1.27	(1.23-1.32)
Chronic Atherosclerosis (CC 83-84)	0.88	(0.85-0.90)	0.89	(0.86-0.91)	0.86	(0.84-0.89)
Arrhythmias (CC 92-93)	1.13	(1.09-1.16)	1.16	(1.13-1.20)	1.14	(1.10-1.17)
Vascular or Circulatory Disease (CC 104-106)	1.05	(1.02-1.08)	1.05	(1.02-1.08)	1.03	(1.00-1.06)
Fibrosis of Lung and Other Chronic Lung Disorder (CC 109)	1.10	(1.06-1.14)	1.09	(1.06-1.13)	1.07	(1.03-1.11)
Asthma (CC 110)	0.68	(0.65-0.70)	0.67	(0.64-0.69)	0.68	(0.65-0.71)
Pneumonia (CC 111-113)	1.47	(1.42-1.52)	1.28	(1.25-1.32)	1.26	(1.22-1.30)
Pleural Effusion/Pneumothorax (CC 114)	1.17	(1.12-1.22)	1.18	(1.13-1.22)	1.18	(1.13-1.22)
Other Lung Disorders (CC 115)	0.79	(0.76-0.81)	0.81	(0.79-0.84)	0.84	(0.82-0.87)
Comorbidities						
Metastatic Cancer and Acute Leukemia (CC 7)	2.29	(2.14-2.45)	2.24	(2.10-2.39)	2.39	(2.24-2.56)
Lung, Upper Digestive Tract, and Other Severe Cancers (CC 8)	1.95	(1.85-2.06)	1.88	(1.79-1.98)	1.85	(1.77-1.94)
Lymphatic, Head and Neck, Brain, and Other Major Cancers; Breast, Prostate, Colorectal and Other Cancers and Tumors; Other Respiratory and Heart Neoplasms (CC 9-11)	1.01	(0.97-1.05)	1.02	(0.98-1.06)	1.02	(0.98-1.06)
Other Digestive and Urinary Neoplasms(CC 12)	0.91	(0.86-0.96)	0.88	(0.83-0.93)	0.81	(0.76-0.86)
Diabetes and DM Complications (CC 15-20, 119-120)	0.90	(0.88-0.93)	0.90	(0.88-0.93)	0.90	(0.87-0.92)
Protein-calorie Malnutrition (CC 21)	2.05	(1.96-2.14)	2.12	(2.04-2.20)	2.09	(2.01-2.18)
Disorders of Fluid/Electrolyte/Acid-Base (CC 22-23)	1.17	(1.13-1.21)	1.18	(1.15-1.22)	1.19	(1.15-1.23)
Other Endocrine/Metabolic/Nutritional Disorders (CC 24)	0.78	(0.75-0.80)	0.76	(0.74-0.78)	0.78	(0.76-0.81)
Other Gastrointestinal Disorders (CC 36)	0.81	(0.79-0.84)	0.80	(0.77-0.82)	0.83	(0.80-0.85)
Osteoarthritis of Hip or Knee (CC 40)	0.72	(0.68-0.76)	0.77	(0.73-0.81)	0.73	(0.69-0.78)
Other Musculoskeletal and Connective Tissue Disorders (CC 43)	0.84	(0.81-0.87)	0.83	(0.81-0.86)	0.82	(0.79-0.84)
Iron Deficiency and Other/Unspecified Anemias and Blood Disease (CC 47)	1.09	(1.05-1.12)	1.08	(1.05-1.11)	1.09	(1.06-1.12)
Dementia and Senility (CC 49-50)	1.09	(1.05-1.13)	1.09	(1.05-1.13)	1.09	(1.06-1.13)
Drug/Alcohol Abuse, Without Dependence (CC 53)	0.76	(0.73-0.79)	0.78	(0.75-0.80)	0.76	(0.73-0.79)
Other Psychiatric Disorders (CC 60)	1.05	(1.01-1.09)	1.12	(1.08-1.16)	1.08	(1.04-1.12)
Quadriplegia, paraplegia, functional disability (CC 67-69, 100-102, 177-178)	1.01	(0.95-1.08)	1.05	(0.99-1.12)	1.04	(0.98-1.10)
Mononeuropathy, Other Neurological Conditions/Injuries (CC 76)	0.82	(0.78-0.86)	0.87	(0.83-0.91)	0.83	(0.80-0.88)
Hypertension and Hypertensive Disease (CC 90-91)	0.81	(0.78-0.83)	0.79	(0.76-0.81)	0.81	(0.78-0.84)
Stroke (CC 95-96)	1.01	(0.96-1.07)	0.99	(0.94-1.04)	1.04	(0.98-1.10)
Retinal Disorders, Except Detachment and Vascular Retinopathies (CC 121)	0.88	(0.84-0.93)	0.89	(0.85-0.93)	0.95	(0.91-0.99)
Other Eye Disorders (CC 124)	0.87	(0.84-0.91)	0.90	(0.87-0.93)	0.93	(0.89-0.96)
Other Ear, Nose, Throat, and Mouth Disorders (CC 127)	0.77	(0.75-0.80)	0.82	(0.79-0.84)	0.81	(0.78-0.83)
Renal Failure (CC 131)	1.15	(1.11-1.20)	1.13	(1.09-1.17)	1.14	(1.10-1.18)
Decubitus ulcer or chronic skin ulcer (CC 148-149)	1.35	(1.29-1.42)	1.30	(1.24-1.36)	1.39	(1.33-1.45)

Description	2007 n= 259,911		2008 n= 299,681		2009 n=279,377	
	OR	95% CI	OR	95% CI	OR	95% CI
Other Dermatological Disorders (CC 153)	0.89	(0.86-0.92)	0.90	(0.87-0.93)	0.91	(0.88-0.94)
Trauma (CC 154-156, 158-161)	1.10	(1.05-1.15)	1.12	(1.07-1.17)	1.14	(1.09-1.19)
Vertebral Fractures (CC 157)	1.37	(1.29-1.45)	1.31	(1.25-1.39)	1.44	(1.36-1.52)
Major Complications of Medical Care and Trauma (CC 164)	0.89	(0.84-0.95)	0.82	(0.77-0.87)	0.89	(0.84-0.94)

* Each variable in the model is adjusted for the effects of the others

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6. APPENDIX

6.1 Appendix A - Conditions That May Represent Adverse Outcomes of Care Received During Index Admission

CC	Description
2	Septicemia/Shock
6	Other Infectious Diseases
17	Diabetes with Acute Complications
23	Disorders of Fluid/Electrolyte/Acid-Base
28	Acute Liver Failure/Disease
31	Intestinal Obstruction/Perforation
34	Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders
46	Coagulation Defects and Other Specified Hematological Disorders
48	Delirium and Encephalopathy
75	Coma, Brain Compression/Anoxic Damage
77	Respirator Dependence/Tracheostomy Status
78	Respiratory Arrest
79	Cardio-respiratory failure and shock
80	Congestive heart failure
81	Acute myocardial infarction
82	Unstable angina
92	Specified Heart Arrhythmias
93	Other Heart Rhythm and Conduction Disorders
95	Cerebral Hemorrhage
96	Ischemic or Unspecified Stroke
97	Precerebral Arterial Occlusion and Transient Cerebral Ischemia
100	Hemiplegia/Hemiparesis
101	Cerebral Palsy and Other Paralytic Syndromes
102	Speech, Language, Cognitive, Perceptual
104	Vascular Disease with Complications
105	Vascular Disease
106	Other Circulatory Disease
111	Aspiration and Specified Bacterial Pneumonias
112	Pneumococcal Pneumonia, Emphysema, Lung Abscess
114	Pleural Effusion/Pneumothorax
130	Dialysis Status
131	Renal failure
132	Nephritis
133	Urinary Obstruction and Retention
135	Urinary Tract Infection
148	Decubitus Ulcer of Skin
152	Cellulitis, Local Skin Infection
154	Severe Head Injury
155	Major Head Injury
156	Concussion or Unspecified Head Injury
158	Hip Fracture/Dislocation
159	Major Fracture, Except of Skull, Vertebrae, or Hip
163	Poisonings and Allergic Reactions
164	Major Complications of Medical Care and Trauma
165	Other Complications of Medical Care
174	Major Organ Transplant Status
175	Other Organ Transplant/Replacement
177	Amputation Status, Lower Limb/Amputation
178	Amputation Status, Upper Limb

6.2 Appendix B - CCs Not Considered for Risk Adjustment

CC	Description	Rationale
66	Attention Deficit Disorder	Pediatric ; Low frequency
123	Cataracts	Marker of clinical practice, not clinically relevant
129	End Stage Renal Disease	Not included in CMS-HCC Model
137	Female Infertility	Irrelevant to Medicare FFS Population
141	Ectopic Pregnancy	Irrelevant to Medicare FFS Population
142	Miscarriage/Abortion	Irrelevant to Medicare FFS Population
143	Completed Pregnancy with Major Complications	Irrelevant to Medicare FFS Population
144	Completed Pregnancy with Complications	Irrelevant to Medicare FFS Population
145	Completed Pregnancy without Complication	Irrelevant to Medicare FFS Population
146	Uncompleted Pregnancy with Complications	Irrelevant to Medicare FFS Population
147	Uncompleted Pregnancy with No or Minor Complications	Irrelevant to Medicare FFS Population
168	Extremely Low Birthweight Neonates	Fetal Effects; Irrelevant to Medicare FFS Population
169	Very Low Birthweight Neonates	Fetal Effects; Irrelevant to Medicare FFS Population
170	Serious Perinatal Problems Affecting Newborn	Fetal Effects; Irrelevant to Medicare FFS Population
171	Other Perinatal Problems Affecting Newborn	Fetal Effects; Irrelevant to Medicare FFS Population
172	Normal, Single Birth	Fetal Effects; Irrelevant to Medicare FFS Population
173	Major Organ Transplant	Not included in CMS-HCC Model
176	Artificial Openings for Feeding or Elimination	CC too heterogeneous; Mix of disparate codes
179	Post-Surgical States/Aftercare/Elective	CC too heterogeneous; Mix of disparate codes
180	Radiation Therapy	CC too heterogeneous; Mix of disparate codes
181	Chemotherapy	CC too heterogeneous; Mix of disparate codes
182	Rehabilitation	CC too heterogeneous; Mix of disparate codes
183	Screening/Observation/Special Exams	CC too heterogeneous; Mix of disparate codes
184	History of Disease	CC too heterogeneous; Mix of disparate codes
185	Oxygen	Not included in CMS-HCC Model; Durable Medical Equipment (DME)
186	CPAP/IPPB/Nebulizers	Not included in CMS-HCC Model; DME
187	Patient Lifts, Power Operated Vehicles, Beds	Not included in CMS-HCC Model; DME
188	Wheelchairs, Commodes	Not included in CMS-HCC Model; DME
189	Walkers	Not included in CMS-HCC Model; DME