

**Hybrid Hospital-Wide (All-Condition, All-Procedure) Risk-  
Standardized Mortality Measure with Electronic Health Record  
Extracted Risk Factors: Measure Methodology for Public Comment**

**Submitted by**

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# 1. EXECUTIVE SUMMARY

## Goal of Measure

The goal of developing a Hybrid Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure with Electronic Health Record Extracted Risk Factors, or hybrid HWM measure, was to broadly measure the quality of care across hospitals and to be able to measure the quality of care in smaller volume hospitals. This measure will provide information to hospitals that can facilitate targeted quality improvement, provide more transparent information for the public, and allow policymakers to monitor a very important outcome. In addition, the goal of this hybrid HWM measure, that employs a combination of administrative claims data and clinical electronic health record (EHR) data, is to minimize provider burden while enhancing clinical case mix adjustment with clinical data.

This measure was developed in parallel with the harmonized claims-only HWM measure to incentivize quality reporting using electronic data sources. When referring to either measure, we referred to the measure described in this report as the “hybrid HWM measure”, to reflect its dual data sources, and referred to the measure utilizing only claims data as the “claims-only HWM measure”.

## Background and Rationale

Mortality is an important health outcome that is meaningful to patients and providers, and updated estimates suggest that more than 400,000 patients die each year from preventable harm in hospitals.<sup>1</sup> The vast majority of patients admitted to the hospital have survival as a primary goal. Existing condition-specific mortality measures support targeted quality improvement work and may have contributed to national declines in hospital mortality rates for measured conditions and/or procedures.<sup>2</sup> They do not, however, allow for measurement of a hospital’s broader performance, nor do they meaningfully capture performance for smaller volume hospitals. While we do not ever expect mortality rates to be zero, studies have shown that mortality within 30 days of hospital admission is related to quality of care and that high and variable mortality rates across hospitals indicate opportunities for improvement.<sup>3,4</sup> Therefore, it is reasonable to consider an all-condition, all-procedure, risk-standardized 30-day mortality rate as a quality measure.

Development of a hybrid version of a hospital-wide mortality measure addressed stakeholder preference for the use of patient-level clinical EHR data to support risk adjustment in assessing hospital performance by using data from claims as well as clinical data elements pulled from the EHR for risk adjustment.

## Measure Development Process

This measure aimed to report the hospital-level, risk-standardized rate of mortality within 30 days of hospital admission for most conditions or procedures. The Center for Outcomes Research and Evaluation (CORE) initially developed a claims-only HWM measure, which is detailed in a separate report, Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment, which is also posted on the CMS Public Comment website, within the same zip file as this report. To develop the hybrid HWM measure, CORE built upon the claims-only HWM measure by utilizing the same concept, outcome, and cohort, and adding clinical data elements extracted from EHR to augment the risk adjustment models. We aimed to enhance the claims-only HWM measure by adding clinical data derived from the EHR.



We engaged with several stakeholder groups throughout the development process of both the claims-only HWM measure and the hybrid HWM measure. We elicited feedback on the measure concept, outcome, cohort, risk model variables (including claims variables and clinical EHR variables), and how to develop and report measure results in a meaningful way for patients, family caregivers, and providers. These engagements have included two advisory groups in the form of a Technical Work Group and a Patient and Family Caregiver Work Group. We also convened a national Technical Expert Panel (TEP) consisting of a diverse set of stakeholders, including providers and patients. In 2016, we also sought comment from the general public in the form of an interim public comment period on the draft claims-only HWM measure, upon which this measure is based. The Public Comment Summary Report is posted under Hospital-Wide Risk-Standardized Mortality Measure zip file, at <https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/MMS/PC-Updates-on-Previous-Comment-Periods.html>. We are now seeking input from the general public in this public comment period on the completed measure specifications.

### **Measure Specifications**

Our cohort definition uses the same cohort definition as the claims-only HWM measure and attempts to capture as many admissions as possible for which survival would be a reasonable indicator of quality and for which adequate risk adjustment is possible. We assumed survival would be a reasonable indicator of quality for admissions fulfilling two criteria: 1) survival is most likely the primary goal of the patient when they enter the hospital; and 2) the hospital can reasonably influence the chance of survival through quality of care. We determined the adequacy of risk adjustment using clinical judgement and by examining survival patterns and model performance. Therefore, we included in the measure all admissions except those for which 30-day mortality cannot reasonably be considered a signal of quality care, or for which risk adjustment presented specific challenges using International Classification of Diseases, Ninth Revision (ICD-9) claims data. We further narrowed the cohort definition in this initial measure version based upon concerns with adequate risk adjustment using ICD-9 codes, but will revisit these exclusions in the next measure iteration during updating to International Classification of Diseases, Tenth Revision (ICD-10) codes.

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

To compare mortality performance across hospitals, the measure accounts for differences in patient characteristics (patient case mix) as well as differences in mixes of services and procedures offered by hospitals (hospital service mix). We account for differences in patient case mix using patient clinical comorbidity variables and patient clinical data derived from the EHR, and account for differences in hospital service mix using the patient's principal discharge diagnosis.

Rather than assume that the effects of risk variables are homogeneous across all discharge condition and procedure categories, we separated the cohort into 13 different service-line divisions and estimated separate risk models within each. We then derived a single summary score from the results of the 13 models by combining separate standardized mortality ratios to calculate one hospital-wide mortality rate for each hospital. Using 13 models rather than a single model allows for better risk adjustment for diverse patient groups and improves the usability of the measure. The 13 service-line divisions allow hospitals and consumers to have more detailed information on hospital performance. The 13 service-line divisions include Non-Surgical: Cancer, Cardiac, Gastrointestinal, Infectious Disease, Neurology,

Orthopedics, Pulmonary, Renal; Surgical: Cancer, Cardiothoracic, General, Neurosurgery, Orthopedics. While the measure is intended to include all 13 service-line divisions, the dataset used to develop and test the hybrid HWM measure did not contain enough patients in the Neurosurgery service-line division, so most results only capture 12 service-line divisions.

This report serves as a summary of the measure development, stakeholder input, measure specifications, and measure testing for the hybrid HWM measure. The hybrid HWM measure utilizes some of the core clinical data elements, which are data derived from hospital EHR systems. To use these data to calculate the measure, CMS will provide electronic specifications in the form of the Measure Authoring Tool (MAT) Output. We intend for the hybrid HWM measure to use the same measure logic as is used in the electronic specifications for the hybrid hospital-wide readmission (HWR) measure, found at the eCQI Resource Center here: <https://ecqi.healthit.gov/ecqm/measures/cms529v4>, and will update the electronic specifications as needed. In addition, the measure is currently undergoing reevaluation to update its claims-based components for use in ICD-10 data.

## 2. PUBLIC COMMENT

### Purpose of the Public Comment Period

We are seeking stakeholder feedback on two measures: 1) the Claims-Only Hospital-Wide Mortality Measure (claims-only HWM measure) and 2) the harmonized Hybrid Hospital-Wide Mortality Measure (hybrid HWM measure). Both measures are in public comment simultaneously. This is the report for the hybrid HWM measure. The report for the claims-only HWM measure is also posted on the CMS Public Comment website, within the same zip file as this report.

Both measures have the same cohort, outcome, and service-line divisions. The hybrid HWM measure uses a combination of claims and clinical electronic health record (EHR) data in the risk adjustment model. Developing two measures of hospital-wide mortality is intended to give CMS options for implementation, as they move toward including more clinical EHR data in outcome measures. This public comment period seeks input from a wide variety of stakeholders regarding several key decisions including the final measure cohort, measure outcome, risk adjustment models, and overall model performance.

We seek public input on the entire measure methodology, but we ask for specific input on the following aspects of the measure:

- Do you have input on the measure testing approach?
  - What validity testing would be meaningful for this measure?
- Do you have input on how the measure results might be presented to the public?
  - How could CMS present supplemental hospital performance information in public reporting, such as service-line division-level results, to create a more meaningful and usable measure?

These questions are also flagged in call out boxes throughout the document.

### Instructions for Providing Feedback

CMS requests that interested parties submit comments on the methodology for the hybrid HWM measure. Instructions are as follows:

- If you are providing comments on behalf of an organization, include the organization's name and contact information.
- If you are commenting as an individual, submit identifying or contact information.
- See the public comment website for deadline to submit comments.
- Please do not include personal health information in your comments.
- Send your comments to [cms\\_hwmmeasure@yale.edu](mailto:cms_hwmmeasure@yale.edu).

### 3. INTRODUCTION

#### 3.1. Overview of Report

The Centers for Medicare & Medicaid Services (CMS) contracted with Yale New Haven Health System/Center for Outcomes Research and Evaluation (YNHHS/CORE) to develop a Hybrid Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure with Electronic Health Record Extracted Risk Factors based on administrative claims data and clinical electronic health record (EHR) data. Throughout this report, we refer to this measure as the hybrid HWM measure.

This measure was built to be harmonized with the Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure, which was developed in parallel and is frequently referenced in this report as the claims-only HWM measure. The claims-only HWM measure decisions were used to determine the cohort, outcome, service-line divisions, and claims-based risk variables for this hybrid HWM measure. The measure specifications for these two hospital-wide measures are identical except for the use of clinical EHR data in the division-level risk models of the hybrid HWM measure. Developing these two measures of hospital-wide mortality is intended to give CMS options for implementation, as they move toward including more clinical EHR data in outcome measures. All key decisions that are shared by both measures are outlined in this report, with additional reference to the claims-only HWM for further details. The parallel Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment is also posted on the CMS Public Comment website, within the same zip file as this report.

Under contract with CMS, CORE had previously identified a set of core clinical data elements (CCDE) that are routinely collected on hospitalized adults, feasibly extracted from hospital EHR systems, and are related to patients' clinical status at the start of an inpatient encounter. The CCDE are the first captured vital signs and laboratory results. The CCDE have been utilized in conjunction with administrative claims data to create hybrid outcome measures, which are quality measures that utilize more than one source of data. This report builds on this prior work by using the CCDE as candidate risk variables to test various risk models of the Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure to develop a hybrid HWM measure. For more information on how the CCDE were originally developed, we refer readers to the Core Clinical Data Elements Technical Report and the Hybrid Hospital-Wide Readmission Measure with Electronic Health Record Extracted Risk Factors report posted at <https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/HospitalQualityInits/Measure-Methodology.html> under "Core Clinical Data Elements and Hybrid Measures.zip". For testing results of the electronic specifications of the CCDE included in the Hybrid Hospital-Wide Readmission Measure with Claims and Electronic Health Record Data, we refer readers to the specifications posted on [Quality Positioning System](#) section of the National Quality Forum (NQF) website.

Mortality is an important outcome that is meaningful to patients and providers. The vast majority of patients admitted to the hospital have survival as a primary goal. This important outcome is already the focus of existing CMS condition- and procedure-specific mortality quality measures; hospital-level risk-standardized mortality rates (RSMRs) are reported for patients admitted for heart failure, pneumonia, acute myocardial infarction, chronic obstructive pulmonary disease, stroke, and coronary artery bypass graft surgery.<sup>5,6</sup> Existing mortality measures support targeted quality improvement work around specific conditions and may have contributed to national declines in hospital mortality rates for measured

conditions and/or procedures.<sup>2</sup> They do not, however, capture admissions for patients admitted for a majority of the conditions or procedures for which a patient may use the hospital or allow for measurement of a hospital's broader performance. In addition, the condition and procedure-specific mortality measures fail to measure performance for smaller volume hospitals.

In Medicare data from July 2014 through June 2015, there were more than eight million inpatient admissions among Medicare fee-for-service (FFS) beneficiaries ages 65 and over across 4,766 United States (US) hospitals. The observed 30-day mortality rate was more than 9%, ranging from 5.6% among those 65-69 years old (representing approximately 20% of this population) to 21.1% among those 95-99 years old (roughly 2% of the population).

In addition to the obvious harm to individuals and their families and caregivers that results from preventable death, there are also significant financial costs to the healthcare system. Capturing monetary savings for preventable mortality events is challenging, as patients who die may incur fewer expenses than those who survive. Further, distinguishing between truly preventable hospital deaths and those deaths that are truly not preventable is challenging. However, using two recent estimates of the number of deaths due to preventable medical errors, and assuming an average of ten lost years of life per death (valued at \$75,000 per year in lost quality adjusted life years), the annual direct and indirect cost of potentially preventable deaths could be as much as \$73.5 to \$735 billion.<sup>7-9</sup>

In this technical report, we provide detailed information on the development and specifications of the hybrid HWM measure. This includes details on the major decisions to form the cohort, the outcome, and the divisions, as also described in further detail in the claims-only HWM measure report. It also includes hybrid-specific information on risk adjustment, measure testing, and reporting considerations. The hybrid HWM measure complies with accepted standards for outcomes measure development, including appropriate risk adjustment and transparency of specifications. Our goal is to include admissions for patients for whom mortality is likely to present a quality signal and those where the hospital has the ability to influence the outcome for the patient. The performance metric, risk-standardized mortality rates (RSMR), are derived from the combined results of multiple statistical models built for groups of admissions that are clinically related and share similar risk profiles. This report reflects specifications that have been developed with close input from patients, caregivers, clinicians and methodological experts. In addition, the measure reflects input from a nationally convened Technical Expert Panel (TEP) representing a diverse set of stakeholders as well as input from an interim public comment period.

### 3.2. Hospital-Wide Mortality as a Quality Indicator

#### 3.2.1 Importance

Mortality is an unwanted outcome for the overwhelming majority of patients admitted to US hospitals. Although mortality within 30 days of hospitalization is uncommon, when assessed among appropriate patients, it provides a concrete signal of care quality across conditions and procedures. It captures the result of care processes, such as peri-operative management protocols, and the impact of both optimal care and adverse events resulting from medical care.

Evidence supports that optimal medical care reduces mortality.<sup>3,4</sup> We know from ongoing improvements in condition- and procedure-specific mortality rates that interventions to improve these outcomes are feasible.<sup>2</sup> Multiple organizations, including the Institute for Healthcare Improvement (IHI), promote a range of evidence-based strategies to reduce hospital mortality.<sup>10</sup> These strategies include:

- Adoption of strategies shown to reduce ventilator-associated pneumonia;<sup>11-13</sup>
- Delivery of reliable, evidence-based care for acute myocardial infarction;<sup>14,15</sup>
- Prevention of adverse drug events through medication reconciliation;<sup>16</sup>
- Prevention of central line infections through evidence-based guideline-concordant care;<sup>17</sup> and
- Prevention of surgical site infections through evidence-based guideline-concordant care.<sup>18,19</sup>

To reduce mortality, the IHI further encourages hospitals to use multidisciplinary rounds to improve communication, employ Rapid Response Teams to attend to patients at the first sign of clinical decline, identify high-risk patients on admission and increase nursing care and physician contact accordingly, standardize patient handoffs to avoid miscommunication or gaps in care, and establish partnerships with community providers to promote evidenced-based practices to reduce hospitalizations before patients become critically ill.<sup>20</sup> The IHI's 100,000 Lives Campaign, which was created to enlist hospitals in a coordinated effort to adopt the above interventions, led to an estimated more than 120,000 lives saved over the first 18 months of the campaign.<sup>21</sup>

Some of the evidence-based recommendations above apply to specific diagnoses. While condition- and procedure-specific initiatives to reduce mortality may broadly impact mortality rates across other conditions and procedures, there is likely more to be gained by a measure of hospital-wide mortality that can inform and encourage quality improvement efforts for patients not currently captured by existing CMS mortality measures. In addition, there is evidence that a hospital's organizational culture is linked to key measures of hospital quality performance.<sup>22</sup> Since these cultural and leadership qualities affect the entire hospital, the HWM measure may provide important incentives for hospitals not only to examine their care processes and improve care for individual conditions, but may also provide incentives to encourage care transformation and improve overall organizational culture.

In fact, because of its importance, hospital-wide mortality has been the focus of a number of previous quality reporting initiatives in the US and other countries. Prior efforts have met with some success and a number of challenges. Despite these challenges, countries such as the United Kingdom, Scotland, and Australia, continue to report measures of hospital-wide mortality.<sup>23</sup>

While we do not expect optimal mortality rates to be zero, we know, as stated above, that studies have shown that mortality within 30 days is related to quality of care; that interventions have been able to reduce 30-day mortality rates for a variety of specific conditions; and that high and variable mortality rates indicate opportunity for improvement. Therefore, it is reasonable to consider an all-condition, all-procedure risk-standardized 30-day mortality rate as an important quality performance measure for hospitals.

### 3.2.2 Feasibility

Since the initial CMS hospital-wide mortality effort, much has changed to improve potential feasibility. As of 2015, administrative claims coding has advanced significantly. Advancements include allowing up to 25 diagnostic codes per admission encounter (previously there were only 10 available diagnostic codes) and expanding the use of present on admission codes to signify conditions that were present prior to admission. CMS also has the benefit of years of experience successfully calculating and reporting the claims-based condition- and procedure-specific mortality measures, including performing chart-based validation of a number of these measures. Additionally, CMS has reported results for the claims-based Hospital-Wide Readmission (HWR) Measure since July 2013, which utilizes novel methods to

aggregate readmission rates across diverse patient cohorts, to adjust more accurately for service mix. Moreover, CMS has further evolved its measure development approach to expand stakeholder engagement across all phases of measure development and to specifically include patients' perspectives and input to ensure more patient-centered measures. Therefore, it is now feasible to construct a measure which will be scientifically sound and acceptable to stakeholders.

Finally, the use of electronic clinical data in this hybrid HWM measure will allow us to know more critical clinical information about the patient's health status at the time of arrival to the hospital. This information can be incorporated into risk adjustment for more detailed clinical risk adjustment. This electronic clinical information is now more broadly available, due to national incentives aimed at increasing EHR adoption<sup>i</sup>, related work to standardize data element definitions across providers<sup>ii</sup>, and specific work by our team to develop and test a core set of clinical data elements (CCDEs), some of which are used in this risk adjustment model. The clinical data required in the risk adjustment model will be derived electronically from hospital EHRs. We have previously tested the feasibility of each of these data elements empirically and have shown them to be consistently captured for nearly all adults hospitalized for acute care and extractable from hospital EHRs. Since the EHR system used by these 22 hospitals (Epic) is widely used in the United States, we can make the reasoned inference that these data are representative. For testing results of the CCDE included in the Hybrid Hospital-Wide Readmission Measure with Claims and Electronic Health Record Data, we refer readers to the specifications posted on the on [Quality Positioning System](#) section of the NQF website.

### 3.2.3 Usability

A primary motivation for this measure was to provide policymakers with a summary performance assessment of patient survival, particularly for lower volume hospitals that care for insufficient numbers of patients to produce stable, reportable performance estimates using condition- and procedure-specific measures. In addition, from the outset, CMS and CORE sought to make this measure broadly usable by both patients and providers, as well as policymakers. Therefore, we approached this measure development from three distinct perspectives – policymakers; providers; and patient and family caregivers – in order to create a measure that provides meaningful, scientifically acceptable hospital performance information for all of these user groups.

The multiple model approach, which uses results for each of the service-line division models to create the overall hospital-wide mortality measure score, could increase the practical utility of the measure by providing information on differences in performance among divisions (service-line areas) within hospitals. This aspect of the measure will allow hospitals to better target quality improvement efforts and was strongly supported by patients and family caregivers. In addition, as expressed by all of our work groups and our TEP, in order for this measure to be more useful and meaningful, some additional information should be available to the public at a level that is more granular than a single summary hospital RSMR. However, the final decision to share divisional or other granular performance

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<sup>i</sup> EHR Incentive Program. <http://www.cms.gov/EHRIncentivePrograms/>

<sup>ii</sup> Health Information Technology (IT) for Economic and Clinical Health (HITECH) Act of 2009 provided Health and Human Services with authority to establish programs to improve healthcare quality, safety, and efficiency through the promotion of health IT, establishing the Office of National Coordinator to set standards, implementation specifications, and certification criteria for electronic exchange and use of health information. <https://www.healthit.gov/policy-researchers-implementers/health-it-legislation-and-regulations>

information that is supplemental to the overall HWM measure result will need to balance the input of patients and providers, who seek greater transparency and granularity, with the fact that such granular information may be less reliable than the aggregated HWM measure result. This measure was developed in tandem with the claims-only HWM measure to give CMS options in the implementation of a hospital-wide mortality measure, as they move toward more EHR-based measures. It is not designed to compete directly with the claims-only HWM measure.

### 3.3. Approach to Measure Development

In addition to leveraging the earlier work to develop the claims-only HWM measure, we developed this measure in consultation with national guidelines for publicly reported outcome measures, following the technical approach to outcomes measurement set forth in NQF guidance for outcome measures, 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.”<sup>28,29</sup> Further, we have engaged with several stakeholder groups continuously during the development process, eliciting feedback on the measure concept, outcome, cohort, risk model variables, measure results, and how to present the measure results in a meaningful way for patients, family caregivers, and providers. These have included two formal advisory groups:

- A Technical Work Group, comprised of clinicians and a statistician; and
- A Patient and Family Caregiver Work Group (formerly two separate groups during the claims-only HWM measure development), comprised of patients, family members, and caregivers for patients who have had multiple encounters with the healthcare system.

We also convened a national Technical Expert Panel (TEP) of diverse stakeholders, including providers and patients. We are now seeking input from the general public in this public comment period on this measure. We previously sought comment on the measure concept, cohort, outcome, approach to risk adjustment, and plans for presenting the results to the public; we are now specifically seeking public comment on the final measure cohort, risk adjustment models, discrimination (c-statistic), reliability, and validity of the measure.

We plan on updating the claims-based specifications for use in ICD-10 data and submitting this measure to NQF for endorsement.



## 4. METHODS

### 4.1. Overview

This document aims to report the development and specifications of the measurement of hospital-level, risk-standardized mortality within 30 days of hospital admission for most conditions or procedures. The measure will be reported as a single summary score, derived from the results of risk-adjustment models, for 13 mutually exclusive divisions (admissions grouped based on categories of discharge diagnoses or procedures). Hospitalizations were eligible for inclusion in the measure if the patient was hospitalized at a non-Federal short-stay acute care hospital or critical access hospital. To compare mortality performance across hospitals, the measure accounted for differences in patient characteristics (patient case mix) as well as differences in mixes of services and procedures offered by hospitals (hospital service mix).

The measure cohort, outcome, divisions, and approach to risk factors were initially developed in CMS administrative claims data, with key decisions described below, and further detail described in the claims-only HWM measure report. Because there is currently no large national dataset that includes patient-level EHR data to develop, test, and validate various risk models using clinical EHR data, we used data from Kaiser Permanente Northern California (KPNC) from their EHR data warehouses, which contain patient-level clinical variables (for example, laboratory test results, vital signs, care directives) to develop the risk-adjustment models for the hybrid HWM measure. KPNC serves more than 4.1 million members at its 22 acute care hospitals. While the risk model was developed using these 22 hospitals, the hybrid HWM measure is designed to be implemented in all non-Federal short-stay acute care hospitals in the United States. In this report, we have described the decisions and final measure specifications as it would be implemented in the Medicare FFS population. However, for development purposes, throughout this report we note where we used slightly modified specifications that were necessary for testing purposes due to the smaller number of hospitals in the dataset provided by KPNC, referred to as the Clinical Hybrid Dataset ([Section 4.2 Data Sources](#)). Throughout this Methods section, we focus on and outline the final measure specifications (as developed for Medicare FFS population), and note the differences used for hybrid HWM measure development only. In the Results section of this report, we refer to the claims-only HWM measure report for results that use the Medicare FFS data source and the claims-only HWM measure specifications. For hybrid HWM measure-specific results (or results that incorporate clinical EHR data), we report results based on the modified measure specifications using the Clinical Hybrid Dataset.

This section provides details about the measure development and final measure specifications of the hybrid hospital-level, risk-standardized mortality measure. Below we detail the data sources used, the measure cohort inclusion and exclusion criteria, the outcome definition and attribution, the approach to risk adjustment, final risk models, reliability testing, and validity testing of measure results. We are currently seeking comment on each of these.

### 4.2. Data Sources

As noted above, we built the hybrid HWM measure based on the work and information that we learned while developing the claims-only HWM measure using a nationwide Medicare FFS data source. Therefore, to develop the majority of these hybrid HWM measure specifications, including the cohort, outcome, service-line divisions, and claims-based risk variables, we mirrored the claims-only HWM measure and based all decisions on the Claims-Only Development Dataset as described briefly below

and in more detail in the claims-only HWM report. To develop and test the risk model for the hybrid HWM measure, we used data provided by KPNC; this data included claims-based data along with clinical information extracted from the EHR to create the Clinical Hybrid Dataset. A detailed description of this dataset is provided below. This Clinical Hybrid Dataset was also used to validate the claims-only HWM measure, which is detailed separately in that respective report. See Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment, which is also posted on the CMS Public Comment website, within the same zip file as this report.

Datasets used are as follows:

1. [Medicare] Claims-Only [Measure] Development Dataset (used to inform development decisions derived from claims-only measure development). Several sources of data collected for Medicare Fee-For-Service claims were used to define the measure specifications; see Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment, which is also posted on the CMS Public Comment website, within the same zip file as this report.
2. Clinical Hybrid Dataset. Constructed using Kaiser Permanente Northern California matched administrative claims and electronic health record (EHR) data, admission dates from January 1, 2009 – June 30, 2015. The total number of admissions prior to inclusions and exclusions in this cohort was 1,291,592.

#### 4.2.1. Clinical Hybrid Dataset Description

Data used to develop the hybrid HWM measure were provided by KPNC from their EHR data warehouses. KPNC is an integrated healthcare delivery system that serves over 4.1 million members at its 22 acute care hospitals. Although the number of KPNC hospitals is much smaller than the number of hospitals in the nation that will be ultimately included in the implemented measure, the patients within the KPNC hospitals represent adequate sample for measure development. Comparison of similarly aged patients (65 years and older) in the Clinical Hybrid Dataset and Claims-Only Development Dataset demonstrated similar prevalence of those comorbidities included in the claims-only HWM measure risk model; see [Appendix B Comorbidity Comparison: Claims vs Clinical Hybrid Datasets](#). All KPNC hospitals use an integrated EHR system that runs Epic software to capture and store patient management, administrative, and clinical data in their outpatient and inpatient healthcare settings. The Systems Research Initiative within the Kaiser Permanente Division of Research has worked to develop an extensive clinical risk-adjustment methodology for internal benchmarking and quality assurance and is in the process of developing the capability to use these clinical data in real time for clinical decision support and quality measurement. Their work has required mapping specific clinical data elements within their databases, extracting data, and validating their source and accuracy.

Additionally, members enrolled in the KPNC health system receive nearly all of their care from the KPNC network of outpatient and inpatient providers. In the rare instance that a member is admitted to an acute care facility outside of the network, KPNC will receive a claim for those services unless the patient decides to pay out-of-pocket. Thus, almost all hospital admissions in this patient population are captured by KPNC databases, which facilitates the observation of mortality outcomes.

We partnered with KPNC to provide datasets that include all admissions for adult patients to any of their member hospitals between January 1, 2009 and June 30, 2015. These datasets contained both the

claims data as well as the clinical data that were used to derive the cohort, outcome, comorbidities, and CCDE. The clinical data included values for the 21 data elements in the CCDE from which we derived first-captured vital signs and laboratory test results from all hospital entry locations including the emergency department, operating rooms, inpatient floors, and units. Specifically, they provided:

- Hospital identifier and hospital entry location;
- Time and date stamps for patients' arrival at the hospital for care;
- Principal discharge diagnosis (ICD-9 and minimal ICD-10 codes);
- Secondary diagnoses (ICD-9 codes);
- The patients' vital signs and laboratory test results from each admission (including data values, time and date stamps);
- Variables related to cohort exclusion criteria (discharged against medical advice, transferred from another acute care facility, discharge status); and
- Comfort care-only orders.
- Whether the patient died for any reason within 30-days from admission (from their linked administrative claims).

In addition, they provided the following information from claims submitted by their members for admissions to out-of-network hospitals: admission dates, discharge dates, and principal discharge diagnoses. In this dataset, all of these data elements were linked to a single hospital admission using a unique encounter identification number. Individual patients may have had one or more admissions in the database and were linked using unique patient identifiers assigned by KPNC.

#### 4.3. Cohort

Aligning with the claims-only HWM measure, our guiding principle for defining eligible admissions was that the measure should appropriately reflect a meaningful quality signal across a large number of acute care hospitals. Therefore, our cohort should capture as many admissions as possible for which survival would be a reasonable indicator of quality. We excluded admissions for which adequate risk adjustment was not possible. We defined an admission as having a reasonable indicator of quality if it fulfilled two criteria: 1) survival was most likely the primary goal of the patient when they entered the hospital (for example, a patient admitted at the end of their life under hospice care for comfort measures likely does not have 30-day survival as their primary goal); and 2) the hospital could be reasonably expected to impact the chance of the patient's survival with improved quality of care (for example, the hospital does not have the ability to meaningfully impact the chance of survival for a patient admitted with brain death). Therefore, our cohort was defined in the same way as for the claims-only HWM measure, where in the measure we included all admissions except those for which full data were not available, or for which 30-day mortality cannot reasonably be considered a signal of quality care. We excluded admissions for which risk adjustment presented specific challenges in the development datasets. For each inclusion and exclusion criteria below, using these principles we completed multiple rounds of clinical review internally, and then reviewed and validated each decision with our Technical Work Group, Patient and Family Caregiver Work Group, and TEP during development of the claims-only measure and then applied to this measure. For any admissions excluded due to the challenge of adequate risk adjustment, we will continue to reevaluate the possibility of including those admissions in future iterations of the measure as we explore other options of risk adjustment.

#### 4.3.1. Grouping Patients into Clinically Coherent Categories

For our previous claims-based condition- and procedure-specific outcome measures, we used individual ICD-9 codes for the index admission to define the cohort. Because of the large and diverse number of admissions considered and thousands of included ICD-9 codes in CMS's existing HWR measure, the HWR measure used the Agency for Healthcare Research and Quality (AHRQ) Clinical Classification Software (CCS) to group the numerous ICD-9 codes into clinically meaningful categories. The HWR measure then used those CCS categories for further cohort specification and risk-adjustment modeling. Similar to the HWR measure, the HWM measures use the AHRQ CCS to group the principal discharge diagnoses and major procedures, with slight modifications specific to mortality risk (See [Section 4.3.8 Defining Service-Line Divisions](#)). We will update the measure specifications for use in ICD-10 code data prior to implementation.

CCS is a software tool developed as part of the [Healthcare Cost and Utilization Project \(HCUP\)](#), a Federal-State-Industry partnership sponsored by the AHRQ. It collapses ICD-9 condition and procedure codes into a smaller number of clinically meaningful condition and procedure categories.<sup>30</sup> There are more than 15,000 ICD-9 diagnosis codes, grouped into 287 mutually exclusive AHRQ condition categories, most of which are single, homogenous diseases such as pneumonia or acute myocardial infarction. However, some are aggregates of conditions, such as "other bacterial infections." There are also about 3,900 ICD-9 procedure codes, grouped into 231 mutually exclusive CCS procedure categories.

For further rationale around this decision, please see the Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment.

#### 4.3.2. Inclusion Criteria

Inclusion criteria are consistent with the claims-only HWM measure. These inclusion and exclusion criteria represent what is intended for implementation, and do not indicate the slight changes to the Clinical Hybrid Dataset for development purposes only, which are outlined in [Section 4.3.5 Modifications to Accommodate Hybrid Measure Development Data Source](#). An index admission is the hospitalization to which the mortality outcome is attributed and includes admissions for patients:

1. Enrolled in Medicare FFS Part A for the 12 months prior to the date of admission and during the index admission;
  - a. **Rationale:** This is to ensure that patients are Medicare FFS beneficiaries and their comorbidities are captured from prior claims for adequate risk adjustment.
2. Have not been transferred from another inpatient facility.
  - a. **Rationale:** This measure considers multiple contiguous hospitalizations as a single acute episode of care. Transfer patients are identified by tracking claims for inpatient short-term acute care hospitalizations over time. Admissions to an acute care hospital within one day of discharge from another acute care hospital are considered transfers regardless of whether or not the first institution indicates intent to transfer the patient in the discharge disposition code and regardless of the principal discharge diagnosis. Transferred patients are included in the measure cohort, but it is the initial hospitalization, rather than any later, "transfer-in" hospitalization(s), that is included as the index admission
3. Admitted for acute care;

- a. Do not have a principal discharge diagnosis of a psychiatric disease (CCSs 650, 651, 652, 654, 655, 656, 657, 658, 659, 662 & 670);
    - i. **Rationale:** Patients admitted primarily for psychiatric treatment are typically cared for in separate psychiatric hospitals which are not comparable to acute care hospitals. [**Note:** This measure does include patients who are admitted for acute medical conditions and also have comorbid psychiatric disease.]
  - b. Do not have a principal discharge diagnosis of “rehabilitation care; fitting of prostheses and adjustment devices” (CCS 254);
    - i. **Rationale:** Patients admitted for rehabilitation services are not typically admitted to an acute care hospital and are not admitted for acute care.
- 4. Aged between 65 and 94 years;
  - a. **Rationale:** Medicare patients younger than 65 usually qualify for the program due to disability, end-stage renal disease, or Amyotrophic Lateral Sclerosis (ALS). They are not included in the measure because they are considered to be too clinically distinct from Medicare patients between 65 and 94 years. The characteristics and outcomes of these patients may not be representative of the larger Medicare patient population. While we acknowledge that many elderly patients do have survival beyond 30 days as a primary goal for their hospitalization, we also understand that, on average, very old patients may be less likely to have survival as a primary goal and that the hospital may not always be able to impact the chance of survival in the oldest elderly patients. In order to avoid holding hospitals responsible for the survival of the oldest elderly patients and with the guidance of our work groups and TEP, we decided to only include patients between 65 and 94 years of age.
- 5. Not enrolled in hospice at the time of or in the 12 months prior to their index admission;
  - a. **Rationale:** Patients enrolled in hospice in the prior 12 months or at the time of admission are unlikely to have 30-day survival as a primary goal of care.
- 6. Not enrolled in hospice within two days of admission. [**Note:** For development purposes, we did not have the date of hospice enrollment. Thus, to operationalize this criteria we made the following modification: Have not died within two days of admission or had a length of stay of two days or fewer and also been enrolled in hospice during admission or at discharge];
  - a. **Rationale:** This exclusion reflects input from our TEP and working groups and analyses performed in response to their feedback. There is not a single, correct approach regarding patients enrolled in hospice during admission or upon discharge – mortality may or may not represent a quality signal for this group of patients and hospice enrollment is inadequate to differentiate this issue. However, based on feedback from stakeholders and experts we consulted during measure development, it is likely that for most patients and/or families who had the discussion and agreed to enroll in hospice within two days of admission, survival is not likely the primary goal due to a condition that was present on admission and therefore, mortality should not be used as a marker of quality care. [**Note:** this inclusion was added after the finalization of the development dataset.]

7. Without a principal diagnosis of cancer and enrolled in hospice during their index admission (See [Appendix C AHRQ CCSs for Cancer and Metastatic Cancer](#) for the full list of CCSs capturing cancer principal discharge diagnosis codes);
  - a. **Rationale:** Patients admitted primarily for cancer who are enrolled in hospice at any time during admission are unlikely to have 30-day survival as a primary goal of care.
8. Without any diagnosis of metastatic cancer (See [Appendix C AHRQ CCSs for Cancer and Metastatic Cancer](#) for full list of CCSs capturing metastatic cancer principal discharge diagnosis codes); and
  - a. **Rationale:** Although some patients admitted primarily for a diagnosis of metastatic cancer will have 30-day survival as a primary goal of care, it is more likely than not that death may be a clinically reasonable and patient-centered decision for this group of patients and therefore they are unlikely to have 30-day survival as a primary goal of care.
9. Without a principal discharge diagnosis of a condition which hospitals have limited ability to influence survival, including: anoxic brain damage (ICD-9 3481); persistent vegetative state (ICD-9 78003); prion diseases such as Creutzfeldt-Jakob disease (ICD-9 04619); Cheyne-Stokes respiration (ICD-9 78604); brain death (ICD-9 34882); respiratory arrest (ICD-9 7991); or cardiac arrest (ICD-9 4275) without a secondary diagnosis of acute myocardial infarction.
  - a. **Rationale:** Hospitals have little ability to impact mortality for these conditions. This list of conditions was defined by three independent clinicians who reviewed high mortality conditions, and then reviewed with our TEP and Technical Working Group.

#### 4.3.3.Exclusion Criteria

We then applied several exclusion criteria to the measure population. This measure will exclude index admission for patients:

1. With inconsistent or unknown vital status;
  - a. **Rationale:** We do not include stays for patients where the admission date is after the date of death in the Medicare Enrollment Database, or where the date of death occurs before the date of discharge but the patient was discharged alive.
2. Discharged against medical advice (AMA);
  - a. **Rationale:** Hospitals had limited opportunity to implement high-quality care and is not responsible for events that follow a discharge AMA.
3. With an admission for crush injury (CCS 234), burn (CCS 240), intracranial injury (CCS 233), or spinal cord injury (CCS 227);
  - a. **Rationale:** Even though a hospital likely can influence the outcome of some of these conditions, we felt that there were specific challenges to risk adjustment. These conditions are less frequent events that are unlikely to be uniformly distributed across hospitals and may entail distinct risk profiles. Therefore, we chose to exclude these admissions in this iteration of the measure and plan to revisit them in future iterations.

4. With certain principal discharge diagnosis codes for which mortality may not be a quality signal. This exclusion was added after the Claims-Only Development Dataset was created, and is therefore only found in the Split Sample Datasets;
  - a. **Rationale:** As part of the adjustments to address Heterogeneous CCSs, we removed a few admissions with principal discharge diagnosis ICD-9 codes that were clinically distinct from others in the CCS, for which quality of care was less likely to impact survival, and where there were a small number of patients. See details in [Section 4.5.4 Service Mix Risk Adjustment](#), and Appendix G Heterogeneous CCS Modifications of the Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment.
5. With an admission in a CCS condition or procedure categorized as in the divisions: Other Surgical Procedures or Other Non-Surgical Conditions. See [Appendix D Procedure Categories Defining the Surgery Service-Line Division](#) and [Appendix E Condition Categories Assigned to the Non-Surgical Service-Line Divisions](#) for list of conditions categories. See [Section 4.3.7 Service-Line Division Approach](#) below for more details on how admissions were categorized into service-line divisions; and
  - a. **Rationale:** Even though a hospital likely can influence the outcome of many of these conditions, we felt that there were specific challenges to risk adjustment using ICD-9 data. These divisions are populated by more hospitalizations for conditions based on CCSs that have low volume, variable mortality, and high heterogeneity in risk. The small numbers of admissions and events in each CCS and the large numbers of CCSs included in these service-line divisions create challenges for statistical model convergence. We chose to exclude these admissions in this iteration of the measure and will revisit these admissions, attempting to include them as we re-specify the measure using ICD-10 data.
6. With an admission in a low volume CCS, defined as less than 100 patients with that principal discharge diagnosis per service-line division across all hospitals.
  - a. **Rationale:** To calculate a stable and precise risk model, there are a minimum number of admissions that are needed. In addition, a minimum number of admissions and/or outcome events are required to inform grouping admissions into larger categories. These admissions present challenges to both accurate risk prediction and coherent risk grouping and are therefore excluded.

#### 4.3.4. Other Cohort Considerations

With the approval of our TEP, the measure does not currently utilize billing codes for do-not-resuscitate (DNR) for cohort decisions, as this is not a reliable method for determining a patient's wishes at the time of or during the admission. [**Note:** We will explore clinically relevant data variables related to patient care preferences for end-of-life care during measure validation.]

#### 4.3.5. Modifications to Accommodate Hybrid Measure Development Data Source

For development of our hybrid HWM measure, we are using the Clinical Hybrid Dataset, which included clinical and claims information from 22 acute care hospitals. As noted above, we made certain adaptations to the proposed measure cohort specifications to develop and test the hybrid HWM

measure; these adaptations were in response to having a smaller set of hospitals for development and an aim to maximize the cohort for testing. For example, one adaptation was a cohort change to identify comfort care-only patients, which is only feasible in a measure using EHR data, as a replacement for patients who had prior enrolment in hospice, as that specific data was unavailable in EHR dataset (Clinical Hybrid Dataset). Variations between the testing cohort and the proposed hybrid HWM measure cohort are listed below; not as final measure specifications, but for development and testing only of the hybrid HWM measure:

- **Included patients aged 50-94.** We expanded age to include patients aged 50-64 (only for development purposes). For the final hybrid HWM measure specifications, the measure inclusion criteria will be age 65-94, consistent with the claims-only HWM measure.
- **Included multiple years of admissions (2010-2014).** We expanded our measurement period to have enough data for measure development purposes, with an additional 12 months of historical data (2009) to identify comorbidities for risk adjustment. The final hybrid HWM measure specifications would be a one year measure, similar to the claims-only HWM measure. To address the issue of multiple admissions, we applied the same random selection approach used by existing CMS 30-day mortality measures using multiple years of data.<sup>5</sup>
- **Did NOT include admissions for patients who have comfort care-only orders within 2 days of admission.** Our Clinical Hybrid Dataset currently does not include prior hospice enrollment information, only discharge status to hospice. Therefore, we modified this criteria for the hybrid HWM measure, using care orders as a proxy for hospice enrollment. For the final hybrid HWM measure, we will use hospice enrollment in place of comfort care only orders to be consistent with the claims-only HWM measure and to reflect that care orders are not currently a feasible data element for national measure implementation.
  - In the future, if comfort care-only orders can be validated as a reliable and feasible variable that can be extracted from the EHR at low burden to hospitals, we could consider updating the cohort definition for the hybrid measure to use this data element.
- **Excluded admission in a low volume CCS, defined as less than 25 patients with that principal discharge diagnosis per division across hospitals.** Due to the smaller number of hospitals in the Clinical Hybrid Dataset, we were able to use a smaller cut-off for low volume diagnoses (from 100 to 25) to include more patients for development. As we implement this nationwide, we expect that for statistical stability, we would need to use 100 admissions, similar to the claims-only HWM measure.
- **The neurosurgery division was not tested for all risk modeling approaches in development.** Because this division contains a smaller number of admissions in our Clinical Hybrid Dataset and some hospitals have zero death events, the between hospital variance was zero for several division-level models and therefore we exclude this division from some of our testing, including the final model testing. However, we were able to perform testing with a model that included only the EHR-derived clinical variables, which has fewer risk factor variables than the final proposed model (see [Section 5.2 Final Risk Adjustment Model](#)). Therefore, we propose keeping it in the measure specifications, noting the need for further testing when a more comprehensive data source is available.



#### 4.3.6. Addressing Patients with Multiple Admissions

The risk of mortality is not independent of the number of admissions a patient has had in a given time period, as a patient with multiple admissions can have at most one negative outcome (death). In addition, we know that the overall mortality rate for patients admitted more than once is higher than for those patients with only one admission. We also know that the percent of patients with multiple admissions that a hospital cares for varies. While patients do not always go back to the same hospital for repeat admissions, empiric analyses of Medicare data demonstrate that the majority of patients return to the same hospital. Other condition-specific hospital mortality measures reported by CMS address this issue by randomly selecting only one admission per patient per year.

As this measure includes all conditions and procedures, we systemically investigated different approaches to handling the issue of patients with multiple admissions within the measurement period. There was no practical statistical modeling approach that could account or adjust for the complex relationship between the number of admissions and risk of mortality in the context of a hospital-wide mortality measure. Therefore, in order to provide a scientifically rigorous, statistically appropriate, and technically feasible measure that provides transparency, and where appropriate, emphasizes simplicity, we used the approach currently employed in existing CMS mortality measures of including only one randomly selected admission per patient in the one year measurement period. This reduces the number of admissions, but does not exclude any patients from the measure.

**Rationale:** Random selection better reflects that the results of their hospitalizations can be death or survival when patients enter the hospital. Selecting the last admission would not be as accurate a reflection of the risk of death as random selection, as the last admission is inherently associated with higher mortality risk.

#### 4.3.7. Service-Line Division Approach

This section has been abbreviated for this report. For further detail on how we originally developed the 13 service-line divisions and selected the risk variables from the Claims-Only Development Dataset, please see Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment.

We chose to group our cohort into clinically-related, service-line divisions where risk factors would likely be less heterogeneous, and then estimate separate regression models within each division. For this multiple model approach, we created, tested, and included 13 different service-line division models (detailed below in [Section 4.3.8 Defining Service-Line Divisions](#)). This approach allows risk variables to have different effects for different conditions. For example, the effect of the comorbid risk factor of having diabetes may be different for a patient who is admitted for pneumonia than for a patient admitted for a knee replacement surgery. We then derived a single summary score to get a single hospital-wide mortality rate for each hospital. In addition, we wanted to compare how the inclusion of clinically relevant variables captured in the EHR (such as blood pressure) impacted the predictability of the risk models. Therefore, we compared the 13 divisional risk models four ways, which included variations with and without comorbidities and principal discharge diagnoses from the Claims-Only Development Dataset. In addition to the statistical importance for risk adjustment, the service-line divisions were also supported by the TEP and all of the work groups, because of the importance of providing more detailed information than a single summary score for the usability of this measure for both clinicians and patients.

In summary, using 13 models rather than a single model may allow for better risk adjustment for diverse patient groups and will likely improve the usability of the measure. Using many more risk models (service-line divisions) may not be feasible given the number of cases per hospital in each condition.

#### 4.3.8. Defining Service-Line Divisions

This section has been abbreviated for this report. For further detail on how we originally created the 13 service-line divisions, please see Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment.

We expect the hospital component of mortality risk to be in part related to the care provided by a team of doctors, nurses, care coordinators, pharmacists, etc. Conditions typically cared for by the same team of clinicians would therefore be expected to experience similar added (or reduced) levels of mortality risk. Therefore, we grouped discharge condition categories typically cared for by the same group of clinicians into 13 service-line divisions (See [Table 1](#)). Organizing results by care team in this way will allow hospitals to identify areas of strength and weakness if hospital performance varies across divisions. This approach also addresses the strong preference of patients and caregivers to have a better understanding of the hospital's performance for certain conditions or procedures. Below we describe the major decisions for defining the 13 service-line divisions.

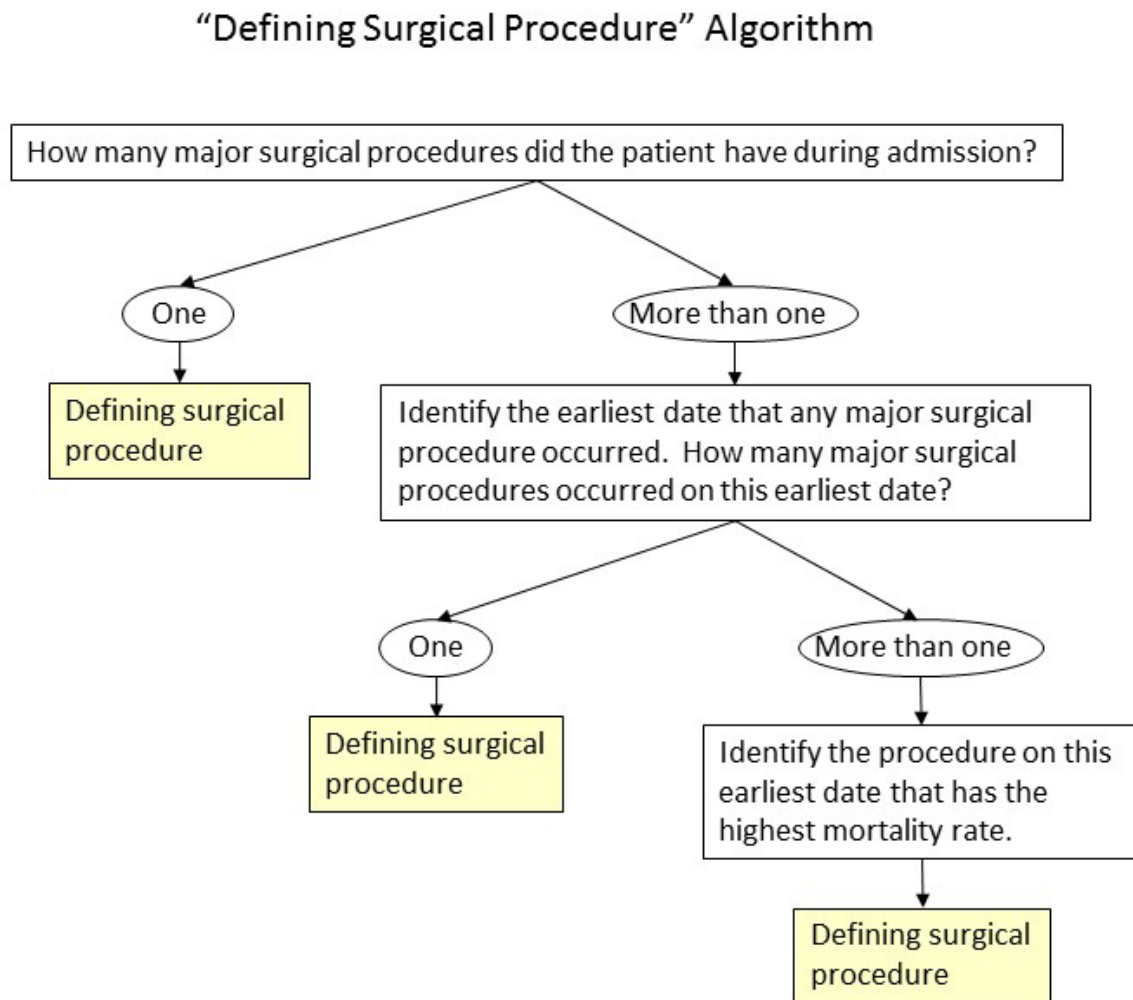
##### Surgical vs. Non-Surgical Assignment

Admissions were first screened for the presence of an eligible surgical procedure category. These were defined as "major surgical procedures," representing procedures for which a patient is likely to be cared for primarily by a surgical service and identified using the approach used by the HWR measure to identify surgical admissions. Admissions with any such major surgical procedures were assigned to a surgical division, regardless of the principal discharge diagnosis code for the admission. All remaining admissions were assigned to divisions based on the principal discharge condition codes.

##### Identifying the Defining Surgical Procedure

Unlike principal discharge diagnoses, of which there can only be one per admission, patients can undergo multiple surgical procedures during a hospital stay, and it is not possible in claims data to determine which, if any, procedure was related to the reason for admission. In order to report on service-line divisions that are more granular than a single division containing all surgical patients, we created an algorithm to assign a "defining surgical procedure" ([Figure 1](#)). If a patient only has one major surgical procedure, that procedure will be the "defining surgical procedure." However, if a patient has more than one major surgical procedure, the first dated major surgical procedure will be assigned as the "defining surgical procedure." If there is more than one major surgical procedure that occurs on that earliest date, the procedure with the highest mortality rate will be the "defining surgical procedure." The highest mortality rate was defined by unadjusted mortality rates for all admissions with major surgical procedures using a subset of the Claims-Only Development Dataset that included admissions from two years prior, from July 1, 2012 – June 30, 2014.

Figure 1. "Defining Surgical Procedure" Algorithm



## Creating the Final 13 Service-Line Divisions

The combined work of our internal team of physicians and input from our work groups and TEP resulted initially in 15 divisions (six surgical and nine non-surgical) to capture hospital service mix. The AHRQ CCS procedure categories for the major surgical procedures by division are shown in [Appendix D Procedure Categories Defining the Surgery Service-Line Division](#). The list of the AHRQ discharge condition categories for each non-surgical division are shown in [Appendix E Condition Categories Assigned to the Non-Surgical Service-Line Divisions](#).

After testing the models, we removed the heterogeneous divisions: “Other Non-Surgical Conditions” and “Other Surgical Procedures”, as detailed in [Section 4.3.3 Exclusion Criteria](#). We plan to reevaluate the exclusion of these two divisions during reevaluation of the measure in ICD-10 data. We will work towards including as many patients as possible. [Table 1](#) shows the number of admission in each of the final 13 divisions in the hybrid HWM measure development cohort. While the measure is intended to include all 13 service-line divisions, the dataset used to develop and test the hybrid HWM measure did not contain enough patients in the Neurosurgery service-line division, so most results only capture 12 service-line divisions (See [Section 4.3.5. Modifications to Accommodate Hybrid Measure Development Data Source](#)).

**Table 1. Service-Line Divisions Admissions, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014)**

Division	Admissions
<b>Non-Surgical Divisions</b>	
Cancer	5,764
Cardiac	57,090
Gastrointestinal	34,366
Infectious Disease	52,627
Neurology	19,425
Orthopedics	11,497
Pulmonary	25,057
Renal	12,116
<b>Surgical Divisions</b>	
Cancer	15,506
Cardiothoracic	7,800
General	34,159
Orthopedics	74,226
<b>Total Development Cohort</b>	<b>349,633</b>

#### 4.4. Outcome

The outcome for this measure is all-cause 30-day mortality. We define mortality as death from any cause within 30 days of the index hospital admission date, which was provided by KPNC.

##### 4.4.1. Thirty-Day Timeframe

This section has been abbreviated for this report. For further detail on the development of the 30-day timeframe, please see Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment, which is also posted on the CMS Public Comment website, within the same zip file as this report.

We combined input from clinical experts with empiric analyses, published literature and consistency with existing CMS mortality measures to define the 30-day timeframe for capturing mortality. We have also reviewed the 30-day timeframe with our Technical and Patient and Family Caregiver Work Groups as well as our TEP, and they supported the 30-day timeframe. In summary, we chose a post-admission observation period of 30-days balancing considerations of empiric data findings, actionability, cross-measure consistency, and fairness of attribution.

##### 4.4.2. All-Cause Mortality

We defined the outcome as “all-cause” mortality rather than related to the index hospitalization for multiple reasons. First, from the patient perspective, mortality for any reason is an undesirable outcome of care. In defining the measure cohort, we worked with clinical experts and patients to only include patients for whom it is reasonable to assume that 30-day survival is a primary goal of care. Second, there is no reliable way to determine whether mortality is related to the index hospitalization based on the documented cause of mortality. As with readmissions, many deaths that might not be deemed related are in fact influenced by the care received during hospitalization. For example, a heart failure patient who is discharged with inappropriately dosed medications may develop renal failure from over diuresis and die. It would be inappropriate to treat this death as unrelated to the care the patient received for heart failure. Third, all existing CMS mortality measures report all-cause mortality, making this approach consistent with existing measures. Finally, defining the outcome as all-cause mortality may encourage hospitals to implement broader initiatives aimed at improving the overall care within the hospital and transitions from the hospital setting instead of limiting the focus to a narrow set of condition- or procedure-specific approaches.

##### 4.4.3. Outcome Attribution

Outcomes are attributed to the admitting hospital. In cases of transfers, the sequence of hospitalizations is treated as one episode of care and the admission and associated outcome are attributed to the first admitting hospital. For example, if a patient is admitted to acute care Hospital A, and then transferred to acute care Hospital B, the admission and associated outcome (survival or death within 30-days) is attributed only to Hospital A.

A surgical transfer patient is defined as a patient who is originally admitted to one hospital where no major surgical procedure is performed and is then transferred to a different hospital where they receive a major surgical procedure. Given that surgical transfer patients are more likely to have risks that are similar to other surgical patients (rather than non-surgical patients), we proposed assigning surgical transfer patients to a surgical division for risk adjustment and reporting (rather than a non-surgical

division). However, the mortality outcome remains attributed to the original admitting hospital that made the decision to both admit and transfer the patient.

#### 4.5. Approach to Risk Adjustment

This section has been abbreviated for this report. For further detail on how we originally selected the comorbidity risk variables from the administrative claims dataset and the AHRQ CCS principal discharge diagnoses, please see Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment, which is also posted on the CMS Public Comment website, within the same zip file as this report.

##### 4.5.1. Risk Adjustment Overview

The goal of risk adjustment is to account for differences across hospitals in patient demographic and clinical characteristics that might be related to the outcome but are unrelated to quality of care. Risk adjustment for this measure was complicated by the fact that it includes many different discharge condition categories, as well as patients undergoing surgical procedures. Therefore, adjusted for both case mix differences (clinical status of the patient on admission, accounted for by adjusting for age, comorbidities, and clinical data) and service mix differences (the types of conditions/procedures cared for by the hospital, accounted for by adjusting for the discharge condition category).

The risk adjustment variables included in the development and testing of the hybrid HWM measure were derived from the Claims-Only Development Dataset and the Clinical Hybrid Dataset. This model built upon the work to identify risk variables in the claims-only HWM measure, and included the following three types of risk variables:

1. Case Mix (claims-derived comorbidities): comorbidity risk variables derived from administrative claims data. Comorbidities for inclusion were identified during the 12 months prior to and including the index admission. To assemble the more than 14,000 ICD-9 codes into clinically coherent variables for risk adjustment, the measure employs the publicly available CMS condition categories (CMS-CCs) to group codes into CMS-CCs, and selects comorbidities on the basis of clinical relevance and statistical significance;<sup>31</sup>
2. Case Mix (clinical EHR data): clinical data outlined in [Section 4.5.3 Case Mix Risk Adjustment \(EHR-Based Risk Variables\)](#), derived from the Clinical Hybrid Dataset; and
3. Service Mix (principal discharge diagnoses): the AHRQ CCS categories for the principal discharge diagnosis associated with each index admission derived from ICD-9 codes in administrative claims data from the index admission. These are also the codes that are used to define the service-line divisions for the non-surgical divisions.

Below, we briefly summarize the derivation of the case mix comorbidity risk variables derived from claims and service mix variables of AHRQ CCS categories for the principal discharge diagnoses. These represent the variables used in the harmonized claims-only HWM measure. For a full description of our approach to developing and selecting the clinical variables, see Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment, which is also posted on the CMS Public Comment website, within the same zip file as this report.

We do not plan to adjust for patients' admission source or discharge disposition (for example, skilled nursing facilities) because these factors are associated with structure of the healthcare system, and may

reflect the quality of care delivered by the system. We are currently not planning on adjusting for socioeconomic status, gender, race, or ethnicity because hospitals should not be held to different standards of care based on the demographics of their patients; however, we will examine these factors during ongoing testing and consider the most recent guidance from the NQF in our final decision.

#### 4.5.2. Case Mix Risk Adjustment (Claims-Based Comorbidity Variables)

This section has been abbreviated for this report. For further detail on how we selected the risk variables from the Claims-Only Development Dataset, please see Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment, which is also posted on the CMS Public Comment website, within the same zip file as this report.

Our goal was to develop parsimonious models that include clinically relevant variables strongly associated with the risk of mortality in the 30 days following an index admission. For candidate variable selection, using the Claims-Only Development Dataset, we started with the CMS-CC grouper, used in previous CMS risk-standardized outcome measures, to group ICD-9-CM codes into comorbid risk-adjustment variables. We then combined some of these CMS-CCs into clinically coherent groups to ensure adequate case volume. All candidate risk variables are listed in [Appendix F Candidate Comorbid \(Claims-Based\) Risk Variables](#).

#### Complications of Hospitalization

Complications occurring during hospitalization that are not comorbid illnesses, may reflect hospital quality of care, and should **not** be used for risk adjustment. Although adverse events during hospitalization may increase the risk of mortality, including them as risk factors in a risk-adjusted model could lessen the measure's ability to characterize the quality of care delivered by hospitals. We have previously reviewed every CMS-CC and identified those which, if they occur only during the index hospitalization and not in the 12 months prior to admission, would be considered potential complications rather than comorbidities. Fluid, electrolyte, or base disorders; sepsis; and acute liver failure are all examples of CMS-CCs that could potentially be complications of care. The hybrid HWM measure aligned our approach with the claims-only HWM measure, with details found in Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment, which is also posted on the CMS Public Comment website, within the same zip file as this report. The list of potential complications is found in [Appendix G Potential Complications of Care](#).

#### Final Comorbid Claims Risk Variable Selection

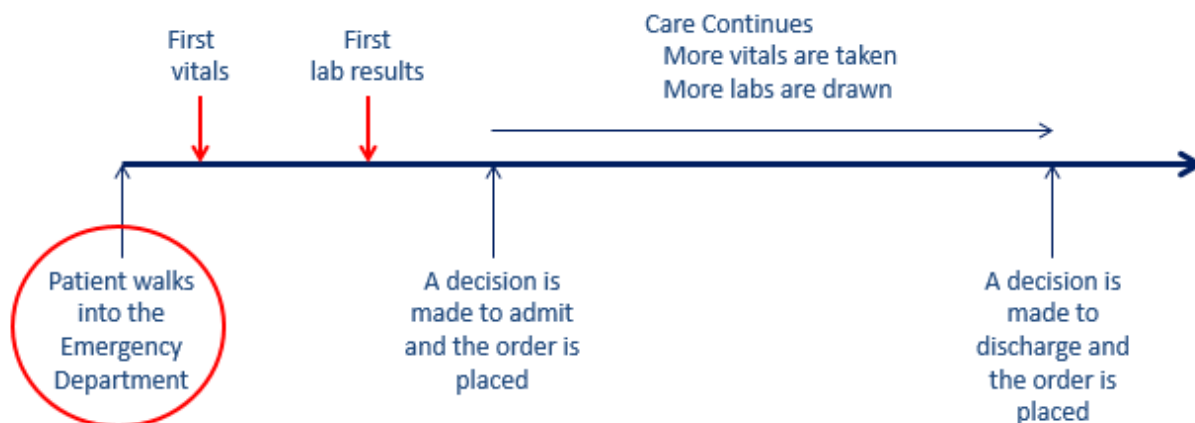
The hybrid HWM measure used the same 20 comorbid risk variables (19 comorbidities and age) as the claims-only HWM measure. We used a fixed, common set of comorbidity variables in all hybrid HWM measure models for simplicity and ease of implementation and analysis. For the final comorbid risk variables from claims, see [Section 5.2 Final Risk Adjustment Model](#).

EHR-based clinical variables were also used for case mix risk adjustment, outlined in [Section 4.5.3 Case Mix Risk Adjustment \(EHR-Based Risk Variables\)](#).

#### 4.5.3. Case Mix Risk Adjustment (EHR-Based Clinical Status Risk Variables)

To be used in risk adjustment, our focus is using clinical information that reflects a patient's clinical status upon arrival to the hospital. Therefore, the data we used is only the first captured value. For example, as shown in the figure below, we would incorporate only the first set of vital statistics (for example, blood pressure) and laboratory results (for example, glucose) on the patient once they arrive at the hospital.

**Figure 2. Identifying First Captured Values for the Core Clinical Data Elements**



To be able to use electronic clinical data for a measure of hospitals nationally, we must collect accurate data from all hospitals. Because of this, any electronic clinical data that we use must meet the following criteria:

1. Consistently captured on all adult hospitalized inpatients;
2. Captured with a standard definition; and
3. Entered into the electronic health record in a structured field and feasibly extracted.

Example of usable data elements: Blood Pressure

- ✓ Captured on all patients upon arrival at the hospital in any setting (hospital outpatient, inpatient, emergency department),
- ✓ Captured using the same units of measurement across the country (mmHg), and
- ✓ Entered into a structured field (numeric) in the EHR that can be extracted.

Example of unusable data element: Medication history or adherence

- × Inconsistently or not reliably collected on all patients by clinicians (<90% capture rate)
- × Units of measurement could range; name of medication could differ
- × Possibly captured in clinical notes, and not a structured field

#### Core Clinical Data Elements (CCDE)

The CCDE are a standard "set" of clinical data consistently obtained on hospital inpatients and feasibly extracted from EHRs, as shown in [Table 2 Currently Specified CCDE Variables](#). We have shown that these variables are consistently captured with a standard definition, entered in a structured field, and feasibly



extracted.<sup>32,33</sup> Therefore, they represent a feasible set of candidate variables from which to select our risk model. The CCDE were designed to be a dynamic list that can be modified for specific measures, and potentially expanded as the use of EHRs evolves and clinical practice changes over time.

**Table 2. Currently Specified CCDE Variables**

Clinical Data Elements	Units of Measurement	Window for First Captured Values
<b>Patient Characteristics</b>		
<b>Age</b>	Years	---
<b>First-Captured Vital Signs</b>		
<b>Diastolic Blood Pressure</b>	mmHg	0-2 hours
<b>Heart Rate</b>	Beats per minute	0-2 hours
<b>Oxygen Saturation</b>	Percent	0-2 hours
<b>Respiratory Rate</b>	Breath per minute	0-2 hours
<b>Systolic Blood Pressure</b>	mmHg	0-2 hours
<b>Temperature</b>	Degrees Fahrenheit	0-2 hours
<b>Weight</b>	Pounds	0-24 hours
<b>First-Captured Laboratory Results</b>		
<b>Anion Gap</b>	mEq/L	0-24 hours
<b>Bicarbonate</b>	mmol/L	0-24 hours
<b>BUN</b>	mg/dL	0-24 hours
<b>Chloride</b>	mEq/L	0-24 hours
<b>Creatinine</b>	mg/dL	0-24 hours
<b>Glucose</b>	mg/dL	0-24 hours
<b>Hematocrit</b>	% red blood cells	0-24 hours
<b>Hemoglobin</b>	g/dL	0-24 hours
<b>Platelet</b>	Count	0-24 hours
<b>Potassium</b>	mEq/L	0-24 hours
<b>Sodium</b>	mEq/L	0-24 hours
<b>WBC Count</b>	Cells/mL	0-24 hours

## CCDE Risk Variable Selection

To select candidate clinical EHR variables, we began with the list of CCDE variables, listed above in [Table 2 Currently Specified CCDE Variables](#).

First, we looked at how many admissions in our Clinical Hybrid Dataset were missing values for each CCDE. The non-surgical divisions had fewer than 10% of admissions that were missing values. However, in the surgical divisions, while vitals were missing in fewer than 10% of admissions, the laboratory result values were missing in 15% - 50% of admissions, depending upon division. For **development purposes only**, we imputed values for missing labs or vital signs, as described below:

- For all admissions missing any vital signs and for admissions within the non-surgical divisions missing any laboratory result values, we used multiple imputation (imposing limits to ensure the imputed values were within clinical possibilities) with 5 copies of data with different imputations based on a multi-normal distribution.
- For admissions within the surgical divisions missing any laboratory results, we randomly imputed a value within the normal range for that lab. For the normal ranges, see [Table 3 Candidate Clinical EHR Risk Variable \(CCDE\) Mortality Association Modelling Approaches](#) below.
  - **Rationale:** Surgical patients that are missing initial labs are most likely elective surgical admissions that had the labs collected within 30 days PRIOR TO ADMISSION. It is less likely that a patient with an extremely abnormal lab value would undergo an elective surgery without having the labs checked again on admission. **This approach is for development purpose only.**

Second, we selected which CCDE would be the most appropriate to include in the hybrid HWM measure. We approached risk variable selection from the perspective of ensuring a parsimonious list of clinical EHR variables that would minimize hospital burden to report the data and provide face validity from a clinical perspective.

Therefore, we first sought to ensure that each candidate variable was modeled in a clinically appropriate way. For example, the laboratory value sodium has a U-shaped predictive association with mortality: Normal sodium levels are associated with a low risk of mortality, while both abnormally high and abnormally low levels are associated with an increased risk of mortality. The association between each CCDE variable and mortality was reviewed by four clinicians and selected based on the best association. See [Table 3 Candidate Clinical EHR Risk Variable \(CCDE\) Mortality Association Modelling Approaches](#) for the approach used for each risk variable. In addition, we report the normal values used for imputing missing laboratory results within the surgical divisions.

**Table 3. Candidate Clinical EHR Risk Variable (CCDE) Mortality Association Modelling Approaches**

Candidate EHR Risk Variables	Normal Range	Modelling Approach
Age	-	linear
Diastolic Blood Pressure	-	splined, knot at 80
Heart Rate	-	linear
Oxygen Saturation	-	linear
Respiratory Rate	-	splined, knot at 16
Systolic Blood Pressure	-	splined, knot at 140

Candidate EHR Risk Variables	Normal Range	Modelling Approach
<b>Temperature</b>	-	linear
<b>Weight</b>	-	splined, knot at 180
<b>Anion Gap</b>	7-17	splined, knot at 10
<b>Bicarbonate</b>	22-30	splined, knot at 26
<b>BUN</b>	8-18	splined, knot at 14 and 40
<b>Chloride</b>	96-106	linear
<b>Creatinine</b>	0.5-1.2	linear but winsorized at 5
<b>Glucose</b>	70-100	splined, knot at 180
<b>Hematocrit</b>	37-52	linear
<b>Hemoglobin</b>	12-18	linear
<b>Platelets</b>	140-440	splined, knot at 200
<b>Potassium</b>	3.3-5.0	splined knot at 4.0
<b>Sodium</b>	135-145	splined, knot at 140
<b>White Blood Count</b>	4.0-10.0	splined, knot at 7.0

Next, we examined the strength of different clinical variables in the context of a multivariable model. We performed bootstrapping with 1,000 iterations allowing patient admissions to be repeatedly selected and produced 1,000 bootstrapping samples for each of the 5 multiple imputations (for the missing data). We used logistic regression with stepwise selection to create risk models for each division in each bootstrapping sample in each imputation run, identifying the variables most significantly associated with mortality for that division (present in 80% or more of runs). This approach produced risk models that might be missing important clinical variables. For example, the selected model for the Surgical Cancer Division contained only age and blood urea nitrogen (BUN) and the model discrimination (judged by using the c-statistic) was not as strong as compared to the model that only used administrative claims (comorbidities, principal discharge diagnosis).

Based upon this information, we selected a standard set of clinically coherent risk variables in order to ensure that each division-level risk model included key laboratory results and vital signs data. As with prior hybrid measures that use EHR data in their risk model, we did not include risk variables if they were strongly correlated with another variable. For example, we selected systolic blood pressure but not diastolic blood pressure, as these variables were highly correlated and provide very similar risk prediction. Using a standard set of clinically selected variables produced improved c-statistics compared to the models based purely upon stepwise selection. We also tested allowing the risk variables to vary across the 15 divisions (using stepwise selection) but still forcing in clinical variables and found that the model discrimination (c-statistic) was very similar, in some cases identical, to using a standard set of variables. Therefore, we proceeded with a common set of 10 clinical risk variables plus age across all divisions for the remainder of the risk model development work. For the final list of EHR-based clinical risk variables [see Section 4.3 Final Risk Adjustment Model](#).

#### 4.5.4. Service Mix Risk Adjustment

This section has been abbreviated for this report. For further detail on how we derived the principal discharge diagnosis variables from the Claims-Only Development Dataset, please see Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment, which is also posted on the CMS Public Comment website, within the same zip file as this report.

As described in [Section 4.3.7 Service-Line Division Approach](#), we used a modified AHRQ CCS grouper to group all ICD-9 principal discharge diagnoses into clinically coherent categories. For each AHRQ CCS principal discharge diagnoses with sufficient volume, we also included a discharge diagnosis indicator in the model. This will ensure that the principal discharge diagnosis for each patient is also included in the risk model, in addition to the 19 comorbid risk variables plus age as described above, and the EHR-based clinical variables as described below.

**Rationale:** Principal discharge diagnoses differ in their baseline mortality risks and hospitals will differ in their relative distribution of these principal discharge diagnoses (service mix) within each division. Therefore, adjusting for these principal discharge diagnoses levels the playing field across hospitals with different service mixes.

#### Low Risk CCSs

There were CCSs with zero mortality events (even after excluding those with fewer than 100 admissions). Because CCSs without mortality events are not useable in the logistic regression models, we combined these CCSs into a single grouped CCS indicator variable for each division: low risk CCS. The low risk CCS combined CCSs with 0 mortality events into the next lowest mortality CCS. This was reviewed and approved by our Technical Working Group and our TEP.

#### Highly Heterogeneous CCSs

For some of the AHRQ CCS groups, risk of mortality varied significantly across the different ICD-9 diagnoses within the CCS. There was concern voiced by our Technical Working Group and TEP that we may not be adequately risk adjusted using these heterogeneous CCS categories. Using an approach described in detail in the claims-only HWM report, we identified 37 CCS that had high heterogeneity.

To address the heterogeneity, three clinicians independently, and then through consensus, clinically modified the highly heterogeneous CCSs through three mechanisms: 1. Splitting the CCS into more than one CCS, 2. Moving ICD-9 codes from one CCS into another more clinically coherent CCS, and 3. Excluding ICD-9 codes that were clinically different from others in the CCS, for which quality of care less likely impacts survival, and where there were a small number of patients. The changes are described in detail in Appendix G: Heterogeneous CCS Modifications in the Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment. This was reviewed with the Technical Working Group and TEP as well.

Consequences of CCS modification: the changes to the CCSs resulted in more homogenous CCS risk variable groups and increased the face validity and performance of the risk model. However, due to the infrequency of outcome (mortality) events and an increased number of risk variables, the statistical model became too unstable in 2 of 15 divisions and would not converge to give results for the claims-only measure. Those divisions were the “Other Surgical Procedures” and “Other Non-Surgical Conditions” divisions, which had the highest number of CCS variables.

To preserve the statistical and face validity of the measure, we removed the service-line divisions “Other Surgical Procedures” and “Other Non-Surgical Conditions” for this iteration of the measure, as detailed in [Section 4.3.3 Exclusion Criteria](#). We will revisit this issue in greater depth when we reevaluate the measure to include ICD-10 codes. We reviewed this decision with the TEP and our working groups.

For a final list of service mix risk adjustment variables in each division, see [Appendix H Hierarchical Logistic Regression Model Results](#).

#### 4.5.5.Final Risk Model Selection

After we finalized the risk variables including age, the 10 clinical EHR-based risk variables, the 19 claims-based comorbid risk variables, and the principal discharge diagnosis variables, we tested four different risk models within the Clinical Hybrid Dataset. We directly compared the claims-only risk model calculated in the Clinical Hybrid Dataset to multiple variants that included clinical EHR-based risk variables and selected the best risk model based upon statistical performance and face validity as determined by our TEP. We tested the following risk models:

1. “Claims-Only Risk Model”: Uses only claims-based variables in risk model
  - a. Service mix: AHRQ CCS categories for patients’ principal discharge diagnoses captured from claims data
  - b. Case mix: CMS Condition Categories (CCs) for patients’ comorbidities captured from claims data during hospitalizations in the 12 months prior to and including the index admission (age plus 19 CC risk variables for each service-line division risk model from claims-only HWM measure)
2. “Clinical-Only Risk Model”: Uses only EHR-based clinical variables in risk model (no claims comorbidity OR principal discharge diagnoses)
  - a. Service mix: None
  - b. Case mix: age plus 10 clinical variables captured from EHR data
3. “Clinical + Principal Discharge Diagnoses Risk Model”: Uses EHR-based clinical variables with claims-based principal discharge diagnoses in risk model (no claims comorbidity)
  - a. Service mix: AHRQ CCS categories for patients’ principal discharge diagnoses captured from claims data
  - b. Case mix: age plus 10 clinical variables captured from EHR data
4. “Clinical + Claims Risk Model”: Uses EHR-based clinical variables + claims-based comorbidity and principal discharge diagnosis variables in risk model:
  - a. Service mix: AHRQ CCS categories for patients’ principal discharge diagnoses captured from claims data
  - b. Case mix: Both the age plus 10 clinical variables captured from EHR data and the CCs for patients’ comorbidities captured from claims data during hospitalizations in the 12 months prior to and including the index admission (19 CC risk variables and age plus 10 clinical variables for each division risk model)

[Table 4](#) shows the c-statistics produced by each of the four models for each division and demonstrates that all four models provide similar discrimination. As noted above in [Section 4.3.5 Modifications to Accommodate Hybrid Measure Development Data Source](#), we were unable to calculate results for the Neurosurgery Division, with the exception of the “Clinical-Only Risk Model”, due to the small number of admissions and low event rate. Each risk model offers slightly different advantages. The risk models with clinical data offer greater face validity and capture data reflecting the status of patients upon presentation. The Clinical + Principal Discharge Diagnoses Risk Model, without claims-based comorbidity data, would allow inclusion of patients who do not have 12 months of history data available (approximately 700,000 more potential admissions in the measure cohort when applied to the entire

Medicare FFS population). However, this model performed slightly worse than other models. After reviewing the results with our TEP and based upon their preference for higher discrimination over other features (parsimony, not requiring 12 months of history data), we selected Clinical + Claims Risk Model for this iteration of the hybrid HWM measure.

**Rationale:** The Clinical + Claims Risk Model, which includes the broadest set of risk variables, had the best statistical performance and the highest face validity per the majority of the TEP by accounting for clinical EHR variables, principal discharge diagnoses, and comorbidities identified using claims-data. While it does require the exclusion of patients not enrolled in Medicare for 12 months prior to admission, this was the preferred model by the majority of the TEP. Alternate approaches using different models can be considered in future iterations if broader public input warrants it.

For the final model results, see [Section 5.2 Final Risk Adjustment Model](#).

**Table 4. Comparison of C-Statistics by Division of Clinical-Only Model, Claims-Only Model, Clinical + Principal Discharge Diagnoses Model, and Final Hybrid (Clinical + Claims) Model, Using Clinical Hybrid Dataset (January 1, 2010 – December 31, 2015)**

Division	Clinical-Only Model C-Statistic	Claims-Only Model C-Statistic	Clinical + Principal Discharge Diagnoses Model C-Statistic	Clinical + Claims (Final Hybrid) Model C-Statistic
Non-Surgical Cancer	0.79	0.83	0.84	0.87
Non-Surgical Cardiac	0.84	0.84	0.86	0.88
Non-Surgical Gastrointestinal	0.81	0.87	0.85	0.89
Non-Surgical Infectious Disease	0.79	0.78	0.79	0.83
Non-Surgical Neurology	0.74	0.81	0.80	0.83
Non-Surgical Orthopedics	0.82	0.86	0.85	0.88
Non-Surgical Pulmonary	0.75	0.76	0.78	0.80
Non-Surgical Renal	0.82	0.83	0.83	0.86
Surgical Cardiothoracic	0.80	0.83	0.85	0.85
General Surgery	0.89	0.92	0.93	0.94

Division	Clinical-Only Model C- Statistic	Claims- Only Model C- Statistic	Clinical + Principal Discharge Diagnoses Model C-Statistic	Clinical + Claims (Final Hybrid) Model C-Statistic
Neurosurgery	0.85	---	---	---
Surgical Orthopedics	0.89	0.92	0.92	0.93

#### 4.5.6. Calculating the RSMR

This section has been abbreviated for this report. For future implementation, we intend for the hybrid HWM measure to calculate the RSMR point estimates as outlined by the claims-only HWM measure, see Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment, which is also posted on the CMS Public Comment website, within the same zip file as this report.

To calculate an overall hospital-wide mortality rate, we need to combine the results of the 13 risk models (service-line divisions) into one overall score. We envision a hospital-wide mortality measure that will provide a broad indication of a hospital's performance and capture cross-cutting hospital-wide characteristics that contribute to quality of care. As with CMS's other claims-only performance measures, the measure result will be a point estimate (the RSMR) and will be reported with an estimate of the uncertainty surrounding the RSMR. While there exist multiple approaches to calculate this overall RSMR through combining the results of the 13 models, after consultation with multiple statisticians, review with our Technical Working Group, our Patient and Family Caregiver Working Group, and our TEP, we propose using a weighted mean with empirical correlation approach, as this approach (described in detail in Section 4.5.6 Calculating the RSMR of the companion Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment) provides a statistically precise and conservative estimate of better and worse outliers. We will incorporate input from public comment on approaches to reporting uncertainty around the overall hospital-level RSMR estimate as well as service-line division-level results. For development purposes necessitated by the Clinical Hybrid Dataset, we made minor modifications to calculating the RSMR, as outlined in [Appendix I Risk Adjustment Development](#). This appendix also includes the modeling for each service-line division. Below we summarize our approach used for measure development and initial measure testing.

We created 13 service-line division patient-level risk-adjustment models using logistic regression, with the outcome equal to 1 if the patient died within 30 days of admission and 0 otherwise. The patient-level risk-adjustment models allowed us to assess risk factors and model performance without reference to the variation in performance across hospitals.

For the hospital-level results for each of the 13 service-line divisions, we used hierarchical logistic regression models where death within 30 days is modeled as a function of patient-level demographic and clinical characteristics and a random hospital-level intercept. This accounted both for the natural clustering of observations within hospitals and captured a hospital-specific signal. We used the results of each hierarchical logistic regression model to calculate a standardized mortality ratio (SMR) for each



hospital. The SMR was computed as the predicted mortality rate divided by the expected mortality rate at each hospital for each division. These contributing SMRs were then pooled for each hospital to create a composite hospital-wide SMR. To aid interpretation, this ratio was then multiplied by the overall national observed mortality rate for all index admissions in all cohorts, to produce the risk-standardized mortality rate or RSMR.

#### 4.6. Measure Testing

We tested the measure's data elements and measure score. We used both reliability and validity testing as described below.

##### 4.6.1. Data Element Testing

###### Data Element Reliability Testing

In constructing the hybrid HWM measure we aimed to utilize only those data elements that have reliability. We tested the reliability of the claims-only elements by comparing risk factor frequencies and Odds Ratios (ORs), as detailed in the Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment, which is also posted on the CMS Public Comment website, within the same zip file as this report.

For reliability of the clinical data elements, we selected from only candidate risk variables known to be reliably and reproducibly captured through regular clinical care (the CCDEs). Further empiric data element reliability testing was performed through field testing of the Measuring Authoring Tool (MAT) Output described below under Data Element Validity Testing.

###### Data Element Validity Testing

For validity of the claims-only data elements (principal discharge diagnosis and comorbidities), the CORE Project Team has already demonstrated for a number of other outcome measures the validity of claims-only measures for profiling hospitals by comparing either the measure results or individual data elements against medical records, as discussed further in the results [Section 5.4.1 Data Element Reliability and Validity Testing](#).

For the EHR clinical data elements, the final hybrid HWM measure risk model included age plus 10 clinical risk variables that were drawn from the list of CCDEs. These variables previously completed data element validity testing in multiple hospitals and multiple EHR systems, as required by NQF. In 2015 and 2016, we tested the MAT Output for extraction of all of the 21 CCDEs in a hospital-wide cohort of all patients over the age of 65 years, in four hospitals that used different EHR systems. Data elements electronically derived were validated by a random sample of chart reviews. Analyses completed included the rate of capture for each CCDE per admission, and the rates of matching of the CCDE value extracted from stored EHR data to the data values found upon manual inspection patients' charts (validity). Results of these analyses were submitted to NQF during the process of initial endorsement of the hybrid HWR measure (NQF #2879). NQF endorsed the hybrid HWR measure in December 2016. The hybrid HWM measure uses clinical risk variables selected from the same rigorously tested group of candidate variables (CCDE) and shares several clinical risk variables with the hybrid HWR measure.

Electronic specifications will be developed for the hybrid HWM measure that use the Measuring Authoring Tool (MAT) Output. The measure logic in the MAT Output will align with the HWR measure,



which can be found on the eCQI Resource Center here:

<https://ecqi.healthit.gov/ecqm/measures/cms529v4>. The full MAT Output for all of the CCDE was field tested in multiple hospitals, and the hybrid HWR measure received NQF endorsement based upon this testing. Further, the hybrid HWR measure is currently a voluntary measure in the Inpatient Quality Reporting program. Therefore, we anticipate no further testing of the MAT Output for the hybrid HWM measure will be needed.

#### 4.6.2.Measure Score Testing

##### Measure Score Reliability Testing

Because the Clinical Hybrid Dataset included only 22 hospitals, we were not able to perform split-sample testing of our hybrid HWM measure. However, extensive measure score testing was completed in the claims-only HWM measure, as detailed in the claims-only HWM measure report.

##### Measure Score Validity Testing

We are developing this measure in consultation with national guidelines for publicly reported outcome measures, with outside experts, and with the public. The measure will be consistent with the technical approach to outcomes measurement set forth in NQF guidance for outcome measures, 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”.<sup>28,29,34</sup>

To assess face validity, we plan to survey the TEP and ask each member to rate the validity of the hybrid HWM measure.

##### **Question for public comment:**

***Do you have input on the measure testing approach?***

***What additional validity testing would be meaningful for this measure?***

## 5. RESULTS

### 5.1. Cohort

The Clinical Hybrid Dataset contained 1,014,435 admissions. After applying inclusion criteria, our initial index cohort contained 599,581 admissions, with the largest exclusion being for age out of range. This pattern of exclusions was consistent with the claims-only HWM measure. We then applied exclusion criteria and randomly selected one index admission per patient per year. This resulted in a preliminary index cohort of 352,420 admissions; we calculated our final results without the neurosurgery division for a cohort of 349,633 admissions.

### 5.2. Final Risk Adjustment Model

As presented in [Section 4.5.5 Final Risk Model Selection](#), the final hybrid HWM measure included the Clinical + Claims Risk Model, which includes age, select CCDEs, claims-based comorbidities, and principal discharge diagnoses as risk variables. The AHRQ CCS categories (patients' principal discharge diagnoses) adjust for service mix and the CCDE and CCs (patients' claims-based comorbidities) adjust for case mix. This final model includes age plus 19 CC risk variables + 10 CCDEs for each division risk model, as shown below (For final CCS risk variables in each division, see [Appendix H Hierarchical Logistic Regression Model Results](#)):

- Age (linear)
- Comorbidities from claims data:
  - Other Infectious Diseases (CC 7)
  - Metastatic & Severe Cancers (CC 8,9)
  - Protein-Calorie Malnutrition (CC 21)
  - Disorders of Fluid/Electrolyte/Acid-Base Balance (CC 24)
  - Disorders of Lipoid Metabolism (CC 25)
  - Liver Failure (CC 27,30)
  - Other GI Disorders (CC 34-38)
  - Other Musculoskeletal and Connective Tissue Disorders (CC 44,45)
  - Hematologic or Immunity Disorders (CC 46-48)
  - Dementia and Other Nonpsychotic Organic Brain Syndromes (CC 51-53)
  - Respiratory Failure, Respirator Dependence, Shock (CC 82-84)
  - Congestive Heart Failure (CC 85)
  - Hypertension and hypertensive heart disease (CC 94,95)
  - Pneumonia (CC 114-116)
  - Dialysis or Severe Chronic Kidney Disease (CC 134,136,137)
  - Acute or Unspecified Renal Failure (CC 135,140)
  - Poisonings and Allergic and Inflammatory Reactions (CC 175)
  - Minor Symptoms, Signs, Findings (CC 179)
- CCDE from EHR data:
  - Heart rate (linear)
  - Oxygen saturation (linear)
  - Systolic blood pressure (splined, knot at 140)
  - Temperature (linear)
  - Bicarbonate (splined, knot at 26)

- Creatinine (linear, winsorized at 5)
- Hemoglobin (linear)
- Platelet (splined, knot at 200)
- Sodium (splined, knot at 140)
- White blood count (splined, knot at 7.0)

#### Hierarchical Logistic Regression Model

The results of the model performance for each service-line division. [Appendix H Hierarchical Logistic Regression Model Results](#) shows the full list of risk variables for each model, including the percent of patients with the risk variable, parameter estimate (standard error), and the ORs with 95% confidence intervals for mortality risk in the Clinical Hybrid Dataset. Results were calculated using hierarchical logistic regression models.

##### 5.2.1. Service-Line Division-Level Model Performance

For each logistic regression model ([Table 5](#)), we computed multiple summary statistics to assess model performance: c-statistics, predictive ability, and the residuals lack of fit. The tables also include the number of admissions, observed mortality rate, and number of covariates for reference. Results for the Neurosurgery Division are excluded from the Surgical Divisions table as this service-line division had too few patients and outcomes for model testing in the development data sample.

The c-statistic is a measure of how accurately a statistical model is able to distinguish between a patient with and without an outcome. While a higher c-statistic is desirable, we do not want to maximize it by adjusting for factors that should not be adjusted for. The range of c-statistic results is 0.80 to 0.94 which is better than results we have seen for other 30-day mortality measures. Discrimination in predictive ability measures the ability to distinguish high-risk subjects from low-risk subjects. Therefore, we would hope to see a wide range between the lowest decile and highest decile, which these models show.

**Table 5. Logistic Regression Model Performance, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014)**

Service-Line Division	Number of Admissions	Observed Mortality Rate (%)	C-Statistic	Predictive Ability, % (lowest decile, highest decile)	Residuals Lack of Fit (Pearson Residual Fall %)				Number of Covariates
					<-2	[-2, 0)	[0, 2)	[2+]	
Non-Surgical Cancer	5764	3.66	0.87	(0.00, 19.31)	0.00	96.34	1.10	2.56	57
Non-Surgical Cardiac	57090	4.03	0.88	(0.10, 22.98)	0.01	95.97	1.32	2.71	46
Non-Surgical Gastrointestinal	34366	2.62	0.89	(0.12, 16.32)	0.00	97.38	0.75	1.87	57
Non-Surgical Infectious Disease	52627	10.03	0.83	(0.11, 39.67)	0.04	89.92	5.16	4.88	46

Service-Line Division	Number of Admissions	Observed Mortality Rate (%)	C-Statistic	Predictive Ability, % (lowest decile, highest decile)	Residuals Lack of Fit (Pearson Residual Fall %)				Number of Covariates
					<-2	[-2, 0)	[0, 2)	[2+]	
Non-Surgical Neurology	19425	6.84	0.83	(0.25, 27.12)	0.01	93.15	2.37	4.48	47
Non-Surgical Orthopedics	11497	2.32	0.88	(0.00, 13.49)	0.00	97.68	0.44	1.88	49
Non-Surgical Pulmonary	25057	8.25	0.80	(0.34, 29.64)	0.01	91.74	2.95	5.31	44
Non-Surgical Renal	12116	6.92	0.86	(0.17, 32.72)	0.04	93.03	3.14	3.79	40
Surgical Cancer	15506	0.55	0.91	(0.00, 4.06)	0.00	99.45	0.06	0.49	54
Surgical Cardiothoracic	7800	4.13	0.85	(0.13, 23.33)	0.03	95.85	1.51	2.62	52
General Surgery	34159	1.62	0.94	(0.03, 13.45)	0.00	98.38	0.59	1.03	80
Surgical Orthopedics	74226	0.94	0.93	(0.01, 7.81)	0.00	99.06	0.22	0.72	74

### 5.3. Final Measure

#### 5.3.1. Hospital-Level Overall RSMR Results

[Table 6](#) below estimates the SMR and RSMR distributions using the final hybrid (Clinical + Claims Model) HWM measure risk model. As expected in these 22 hospitals within a single health system, there is less overall variation than with the claims-only HWM measure which uses national Medicare FFS data.

**Table 6. Hospital-Level Overall RSMR Results, Final Hybrid HWM Measure, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014) (22 Hospitals with 349,633 Admissions)**

Description	SMR	RSMR (%)
Mean	1.00	4.3
Standard Deviation	0.10	0.4
100% Max	1.27	5.4
95%	1.15	4.9
75% Q3	1.08	4.6
50% Median	0.97	4.1
25% Q1	0.92	3.9
5%	0.81	3.4
0% Min	0.81	3.4

### 5.3.2. Hospital-Level Service-Line Division-Level Results

Hospital-level service-line division-level results with the number of patients and the mean, standard deviation, and median SMR and RSMR for each of the 12 divisions for which we were able to calculate the SMR are in [Appendix J Hospital-Level Service-Line Division-Level Final Model](#).

**Question for public comment:**

***Do you have input on how the measure results might be presented to the public?***

***How could CMS present supplemental hospital performance information in public reporting, such as service line division-level results, to create a more meaningful and usable measure?***

### 5.4. Measure Testing Results

#### 5.4.1. Data Element Reliability and Validity Testing

To ensure that we use data elements that are reliable, we avoid the use of claims data elements that are thought to be coded inconsistently across hospitals or providers. Additionally, CMS has in place several hospital auditing programs used to assess overall claims code accuracy, to 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.

For results on the reliability of the claims-only elements by comparing risk factor frequencies and ORs, see Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment, which is also posted on the CMS Public Comment website, within the same zip file as this report.

The CORE Project Team has already demonstrated, for a number of prior measures, the validity of claims-based measures for profiling hospitals by comparing either the measure results or individual data elements against medical records. CMS validated the six NQF-endorsed claims-based measures currently in public reporting (AMI, heart failure, and pneumonia mortality and readmission) with models that used medical record-abstracted data for risk-adjustment. Specifically, claims model validation was conducted by building comparable models using abstracted 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 both models were applied to the same 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 claims-based models for public reporting.

We have also completed two national, multi-site validation efforts for two procedure-based complications measures (for primary elective hip/knee arthroplasty and implantable cardioverter defibrillator [ICD]). Both projects demonstrated strong agreement between complications coded in claims and abstracted medical record data. Similarly, validation of the claims-based risk model for CMS's coronary artery bypass graft surgery (CABG) mortality measure demonstrated similar performance when compared to state registry data.<sup>35</sup> These validation efforts suggest that such claims data variables are valid across a variety of conditions. The results from reliability and validity testing of the 10 final EHR-based risk variables from the CCDE in separate hospitals were submitted to NQF for the hybrid HWR measure (NQF #2879) and are posted on the NQF website [here](#).

#### 5.4.2.Measure Score Results

##### Measure Score Reliability and Validity Testing

For results on additional measure score testing performed for the claims-only HWM measure, see Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment, which is also posted on the CMS Public Comment website, within the same zip file as this report. Assessment of face validity by the TEP is planned following update of the measure specifications in ICD-10 data.

#### 5.5. Presenting Results

In developing this measure, our goal was to produce a valid, single summary measure of hospital-wide mortality that would be used by policymakers, clinicians, patients, and family caregivers. During the process of development, we consistently heard from stakeholders about the importance of having a more granular level of information available, not only for hospitals, but also for the public. As we continue to build this measure, we will continue to explore how to present more granular information in a manner that is usable and accurate, without being misleading.

## 6. SUMMARY

This report summarizes the development, specifications, and testing to date of a hospital-level all-cause hospital-wide 30-day mortality measure based on administrative claims data enhanced with clinical data elements for risk prediction. This measure benefited from close input from patients and clinicians throughout the development process.

This measure offers several important benefits. It provides CMS with a tool for broad performance assessment across a wide span of hospitals. It allows for monitoring of an important, patient-centered outcome and complements CMS's existing claims-only and hybrid hospital-wide readmission measures. It does so with minimal burden to hospitals and no burden to patients. It leverages reliably captured and valid clinical data elements that have been shown to be feasibly extracted without changes to standard clinical workflow to improve the risk model. We also used a standard, accepted, and transparent approach to develop the measure. The measure can provide more granular division-level performance information prioritized by both patients and clinicians. The results demonstrated a range of hospital performance within the development sample.

The measure also has its challenges. It currently excludes patients in Other Surgical Procedures or Other Non-Surgical Conditions service-line divisions due to limited risk adjustment, stemming from high patient heterogeneity and low mortality rates; we are revisiting these exclusions during the transition to ICD-10 code data to attempt to capture additional patients. Due to the low numbers of neurosurgery patients and deaths in the development data sample, the current report does not include testing results for the Neurosurgical Division. Overall measure results reliability testing has yet to be performed due to the absence of large scale EHR-based testing data.

Measuring hospital-wide mortality is difficult. Earlier attempts did not exclude patients for whom mortality is likely not a quality signal nor did they have the benefit of close patient and clinician engagement in measure design. Throughout our discussions with stakeholders, including our TEP, we heard support for the concept of measuring hospital-wide mortality and a strong desire for a measure that offers patients and providers meaningful, detailed, and statistically valid performance data. TEP members expressed a tension between the need for greater transparency about hospital performance and the potential unintended consequences of that transparency. This measure offers the extra benefit of clinical risk variables without adding to the overall measure burden.

With this measure, we worked to balance all voices and input, to use the most rigorous methods, to leverage feasible and low burden EHR data to improve risk prediction, and to design a measure that offers meaningful performance data about as many hospitals as possible. We anticipate the transition to ICD-10 data will provide more opportunities for improving the measure and we look forward to the public's input to inform those improvements.

## GLOSSARY

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

**Case mix:** The particular illness severity 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 (CMS-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](http://www.cms.hhs.gov/Reports/downloads/pope_2000_2.pdf).

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

**Core clinical data elements (CCDE):** A standardized set of clinical data that are consistently obtained on adult hospital inpatients that could be feasibly extracted from electronic health records, to be used in risk adjustment for hospital quality outcome measures.

**Discharge condition category:** A group of related discharge diagnosis ICD-9 codes (principal diagnoses), as grouped by the AHRQ CCS.

**Electronic health record (EHR):** A record in digital format that allows for systematic collection of electronic health information about individual patients or populations. It theoretically allows for sharing information across different healthcare settings.

**Electronic health record data:** Data derived specifically from the hospital EHR. In this report, in most cases we are referring to the clinical data on patients, which are the CCDE.

**Electronic specification:** Refers to measure specifications derived from EHRs and contain four main components, which are contained within the Measure Authoring Tool (MAT) Output: measure overview/description, measure logic, measure code lists, and quality datasets elements.

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



**First captured values:** The first value for a data element recorded in the electronic health record after a patient arrives at the facility for care. Identification of the first value requires a time and date stamp for the first interaction a patient has with facility staff which results in a time or date stamp being entered in the Patient Management System. This is most often the time and date of registration when basic demographic and insurance information are provided and confirmed by non-clinical staff. An arrival location is also required because patients can arrive in various locations including the emergency department, pre-operative area, or to an inpatient unit or floor. The time and date stamps associated with the specific data elements are then compared against the time of arrival to identify the first captured value.

**Hierarchical model:** A widely accepted statistical method that enables fair evaluation of relative hospital performance by accounting for patient risk factors as well as 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 mortality rates overall is accounted for by patients' individual risk factors (such as age and other medical conditions); and (2) how much variation is accounted for by hospital contribution to mortality risk.

**Hybrid measure:** A measure that uses two separate data sources. Specifically, the hybrid HWM measure uses Medicare claims data to derive the cohort, outcome, and comorbidities, and EHR-derived data to add patient-level clinical data into the risk adjustment. This is in comparison to only using Medicare claims as a single source of data for measure development and implementation.

**Index admission:** Any admission included in the measure calculation as the initial admission for an episode of care to which the outcome is attributed.

**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 this measure.

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

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

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

**Predicted mortality:** The number of deaths within 30 days, predicted based on the hospital's performance with its observed case mix and service mix.

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

**Risk-standardized mortality rate (RSMR):** The risk-standardized mortality rate is the standardized mortality ratio (SMR) (see definition below), multiplied by the national observed mortality rate.

**Service-line divisions:** A group of index admissions for patients with related conditions or procedures categories that are likely treated by similar care teams. There were 15 defined cohorts in this report,

with 13 being in the final measure. Each service-line division has its own risk model. They are Non-Surgical: Cancer, Cardiac, Gastrointestinal, Infectious Disease, Neurology, Orthopedics, Pulmonary, Renal; Surgical: Cancer, Cardiothoracic, General, Neurosurgery, Orthopedics.

**Service mix:** The particular conditions and procedures of the patients with index admissions at a given hospital.

**Standardized mortality ratio (SMR):** For each hospital, the numerator of the ratio is the number of deaths predicted for the hospital's patients, accounting for its observed mortality rate, the number of patients, and the hospital's case- and service-line mix. The denominator is the number of deaths expected nationally for that hospital's case/service-line mix. A ratio greater than one indicates that more patients died at that hospital than expected, compared to an average hospital with similar case/service-line mix. A ratio less than one indicates that the hospital's patients have fewer deaths than expected, compared to an average hospital with a similar case/service-line mix.

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## APPENDIX A – Acknowledgement Details

We would like to thank the members of the Technical Expert Panel (TEP). The TEP members provided important insight and feedback on key measure decisions for the development of the hospital-wide mortality measure.

### TEP Members:

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### Technical Working Group Members:

**Dr. Lee Fleisher, MD** – Chair, Department of Anesthesiology and Critical Care, University of Pennsylvania Health System; and Vice-Chair of the Consensus Standards Advisory Committee (CSAC) and co-chair of the Surgery Standing Committee of the NQF.

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**Dr. David M. Shahian, MD** – Professor of Surgery at Harvard Medical School; Vice President of the Massachusetts General Hospital (MGH) Center for Quality and Safety; and Associate Director of the MGH Codman Center for Clinical Effectiveness in Surgery; Vice Chair of the NQF Health Professionals Council; Chair of The Society of Thoracic Surgeons (STS) Workforce on National Databases and its Quality Measurement Task Force.

## APPENDIX B – Comorbidity Comparison: Claims vs Clinical Hybrid Datasets

[Table 7](#) below compares patients 65 years and older in both the [Medicare] Claims-Only Development Dataset and the Clinical Hybrid Dataset. The mean age and standard deviation of the population is very similar. Comorbidity burden is relatively similar across the two datasets, although some specific diagnoses are more common in the Claims-Only Development Dataset (such as Disorders of Fluid/Electrolyte/Acid-Base Balance and Congestive Heart Failure), while others (such as Disorders of lipid Metabolism and Septicemia) are more common in the Clinical Hybrid Dataset.

**Table 7. Risk Variable Frequencies Comparing Claims-Only Dataset and Clinical Hybrid Dataset**

Risk Variable	Claims-Only Development Dataset		Clinical Hybrid Dataset	
	Frequency #	Percentage (%)	Frequency #	Percentage (%)
Age (Mean/SD)	77.87	7.90	77.45	7.93
Other Infectious Diseases (CC 7)	539171	13.93	12458	5.35
Metastatic & Severe Cancers (CC 8,9)	103144	2.66	6259	2.69
Protein-Calorie Malnutrition (CC 21)	296449	7.66	24746	10.62
Disorders of Fluid/Electrolyte/Acid-Base Balance (CC 24)	1388492	35.87	23226	9.97
Disorders of Lipoid Metabolism (CC 25)	2117182	54.70	158747	68.13
Liver Failure (CC 27,30)	51192	1.32	2540	1.09
Other GI Disorders (CC 34-38)	1822504	47.09	142036	60.96
Other Musculoskeletal and Connective Tissue Disorders (CC 44,45)	1333561	34.45	107530	46.15
Hematologic or Immunity Disorders (CC 46-48)	355945	9.20	11400	4.89
Dementia and Other Nonpsychotic Organic Brain Syndromes (CC 51-53)	686894	17.75	39206	16.83
Coma/Brain Compression/Anoxic Injury and Severe Head Injury (CC 80,166)	42028	1.09	908	0.39
Respiratory Failure, Respirator Dependence, Shock (CC 82-84)	524093	13.54	15202	6.52
Congestive Heart Failure (CC 85)	1112605	28.75	24276	10.42
Hypertension and hypertensive heart disease (CC 94,95)	2448768	63.27	145258	62.34
Pneumonia (CC 114-116)	593118	15.32	44056	18.91



Risk Variable	Claims-Only Development Dataset		Clinical Hybrid Dataset	
	Frequency #	Percentage (%)	Frequency #	Percentage (%)
Dialysis or Severe Chronic Kidney Disease (CC 134,136,137)	223271	5.77	12231	5.25
Acute or Unspecified Renal Failure (CC 135,140)	710072	18.35	11172	4.79
Poisonings and Allergic and Inflammatory Reactions (CC 175)	200537	5.18	9937	4.26
Minor Symptoms, Signs, Findings (CC 179)	1626182	42.01	152483	65.44
Principal Discharge Diagnosis CCS				
Tuberculosis (CCS 1)	286	0.01	32	0.01
Septicemia (except in labor) (CCS 2)	296918	7.67	34017	14.60
Bacterial infection; unspecified site (CCS 3)	588	0.02	52	0.02
Mycoses (CCS 4)	3158	0.08	104	0.04
HIV infection (CCS 5)	407	0.01	32	0.01
Hepatitis (CCS 6)	1764	0.05	169	0.07
Viral infection (CCS 7)	6800	0.18	244	0.10
Other infections; including parasitic (CCS 8)	1726	0.04	--	--
Sexually transmitted infections (not HIV or hepatitis) (CCS 9)	193	<0.00	--	--
Cancer of head and neck (CCS 11)	3552	0.09	316	0.14
Cancer of esophagus (CCS 12)	1410	0.04	132	0.06
Cancer of stomach (CCS 13)	2626	0.07	204	0.09
Cancer of colon (CCS 14)	16978	0.44	1300	0.56
Cancer of rectum and anus (CCS 15)	4942	0.13	332	0.14
Cancer of liver and intrahepatic bile duct (CCS 16)	2438	0.06	363	0.16
Cancer of pancreas (CCS 17)	3630	0.09	306	0.13
Cancer of other GI organs; peritoneum (CCS 18)	2400	0.06	185	0.08
Cancer of bronchus; lung (CCS 19)	18505	0.48	1234	0.53
Cancer; other respiratory and intrathoracic (CCS 20)	326	0.01	31	0.01
Cancer of bone and connective tissue (CCS 21)	1589	0.04	131	0.06
Melanomas of skin (CCS 22)	330	0.01	--	--
Other non-epithelial cancer of skin (CCS 23)	1214	0.03	--	--
Cancer of breast (CCS 24)	5497	0.14	1954	0.84

Risk Variable	Claims-Only Development Dataset		Clinical Hybrid Dataset	
	Frequency #	Percentage (%)	Frequency #	Percentage (%)
Cancer of uterus (CCS 25)	4481	0.12	649	0.28
Cancer of cervix (CCS 26)	411	0.01	--	--
Cancer of ovary (CCS 27)	1698	0.04	--	--
Cancer of other female genital organs (CCS 28)	925	0.02	--	--
Cancer of prostate (CCS 29)	12301	0.32	1871	0.80
Cancer of other male genital organs (CCS 31)	110	<0.00	--	--
Cancer of bladder (CCS 32)	6266	0.16	898	0.39
Cancer of kidney and renal pelvis (CCS 33)	8416	0.22	602	0.26
Cancer of other urinary organs (CCS 34)	974	0.03	--	--
Cancer of brain and nervous system (CCS 35)	3605	0.09	259	0.11
Cancer of thyroid (CCS 36)	1042	0.03		
Non-Hodgkin's lymphoma (CCS 38)	4873	0.13	354	0.15
Leukemias (CCS 39)	4078	0.11	181	0.08
Multiple myeloma (CCS 40)	2646	0.07	91	0.04
Cancer; other and unspecified primary (CCS 41)	656	0.02	75	0.03
Malignant neoplasm without specification of site (CCS 43)	995	0.03	109	0.05
Neoplasms of unspecified nature or uncertain behavior (CCS 44)	6918	0.18	389	0.17
Maintenance chemotherapy; radiotherapy (CCS 45)	4511	0.12	188	0.08
Benign neoplasm of uterus (CCS 46)	197	0.01	--	--
Other and unspecified benign neoplasm (CCS 47)	12349	0.32	1677	0.72
Diabetes mellitus with complications (CCS 50)	9035	0.23	626	0.27
Gout and other crystal arthropathies (CCS 54)	167	<0.00	--	--
Fluid and electrolyte disorders (CCS 55)	72337	1.87	3259	1.40
Deficiency and other anemia (CCS 59)	211	0.01	--	--
Coagulation and hemorrhagic disorders (CCS 62)	165	<0.00	15	0.01
Other hematologic conditions (CCS 64)	135	<0.00	--	--

Risk Variable	Claims-Only Development Dataset		Clinical Hybrid Dataset	
	Frequency #	Percentage (%)	Frequency #	Percentage (%)
<b>Meningitis (except that caused by tuberculosis or sexually transmitted disease) (CCS 76)</b>	1270	0.03	66	0.03
<b>Encephalitis (except that caused by tuberculosis or sexually transmitted disease) (CCS 77)</b>	1120	0.03	61	0.03
<b>Other CNS infection and poliomyelitis (CCS 78)</b>	707	0.02	56	0.02
<b>Parkinson`s disease (CCS 79)</b>	4006	0.10	92	0.04
<b>Multiple sclerosis (CCS 80)</b>	834	0.02	41	0.02
<b>Other hereditary and degenerative nervous system conditions (CCS 81)</b>	8496	0.22	211	0.09
<b>Paralysis (CCS 82)</b>	552	0.01	--	--
<b>Epilepsy; convulsions (CCS 83)</b>	21684	0.56	1014	0.44
<b>Coma; stupor; and brain damage (CCS 85)</b>	2066	0.05	620	0.27
<b>Heart valve disorders (CCS 96)</b>	36247	0.94	1714	0.74
<b>Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transmitted disease) (CCS 97)</b>	7576	0.20	503	0.22
<b>Essential hypertension (CCS 98)</b>	8910	0.23	213	0.09
<b>Hypertension with complications and secondary hypertension (CCS 99)</b>	42013	1.09	1516	0.65
<b>Acute myocardial infarction (CCS 100)</b>	131410	3.40	7036	3.02
<b>Coronary atherosclerosis and other heart disease (CCS 101)</b>	88744	2.29	6162	2.64
<b>Nonspecific chest pain (CCS 102)</b>	41726	1.08	3923	1.68
<b>Pulmonary heart disease (CCS 103)</b>	34976	0.90	2057	0.88
<b>Conduction disorders (CCS 105)</b>	18702	0.48	1838	0.79
<b>Cardiac dysrhythmias (CCS 106)</b>	183804	4.75	7764	3.33
<b>Congestive heart failure; nonhypertensive (CCS 108)</b>	203230	5.25	11071	4.75
<b>Occlusion or stenosis of precerebral arteries (CCS 110)</b>	3690	0.10	639	0.27
<b>Other and ill-defined cerebrovascular disease (CCS 111)</b>	2752	0.07	120	0.05
<b>Transient cerebral ischemia (CCS 112)</b>	39882	1.03	1574	0.68
<b>Late effects of cerebrovascular disease (CCS 113)</b>	3027	0.08	269	0.12

Risk Variable	Claims-Only Development Dataset		Clinical Hybrid Dataset	
	Frequency #	Percentage (%)	Frequency #	Percentage (%)
Peripheral and visceral atherosclerosis (CCS 114)	3459	0.09	235	0.10
Aortic and peripheral arterial embolism or thrombosis (CCS 116)	184	<0.00	--	--
Phlebitis; thrombophlebitis and thromboembolism (CCS 118)	57	<0.00	--	--
Hemorrhoids (CCS 120)	5785	0.15	325	0.14
Pneumonia (except that caused by tuberculosis or sexually transmitted disease) (CCS 122)	199409	5.15	6198	2.66
Influenza (CCS 123)	20888	0.54	275	0.12
Acute bronchitis (CCS 125)	12931	0.33	272	0.12
Other upper respiratory infections (CCS 126)	3942	0.10	194	0.08
Chronic obstructive pulmonary disease and bronchiectasis (CCS 127)	132341	3.42	3020	1.30
Asthma (CCS 128)	28473	0.74	2003	0.86
Aspiration pneumonitis; food/vomitus (CCS 129)	39964	1.03	1507	0.65
Pleurisy; pneumothorax; pulmonary collapse (CCS 130)	16124	0.42	772	0.33
Respiratory failure; insufficiency; arrest (adult) (CCS 131)	68985	1.78	4388	1.88
Lung disease due to external agents (CCS 132)	1010	0.03	35	0.02
Other lower respiratory disease (CCS 133)	18308	0.47	1395	0.60
Other upper respiratory disease (CCS 134)	277	0.01	--	--
Intestinal infection (CCS 135)	35578	0.92	1570	0.67
Esophageal disorders (CCS 138)	15068	0.39	955	0.41
Gastritis and duodenitis (CCS 140)	12060	0.31	515	0.22
Other disorders of stomach and duodenum (CCS 141)	9945	0.26	540	0.23
Appendicitis and other appendiceal conditions (CCS 142)	10224	0.26	1205	0.52
Abdominal hernia (CCS 143)	34344	0.89	3006	1.29
Regional enteritis and ulcerative colitis (CCS 144)	5428	0.14	281	0.12
Intestinal obstruction without hernia (CCS 145)	68942	1.78	4091	1.76

Risk Variable	Claims-Only Development Dataset		Clinical Hybrid Dataset	
	Frequency #	Percentage (%)	Frequency #	Percentage (%)
<b>Diverticulosis and diverticulitis (CCS 146)</b>	63076	1.63	2867	1.23
<b>Anal and rectal conditions (CCS 147)</b>	6193	0.16	566	0.24
<b>Biliary tract disease (CCS 149)</b>	56274	1.45	4170	1.79
<b>Pancreatic disorders (not diabetes) (CCS 152)</b>	26989	0.70	1798	0.77
<b>Gastrointestinal hemorrhage (CCS 153)</b>	82245	2.12	4851	2.08
<b>Noninfectious gastroenteritis (CCS 154)</b>	19058	0.49	553	0.24
<b>Other gastrointestinal disorders (CCS 155)</b>	27867	0.72	2093	0.90
<b>Nephritis; nephrosis; renal sclerosis (CCS 156)</b>	712	0.02	26	0.01
<b>Acute and unspecified renal failure (CCS 157)</b>	112224	2.90	3813	1.64
<b>Chronic kidney disease (CCS 158)</b>	2108	0.05	246	0.11
<b>Urinary tract infections (CCS 159)</b>	125457	3.24	3801	1.63
<b>Other diseases of kidney and ureters (CCS 161)</b>	3433	0.09	261	0.11
<b>Other diseases of bladder and urethra (CCS 162)</b>	842	0.02	--	--
<b>Hyperplasia of prostate (CCS 164)</b>	127	<0.00	--	--
<b>Nonmalignant breast conditions (CCS 167)</b>	160	<0.00	--	--
<b>Inflammatory diseases of female pelvic organs (CCS 168)</b>	114	<0.00	--	--
<b>Prolapse of female genital organs (CCS 170)</b>	936	0.02	--	--
<b>Ovarian cyst (CCS 172)</b>	231	0.01	--	--
<b>Menopausal disorders (CCS 173)</b>	46	<0.00	--	--
<b>Other female genital disorders (CCS 175)</b>	937	0.02	68	0.03
<b>Skin and subcutaneous tissue infections (CCS 197)</b>	72797	1.88	2608	1.12
<b>Chronic ulcer of skin (CCS 199)</b>	778	0.02	--	--
<b>Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted disease) (CCS 201)</b>	8630	0.22	538	0.23
<b>Rheumatoid arthritis and related disease (CCS 202)</b>	890	0.02	--	--

Risk Variable	Claims-Only Development Dataset		Clinical Hybrid Dataset	
	Frequency #	Percentage (%)	Frequency #	Percentage (%)
<b>Osteoarthritis (CCS 203)</b>	319802	8.26	25820	11.08
<b>Other non-traumatic joint disorders (CCS 204)</b>	9679	0.25	303	0.13
<b>Spondylosis; intervertebral disc disorders; other back problems (CCS 205)</b>	104694	2.70	5258	2.26
<b>Pathological fracture (CCS 207)</b>	14886	0.38	871	0.37
<b>Acquired foot deformities (CCS 208)</b>	218	0.01	--	--
<b>Other acquired deformities (CCS 209)</b>	11662	0.30	390	0.17
<b>Other connective tissue disease (CCS 211)</b>	2639	0.07	392	0.17
<b>Other bone disease and musculoskeletal deformities (CCS 212)</b>	9090	0.23	530	0.23
<b>Cardiac and circulatory congenital anomalies (CCS 213)</b>	970	0.03	20	0.01
<b>Digestive congenital anomalies (CCS 214)</b>	362	0.01	--	--
<b>Nervous system congenital anomalies (CCS 216)</b>	99	<0.00	--	--
<b>Other congenital anomalies (CCS 217)</b>	3162	0.08	--	--
<b>Joint disorders and dislocations; trauma-related (CCS 225)</b>	3105	0.08	190	0.08
<b>Fracture of neck of femur (hip) (CCS 226)</b>	121231	3.13	6536	2.81
<b>Skull and face fractures (CCS 228)</b>	2932	0.08	105	0.05
<b>Fracture of upper limb (CCS 229)</b>	25228	0.65	1412	0.61
<b>Fracture of lower limb (CCS 230)</b>	34873	0.90	1983	0.85
<b>Other fractures (CCS 231)</b>	56917	1.47	1881	0.81
<b>Sprains and strains (CCS 232)</b>	3256	0.08	145	0.06
<b>Open wounds of head; neck; and trunk (CCS 235)</b>	2058	0.05	135	0.06
<b>Open wounds of extremities (CCS 236)</b>	1657	0.04	124	0.05
<b>Complication of device; implant or graft (CCS 237)</b>	46649	1.21	2880	1.24
<b>Complications of surgical procedures or medical care (CCS 238)</b>	10409	0.27	1171	0.50
<b>Superficial injury; contusion (CCS 239)</b>	7477	0.19	419	0.18
<b>Syncope (CCS 245)</b>	36058	0.93	2989	1.28

Risk Variable	Claims-Only Development Dataset		Clinical Hybrid Dataset	
	Frequency #	Percentage (%)	Frequency #	Percentage (%)
Fever of unknown origin (CCS 246)	5620	0.15	327	0.14
Lymphadenitis (CCS 247)	239	0.01	33	0.01
Gangrene (CCS 248)	3082	0.08	58	0.02
Shock (CCS 249)	343	0.01	40	0.02
Nausea and vomiting (CCS 250)	3987	0.10	389	0.17
Abdominal pain (CCS 251)	10576	0.27	849	0.36
Other aftercare (CCS 257)	532	0.01	3140	1.35
Residual codes; unclassified (CCS 259)	115	<0.00	--	--
Other and ill-defined heart disease (CCS 104_2)	2222	0.06	153	0.07
Cardiac arrest and ventricular fibrillation (CCS 107_1)	178	<0.00	18	0.01
Cardiac arrest and ventricular fibrillation (CCS 107_2)	2200	0.06	109	0.05
Acute cerebrovascular disease (CCS 109_1)	28019	0.72	1700	0.73
Acute cerebrovascular disease (CCS 109_2)	128914	3.33	7262	3.12
Aortic; peripheral; and visceral artery aneurysms (CCS 115_1)	182	<0.00	--	--
Aortic; peripheral; and visceral artery aneurysms (CCS 115_2)	501	0.01	--	--
Aortic; peripheral; and visceral artery aneurysms (CCS 115_3)	1015	0.03	35	0.02
Other circulatory disease (CCS 117_2)	179	<0.00	--	--
Gastroduodenal ulcer (except hemorrhage) (CCS 139_1)	3865	0.10	224	0.10
Gastroduodenal ulcer (except hemorrhage) (CCS 139_2)	3768	0.10	195	0.08
Peritonitis and intestinal abscess (CCS 148_1)	853	0.02	47	0.02
Peritonitis and intestinal abscess (CCS 148_2)	1563	0.04	88	0.04
Other liver diseases (CCS 151_1)	10153	0.26	634	0.27
Other liver diseases (CCS 151_2)	2461	0.06	216	0.09
Other injuries and conditions due to external causes (CCS 244_1)	978	0.03	45	0.02
Other injuries and conditions due to external causes (CCS 244_2)	6752	0.17	398	0.17
Other nutritional; endocrine; and metabolic disorders (CCS 58_2)	4474	0.12	--	--

Risk Variable	Claims-Only Development Dataset		Clinical Hybrid Dataset	
	Frequency #	Percentage (%)	Frequency #	Percentage (%)
<b>Other nervous system disorders (CCS 95_1)</b>	19952	0.52	176	0.08
<b>Other nervous system disorders (CCS 95_2)</b>	18617	0.48	1330	0.57



## APPENDIX C – AHRQ CCSs for Cancer and Metastatic Cancer

**Table 8. AHRQ CCS Primary Discharge Diagnosis Categories for Cancer, Not Included in Initial Index Cohort of Measure if Patient Also Enrolled in Hospice**

AHRQ Diagnosis CCS	Description of CCS
11	Cancer of head and neck
12	Cancer of esophagus
13	Cancer of stomach
14	Cancer of colon
15	Cancer of rectum and anus
16	Cancer of liver and intrahepatic bile duct
17	Cancer of pancreas
18	Cancer of other GI organs; peritoneum
19	Cancer of bronchus; lung
20	Cancer; other respiratory and intrathoracic
21	Cancer of bone and connective tissue
22	Melanomas of skin
23	Other non-epithelial cancer of skin
24	Cancer of breast
25	Cancer of uterus
26	Cancer of cervix
27	Cancer of ovary
28	Cancer of other female genital organs
29	Cancer of prostate
30	Cancer of testis
31	Cancer of other male genital organs
32	Cancer of bladder
33	Cancer of kidney and renal pelvis
34	Cancer of other urinary organs
35	Cancer of brain and nervous system
36	Cancer of thyroid
37	Hodgkin's disease
38	Non-Hodgkin's lymphoma
39	Leukemias
40	Multiple myeloma
41	Cancer; other and unspecified primary
43	Malignant neoplasm without specification of site
44	Neoplasms of unspecified nature or uncertain behavior
45	Maintenance chemotherapy; radiotherapy

**Table 9. ICD-9 Discharge Diagnosis Codes for Metastatic Cancer Based Upon AHRQ CCS ICD-9 Crosswalk, Not Included in Initial Cohort of Measure**

[illegible]

AHRQ Diagnosis CCS	Diagnosis CCS Description
<b>42</b>	Secondary malignancies

## APPENDIX D – Procedure Categories Defining the Surgery Service-Line Divisions

The Surgical Cancer service-line division is defined by having any of the procedures and principal discharge diagnosis of cancer along with a major surgical procedure and is therefore not represented in the table below.

**Table 10. Frequency and 30-day Observed Mortality Rate of Surgical Procedures by AHRQ CCS, Surgical Procedure Algorithm (Claims-Only) Dataset (July 1, 2012 – June 30, 2014)**

Defining Surgical Procedure AHRQ CCS	CCS Description	Surgical Division of Procedure	Frequency of Procedure	% of Total Procedures	30-Day Observed Mortality Rate (%)
36	Lobectomy or pneumonectomy	Cardiothoracic	13,801	1.1	2.3
42	Other OR Rx procedures on respiratory system and mediastinum	Cardiothoracic	9,186	0.7	7.6
43	Heart valve procedures	Cardiothoracic	30,914	2.5	4.1
44	Coronary artery bypass graft (CABG)	Cardiothoracic	33,394	2.7	2.2
49	Other OR heart procedures	Cardiothoracic	39,153	3.1	12.7
66	Procedures on spleen	General	1,964	0.2	6.7
67	Other therapeutic procedures; hemic and lymphatic system	General	26,200	2.1	3.1
72	Colostomy; temporary and permanent	General	6,904	0.6	16.0
73	Ileostomy and other enterostomy	General	5,955	0.5	19.8
74	Gastrectomy; partial and total	General	4,206	0.3	2.9
75	Small bowel resection	General	13,282	1.1	12.1
78	Colorectal resection	General	39,417	3.1	3.8
79	Local excision of large intestine lesion (not endoscopic)	General	162	0.0	2.5
80	Appendectomy	General	8,540	0.7	1.2
84	Cholecystectomy and common duct exploration	General	40,558	3.2	2.1
85	Inguinal and femoral hernia repair	General	6,718	0.5	2.8
86	Other hernia repair	General	14,452	1.2	2.0
89	Exploratory laparotomy	General	2,982	0.2	26.0

Defining Surgical Procedure AHRQ CCS	CCS Description	Surgical Division of Procedure	Frequency of Procedure	% of Total Procedures	30-Day Observed Mortality Rate (%)
<b>90</b>	Excision; lysis peritoneal adhesions	General	18,210	1.5	4.0
<b>94</b>	Other OR upper GI therapeutic procedures	General	13,433	1.1	6.2
<b>96</b>	Other OR lower GI therapeutic procedures	General	13,067	1.0	4.5
<b>99</b>	Other OR gastrointestinal therapeutic procedures	General	16,075	1.3	6.0
<b>105</b>	Kidney transplant	General	1,076	0.1	1.1
<b>166</b>	Lumpectomy; quadrantectomy of breast	General	428	0.0	1.4
<b>167</b>	Mastectomy	General	1,847	0.2	0.8
<b>176</b>	Organ transplantation (other than bone marrow, corneal or kidney)	General	349	0.0	4.0
<b>10</b>	Thyroidectomy; partial or complete	Other	1,678	0.1	1.1
<b>12</b>	Other therapeutic endocrine procedures	Other	3,016	0.2	1.5
<b>13</b>	Corneal transplant	Other	37	0.0	8.1
<b>14</b>	Glaucoma procedures	Other	25	0.0	8.0
<b>15</b>	Lens and cataract procedures	Other	159	0.0	2.5
<b>16</b>	Repair of retinal tear; detachment	Other	10	0.0	0.0
<b>17</b>	Destruction of lesion of retina and choroid	Other	44	0.0	0.0
<b>20</b>	Other intraocular therapeutic procedures	Other	357	0.0	2.2
<b>21</b>	Other extraocular muscle and orbit therapeutic procedures	Other	497	0.0	2.2
<b>22</b>	Tympanoplasty	Other	5	0.0	0.0
<b>23</b>	Myringotomy	Other	204	0.0	5.9
<b>24</b>	Mastoidectomy	Other	46	0.0	4.4
<b>26</b>	Other therapeutic ear procedures	Other	1,098	0.1	5.3
<b>28</b>	Plastic procedures on nose	Other	1,120	0.1	3.8
<b>30</b>	Tonsillectomy and/or adenoidectomy	Other	39	0.0	5.1
<b>33</b>	Other OR therapeutic procedures on nose; mouth and pharynx	Other	2,846	0.2	2.3

Defining Surgical Procedure AHRQ CCS	CCS Description	Surgical Division of Procedure	Frequency of Procedure	% of Total Procedures	30-Day Observed Mortality Rate (%)
51	Endarterectomy; vessel of head and neck	Other	28,807	2.3	0.9
52	Aortic resection; replacement or anastomosis	Other	16,145	1.3	4.5
53	Varicose vein stripping; lower limb	Other	54	0.0	1.9
55	Peripheral vascular bypass	Other	7,604	0.6	4.4
56	Other vascular bypass and shunt; not heart	Other	1,562	0.1	12.9
59	Other OR procedures on vessels of head and neck	Other	9,606	0.8	9.9
60	Embolectomy and endarterectomy of lower limbs	Other	11,451	0.9	7.0
101	Transurethral excision; drainage; or removal urinary obstruction	Other	18,813	1.5	3.9
103	Nephrotomy and nephrostomy	Other	6,107	0.5	8.0
104	Nephrectomy; partial or complete	Other	8,202	0.7	1.1
106	Genitourinary incontinence procedures	Other	173	0.0	0.0
112	Other OR therapeutic procedures of urinary tract	Other	6,543	0.5	2.7
113	Transurethral resection of prostate (TURP)	Other	6,274	0.5	1.5
114	Open prostatectomy	Other	3,796	0.3	0.3
118	Other OR therapeutic procedures; male genital	Other	1,489	0.1	3.0
119	Oophorectomy; unilateral and bilateral	Other	4,937	0.4	0.4
120	Other operations on ovary	Other	195	0.0	0.5
123	Other operations on fallopian tubes	Other	274	0.0	0.7
124	Hysterectomy; abdominal and vaginal	Other	817	0.1	0.2
125	Other excision of cervix and uterus	Other	268	0.0	1.1
129	Repair of cystocele and rectocele; obliteration of vaginal vault	Other	776	0.1	0.1
131	Other non-OR therapeutic procedures; female organs	Other	401	0.0	8.5
132	Other OR therapeutic procedures; female organs	Other	4,017	0.3	0.7
135	Forceps; vacuum; and breech delivery	Other	2	0.0	0.0
144	Treatment; facial fracture or dislocation	Other	627	0.1	4.6

Defining Surgical Procedure AHRQ CCS	CCS Description	Surgical Division of Procedure	Frequency of Procedure	% of Total Procedures	30-Day Observed Mortality Rate (%)
<b>160</b>	Other therapeutic procedures on muscles and tendons	Other	33,900	2.7	3.4
<b>164</b>	Other OR therapeutic procedures on musculoskeletal system	Other	2,228	0.2	4.2
<b>172</b>	Skin graft	Other	3,815	0.3	2.5
<b>175</b>	Other OR therapeutic procedures on skin and breast	Other	2,116	0.2	1.0
<b>1</b>	Incision and excision of CNS	Neurosurgery	10,168	0.8	12.0
<b>2</b>	Insertion; replacement; or removal of extracranial ventricular shunt	Neurosurgery	2,833	0.2	2.1
<b>9</b>	Other OR therapeutic nervous system procedures	Neurosurgery	18,677	1.5	7.2
<b>3</b>	Laminectomy; excision intervertebral disc	Orthopedics	22,478	1.8	0.6
<b>142</b>	Partial excision bone	Orthopedics	37,321	3.0	1.3
<b>143</b>	Bunionectomy or repair of toe deformities	Orthopedics	126	0.0	1.6
<b>145</b>	Treatment; fracture or dislocation of radius and ulna	Orthopedics	7,340	0.6	2.2
<b>146</b>	Treatment; fracture or dislocation of hip and femur	Orthopedics	93,421	7.4	5.3
<b>147</b>	Treatment; fracture or dislocation of lower extremity (other than hip or femur)	Orthopedics	17,693	1.4	1.7
<b>148</b>	Other fracture and dislocation procedure	Orthopedics	17,869	1.4	2.1
<b>150</b>	Division of joint capsule; ligament or cartilage	Orthopedics	1,265	0.1	0.2
<b>151</b>	Excision of semilunar cartilage of knee	Orthopedics	497	0.0	0.4
<b>152</b>	Arthroplasty knee	Orthopedics	214,167	17.1	0.2
<b>153</b>	Hip replacement; total and partial	Orthopedics	150,327	12.0	1.9
<b>154</b>	Arthroplasty other than hip or knee	Orthopedics	27,746	2.2	0.3
<b>157</b>	Amputation of lower extremity	Orthopedics	17,973	1.4	7.5
<b>158</b>	Spinal fusion	Orthopedics	26,935	2.2	0.6
<b>161</b>	Other OR therapeutic procedures on bone	Orthopedics	17,529	1.4	2.6
<b>162</b>	Other OR therapeutic procedures on joints	Orthopedics	16,277	1.3	2.3

Defining Surgical Procedure AHRQ CCS	CCS Description	Surgical Division of Procedure	Frequency of Procedure	% of Total Procedures	30-Day Observed Mortality Rate (%)
<b>Total</b>	--	--	<b>1,255,095</b>	100.0	<b>3.3</b>



## APPENDIX E – Condition Categories Assigned to the Non-Surgical Service-Line Divisions

**Table 11. AHRQ CCSs Assigned to the Non-Surgical Service-Line Divisions and CCS Description**

Non-Surgical Division	AHRQ Diagnosis CCS	Description
<b>Cancer</b>		
Cancer	11	Cancer of head and neck
Cancer	12	Cancer of esophagus
Cancer	13	Cancer of stomach
Cancer	14	Cancer of colon
Cancer	15	Cancer of rectum and anus
Cancer	16	Cancer of liver and intrahepatic bile duct
Cancer	17	Cancer of pancreas
Cancer	18	Cancer of other GI organs; peritoneum
Cancer	19	Cancer of bronchus; lung
Cancer	20	Cancer; other respiratory and intrathoracic
Cancer	21	Cancer of bone and connective tissue
Cancer	22	Melanomas of skin
Cancer	23	Other non-epithelial cancer of skin
Cancer	24	Cancer of breast
Cancer	25	Cancer of uterus
Cancer	26	Cancer of cervix
Cancer	27	Cancer of ovary
Cancer	28	Cancer of other female genital organs
Cancer	29	Cancer of prostate
Cancer	30	Cancer of testis
Cancer	31	Cancer of other male genital organs
Cancer	32	Cancer of bladder
Cancer	33	Cancer of kidney and renal pelvis
Cancer	34	Cancer of other urinary organs
Cancer	35	Cancer of brain and nervous system
Cancer	36	Cancer of thyroid
Cancer	37	Hodgkin's disease
Cancer	38	Non-Hodgkin's lymphoma
Cancer	39	Leukemias
Cancer	40	Multiple myeloma
Cancer	41	Cancer; other and unspecified primary
Cancer	43	Malignant neoplasm without specification of site
Cancer	44	Neoplasms of unspecified nature or uncertain behavior
Cancer	45	Maintenance chemotherapy; radiotherapy
<b>Cardiac</b>		
Cardiac	96	Heart valve disorders

Non-Surgical Division	AHRQ Diagnosis CCS	Description
Cardiac	97	Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transmitted disease)
Cardiac	100	Acute myocardial infarction
Cardiac	101	Coronary atherosclerosis and other heart disease
Cardiac	102	Nonspecific chest pain
Cardiac	103	Pulmonary heart disease
Cardiac	104	Other and ill-defined heart disease
Cardiac	105	Conduction disorders
Cardiac	106	Cardiac dysrhythmias
Cardiac	107	Cardiac arrest and ventricular fibrillation
Cardiac	108	Congestive heart failure; nonhypertensive
Cardiac	213	Cardiac and circulatory congenital anomalies
Cardiac	245	Syncope
Cardiac	249	Shock
<b>Gastrointestinal</b>		
Gastrointestinal	6	Hepatitis
Gastrointestinal	120	Hemorrhoids
Gastrointestinal	138	Esophageal disorders
Gastrointestinal	139	Gastroduodenal ulcer (except hemorrhage)
Gastrointestinal	140	Gastritis and duodenitis
Gastrointestinal	141	Other disorders of stomach and duodenum
Gastrointestinal	142	Appendicitis and other appendiceal conditions
Gastrointestinal	143	Abdominal hernia
Gastrointestinal	144	Regional enteritis and ulcerative colitis
Gastrointestinal	145	Intestinal obstruction without hernia
Gastrointestinal	146	Diverticulosis and diverticulitis
Gastrointestinal	147	Anal and rectal conditions
Gastrointestinal	148	Peritonitis and intestinal abscess
Gastrointestinal	149	Biliary tract disease
Gastrointestinal	150	Liver disease; alcohol related
Gastrointestinal	151	Other liver diseases
Gastrointestinal	152	Pancreatic disorders (not diabetes)
Gastrointestinal	153	Gastrointestinal hemorrhage
Gastrointestinal	154	Noninfectious gastroenteritis
Gastrointestinal	155	Other gastrointestinal disorders
Gastrointestinal	214	Digestive congenital anomalies
Gastrointestinal	250	Nausea and vomiting
Gastrointestinal	251	Abdominal pain
<b>Infectious Diseases</b>		

Non-Surgical Division	AHRQ Diagnosis CCS	Description
Infectious Disease	1	Tuberculosis
Infectious Disease	2	Septicemia (except in labor)
Infectious Disease	3	Bacterial infection; unspecified site
Infectious Disease	4	Mycoses
Infectious Disease	5	HIV infection
Infectious Disease	7	Viral infection
Infectious Disease	8	Other infections; including parasitic
Infectious Disease	9	Sexually transmitted infections (not HIV or hepatitis)
Infectious Disease	76	Meningitis (except that caused by tuberculosis or sexually transmitted disease)
Infectious Disease	77	Encephalitis (except that caused by tuberculosis or sexually transmitted disease)
Infectious Disease	135	Intestinal infection
Infectious Disease	159	Urinary tract infections
Infectious Disease	197	Skin and subcutaneous tissue infections
Infectious Disease	201	Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted disease)
Infectious Disease	246	Fever of unknown origin
<b>Other Conditions</b>		
Other Conditions	237	Complication of device; implant or graft
Other Conditions	238	Complications of surgical procedures or medical care
Other Conditions	198	Other inflammatory condition of skin
Other Conditions	199	Chronic ulcer of skin
Other Conditions	200	Other skin disorders
Other Conditions	48	Thyroid disorders
Other Conditions	49	Diabetes mellitus without complication
Other Conditions	50	Diabetes mellitus with complications
Other Conditions	51	Other endocrine disorders
Other Conditions	53	Disorders of lipid metabolism
Other Conditions	58	Other nutritional; endocrine; and metabolic disorders
Other Conditions	206	Osteoporosis
Other Conditions	92	Otitis media and related conditions
Other Conditions	94	Other ear and sense organ disorders
Other Conditions	124	Acute and chronic tonsillitis
Other Conditions	134	Other upper respiratory disease
Other Conditions	136	Disorders of teeth and jaw
Other Conditions	137	Diseases of mouth; excluding dental
Other Conditions	46	Benign neoplasm of uterus
Other Conditions	160	Calculus of urinary tract

Non-Surgical Division	AHRQ Diagnosis CCS	Description
Other Conditions	161	Other diseases of kidney and ureters
Other Conditions	162	Other diseases of bladder and urethra
Other Conditions	163	Genitourinary symptoms and ill-defined conditions
Other Conditions	164	Hyperplasia of prostate
Other Conditions	165	Inflammatory conditions of male genital organs
Other Conditions	166	Other male genital disorders
Other Conditions	167	Nonmalignant breast conditions
Other Conditions	168	Inflammatory diseases of female pelvic organs
Other Conditions	169	Endometriosis
Other Conditions	170	Prolapse of female genital organs
Other Conditions	171	Menstrual disorders
Other Conditions	172	Ovarian cyst
Other Conditions	173	Menopausal disorders
Other Conditions	174	Female infertility
Other Conditions	175	Other female genital disorders
Other Conditions	215	Genitourinary congenital anomalies
Other Conditions	59	Deficiency and other anemia
Other Conditions	60	Acute posthemorrhagic anemia
Other Conditions	61	Sickle cell anemia
Other Conditions	62	Coagulation and hemorrhagic disorders
Other Conditions	63	Diseases of white blood cells
Other Conditions	64	Other hematologic conditions
Other Conditions	247	Lymphadenitis
Other Conditions	54	Gout and other crystal arthropathies
Other Conditions	57	Immunity disorders
Other Conditions	202	Rheumatoid arthritis and related disease
Other Conditions	210	Systemic lupus erythematosus and connective tissue disorders
Other Conditions	211	Other connective tissue disease
Other Conditions	253	Allergic reactions
Other Conditions	84	Headache; including migraine
Other Conditions	93	Conditions associated with dizziness or vertigo
Other Conditions	10	Immunizations and screening for infectious disease
Other Conditions	47	Other and unspecified benign neoplasm
Other Conditions	52	Nutritional deficiencies
Other Conditions	217	Other congenital anomalies
Other Conditions	252	Malaise and fatigue
Other Conditions	255	Administrative/social admission
Other Conditions	256	Medical examination/evaluation
Other Conditions	257	Other aftercare

Non-Surgical Division	AHRQ Diagnosis CCS	Description
Other Conditions	258	Other screening for suspected conditions (not mental disorders or infectious disease)
Other Conditions	259	Residual codes; unclassified
Other Conditions	86	Cataract
Other Conditions	87	Retinal detachments; defects; vascular occlusion; and retinopathy
Other Conditions	88	Glaucoma
Other Conditions	89	Blindness and vision defects
Other Conditions	90	Inflammation; infection of eye (except that caused by tuberculosis or sexually transmitted disease)
Other Conditions	91	Other eye disorders
Other Conditions	653	Delirium, dementia, and amnestic and other cognitive disorders
Other Conditions	241	Poisoning by psychotropic agents
Other Conditions	242	Poisoning by other medications and drugs
Other Conditions	243	Poisoning by nonmedicinal substances
Other Conditions	660	Alcohol-related disorders
Other Conditions	661	Substance-related disorders
Other Conditions	663	Screening and history of mental health and substance abuse codes
Other Conditions	114	Peripheral and visceral atherosclerosis
Other Conditions	115	Aortic; peripheral; and visceral artery aneurysms
Other Conditions	116	Aortic and peripheral arterial embolism or thrombosis
Other Conditions	117	Other circulatory disease
Other Conditions	118	Phlebitis; thrombophlebitis and thromboembolism
Other Conditions	119	Varicose veins of lower extremity
Other Conditions	121	Other diseases of veins and lymphatics
Other Conditions	248	Gangrene
<b>Neurology</b>		
Neurology	78	Other CNS infection and poliomyelitis
Neurology	79	Parkinson's disease
Neurology	80	Multiple sclerosis
Neurology	81	Other hereditary and degenerative nervous system conditions
Neurology	82	Paralysis
Neurology	83	Epilepsy; convulsions
Neurology	85	Coma; stupor; and brain damage
Neurology	95	Other nervous system disorders
Neurology	109	Acute cerebrovascular disease
Neurology	110	Occlusion or stenosis of precerebral arteries
Neurology	111	Other and ill-defined cerebrovascular disease
Neurology	112	Transient cerebral ischemia
Neurology	113	Late effects of cerebrovascular disease

Non-Surgical Division	AHRQ Diagnosis CCS	Description
Neurology	216	Nervous system congenital anomalies
<b>Orthopedics</b>		
Orthopedics	235	Open wounds of head; neck; and trunk
Orthopedics	236	Open wounds of extremities
Orthopedics	239	Superficial injury; contusion
Orthopedics	244	Other injuries and conditions due to external causes
Orthopedics	203	Osteoarthritis
Orthopedics	204	Other non-traumatic joint disorders
Orthopedics	205	Spondylosis; intervertebral disc disorders; other back problems
Orthopedics	207	Pathological fracture
Orthopedics	208	Acquired foot deformities
Orthopedics	209	Other acquired deformities
Orthopedics	212	Other bone disease and musculoskeletal deformities
Orthopedics	225	Joint disorders and dislocations; trauma-related
Orthopedics	226	Fracture of neck of femur (hip)
Orthopedics	228	Skull and face fractures
Orthopedics	229	Fracture of upper limb
Orthopedics	230	Fracture of lower limb
Orthopedics	231	Other fractures
Orthopedics	232	Sprains and strains
<b>Pulmonary</b>		
Pulmonary	56	Cystic fibrosis
Pulmonary	122	Pneumonia (except that caused by tuberculosis or sexually transmitted disease)
Pulmonary	123	Influenza
Pulmonary	125	Acute bronchitis
Pulmonary	126	Other upper respiratory infections
Pulmonary	127	Chronic obstructive pulmonary disease and bronchiectasis
Pulmonary	128	Asthma
Pulmonary	129	Aspiration pneumonitis; food/vomitus
Pulmonary	130	Pleurisy; pneumothorax; pulmonary collapse
Pulmonary	131	Respiratory failure; insufficiency; arrest (adult)
Pulmonary	132	Lung disease due to external agents
Pulmonary	133	Other lower respiratory disease
<b>Renal</b>		
Renal	55	Fluid and electrolyte disorders
Renal	98	Essential hypertension
Renal	99	Hypertension with complications and secondary hypertension
Renal	156	Nephritis; nephrosis; renal sclerosis

Non-Surgical Division	AHRQ Diagnosis CCS	Description
<b>Renal</b>	157	Acute and unspecified renal failure
<b>Renal</b>	158	Chronic kidney disease

## APPENDIX F – Candidate Comorbid (Claims-Based) Risk Variables

**Table 12. Candidate Claims-Based Risk Variables and Associated Condition Category (CC)**

Risk Adjustment Variable	CC
Age	N/A
Transfer from Outside ED	N/A
Opportunistic/Chronic Infections	CC 1, 3-6, 39
Lymphoma & Other Cancers	CC 10
TIA and Other Cerebrovascular Disease	CC 101, 102
Vascular Disease with Complications	CC 106, 107
Vascular Disease	CC 108
Other Circulatory Disease	CC 109
Other Cancers & Heart or Respiratory Tumors	CC 11-13
Fibrosis of Lung and Other Chronic Lung Disorders	CC 110, 112
Chronic Obstructive Pulmonary Disease	CC 111
Asthma	CC 113
Pneumonia	CC 114-116
Pleural Effusion/Pneumothorax	CC 117
Other Respiratory Disorders	CC 118
Eye Infections and Retinal Disorders	CC 120-122, 124, 125
Glaucoma	CC 126
Other Eye Disorders	CC 128
Other ENT and Mouth Disorders	CC 129, 131
Hearing Loss	CC 130
Transplant Status	CC 132, 186, 187
Dialysis or Severe Chronic Kidney Disease	CC 134, 136, 137
Acute or Unspecified Renal Failure	CC 135, 140
Mild to Moderate Chronic Kidney Disease	CC 138, 139
Other Benign Tumors	CC 14-16
Other Renal or Urinary Tract Disorders	CC 141, 145
Urinary Obstruction and Retention	CC 142
Urinary Incontinence	CC 143
Urinary Tract Infection	CC 144
Female Genital Disorders	CC 147, 148
Male Genital Disorders	CC 149
Pressure Ulcer	CC 157-160
Burns, Non-pressure Ulcers	CC 161-163
Cellulitis, Local Skin Infection	CC 164
Other Dermatological Disorders	CC 165



Risk Adjustment Variable	CC
Other Head Injuries or Concussion	CC 167, 168
Amputation Status and Major Fractures Including Vertebral, Hip, and Other	CC 169-171, 173, 189, 190
Diabetes	CC 17-19
Other Injuries	CC 172, 174
Poisonings and Allergic and Inflammatory Reactions	CC 175
Complications of Care	CC 176, 177
Major Symptoms, Abnormalities	CC 178
Minor Symptoms, Signs, Findings	CC 179
Septicemia, Sepsis, Systemic Inflammatory Response Syndrome/Shock	CC 2
Protein-Calorie Malnutrition	CC 21
Morbid Obesity	CC 22
Other Significant Endocrine and Metabolic Disorders	CC 23
Disorders of Fluid/Electrolyte/Acid-Base Balance	CC 24
Disorders of Lipoid Metabolism	CC 25
Other Endocrine/Metabolic/Nutritional Disorders	CC 26
Liver Failure	CC 27, 30
Cirrhosis & Chronic Hepatitis	CC 28, 29
Other Liver & Biliary Disease	CC 31, 32
Intestinal Obstruction/Perforation, Peptic Ulcer, Hemorrhage, and Other Specified GI Disorders	CC 33, 36
Other GI Disorders	CC 34, 35, 37, 38
Rheumatoid Arthritis and Inflammatory Connective Tissue Disease	CC 40
Disorders of the Vertebrae and Spinal Discs	CC 41
Osteoarthritis of Hip or Knee	CC 42
Osteoporosis and Other Bone/Cartilage Disorders	CC 43
Other Musculoskeletal and Connective Tissue Disorders	CC 44, 45
Hematologic or Immunity Disorders	CC 46-48
Iron Deficiency and Other/Unspecified Anemias and Blood Disease	CC 49
Delirium and Encephalopathy	CC 50
Dementia and Other Nonpsychotic Organic Brain Syndromes	CC 51-53
Drug/Alcohol Dependence or Psychosis	CC 54, 55
Drug/Alcohol Abuse, Without Dependence	CC 56
Psychosis: Schizophrenia, Reactive, and Unspecified	CC 57, 59

Risk Adjustment Variable	CC
Major Depressive, Bipolar, and Paranoid Disorders	CC 58
Other Psychiatric Disorders	CC 60, 63
Depression	CC 61
Anxiety Disorders	CC 62
Other Developmental Disorders	CC 64-68
Other Infectious Diseases	CC 7
Paralytic Syndromes	CC 70-72, 103, 104
Neuromuscular Disorders	CC 73-76, CC78
Seizure Disorders and Convulsions	CC 79
Metastatic & Severe Cancers	CC 8, 9
Coma/Brain Compression/Anoxic Injury and Severe Head Injury	CC 80, 166
Polyneuropathy, Mononeuropathy, and Other Neurological Conditions/Injuries	CC 81
Respiratory Failure, Respirator Dependence, Shock	CC 82-84
Congestive Heart Failure	CC 85
Acute Myocardial Infarction	CC 86
Angina and Unstable Angina	CC 87, 88
Coronary Atherosclerosis/Other Chronic Ischemic Heart Disease	CC 89
Other and Unspecified Heart Disease	CC 90, 92, 93, 98
Valvular and Rheumatic Heart Disease	CC 91
Hypertension and Hypertensive Heart Disease	CC 94, 95
Heart Rhythm and Conduction Disorders	CC 96, 97
Cerebral Hemorrhage, Stroke, Late Effects of Stroke	CC 99, 100, 105

**Note:** Descriptions of the Condition Categories can be found at [http://www.cms.hhs.gov/Reports/downloads/pope\\_2000\\_2.pdf](http://www.cms.hhs.gov/Reports/downloads/pope_2000_2.pdf)

## APPENDIX G – Potential Complications of Care

To identify potential complications of care, we first searched the secondary diagnosis codes in the index admission claim and identified the presence of any ICD-9 code associated with a CMS-CC (see table below). If these codes appeared only in the index admission claim, we flagged them because they are potential to complications of care. Next, we determined if these potential complications of care were associated with a “present on admission” code. Any potential complication of care with an associated “present on admission” code was kept in the risk model; any potential complication of care without an associated “present on admission” code was removed (indicated by an “X” in the table below) under the assumption it represented a complication of care.

**Table 13. Complications of Care by CC if Not Indicated as Present on Admission**

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by “X”)
Age, years	N/A	--
Pneumonia	CC 114 Aspiration and Specified Bacterial Pneumonias	X
	CC 115 Pneumococcal Pneumonia, Empyema, Lung Abscess	X
	CC 116 Viral and Unspecified Pneumonia, Pleurisy	--
Dialysis or Severe Chronic Kidney Disease	CC 134 Dialysis Status	X
	CC 136 Chronic Kidney Disease, Stage 5	--
	CC 137 Chronic Kidney Disease, Severe (Stage 4)	--
Acute or Unspecified Renal Failure	CC 135 Acute Renal Failure	X
	CC 140 Unspecified Renal Failure	X
Poisonings and Allergic and Inflammatory Reactions	CC 175 Poisonings and Allergic and Inflammatory Reactions	X
Minor Symptoms, Signs, Findings	CC 179 Minor Symptoms, Signs, Findings	--
Protein-Calorie Malnutrition	CC 21 Protein-Calorie Malnutrition	--
Disorders of Fluid/Electrolyte/Acid-Base Balance	CC 24 Disorders of Fluid/Electrolyte/Acid-Base Balance	X
Disorders of Lipoid Metabolism	CC 25 Disorders of Lipoid Metabolism	--
Liver Failure	CC 27 End-Stage Liver Disease	--
	CC 30 Acute Liver Failure/Disease	X

Description	Variable	Variables Not Used in Risk Adjustment if Occurred Only During Index Admission (indicated by "X")
<b>Other Gastrointestinal Disorders</b>	CC 34 Chronic Pancreatitis	--
	CC 35 Inflammatory Bowel Disease	--
	CC 37 Appendicitis	--
	CC 38 Other Gastrointestinal Disorders	--
<b>Other Musculoskeletal and Connective Tissue Disorders</b>	CC 44 Congenital/Developmental Skeletal and Connective Tissue Disorders	--
	CC 45 Other Musculoskeletal and Connective Tissue Disorders	--
<b>Hematologic or Immunity Disorders</b>	CC 46 Severe Hematological Disorders	--
	CC 47 Disorders of Immunity	--
	CC 48 Coagulation Defects and Other Specified Hematological Disorders	X
<b>Dementia and Other Nonpsychotic Organic Brain Syndromes</b>	CC 51 Dementia With Complications	--
	CC 52 Dementia Without Complications	--
	CC 53 Nonpsychotic Organic Brain Syndromes/Conditions	--
<b>Other Infectious Diseases</b>	CC 7 Other Infectious Diseases	X
<b>Metastatic &amp; Severe Cancers</b>	CC 8 Metastatic Cancer and Acute Leukemia	--
	CC 9 Lung and Other Severe Cancers	--
<b>Coma/Brain Compression/Anoxic Injury and Severe Head Injury</b>	CC 80 Coma, Brain Compression/Anoxic	X
	CC 166 Severe Head Injury	X
<b>Respiratory Failure, Respirator Dependence, Shock</b>	CC 82 Respirator Dependence/Tracheostomy Status	X
	CC 83 Respiratory Arrest	X
	CC 84 Cardio-Respiratory Failure and Shock	X
<b>Congestive Heart Failure</b>	CC 85 Congestive Heart Failure	X
<b>Hypertension and Hypertensive Heart Disease</b>	CC 94 Hypertensive Heart Disease	--
	CC 95 Hypertension	--

## APPENDIX H - Hierarchical Logistic Regression Model Results

Below are tables for each of the 12 divisions, showing the hierarchical logistic regression results; the Neurosurgery Division is not represented as there were too few patients and outcome events in the development dataset to calculate results for that service-line division. We also ran the logistical regression models, but did not include it in this report due to the size of the tables.

Where risk factors have duplicative rows with CCS ending in \_1 or \_2 or \_3, these are the highly heterogeneous CCSs that were clinically modified through one of three mechanisms: 1) Splitting the CCS into more than one CCS; or 2) Moving ICD-9 codes from one CCS into another more clinically coherent CCS; or 3) Excluding ICD-9 codes that were clinically different from others in the CCS, for which quality of care less likely impacts survival, and where there were a small number of patients. The changes are described in detail in Appendix G: Heterogeneous CCS Modifications in the Claims-Only Hospital-Wide (All-Condition, All-Procedure) Risk-Standardized Mortality Measure: Measure Methodology for Public Comment.

The CCS with no parameter estimates and odds ratios were results of CCS with zero mortality events. These CCS were combined with the next lowest mortality CCS. See [Section 4.5.4 Service Mix Risk Adjustment](#).

**Table 14. Non-Surgical Cancer Division Hierarchical Logistic Regression Model Risk Factor Frequencies, Estimate, Standard Error, and Odds Ratios, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014)**

Risk Variable	% Patients with Risk Variable	Estimate	Standard Error	OR (95% CI)
Age	100.00	0.05	0.01	1.05 (1.03 - 1.07)
Systolic blood pressure (<=140)	96.79	0.001	0.01	1.00 (0.99 - 1.01)
Systolic blood pressure (>140)		-0.03	0.01	0.97 (0.96 - 0.99)
Heart rate	96.72	0.02	0.004	1.02 (1.01 - 1.02)
Oxygen saturation	95.33	-0.09	0.02	0.91 (0.87 - 0.95)
Temperature	93.91	-0.48	0.09	0.62 (0.52 - 0.74)
Bicarbonate (<=26)	90.48	-0.09	0.03	0.92 (0.86 - 0.98)
Bicarbonate (>26)		0.08	0.04	1.09 (1.00 - 1.18)
Creatinine (Winsorized at 5)	90.80	0.19	0.11	1.21 (0.97 - 1.51)
Hemoglobin	90.81	-0.10	0.04	0.9 (0.84 - 0.97)
Platelet (<=200)	90.84	-0.003	0.002	1.00 (0.99 - 1.00)
Platelet (>200)		0.0005	0.001	1.00 (1.00 - 1.00)
Sodium (<=140)	90.54	-0.03	0.02	0.97 (0.93 - 1.00)
Sodium (>140)		-0.13	0.07	0.88 (0.76 - 1.02)
White blood count (<=7.0)	90.98	0.02	0.06	1.02 (0.92 - 1.14)
White blood count (>7.0)		0.01	0.004	1.01 (1.00 - 1.02)
Other Infectious Diseases (CC 7)	5.93	0.14	0.30	1.15 (0.63 - 2.09)
Metastatic & Severe Cancers (CC 8,9)	17.78	0.40	0.19	1.50 (1.03 - 2.18)
Protein-Calorie Malnutrition (CC 21)	12.72	0.73	0.19	2.07 (1.44 - 2.98)

Risk Variable	% Patients with Risk Variable	Estimate	Standard Error	OR (95% CI)
Disorders of Fluid/Electrolyte/Acid-Base Balance (CC 24)	10.57	-0.42	0.28	0.66 (0.38 - 1.14)
Disorders of Lipoid Metabolism (CC 25)	59.21	0.28	0.17	1.33 (0.96 - 1.84)
Liver Failure (CC 27,30)	3.52	0.06	0.43	1.06 (0.46 - 2.45)
Other GI Disorders (CC 34-38)	62.07	0.09	0.17	1.10 (0.78 - 1.54)
Other Musculoskeletal and Connective Tissue Disorders (CC 44,45)	39.82	0.05	0.16	1.05 (0.77 - 1.44)
Hematologic or Immunity Disorders (CC 46-48)	14.40	0.56	0.23	1.76 (1.12 - 2.76)
Dementia and Other Nonpsychotic Organic Brain Syndromes (CC 51-53)	11.10	0.50	0.23	1.65 (1.05 - 2.6)
Respiratory Failure, Respirator Dependence, Shock (CC 82-84)	4.75	-0.50	0.37	0.61 (0.30 - 1.25)
Congestive Heart Failure (CC 85)	6.56	0.03	0.31	1.03 (0.56 - 1.9)
Hypertension and Hypertensive Heart Disease (CC 94,95)	55.67	-0.19	0.16	0.83 (0.60 - 1.13)
Pneumonia (CC 114-116)	18.74	0.11	0.19	1.11 (0.76 - 1.62)
Dialysis or Severe Chronic Kidney Disease (CC 134,136,137)	3.52	-0.26	0.47	0.77 (0.30 - 1.94)
Acute or Unspecified Renal Failure (CC 135,140)	4.49	-0.56	0.38	0.57 (0.27 - 1.2)
Poisonings and Allergic and Inflammatory Reactions (CC 175)	6.42	0.54	0.30	1.72 (0.96 - 3.11)
Minor Symptoms, Signs, Findings (CC 179)	67.31	0.60	0.22	1.82 (1.17 - 2.82)
<b>Principal Diagnosis CCS (Reference: 45)</b>				
Cancer of head and neck (CCS 11)	2.36	1.10	0.57	2.99 (0.98 - 9.14)
Cancer of esophagus (CCS 12)	1.72	-0.21	0.83	0.81 (0.16 - 4.11)
Cancer of stomach (CCS 13)	2.97	-0.13	0.65	0.88 (0.25 - 3.14)
Cancer of colon (CCS 14)	6.12	-0.41	0.61	0.67 (0.20 - 2.21)
Cancer of rectum and anus (CCS 15)	2.32	-1.02	1.09	0.36 (0.04 - 3.05)
Cancer of liver and intrahepatic bile duct (CCS 16)	7.39	1.07	0.47	2.90 (1.16 - 7.24)
Cancer of pancreas (CCS 17)	4.91	1.02	0.48	2.77 (1.09 - 7.07)
Cancer of other GI organs; peritoneum (CCS 18)	1.80	0.86	0.62	2.36 (0.70 - 7.96)
Cancer of bronchus; lung (CCS 19)	11.94	0.64	0.44	1.89 (0.79 - 4.53)
Cancer; other respiratory and intrathoracic (CCS 20)	0.59	0.15	1.16	1.16 (0.12 - 11.22)
Cancer of bone and connective tissue (CCS 21)	0.78	0.13	1.12	1.14 (0.13 - 10.30)
Cancer of breast (CCS 24)	14.87	-2.17	0.82	0.11 (0.02 - 0.57)

Risk Variable	% Patients with Risk Variable	Estimate	Standard Error	OR (95% CI)
Cancer of uterus (CCS 25)	1.39	1.58	0.65	4.85 (1.37 - 17.19)
Cancer of prostate (CCS 29)	2.12	-0.62	1.10	0.54 (0.06 - 4.62)
Cancer of bladder (CCS 32)	5.90	-0.98	0.72	0.37 (0.09 - 1.53)
Cancer of kidney and renal pelvis (CCS 33)	2.67	0.68	0.72	1.97 (0.48 - 8.08)
Cancer of brain and nervous system (CCS 35)	3.80	1.76	0.51	5.82 (2.12 - 15.95)
Non-Hodgkin's lymphoma (CCS 38)	6.07	0.73	0.45	2.08 (0.85 - 5.07)
Leukemias (CCS 39)	4.23	1.54	0.43	4.66 (2.00 - 10.83)
Multiple myeloma (CCS 40)	2.19	0.36	0.61	1.43 (0.43 - 4.75)
Cancer; other and unspecified primary (CCS 41)	0.83	0.05	1.12	1.05 (0.12 - 9.39)
Malignant neoplasm without specification of site (CCS 43)	2.00	0.68	0.61	1.97 (0.60 - 6.52)
Neoplasms of unspecified nature or uncertain behavior (CCS 44)	3.71	-0.0001	0.59	1.00 (0.32 - 3.16)
Maintenance chemotherapy; radiotherapy (CCS 45)	7.32	0.00	--	--

Table 15. Non-Surgical Cardiac Division Hierarchical Logistic Regression Model Risk Factor Frequencies, Estimate, Standard Error, and Odds Ratios, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014)

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Age	100.00	0.05	0.003	1.05 (1.04 - 1.05)
Systolic blood pressure (<=140)	98.19	-0.02	0.002	0.98 (0.98 - 0.98)
Systolic blood pressure (>140)		-0.01	0.002	0.99 (0.98 - 0.99)
Heart rate	98.37	0.01	0.001	1.01 (1.01 - 1.01)
Oxygen saturation	97.34	-0.04	0.01	0.96 (0.95 - 0.97)
Temperature	93.98	-0.29	0.03	0.75 (0.71 - 0.79)
Bicarbonate (<=26)	96.02	-0.11	0.01	0.90 (0.88 - 0.91)
Bicarbonate (>26)		0.12	0.01	1.12 (1.10 - 1.15)
Creatinine (Winsorized at 5)	96.09	0.22	0.03	1.25 (1.18 - 1.33)
Hemoglobin	96.03	-0.06	0.01	0.94 (0.92 - 0.97)
Platelet (<=200)	95.92	-0.01	0.0008	0.99 (0.99 - 1.00)
Platelet (>200)		-0.0002	0.0005	1.00 (1.00 - 1.00)
Sodium (<=140)	96.04	-0.04	0.01	0.96 (0.95 - 0.97)
Sodium (>140)		0.04	0.02	1.04 (1.01 - 1.07)
White blood count (<=7.0)	96.05	0.11	0.03	1.11 (1.04 - 1.19)
White blood count (>7.0)		0.04	0.01	1.05 (1.03 - 1.06)

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Other Infectious Diseases (CC 7)	3.9	-0.10	0.09	0.91 (0.76 - 1.09)
Metastatic & Severe Cancers (CC 8,9)	1.24	0.83	0.13	2.29 (1.77 - 2.96)
Protein-Calorie Malnutrition (CC 21)	5.28	0.68	0.06	1.98 (1.74 - 2.25)
Disorders of Fluid/Electrolyte/Acid-Base Balance (CC 24)	8.73	0.01	0.08	1.01 (0.87 - 1.17)
Disorders of Lipoid Metabolism (CC 25)	74.27	-0.10	0.05	0.9 (0.81 - 1.01)
Liver Failure (CC 27,30)	0.66	0.42	0.18	1.53 (1.07 - 2.18)
Other GI Disorders (CC 34-38)	51.57	-0.24	0.05	0.79 (0.72 - 0.87)
Other Musculoskeletal and Connective Tissue Disorders (CC 44,45)	40.26	-0.06	0.05	0.94 (0.85 - 1.03)
Hematologic or Immunity Disorders (CC 46-48)	4.35	-0.15	0.09	0.86 (0.72 - 1.03)
Dementia and Other Nonpsychotic Organic Brain Syndromes (CC 51-53)	10.22	0.56	0.06	1.75 (1.56 - 1.95)
Respiratory Failure, Respirator Dependence, Shock (CC 82-84)	6.44	-0.03	0.08	0.97 (0.83 - 1.13)
Congestive Heart Failure (CC 85)	14.22	0.33	0.07	1.40 (1.22 - 1.60)
Hypertension and Hypertensive Heart Disease (CC 94,95)	64.84	-0.26	0.05	0.77 (0.70 - 0.85)
Pneumonia (CC 114-116)	15.35	0.28	0.05	1.33 (1.19 - 1.48)
Dialysis or Severe Chronic Kidney Disease (CC 134,136,137)	6.22	0.11	0.09	1.11 (0.93 - 1.33)
Acute or Unspecified Renal Failure (CC 135,140)	4.96	0.14	0.09	1.16 (0.98 - 1.37)
Poisonings and Allergic and Inflammatory Reactions (CC 175)	4.17	-0.02	0.09	0.98 (0.81 - 1.17)
Minor Symptoms, Signs, Findings (CC 179)	63.55	0.58	0.07	1.78 (1.56 - 2.03)
Heart valve disorders (CCS 96)	1.43	-0.18	0.29	0.84 (0.47 - 1.47)
Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transmitted disease) (CCS 97)	1.4	0.00	--	--
Acute myocardial infarction (CCS 100)	16.8	0.80	0.22	2.22 (1.45 - 3.40)
Coronary atherosclerosis and other heart disease (CCS 101)	15.98	-0.90	0.25	0.41 (0.25 - 0.66)
Nonspecific chest pain (CCS 102)	10.98	-1.27	0.27	0.28 (0.16 - 0.48)
Pulmonary heart disease (CCS 103)	5.02	0.16	0.23	1.17 (0.74 - 1.85)
Other and ill-defined heart disease (CCS 104)	0.50	-1.82	1.03	0.16 (0.02 - 1.22)
Conduction disorders (CCS 105)	3.59	-0.79	0.28	0.45 (0.26 - 0.79)



Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Cardiac dysrhythmias (CCS 106)	16.05	-0.64	0.22	0.53 (0.34 - 0.82)
Cardiac arrest and ventricular fibrillation (CCS 107)	0.36	2.14	0.28	8.54 (4.95 - 14.71)
Congestive heart failure; nonhypertensive (CCS 108)	21.87	0.19	0.22	1.21 (0.79 - 1.84)
Syncope (CCS 245)	5.94	-1.62	0.29	0.20 (0.11 - 0.35)
Shock (CCS 249)	0.08	0.63	0.46	1.87 (0.76 - 4.59)

**Table 16. Non-Surgical Gastrointestinal Division Hierarchical Logistic Regression Model Risk Factor Frequencies, Estimate, Standard Error, and Odds Ratios, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014)**

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Age	100.00	0.06	0.004	1.06 (1.05 - 1.07)
Systolic blood pressure (<=140)	98.37	-0.01	0.002	0.99 (0.99 - 0.99)
Systolic blood pressure (>140)		-0.004	0.003	1.00 (0.99 - 1.00)
Heart rate	98.43	0.01	0.002	1.01 (1.00 - 1.01)
Oxygen saturation	96.97	-0.04	0.01	0.96 (0.93 - 0.98)
Temperature	95.73	-0.36	0.05	0.7 (0.64 - 0.77)
Bicarbonate (<=26)	97.70	-0.03	0.01	0.97 (0.94 - 1.00)
Bicarbonate (>26)		0.09	0.02	1.09 (1.06 - 1.13)
Creatinine (Winsorized at 5)	97.76	0.31	0.05	1.36 (1.24 - 1.49)
Hemoglobin	97.91	-0.07	0.02	0.93 (0.90 - 0.96)
Platelet (<=200)	97.79	-0.004	0.001	1.00 (0.99 - 1.00)
Platelet (>200)		0.00009	0.001	1.00 (1.00 - 1.00)
Sodium (<=140)	97.74	-0.05	0.01	0.95 (0.93 - 0.97)
Sodium (>140)		0.07	0.02	1.08 (1.03 - 1.13)
White blood count (<=7.0)	97.90	0.06	0.04	1.06 (0.98 - 1.16)
White blood count (>7.0)		0.05	0.01	1.05 (1.03 - 1.07)
Other Infectious Diseases (CC 7)	5.07	-0.15	0.14	0.86 (0.66 - 1.12)
Metastatic & Severe Cancers (CC 8,9)	3.12	0.93	0.13	2.53 (1.97 - 3.25)
Protein-Calorie Malnutrition (CC 21)	10.00	1.01	0.08	2.74 (2.32 - 3.23)
Disorders of Fluid/Electrolyte/Acid-Base Balance (CC 24)	10.08	-0.21	0.12	0.81 (0.65 - 1.02)
Disorders of Lipoid Metabolism (CC 25)	58.94	-0.14	0.08	0.87 (0.75 - 1.02)
Liver Failure (CC 27,30)	6.38	1.08	0.13	2.95 (2.27 - 3.84)
Other GI Disorders (CC 34-38)	77.76	-0.02	0.10	0.98 (0.82 - 1.19)
Other Musculoskeletal and Connective Tissue Disorders (CC 44,45)	39.25	-0.03	0.08	0.97 (0.83 - 1.13)
Hematologic or Immunity Disorders (CC 46-48)	6.47	0.02	0.12	1.02 (0.81 - 1.3)

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Dementia and Other Nonpsychotic Organic Brain Syndromes (CC 51-53)	9.55	0.65	0.09	1.91 (1.59 - 2.28)
Respiratory Failure, Respirator Dependence, Shock (CC 82-84)	4.38	0.11	0.14	1.12 (0.85 - 1.47)
Congestive Heart Failure (CC 85)	7.13	0.42	0.12	1.52 (1.21 - 1.91)
Hypertension and Hypertensive Heart Disease (CC 94,95)	57.13	-0.23	0.08	0.79 (0.68 - 0.92)
Pneumonia (CC 114-116)	10.35	0.37	0.09	1.45 (1.21 - 1.75)
Dialysis or Severe Chronic Kidney Disease (CC 134,136,137)	4.17	-0.21	0.17	0.81 (0.59 - 1.13)
Acute or Unspecified Renal Failure (CC 135,140)	4.43	-0.11	0.14	0.89 (0.68 - 1.17)
Poisonings and Allergic and Inflammatory Reactions (CC 175)	4.06	0.03	0.14	1.03 (0.78 - 1.37)
Minor Symptoms, Signs, Findings (CC 179)	60.15	0.67	0.11	1.95 (1.56 - 2.43)
Hepatitis (CCS 6)	1.61	0.00	--	--
Hemorrhoids (CCS 120)	1.60	-1.61	0.46	0.20 (0.08 - 0.49)
Esophageal disorders (CCS 138)	3.42	-1.24	0.27	0.29 (0.17 - 0.49)
Gastroduodenal ulcer (except hemorrhage) (CCS 139_1)	0.33	-0.25	0.46	0.78 (0.32 - 1.9)
Gastroduodenal ulcer (except hemorrhage) (CCS 139_2)	0.85	-1.79	0.74	0.17 (0.04 - 0.71)
Gastritis and duodenitis (CCS 140)	2.41	-1.48	0.35	0.23 (0.11 - 0.46)
Other disorders of stomach and duodenum (CCS 141)	1.96	-1.32	0.32	0.27 (0.14 - 0.50)
Appendicitis and other appendiceal conditions (CCS 142)	0.85	-2.31	1.03	0.1 (0.01 - 0.74)
Abdominal hernia (CCS 143)	4.13	-2.14	0.39	0.12 (0.05 - 0.25)
Regional enteritis and ulcerative colitis (CCS 144)	1.56	-1.59	0.50	0.2 (0.08 - 0.54)
Intestinal obstruction without hernia (CCS 145)	13.30	-0.73	0.22	0.48 (0.31 - 0.74)
Diverticulosis and diverticulitis (CCS 146)	11.01	-2.03	0.28	0.13 (0.08 - 0.23)
Anal and rectal conditions (CCS 147)	1.49	-3.63	1.02	0.03 (0.00 - 0.20)
Peritonitis and intestinal abscess (CCS 148_1)	0.30	0.87	0.33	2.38 (1.25 - 4.50)
Peritonitis and intestinal abscess (CCS 148_2)	0.29	-0.94	0.77	0.39 (0.09 - 1.76)
Biliary tract disease (CCS 149)	7.95	-0.91	0.24	0.40 (0.25 - 0.64)
Other liver diseases (CCS 151_1)	3.49	-0.14	0.19	0.87 (0.59 - 1.27)
Other liver diseases (CCS 151_2)	1.12	0.21	0.27	1.24 (0.73 - 2.10)
Pancreatic disorders (not diabetes) (CCS 152)	8.33	-0.94	0.24	0.39 (0.24 - 0.63)

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Gastrointestinal hemorrhage (CCS 153)	18.85	-1.18	0.21	0.31 (0.21 - 0.46)
Noninfectious gastroenteritis (CCS 154)	2.53	-1.95	0.46	0.14 (0.06 - 0.35)
Other gastrointestinal disorders (CCS 155)	7.05	-1.33	0.24	0.26 (0.17 - 0.42)
Nausea and vomiting (CCS 250)	1.67	-1.03	0.34	0.36 (0.18 - 0.70)
Abdominal pain (CCS 251)	3.88	-1.61	0.35	0.20 (0.10 - 0.40)

**Table 17. Non-Surgical Infectious Disease Division Hierarchical Logistic Regression Model Risk Factor Frequencies, Estimate, Standard Error, and Odds Ratios, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014)**

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Age	100.00	0.04	0.002	1.04 (1.04 - 1.04)
Systolic blood pressure (<=140)	98.48	-0.02	0.001	0.98 (0.98 - 0.99)
Systolic blood pressure (>140)		0.00	0.001	1.00 (1.00 - 1.00)
Heart rate	98.62	0.01	0.001	1.01 (1.01 - 1.01)
Oxygen saturation	97.19	-0.05	0.003	0.95 (0.94 - 0.96)
Temperature	96.09	-0.09	0.01	0.92 (0.90 - 0.93)
Bicarbonate (<=26)	98.64	-0.09	0.01	0.92 (0.91 - 0.93)
Bicarbonate (>26)		0.06	0.01	1.06 (1.05 - 1.08)
Creatinine (Winsorized at 5)	98.72	0.18	0.02	1.2 (1.16 - 1.25)
Hemoglobin	98.76	-0.03	0.01	0.97 (0.95 - 0.98)
Platelet (<=200)	98.60	-0.01	0.0005	0.99 (0.99 - 1.00)
Platelet (>200)		0.001	0.0002	1.00 (1.00 - 1.00)
Sodium (<=140)	98.66	-0.02	0.0041	0.98 (0.97 - 0.99)
Sodium (>140)		0.06	0.01	1.06 (1.05 - 1.08)
White blood count (<=7.0)	98.85	-0.11	0.02	0.9 (0.87 - 0.93)
White blood count (>7.0)		0.04	0.003	1.04 (1.03 - 1.04)
Other Infectious Diseases (CC 7)	9.63	-0.13	0.06	0.88 (0.79 - 0.98)
Metastatic & Severe Cancers (CC 8,9)	3.60	0.54	0.07	1.72 (1.50 - 1.97)
Protein-Calorie Malnutrition (CC 21)	19.06	0.72	0.04	2.06 (1.92 - 2.22)
Disorders of Fluid/Electrolyte/Acid-Base Balance (CC 24)	15.37	-0.10	0.05	0.91 (0.82 - 1.00)
Disorders of Lipid Metabolism (CC 25)	62.22	-0.14	0.03	0.87 (0.81 - 0.93)
Liver Failure (CC 27,30)	2.25	0.92	0.09	2.51 (2.12 - 2.97)
Other GI Disorders (CC 34-38)	60.88	-0.08	0.03	0.92 (0.86 - 0.98)

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Other Musculoskeletal and Connective Tissue Disorders (CC 44,45)	46.76	-0.09	0.03	0.92 (0.86 - 0.98)
Hematologic or Immunity Disorders (CC 46-48)	8.62	0.02	0.06	1.02 (0.91 - 1.14)
Dementia and Other Nonpsychotic Organic Brain Syndromes (CC 51-53)	24.26	0.41	0.04	1.50 (1.40 - 1.62)
Respiratory Failure, Respirator Dependence, Shock (CC 82-84)	9.46	-0.13	0.06	0.88 (0.79 - 0.98)
Congestive Heart Failure (CC 85)	12.45	0.37	0.05	1.45 (1.31 - 1.60)
Hypertension and Hypertensive Heart Disease (CC 94,95)	58.88	-0.14	0.03	0.87 (0.81 - 0.92)
Pneumonia (CC 114-116)	39.49	0.64	0.04	1.9 (1.77 - 2.03)
Dialysis or Severe Chronic Kidney Disease (CC 134,136,137)	6.85	-0.02	0.07	0.98 (0.86 - 1.12)
Acute or Unspecified Renal Failure (CC 135,140)	7.59	0.04	0.06	1.04 (0.92 - 1.17)
Poisonings and Allergic and Inflammatory Reactions (CC 175)	6.33	0.05	0.06	1.05 (0.93 - 1.18)
Minor Symptoms, Signs, Findings (CC 179)	76.24	0.76	0.06	2.13 (1.9 - 2.38)
Tuberculosis (CCS 1)	0.11	-0.49	0.80	0.61 (0.13 - 2.94)
Septicemia (except in labor) (CCS 2)	75.80	-0.16	0.49	0.85 (0.33 - 2.22)
Bacterial infection; unspecified site (CCS 3)	0.13	0.03	0.66	1.03 (0.28 - 3.77)
Mycoses (CCS 4)	0.27	-0.18	0.59	0.84 (0.27 - 2.63)
HIV infection (CCS 5)	0.25	0.08	0.59	1.08 (0.34 - 3.44)
Viral infection (CCS 7)	0.71	-0.75	0.58	0.47 (0.15 - 1.45)
Meningitis (except that caused by tuberculosis or sexually transmitted disease) (CCS 76)	0.39	-0.87	0.77	0.42 (0.09 - 1.89)
Encephalitis (except that caused by tuberculosis or sexually transmitted disease) (CCS 77)	0.20	0.00	--	--
Intestinal infection (CCS 135)	3.77	-0.76	0.50	0.47 (0.17 - 1.24)
Urinary tract infections (CCS 159)	7.85	-0.73	0.49	0.48 (0.18 - 1.26)
Skin and subcutaneous tissue infections (CCS 197)	8.74	-1.18	0.50	0.31 (0.11 - 0.83)
Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted disease) (CCS 201)	0.80	-1.16	0.61	0.31 (0.09 - 1.03)
Fever of unknown origin (CCS 246)	0.98	-1.88	0.64	0.15 (0.04 - 0.54)

**Table 18. Non-Surgical Pulmonary Division Hierarchical Logistic Regression Model Risk Factor Frequencies, Estimate, Standard Error, and Odds Ratios, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014)**

<b>Risk Variable</b>	<b>% Patients with Variable</b>	<b>Estimate</b>	<b>Standard Error</b>	<b>OR (95% CI)</b>
<b>Age</b>	100.00	0.04	0.003	1.04 (1.04 - 1.05)
<b>Systolic blood pressure (&lt;=140)</b>	98.49	-0.01	0.002	0.99 (0.99 - 0.99)
<b>Systolic blood pressure (&gt;140)</b>		-0.002	0.002	1.00 (0.99 – 1.00)
<b>Heart rate</b>	98.79	0.01	0.001	1.01 (1.01 - 1.01)
<b>Oxygen saturation</b>	98.00	-0.03	0.004	0.97 (0.96 - 0.98)
<b>Temperature</b>	94.83	-0.23	0.02	0.79 (0.76 - 0.83)
<b>Bicarbonate (&lt;=26)</b>	98.34	-0.07	0.01	0.93 (0.91 - 0.95)
<b>Bicarbonate (&gt;26)</b>		0.06	0.01	1.06 (1.05 - 1.08)
<b>Creatinine (Winsorized at 5)</b>	98.27	0.12	0.04	1.13 (1.05 - 1.22)
<b>Hemoglobin</b>	98.28	-0.08	0.01	0.93 (0.90 - 0.95)
<b>Platelet (&lt;=200)</b>	98.12	-0.01	0.001	0.99 (0.99 – 1.00)
<b>Platelet (&gt;200)</b>		0.001	0.0004	1.00 (1.00 – 1.00)
<b>Sodium (&lt;=140)</b>	98.26	-0.03	0.01	0.97 (0.96 - 0.98)
<b>Sodium (&gt;140)</b>		0.09	0.01	1.09 (1.06 - 1.12)
<b>White blood count (&lt;=7.0)</b>	98.30	0.12	0.04	1.13 (1.04 - 1.22)
<b>White blood count (&gt;7.0)</b>		0.03	0.01	1.03 (1.01 - 1.04)
<b>Other Infectious Diseases (CC 7)</b>	7.38	0.08	0.09	1.08 (0.91 - 1.29)
<b>Metastatic &amp; Severe Cancers (CC 8,9)</b>	3.29	0.75	0.10	2.12 (1.73 - 2.60)
<b>Protein-Calorie Malnutrition (CC 21)</b>	13.76	0.57	0.06	1.78 (1.58 - 1.99)
<b>Disorders of Fluid/Electrolyte/Acid-Base Balance (CC 24)</b>	13.92	-0.24	0.08	0.79 (0.68 - 0.93)
<b>Disorders of Lipoid Metabolism (CC 25)</b>	61.83	-0.05	0.05	0.95 (0.86 - 1.06)
<b>Liver Failure (CC 27,30)</b>	1.17	0.72	0.17	2.06 (1.46 - 2.90)
<b>Other GI Disorders (CC 34-38)</b>	55.53	-0.16	0.05	0.85 (0.77 - 0.95)
<b>Other Musculoskeletal and Connective Tissue Disorders (CC 44,45)</b>	41.83	-0.10	0.05	0.90 (0.81 – 1.00)
<b>Hematologic or Immunity Disorders (CC 46-48)</b>	6.16	-0.05	0.10	0.95 (0.78 - 1.15)
<b>Dementia and Other Nonpsychotic Organic Brain Syndromes (CC 51-53)</b>	16.19	0.27	0.06	1.31 (1.16 - 1.48)
<b>Respiratory Failure, Respirator Dependence, Shock (CC 82-84)</b>	16.47	0.08	0.08	1.08 (0.93 - 1.26)
<b>Congestive Heart Failure (CC 85)</b>	15.59	0.07	0.07	1.07 (0.93 - 1.24)
<b>Hypertension and Hypertensive Heart Disease (CC 94,95)</b>	60.91	-0.11	0.05	0.90 (0.81 - 0.99)

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Pneumonia (CC 114-116)	34.99	0.25	0.06	1.29 (1.16 - 1.44)
Dialysis or Severe Chronic Kidney Disease (CC 134,136,137)	6.00	0.02	0.12	1.02 (0.80 - 1.29)
Acute or Unspecified Renal Failure (CC 135,140)	6.13	0.08	0.10	1.09 (0.9 - 1.32)
Poisonings and Allergic and Inflammatory Reactions (CC 175)	6.75	0.15	0.09	1.16 (0.97 - 1.39)
Minor Symptoms, Signs, Findings (CC 179)	72.24	0.62	0.08	1.86 (1.6 - 2.16)
Pneumonia (except that caused by tuberculosis or sexually transmitted disease) (CCS 122)	28.97	0.12	0.12	1.13 (0.90 - 1.43)
Influenza (CCS 123)	1.50	-0.38	0.31	0.69 (0.37 - 1.26)
Acute bronchitis (CCS 125)	1.38	-1.42	0.47	0.24 (0.10 - 0.60)
Other upper respiratory infections (CCS 126)	1.39	-1.98	0.72	0.14 (0.03 - 0.57)
Chronic obstructive pulmonary disease and bronchiectasis (CCS 127)	14.76	-0.51	0.14	0.60 (0.46 - 0.79)
Asthma (CCS 128)	12.97	-0.60	0.16	0.55 (0.40 - 0.75)
Aspiration pneumonitis; food/vomitus (CCS 129)	6.40	0.85	0.13	2.35 (1.81 - 3.04)
Pleurisy; pneumothorax; pulmonary collapse (CCS 130)	3.58	0.00	0.17	1.00 (0.71 - 1.40)
Respiratory failure; insufficiency; arrest (adult) (CCS 131)	21.96	0.46	0.12	1.58 (1.25 - 2.00)
Lung disease due to external agents (CCS 132)	0.21	0.19	0.52	1.21 (0.44 - 3.35)
Other lower respiratory disease (CCS 133)	6.88	0.00	--	--

Table 19. Non-Surgical Renal Division Hierarchical Logistic Regression Model Risk Factor Frequencies, Estimate, Standard Error, and Odds Ratios, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014)

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Age	100.00	0.07	0.005	1.07 (1.06 - 1.08)
Systolic blood pressure (<=140)	98.46	-0.01	0.002	0.99 (0.98 - 0.99)
Systolic blood pressure (>140)		-0.01	0.003	0.99 (0.99 - 1.00)
Heart rate	98.62	0.01	0.002	1.01 (1.00 - 1.01)
Oxygen saturation	97.21	-0.03	0.01	0.97 (0.95 - 0.99)
Temperature	95.11	-0.26	0.04	0.77 (0.71 - 0.84)
Bicarbonate (<=26)	98.41	-0.01	0.01	0.99 (0.96 - 1.01)

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Bicarbonate (>26)		0.07	0.02	1.07 (1.04 - 1.11)
Creatinine (Winsorized at 5)	98.43	0.30	0.04	1.35 (1.26 - 1.45)
Hemoglobin	97.40	-0.07	0.02	0.94 (0.90 - 0.98)
Platelet (<=200)	97.57	-0.004	0.001	1.00 (0.99 – 1.00)
Platelet (>200)		-0.001	0.001	1.00 (1.00 – 1.00)
Sodium (<=140)	98.47	-0.01	0.01	0.99 (0.97 – 1.00)
Sodium (>140)		0.07	0.01	1.07 (1.05 - 1.09)
White blood count (<=7.0)	97.79	0.08	0.05	1.08 (0.98 - 1.20)
White blood count (>7.0)		0.02	0.01	1.03 (1.00 - 1.05)
Other Infectious Diseases (CC 7)	7.57	0.22	0.14	1.24 (0.95 - 1.62)
Metastatic & Severe Cancers (CC 8,9)	3.18	1.04	0.17	2.83 (2.03 - 3.94)
Protein-Calorie Malnutrition (CC 21)	14.97	0.74	0.09	2.09 (1.75 - 2.50)
Disorders of Fluid/Electrolyte/Acid-Base Balance (CC 24)	16.55	-0.06	0.12	0.94 (0.74 - 1.19)
Disorders of Lipid Metabolism (CC 25)	68.73	-0.12	0.09	0.89 (0.75 - 1.06)
Liver Failure (CC 27,30)	2.12	1.36	0.20	3.88 (2.65 - 5.70)
Other GI Disorders (CC 34-38)	62.61	-0.10	0.09	0.90 (0.76 - 1.07)
Other Musculoskeletal and Connective Tissue Disorders (CC 44,45)	46.76	-0.01	0.08	0.99 (0.84 - 1.17)
Hematologic or Immunity Disorders (CC 46-48)	7.35	0.24	0.14	1.27 (0.97 - 1.66)
Dementia and Other Nonpsychotic Organic Brain Syndromes (CC 51-53)	19.40	0.35	0.09	1.42 (1.18 - 1.70)
Respiratory Failure, Respirator Dependence, Shock (CC 82-84)	8.12	0.15	0.14	1.16 (0.89 - 1.52)
Congestive Heart Failure (CC 85)	15.74	0.63	0.12	1.87 (1.49 - 2.35)
Hypertension and Hypertensive Heart Disease (CC 94,95)	60.86	-0.29	0.08	0.75 (0.64 - 0.88)
Pneumonia (CC 114-116)	18.91	0.27	0.10	1.31 (1.08 - 1.59)
Dialysis or Severe Chronic Kidney Disease (CC 134,136,137)	17.41	0.02	0.12	1.02 (0.81 - 1.29)
Acute or Unspecified Renal Failure (CC 135,140)	10.48	-0.26	0.13	0.77 (0.59 – 1.00)
Poisonings and Allergic and Inflammatory Reactions (CC 175)	5.92	0.06	0.16	1.06 (0.78 - 1.44)
Minor Symptoms, Signs, Findings (CC 179)	75.59	0.60	0.13	1.82 (1.40 - 2.36)
Fluid and electrolyte disorders (CCS 55)	33.91	-0.04	0.14	0.96 (0.73 - 1.27)
Essential hypertension (CCS 98)	2.88	-1.62	1.01	0.2 (0.03 - 1.44)



Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Hypertension with complications and secondary hypertension (CCS 99)	16.99	0.00	--	--
Nephritis; nephrosis; renal sclerosis (CCS 156)	0.48	0.89	0.61	2.44 (0.74 - 7.99)
Acute and unspecified renal failure (CCS 157)	38.90	0.19	0.13	1.21 (0.94 - 1.55)
Chronic kidney disease (CCS 158)	3.43	-2.50	0.60	0.08 (0.03 - 0.27)
Other diseases of kidney and ureters (CCS 161)	3.42	-1.91	0.72	0.15 (0.04 - 0.61)

**Table 20. Non-Surgical Orthopedic Division Hierarchical Logistic Regression Model Risk Factor Frequencies, Estimate, Standard Error, and Odds Ratios, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014)**

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Age	100.00	0.07	0.01	1.07 (1.05 - 1.09)
Systolic blood pressure (<=140)	97.43	0.001	0.01	1.00 (0.99 - 1.01)
Systolic blood pressure (>140)		0.002	0.005	1.00 (0.99 - 1.01)
Heart rate	97.63	0.004	0.004	1.00 (1.00 - 1.01)
Oxygen saturation	96.04	-0.07	0.02	0.93 (0.90 - 0.97)
Temperature	94.36	-0.44	0.09	0.65 (0.54 - 0.77)
Bicarbonate (<=26)	93.90	-0.04	0.03	0.96 (0.90 - 1.02)
Bicarbonate (>26)		0.09	0.03	1.10 (1.04 - 1.16)
Creatinine (Winsorized at 5)	94.14	0.08	0.11	1.09 (0.89 - 1.34)
Hemoglobin	94.52	-0.15	0.04	0.86 (0.80 - 0.93)
Platelet (<=200)	94.36	-0.01	0.002	0.99 (0.99 - 1.00)
Platelet (>200)		-0.002	0.001	1.00 (1.00 - 1.00)
Sodium (<=140)	94.05	0.02	0.02	1.02 (0.98 - 1.06)
Sodium (>140)		0.03	0.05	1.03 (0.95 - 1.13)
White blood count (<=7.0)	94.49	0.26	0.12	1.29 (1.03 - 1.63)
White blood count (>7.0)		0.03	0.02	1.03 (1.00 - 1.07)
Other Infectious Diseases (CC 7)	4.91	-0.10	0.28	0.90 (0.52 - 1.55)
Metastatic & Severe Cancers (CC 8,9)	1.79	0.60	0.37	1.82 (0.88 - 3.79)
Protein-Calorie Malnutrition (CC 21)	8.19	1.10	0.16	3.02 (2.22 - 4.11)
Disorders of Fluid/Electrolyte/Acid-Base Balance (CC 24)	8.69	0.18	0.23	1.20 (0.76 - 1.90)
Disorders of Lipoid Metabolism (CC 25)	61.23	-0.21	0.14	0.81 (0.61 - 1.06)
Liver Failure (CC 27,30)	1.42	0.97	0.41	2.63 (1.17 - 5.90)
Other GI Disorders (CC 34-38)	59.16	-0.33	0.14	0.72 (0.55 - 0.94)



Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Other Musculoskeletal and Connective Tissue Disorders (CC 44,45)	56.17	0.12	0.14	1.12 (0.85 - 1.47)
Hematologic or Immunity Disorders (CC 46-48)	4.32	-0.23	0.30	0.79 (0.44 - 1.43)
Dementia and Other Nonpsychotic Organic Brain Syndromes (CC 51-53)	16.35	0.64	0.14	1.90 (1.44 - 2.51)
Respiratory Failure, Respirator Dependence, Shock (CC 82-84)	4.36	0.13	0.27	1.14 (0.67 - 1.96)
Congestive Heart Failure (CC 85)	7.17	0.58	0.22	1.79 (1.15 - 2.78)
Hypertension and Hypertensive Heart Disease (CC 94,95)	59.49	-0.28	0.14	0.76 (0.58 - 0.99)
Pneumonia (CC 114-116)	14.41	-0.24	0.18	0.79 (0.55 - 1.12)
Dialysis or Severe Chronic Kidney Disease (CC 134,136,137)	3.98	0.35	0.33	1.41 (0.73 - 2.72)
Acute or Unspecified Renal Failure (CC 135,140)	3.08	-0.49	0.38	0.61 (0.29 - 1.29)
Poisonings and Allergic and Inflammatory Reactions (CC 175)	3.67	-0.32	0.35	0.72 (0.36 - 1.45)
Minor Symptoms, Signs, Findings (CC 179)	68.90	0.80	0.22	2.22 (1.44 - 3.44)
Osteoarthritis (CCS 203)	18.33	-1.68	0.57	0.19 (0.06 - 0.57)
Other non-traumatic joint disorders (CCS 204)	4.16	-0.90	0.58	0.40 (0.13 - 1.27)
Spondylosis; intervertebral disc disorders; other back problems (CCS 205)	15.96	-0.11	0.35	0.90 (0.45 - 1.79)
Pathological fracture (CCS 207)	5.17	0.29	0.33	1.33 (0.69 - 2.56)
Other bone disease and musculoskeletal deformities (CCS 212)	1.50	-0.97	1.05	0.38 (0.05 - 2.97)
Fracture of neck of femur (hip) (CCS 226)	11.02	-0.34	0.31	0.71 (0.39 - 1.30)
Skull and face fractures (CCS 228)	1.30	0.04	0.55	1.05 (0.36 - 3.07)
Fracture of upper limb (CCS 229)	5.16	0.10	0.37	1.11 (0.54 - 2.28)
Fracture of lower limb (CCS 230)	5.13	-0.16	0.39	0.85 (0.39 - 1.83)
Other fractures (CCS 231)	16.95	0.36	0.29	1.43 (0.81 - 2.53)
Sprains and strains (CCS 232)	2.26	-1.50	1.05	0.22 (0.03 - 1.76)
Open wounds of head; neck; and trunk (CCS 235)	1.45	-1.77	1.05	0.17 (0.02 - 1.35)
Open wounds of extremities (CCS 236)	1.84	-1.21	1.05	0.30 (0.04 - 2.32)
Superficial injury; contusion (CCS 239)	4.50	-0.53	0.42	0.59 (0.26 - 1.32)

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Other injuries and conditions due to external causes (CCS 244)	0.53	0.85	0.58	2.33 (0.75 - 7.26)
	4.74	0.00	--	--

**Table 21. Non-Surgical Neurology Division Hierarchical Logistic Regression Model Risk Factor Frequencies, Estimate, Standard Error, and Odds Ratios, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014)**

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Age	100.00	0.05	0.003	1.05 (1.04 - 1.06)
Systolic blood pressure (<=140)	98.39	-0.005	0.003	1.00 (0.99 – 1.00)
Systolic blood pressure (>140)		0.01	0.002	1.01 (1.00 - 1.01)
Heart rate	98.46	0.01	0.002	1.01 (1.01 - 1.01)
Oxygen saturation	97.61	0.05	0.01	1.05 (1.02 - 1.07)
Temperature	93.89	-0.20	0.04	0.82 (0.75 - 0.89)
Bicarbonate (<=26)	97.51	-0.06	0.01	0.94 (0.91 - 0.97)
Bicarbonate (>26)		0.02	0.02	1.02 (0.99 - 1.06)
Creatinine (Winsorized at 5)	97.72	0.02	0.05	1.02 (0.91 - 1.13)
Hemoglobin	97.44	-0.03	0.02	0.97 (0.93 - 1.01)
Platelet (<=200)	97.32	-0.01	0.001	0.99 (0.99 – 1.00)
Platelet (>200)		0.0003	0.001	1.00 (1.00 – 1.00)
Sodium (<=140)	97.65	0.02	0.01	1.02 (1.00 - 1.04)
Sodium (>140)		0.07	0.02	1.07 (1.03 - 1.11)
White blood count (<=7.0)	97.46	0.10	0.05	1.10 (1.00 - 1.21)
White blood count (>7.0)		0.07	0.01	1.07 (1.05 - 1.09)
Other Infectious Diseases (CC 7)	4.02	0.07	0.15	1.07 (0.80 - 1.43)
Metastatic & Severe Cancers (CC 8,9)	1.36	0.54	0.20	1.72 (1.16 - 2.55)
Protein-Calorie Malnutrition (CC 21)	7.52	0.40	0.09	1.49 (1.24 - 1.79)
Disorders of Fluid/Electrolyte/Acid-Base Balance (CC 24)	7.74	0.15	0.12	1.16 (0.91 - 1.48)
Disorders of Lipoid Metabolism (CC 25)	66.66	-0.17	0.07	0.85 (0.74 - 0.96)
Liver Failure (CC 27,30)	0.78	0.63	0.29	1.87 (1.06 - 3.33)
Other GI Disorders (CC 34-38)	47.76	-0.13	0.06	0.88 (0.77 - 0.99)
Other Musculoskeletal and Connective Tissue Disorders (CC 44,45)	46.35	-0.28	0.06	0.75 (0.67 - 0.85)
Hematologic or Immunity Disorders (CC 46-48)	3.44	-0.21	0.16	0.81 (0.59 - 1.11)
Dementia and Other Nonpsychotic Organic Brain Syndromes (CC 51-53)	24.95	0.49	0.07	1.62 (1.43 - 1.85)

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Respiratory Failure, Respirator Dependence, Shock (CC 82-84)	3.89	-0.13	0.15	0.88 (0.65 - 1.19)
Congestive Heart Failure (CC 85)	7.06	0.37	0.11	1.45 (1.16 - 1.82)
Hypertension and Hypertensive Heart Disease (CC 94,95)	67.46	-0.18	0.07	0.83 (0.73 - 0.95)
Pneumonia (CC 114-116)	11.17	0.45	0.09	1.57 (1.32 - 1.86)
Dialysis or Severe Chronic Kidney Disease (CC 134,136,137)	4.50	0.36	0.16	1.44 (1.05 - 1.97)
Acute or Unspecified Renal Failure (CC 135,140)	3.19	-0.28	0.17	0.75 (0.54 - 1.06)
Poisonings and Allergic and Inflammatory Reactions (CC 175)	3.61	-0.08	0.16	0.93 (0.67 - 1.27)
Minor Symptoms, Signs, Findings (CC 179)	70.73	0.89	0.09	2.43 (2.03 - 2.91)
Other CNS infection and poliomyelitis (CCS 78)	0.35	1.29	0.67	3.63 (0.98 - 13.43)
Parkinson`s disease (CCS 79)	0.54	1.43	0.50	4.20 (1.57 - 11.22)
Multiple sclerosis (CCS 80)	0.62	0.08	1.05	1.08 (0.14 - 8.39)
Other hereditary and degenerative nervous system conditions (CCS 81)	1.37	1.21	0.38	3.35 (1.58 - 7.07)
Epilepsy; convulsions (CCS 83)	8.40	0.53	0.29	1.69 (0.96 – 3.00)
Coma; stupor; and brain damage (CCS 85)	3.98	1.04	0.29	2.83 (1.60 - 5.04)
Other nervous system disorders (CCS 95_1)	1.18	2.10	0.32	8.13 (4.34 - 15.23)
Other nervous system disorders (CCS 95_2)	8.85	0.00	--	--
Acute cerebrovascular disease (CCS 109_1)	9.81	2.51	0.26	12.36 (7.49 - 20.38)
Acute cerebrovascular disease (CCS 109_2)	46.97	1.90	0.25	6.71 (4.11 - 10.94)
Occlusion or stenosis of precerebral arteries (CCS 110)	4.30	-1.78	0.75	0.17 (0.04 - 0.74)
Other and ill-defined cerebrovascular disease (CCS 111)	0.99	0.90	0.52	2.46 (0.88 - 6.87)
Transient cerebral ischemia (CCS 112)	10.74	-0.21	0.33	0.81 (0.42 - 1.55)
Late effects of cerebrovascular disease (CCS 113)	1.88	0.33	0.43	1.39 (0.61 - 3.21)

**Table 22. Surgical Cancer Division Hierarchical Logistic Regression Model Risk Factor Frequencies, Estimate, Standard Error, and Odds Ratios, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014)**

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Age	100.00	0.04	0.01	1.04 (1.01 - 1.07)
Systolic blood pressure (<=140)	93.05	0.00	0.01	1.00 (0.98 - 1.02)
Systolic blood pressure (>140)		0.01	0.01	1.01 (0.99 - 1.03)
Heart rate	93.62	-0.01	0.01	0.99 (0.98 - 1.01)
Oxygen saturation	92.99	-0.17	0.07	0.84 (0.74 - 0.96)
Temperature	93.38	0.004	0.19	1.00 (0.69 - 1.46)
Bicarbonate (<=26)	62.10	-0.17	0.06	0.84 (0.75 - 0.95)
Bicarbonate (>26)		0.06	0.08	1.07 (0.91 - 1.25)
Creatinine (Winsorized at 5)	63.14	0.48	0.25	1.62 (0.98 - 2.67)
Hemoglobin	71.95	0.01	0.06	1.01 (0.90 - 1.12)
Platelet (<=200)	68.74	-0.01	0.004	0.99 (0.98 - 1.00)
Platelet (>200)		0.01	0.002	1.01 (1.00 - 1.01)
Sodium (<=140)	62.20	-0.06	0.04	0.94 (0.86 - 1.02)
Sodium (>140)		-0.02	0.12	0.98 (0.77 - 1.24)
White blood count (<=7.0)	68.83	-0.25	0.16	0.78 (0.58 - 1.06)
White blood count (>7.0)		0.06	0.03	1.06 (1.00 - 1.12)
Other Infectious Diseases (CC 7)	1.28	1.20	0.49	3.33 (1.27 - 8.72)
Metastatic & Severe Cancers (CC 8,9)	7.29	0.95	0.38	2.58 (1.22 - 5.43)
Protein-Calorie Malnutrition (CC 21)	2.93	0.96	0.32	2.60 (1.39 - 4.88)
Disorders of Fluid/Electrolyte/Acid-Base Balance (CC 24)	2.22	-0.97	0.58	0.38 (0.12 - 1.17)
Disorders of Lipid Metabolism (CC 25)	54.20	0.11	0.25	1.11 (0.68 - 1.82)
Other GI Disorders (CC 34-38)	46.96	-0.06	0.25	0.95 (0.58 - 1.53)
Other Musculoskeletal and Connective Tissue Disorders (CC 44,45)	27.54	0.01	0.25	1.01 (0.62 - 1.64)
Hematologic or Immunity Disorders (CC 46-48)	1.48	0.54	0.50	1.72 (0.64 - 4.62)
Dementia and Other Nonpsychotic Organic Brain Syndromes (CC 51-53)	3.51	0.43	0.42	1.54 (0.68 - 3.48)
Respiratory Failure, Respirator Dependence, Shock (CC 82-84)	0.92	-1.99	1.11	0.14 (0.02 - 1.21)
Congestive Heart Failure (CC 85)	1.35	-0.47	0.68	0.62 (0.17 - 2.35)
Hypertension and Hypertensive Heart Disease (CC 94,95)	50.66	0.41	0.25	1.50 (0.92 - 2.46)
Pneumonia (CC 114-116)	2.93	1.46	0.30	4.33 (2.42 - 7.72)
Dialysis or Severe Chronic Kidney Disease (CC 134,136,137)	0.78	-0.40	0.85	0.67 (0.13 - 3.56)

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Acute or Unspecified Renal Failure (CC 135,140)	0.92	0.50	0.67	1.65 (0.44 - 6.20)
Poisonings and Allergic and Inflammatory Reactions (CC 175)	0.97	0.46	0.63	1.58 (0.46 - 5.47)
Minor Symptoms, Signs, Findings (CC 179)	40.07	0.78	0.28	2.18 (1.25 - 3.81)
Cancer of head and neck (CCS 11)	2.61	-0.43	1.35	0.65 (0.05 - 9.22)
Cancer of esophagus (CCS 12)	0.59	-0.78	1.51	0.46 (0.02 - 8.85)
Cancer of stomach (CCS 13)	0.88	-0.18	1.28	0.84 (0.07 - 10.25)
Cancer of colon (CCS 14)	10.16	0.20	1.17	1.23 (0.12 - 12.23)
Cancer of rectum and anus (CCS 15)	3.10	0.01	1.29	1.01 (0.08 - 12.61)
Cancer of liver and intrahepatic bile duct (CCS 16)	1.28	-1.19	1.52	0.30 (0.02 - 5.96)
Cancer of pancreas (CCS 17)	0.90	0.71	1.24	2.04 (0.18 - 23.40)
Cancer of other GI organs; peritoneum (CCS 18)	1.13	0.42	1.25	1.52 (0.13 - 17.66)
Cancer of bronchus; lung (CCS 19)	6.45	-0.76	1.17	0.47 (0.05 - 4.67)
Cancer of bone and connective tissue (CCS 21)	1.33	0.06	1.35	1.07 (0.08 - 14.90)
Cancer of breast (CCS 24)	15.69	-2.58	1.53	0.08 (0.004 - 1.53)
Cancer of uterus (CCS 25)	8.23	-0.62	1.29	0.54 (0.04 - 6.77)
Cancer of prostate (CCS 29)	29.01	-3.21	1.52	0.04 (0.002 - 0.80)
Cancer of bladder (CCS 32)	4.69	-0.04	1.20	0.96 (0.09 - 10.19)
Cancer of kidney and renal pelvis (CCS 33)	6.53	-0.32	1.22	0.73 (0.07 - 8.00)
Cancer of brain and nervous system (CCS 35)	1.85	0.17	1.33	1.19 (0.09 - 16.18)
Non-Hodgkin's lymphoma (CCS 38)	1.04	0.94	1.19	2.55 (0.25 - 26.37)
Leukemias (CCS 39)	0.23	-0.16	1.59	0.85 (0.04 - 19.20)
Cancer; other and unspecified primary (CCS 41)	0.57	0.45	1.53	1.57 (0.08 - 31.63)
Malignant neoplasm without specification of site (CCS 43)	0.35	0.16	1.57	1.17 (0.05 - 25.36)
Neoplasms of unspecified nature or uncertain behavior (CCS 44)	3.11	-1.34	1.52	0.26 (0.01 - 5.16)
Maintenance chemotherapy; radiotherapy (CCS 45)	0.26	0.00	0.00	1.00 (1.00 - 1.00)

**Table 23. Surgical Cardiothoracic Division Hierarchical Logistic Regression Model Risk Factor Frequencies, Estimate, Standard Error, and Odds Ratios, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014)**

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Age	100	0.07	0.01	1.07 (1.06 - 1.09)
Systolic blood pressure (<=140)	96.54	-0.02	0.005	0.98 (0.97 - 0.99)
Systolic blood pressure (>140)		-0.003	0.01	1.00 (0.99 - 1.01)
Heart rate	96.72	0.01	0.003	1.01 (1.01 - 1.02)
Oxygen saturation	95.73	-0.003	0.02	1.00 (0.96 - 1.04)
Temperature	93.41	-0.03	0.09	0.97 (0.81 - 1.17)
Bicarbonate (<=26)	85.96	-0.11	0.03	0.89 (0.85 - 0.94)
Bicarbonate (>26)		0.10	0.04	1.11 (1.04 - 1.19)
Creatinine (Winsorized at 5)	85.79	0.49	0.10	1.64 (1.34 - 2.00)
Hemoglobin	86.21	0.02	0.03	1.02 (0.96 - 1.09)
Platelet (<=200)	86.03	0.001	0.002	1.00 (1.00 - 1.00)
Platelet (>200)		0.003	0.001	1.00 (1.00 - 1.00)
Sodium (<=140)	86.05	-0.04	0.02	0.97 (0.92 - 1.01)
Sodium (>140)		0.08	0.05	1.08 (0.98 - 1.2)
White blood count (<=7.0)	86.12	-0.08	0.10	0.92 (0.76 - 1.12)
White blood count (>7.0)		0.04	0.02	1.04 (1.00 - 1.07)
Other Infectious Diseases (CC 7)	2.49	-0.62	0.40	0.54 (0.25 - 1.19)
Metastatic & Severe Cancers (CC 8,9)	4.38	0.22	0.37	1.24 (0.60 - 2.56)
Protein-Calorie Malnutrition (CC 21)	4.97	0.64	0.20	1.89 (1.26 - 2.82)
Disorders of Fluid/Electrolyte/Acid-Base Balance (CC 24)	4.83	0.30	0.29	1.36 (0.77 - 2.38)
Disorders of Lipoid Metabolism (CC 25)	75.96	-0.04	0.16	0.96 (0.70 - 1.32)
Other GI Disorders (CC 34-38)	50.42	-0.17	0.13	0.84 (0.65 - 1.09)
Other Musculoskeletal and Connective Tissue Disorders (CC 44,45)	37.60	-0.38	0.14	0.69 (0.53 - 0.90)
Hematologic or Immunity Disorders (CC 46-48)	2.99	0.18	0.33	1.20 (0.64 - 2.28)
Dementia and Other Nonpsychotic Organic Brain Syndromes (CC 51-53)	3.54	0.01	0.27	1.01 (0.59 - 1.73)
Respiratory Failure, Respirator Dependence, Shock (CC 82-84)	3.79	-0.05	0.32	0.95 (0.51 - 1.77)
Congestive Heart Failure (CC 85)	8.04	0.09	0.24	1.10 (0.68 - 1.77)
Hypertension and Hypertensive Heart Disease (CC 94,95)	62.68	-0.24	0.13	0.79 (0.61 - 1.02)
Pneumonia (CC 114-116)	22.21	0.25	0.15	1.28 (0.96 - 1.70)

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Dialysis or Severe Chronic Kidney Disease (CC 134,136,137)	3.83	0.04	0.32	1.04 (0.55 - 1.96)
Acute or Unspecified Renal Failure (CC 135,140)	2.27	0.61	0.34	1.85 (0.95 - 3.59)
Poisonings and Allergic and Inflammatory Reactions (CC 175)	2.51	0.09	0.36	1.10 (0.54 - 2.23)
Minor Symptoms, Signs, Findings (CC 179)	67.09	0.17	0.16	1.19 (0.87 - 1.62)
Septicemia (except in labor) (CCS 2)	4.53	-0.58	0.48	0.56 (0.22 - 1.43)
Other and unspecified benign neoplasm (CCS 47)	13.90	-4.11	1.09	0.02 (0.00 - 0.14)
Diabetes mellitus with complications (CCS 50)	0.65	-1.78	1.13	0.17 (0.02 - 1.54)
Heart valve disorders (CCS 96)	19.09	-0.22	0.46	0.80 (0.33 - 1.97)
Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transmitted disease) (CCS 97)	1.36	0.00	--	--
Acute myocardial infarction (CCS 100)	13.08	0.93	0.44	2.52 (1.06 - 6.00)
Coronary atherosclerosis and other heart disease (CCS 101)	16.88	-0.19	0.47	0.83 (0.33 - 2.08)
Nonspecific chest pain (CCS 102)	1.17	-1.38	1.10	0.25 (0.03 - 2.18)
Pulmonary heart disease (CCS 103)	0.35	0.36	0.91	1.44 (0.24 - 8.52)
Conduction disorders (CCS 105)	0.59	-1.00	1.11	0.37 (0.04 - 3.24)
Cardiac dysrhythmias (CCS 106)	10.17	-1.36	0.56	0.26 (0.08 - 0.77)
Congestive heart failure; nonhypertensive (CCS 108)	3.09	-1.06	0.54	0.35 (0.12 - 1.00)
Pneumonia (except that caused by tuberculosis or sexually transmitted disease) (CCS 122)	1.04	-1.05	0.86	0.35 (0.06 - 1.87)
Pleurisy; pneumothorax; pulmonary collapse (CCS 130)	2.87	-0.67	0.55	0.51 (0.17 - 1.51)
Respiratory failure; insufficiency; arrest (adult) (CCS 131)	0.85	-0.01	0.60	0.99 (0.30 - 3.22)
Other lower respiratory disease (CCS 133)	4.14	-0.57	0.60	0.57 (0.17 - 1.83)
Biliary tract disease (CCS 149)	0.56	-0.51	1.11	0.60 (0.07 - 5.31)
Cardiac and circulatory congenital anomalies (CCS 213)	0.96	0.36	0.85	1.44 (0.27 - 7.64)
Complication of device; implant or graft (CCS 237)	2.23	-1.21	0.63	0.30 (0.09 - 1.01)
Complications of surgical procedures or medical care (CCS 238)	2.50	-1.10	0.64	0.33 (0.09 - 1.17)



**Table 24. General Surgery Division Hierarchical Logistic Regression Model Risk Factor Frequencies, Estimate, Standard Error, and Odds Ratios, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014)**

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Age	100	0.05	0.005	1.06 (1.04 - 1.07)
Systolic blood pressure (<=140)	96.21	-0.01	0.003	0.99 (0.98 - 0.99)
Systolic blood pressure (>140)		0.01	0.004	1.01 (1.00 - 1.02)
Heart rate	96.54	0.01	0.003	1.01 (1.01 - 1.02)
Oxygen saturation	95.26	-0.10	0.02	0.91 (0.87 - 0.95)
Temperature	95.27	-0.20	0.06	0.82 (0.73 - 0.91)
Bicarbonate (<=26)	74.79	-0.12	0.02	0.89 (0.85 - 0.92)
Bicarbonate (>26)		0.07	0.03	1.07 (1.02 - 1.13)
Creatinine (Winsorized at 5)	75.53	0.29	0.06	1.34 (1.19 - 1.50)
Hemoglobin	80.66	-0.10	0.02	0.91 (0.86 - 0.95)
Platelet (<=200)	80.29	-0.01	0.002	0.99 (0.99 - 1.00)
Platelet (>200)		0.001	0.001	1.00 (1.00 - 1.00)
Sodium (<=140)	75.35	-0.05	0.01	0.95 (0.92 - 0.98)
Sodium (>140)		0.11	0.04	1.12 (1.04 - 1.20)
White blood count (<=7.0)	80.38	-0.15	0.07	0.86 (0.76 - 0.98)
White blood count (>7.0)		0.06	0.01	1.06 (1.04 - 1.08)
Other Infectious Diseases (CC 7)	2.82	-0.18	0.22	0.83 (0.54 - 1.28)
Metastatic & Severe Cancers (CC 8,9)	2.34	0.01	0.25	1.01 (0.62 - 1.63)
Protein-Calorie Malnutrition (CC 21)	6.62	0.48	0.11	1.62 (1.30 - 2.03)
Disorders of Fluid/Electrolyte/Acid-Base Balance (CC 24)	4.83	0.09	0.18	1.09 (0.76 - 1.55)
Disorders of Lipoid Metabolism (CC 25)	53.91	-0.11	0.10	0.89 (0.73 - 1.09)
Other GI Disorders (CC 34-38)	78.05	-0.23	0.13	0.79 (0.61 - 1.03)
Other Musculoskeletal and Connective Tissue Disorders (CC 44,45)	32.27	0.01	0.10	1.01 (0.83 - 1.23)
Hematologic or Immunity Disorders (CC 46-48)	2.44	0.41	0.20	1.51 (1.02 - 2.22)
Dementia and Other Nonpsychotic Organic Brain Syndromes (CC 51-53)	3.38	0.24	0.15	1.27 (0.94 - 1.70)
Respiratory Failure, Respirator Dependence, Shock (CC 82-84)	2.01	0.27	0.22	1.31 (0.85 - 2.03)
Congestive Heart Failure (CC 85)	2.75	0.00	0.20	1.00 (0.68 - 1.47)
Hypertension and Hypertensive Heart Disease (CC 94,95)	52.65	-0.23	0.10	0.80 (0.65 - 0.97)
Pneumonia (CC 114-116)	5.43	0.74	0.12	2.11 (1.67 - 2.66)



Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Dialysis or Severe Chronic Kidney Disease (CC 134,136,137)	2.61	0.36	0.22	1.44 (0.93 - 2.22)
Acute or Unspecified Renal Failure (CC 135,140)	2.02	-0.37	0.25	0.69 (0.43 - 1.13)
Poisonings and Allergic and Inflammatory Reactions (CC 175)	2.06	-0.62	0.26	0.54 (0.32 - 0.89)
Minor Symptoms, Signs, Findings (CC 179)	44.97	1.04	0.14	2.83 (2.15 - 3.71)
Septicemia (except in labor) (CCS 2)	5.37	1.96	1.05	7.11 (0.91 - 55.33)
Other and unspecified benign neoplasm (CCS 47)	4.77	1.07	1.09	2.92 (0.34 - 24.9)
Diabetes mellitus with complications (CCS 50)	0.43	-1.14	1.50	0.32 (0.02 - 6.04)
Fluid and electrolyte disorders (CCS 55)	0.26	-0.18	1.47	0.84 (0.05 - 14.85)
Coagulation and hemorrhagic disorders (CCS 62)	0.11	1.56	1.48	4.77 (0.26 - 87.34)
Hypertension with complications and secondary hypertension (CCS 99)	0.18	0.00	--	--
Acute myocardial infarction (CCS 100)	0.30	1.97	1.15	7.21 (0.76 - 68.33)
Pulmonary heart disease (CCS 103)	0.25	1.94	1.21	6.93 (0.65 - 74.14)
Cardiac dysrhythmias (CCS 106)	0.54	0.97	1.20	2.64 (0.25 - 27.85)
Congestive heart failure; nonhypertensive (CCS 108)	0.46	0.53	1.18	1.70 (0.17 - 17.03)
Acute cerebrovascular disease (CCS 109)	0.30	0.86	1.28	2.35 (0.19 - 28.76)
Peripheral and visceral atherosclerosis (CCS 114)	0.53	2.99	1.07	19.83 (2.44 - 160.94)
Aortic; peripheral; and visceral artery aneurysms (CCS 115)	0.16	3.26	1.15	26.00 (2.74 - 246.70)
Pneumonia (except that caused by tuberculosis or sexually transmitted disease) (CCS 122)	0.35	-0.25	1.46	0.78 (0.04 - 13.53)
Chronic obstructive pulmonary disease and bronchiectasis (CCS 127)	0.11	1.88	1.30	6.56 (0.51 - 84.61)
Asthma (CCS 128)	0.13	1.15	1.48	3.17 (0.17 - 57.99)
Aspiration pneumonitis; food/vomitus (CCS 129)	0.10	0.46	1.32	1.59 (0.12 - 21.06)
Respiratory failure; insufficiency; arrest (adult) (CCS 131)	0.30	0.78	1.21	2.18 (0.20 - 23.40)
Intestinal infection (CCS 135)	0.20	1.16	1.23	3.18 (0.29 - 35.45)
Esophageal disorders (CCS 138)	0.90	1.47	1.17	4.34 (0.44 - 42.76)
Gastroduodenal ulcer (except hemorrhage) (CCS 139_1)	0.68	2.89	1.07	17.98 (2.22 - 145.53)

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Gastroduodenal ulcer (except hemorrhage) (CCS 139_2)	0.09	2.39	1.48	10.97 (0.61 - 197.69)
Other disorders of stomach and duodenum (CCS 141)	0.30	1.79	1.27	6.00 (0.49 - 73.05)
Appendicitis and other appendiceal conditions (CCS 142)	9.65	0.45	1.09	1.56 (0.18 - 13.33)
Abdominal hernia (CCS 143)	11.66	1.19	1.06	3.29 (0.41 - 26.10)
Regional enteritis and ulcerative colitis (CCS 144)	0.34	1.91	1.21	6.78 (0.63 - 73.22)
Intestinal obstruction without hernia (CCS 145)	4.48	2.01	1.05	7.47 (0.95 - 58.93)
Diverticulosis and diverticulitis (CCS 146)	2.67	1.68	1.08	5.35 (0.65 - 44.21)
Anal and rectal conditions (CCS 147)	1.87	0.67	1.16	1.95 (0.20 - 19.01)
Peritonitis and intestinal abscess (CCS 148)	0.21	1.91	1.28	6.76 (0.55 - 82.96)
Biliary tract disease (CCS 149)	15.69	0.21	1.07	1.24 (0.15 - 10.08)
Other liver diseases (CCS 151)	0.24	1.99	1.21	7.33 (0.68 - 78.77)
Pancreatic disorders (not diabetes) (CCS 152)	2.96	0.62	1.11	1.86 (0.21 - 16.55)
Gastrointestinal hemorrhage (CCS 153)	0.68	2.32	1.07	10.15 (1.24 - 83.47)
Other gastrointestinal disorders (CCS 155)	3.29	-0.22	1.16	0.81 (0.08 - 7.85)
Acute and unspecified renal failure (CCS 157)	0.37	0.36	1.19	1.43 (0.14 - 14.75)
Urinary tract infections (CCS 159)	0.28	0.004	1.46	1.00 (0.06 - 17.62)
Other female genital disorders (CCS 175)	0.61	1.51	1.27	4.51 (0.37 - 54.74)
Pathological fracture (CCS 207)	0.10	0.95	1.48	2.58 (0.14 - 47.08)
Other connective tissue disease (CCS 211)	0.49	1.48	1.28	4.39 (0.36 - 53.63)
Other fractures (CCS 231)	0.13	1.65	1.35	5.22 (0.37 - 73.15)
Complication of device; implant or graft (CCS 237)	1.66	1.28	1.07	3.60 (0.44 - 29.28)
Complications of surgical procedures or medical care (CCS 238)	3.13	0.60	1.09	1.82 (0.22 - 15.46)
Other injuries and conditions due to external causes (CCS 244)	0.10	3.44	1.22	31.11 (2.85 - 339.42)
Lymphadenitis (CCS 247)	0.23	1.54	1.47	4.67 (0.26 - 82.43)
Nausea and vomiting (CCS 250)	0.15	1.23	1.47	3.40 (0.19 - 60.96)
Abdominal pain (CCS 251)	0.41	0.80	1.46	2.23 (0.13 - 38.91)
Other aftercare (CCS 257)	21.81	-3.35	1.45	0.04 (0.002 - 0.60)

**Table 25. Surgical Orthopedic Division Hierarchical Logistic Regression Model Risk Factor Frequencies, Estimate, Standard Error, and Odds Ratios, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014)**

<b>Risk Variable</b>	<b>% Patients with Variable</b>	<b>Estimate</b>	<b>Standard Error</b>	<b>OR (95% CI)</b>
<b>Age</b>	100.00	0.06	0.01	1.06 (1.05 - 1.08)
<b>Systolic blood pressure (&lt;=140)</b>	95.44	-0.01	0.004	0.99 (0.98 - 0.99)
<b>Systolic blood pressure (&gt;140)</b>		-0.001	0.003	1.00 (0.99 – 1.00)
<b>Heart rate</b>	96.02	0.005	0.003	1.00 (1.00 - 1.01)
<b>Oxygen saturation</b>	95.10	-0.08	0.02	0.92 (0.89 - 0.96)
<b>Temperature</b>	95.32	-0.17	0.07	0.85 (0.75 - 0.96)
<b>Bicarbonate (&lt;=26)</b>	64.66	-0.12	0.03	0.89 (0.85 - 0.94)
<b>Bicarbonate (&gt;26)</b>		0.17	0.02	1.18 (1.13 - 1.23)
<b>Creatinine (Winsorized at 5)</b>	64.60	0.53	0.07	1.69 (1.47 - 1.96)
<b>Hemoglobin</b>	84.46	-0.04	0.02	0.96 (0.92 - 1.01)
<b>Platelet (&lt;=200)</b>	77.85	-0.01	0.002	0.99 (0.99 – 1.00)
<b>Platelet (&gt;200)</b>		0.002	0.001	1.00 (1.00 – 1.00)
<b>Sodium (&lt;=140)</b>	65.46	-0.06	0.01	0.95 (0.92 - 0.97)
<b>Sodium (&gt;140)</b>		0.07	0.03	1.07 (1.00 - 1.14)
<b>White blood count (&lt;=7.0)</b>	77.92	-0.07	0.07	0.94 (0.81 - 1.08)
<b>White blood count (&gt;7.0)</b>		0.04	0.01	1.04 (1.01 - 1.06)
<b>Other Infectious Diseases (CC 7)</b>	2.33	-0.24	0.19	0.78 (0.54 - 1.15)
<b>Metastatic &amp; Severe Cancers (CC 8,9)</b>	0.47	1.15	0.27	3.14 (1.86 - 5.31)
<b>Protein-Calorie Malnutrition (CC 21)</b>	3.03	0.86	0.10	2.36 (1.92 - 2.89)
<b>Disorders of Fluid/Electrolyte/Acid-Base Balance (CC 24)</b>	3.30	-0.56	0.17	0.57 (0.41 - 0.80)
<b>Disorders of Lipoid Metabolism (CC 25)</b>	58.58	0.16	0.09	1.17 (0.98 - 1.39)
<b>Other GI Disorders (CC 34-38)</b>	48.75	-0.04	0.09	0.96 (0.81 - 1.14)
<b>Other Musculoskeletal and Connective Tissue Disorders (CC 44,45)</b>	51.59	-0.06	0.09	0.94 (0.79 - 1.11)
<b>Hematologic or Immunity Disorders (CC 46-48)</b>	1.44	0.39	0.18	1.48 (1.03 - 2.11)
<b>Dementia and Other Nonpsychotic Organic Brain Syndromes (CC 51-53)</b>	6.06	0.70	0.09	2.02 (1.69 - 2.43)
<b>Respiratory Failure, Respirator Dependence, Shock (CC 82-84)</b>	1.34	-0.19	0.20	0.83 (0.56 - 1.21)
<b>Congestive Heart Failure (CC 85)</b>	2.40	0.55	0.15	1.74 (1.29 - 2.34)
<b>Hypertension and Hypertensive Heart Disease (CC 94,95)</b>	56.52	-0.07	0.09	0.93 (0.78 - 1.10)
<b>Pneumonia (CC 114-116)</b>	3.08	0.86	0.11	2.36 (1.89 - 2.95)

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Dialysis or Severe Chronic Kidney Disease (CC 134,136,137)	1.83	0.01	0.21	1.01 (0.67 - 1.54)
Acute or Unspecified Renal Failure (CC 135,140)	1.20	0.13	0.21	1.14 (0.75 - 1.72)
Poisonings and Allergic and Inflammatory Reactions (CC 175)	1.64	0.36	0.20	1.43 (0.96 - 2.12)
Minor Symptoms, Signs, Findings (CC 179)	44.62	0.77	0.13	2.15 (1.68 - 2.77)
Septicemia (except in labor) (CCS 2)	2.53	0.76	1.02	2.14 (0.29 - 15.83)
Hepatitis (CCS 6)	0.04	3.15	1.30	23.38 (1.83 - 298.95)
Diabetes mellitus with complications (CCS 50)	1.42	1.18	1.04	3.27 (0.43 - 24.87)
Other CNS infection and poliomyelitis (CCS 78)	0.04	1.97	1.46	7.16 (0.41 - 124.72)
Other nervous system disorders (CCS 95)	0.56	0.00	--	--
Acute myocardial infarction (CCS 100)	0.35	0.92	1.14	2.51 (0.27 - 23.34)
Pulmonary heart disease (CCS 103)	0.19	1.10	1.24	2.99 (0.26 - 34.26)
Conduction disorders (CCS 105)	0.12	0.18	1.45	1.19 (0.07 - 20.27)
Cardiac dysrhythmias (CCS 106)	0.44	0.11	1.24	1.12 (0.10 - 12.68)
Congestive heart failure; nonhypertensive (CCS 108)	0.42	-1.54	1.43	0.21 (0.01 - 3.50)
Acute cerebrovascular disease (CCS 109)	0.07	0.64	1.48	1.90 (0.10 - 34.25)
	0.31	1.20	1.10	3.31 (0.38 - 28.61)
Peripheral and visceral atherosclerosis (CCS 114)	0.16	1.44	1.12	4.22 (0.47 - 37.79)
Pneumonia (except that caused by tuberculosis or sexually transmitted disease) (CCS 122)	0.28	0.22	1.18	1.25 (0.12 - 12.60)
Chronic obstructive pulmonary disease and bronchiectasis (CCS 127)	0.11	0.20	1.44	1.22 (0.07 - 20.66)
Aspiration pneumonitis; food/vomitus (CCS 129)	0.08	-0.22	1.45	0.80 (0.05 - 13.79)
Respiratory failure; insufficiency; arrest (adult) (CCS 131)	0.20	-0.02	1.25	0.98 (0.08 - 11.29)
Intestinal infection (CCS 135)	0.12	-0.26	1.48	0.77 (0.04 - 14.01)
Other disorders of stomach and duodenum (CCS 141)	0.06	1.13	1.51	3.10 (0.16 - 60.34)
Intestinal obstruction without hernia (CCS 145)	0.21	-0.05	1.44	0.95 (0.06 - 15.87)
Gastrointestinal hemorrhage (CCS 153)	0.30	-0.62	1.44	0.54 (0.03 - 9.04)

Risk Variable	% Patients with Variable	Estimate	Standard Error	OR (95% CI)
Acute and unspecified renal failure (CCS 157)	0.20	-0.54	1.26	0.59 (0.05 - 6.94)
Urinary tract infections (CCS 159)	0.24	-0.85	1.43	0.43 (0.03 - 7.03)
Skin and subcutaneous tissue infections (CCS 197)	0.32	-0.45	1.45	0.64 (0.04 - 10.91)
Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted disease) (CCS 201)	0.74	0.69	1.09	2.00 (0.24 - 16.88)
Osteoarthritis (CCS 203)	53.69	-0.87	1.02	0.42 (0.06 - 3.10)
Spondylosis; intervertebral disc disorders; other back problems (CCS 205)	9.70	0.60	1.04	1.82 (0.24 - 13.85)
Pathological fracture (CCS 207)	0.53	1.45	1.05	4.26 (0.54 - 33.63)
Other acquired deformities (CCS 209)	0.99	0.97	1.16	2.63 (0.27 - 25.79)
Other connective tissue disease (CCS 211)	0.85	-0.24	1.42	0.79 (0.05 - 12.83)
Other bone disease and musculoskeletal deformities (CCS 212)	1.24	1.40	1.07	4.06 (0.50 - 33.18)
Joint disorders and dislocations; trauma-related (CCS 225)	0.65	0.11	1.43	1.12 (0.07 - 18.47)
Fracture of neck of femur (hip) (CCS 226)	8.03	1.85	1.01	6.33 (0.87 - 46.10)
Fracture of upper limb (CCS 229)	2.45	0.09	1.11	1.09 (0.13 - 9.56)
Fracture of lower limb (CCS 230)	4.02	1.57	1.02	4.81 (0.65 - 35.63)
Other fractures (CCS 231)	0.65	1.33	1.07	3.80 (0.46 - 31.06)
Complication of device; implant or graft (CCS 237)	5.67	0.18	1.04	1.19 (0.16 - 9.09)
Complications of surgical procedures or medical care (CCS 238)	1.17	0.83	1.06	2.29 (0.29 - 18.24)
Syncope (CCS 245)	0.24	-0.16	1.43	0.85 (0.05 - 14.01)
Gangrene (CCS 248)	0.10	2.50	1.06	12.17 (1.51 - 98.08)
Abdominal pain (CCS 251)	0.11	0.97	1.48	2.65 (0.14 - 48.48)
Other aftercare (CCS 257)	0.39	-0.23	1.44	0.80 (0.05 - 13.40)

## APPENDIX I – Risk Adjustment Development

### Variations for Hybrid Development

For development of the hybrid HWM measure we used the Clinical Hybrid Dataset. We used this dataset to recreate the claims-only risk model we built in Medicare data to compare to the risk models that use EHR data. While the statistical calculations of the SMR for each hospital and the statistical method used to pool those results to calculate the hospital-wide RSMR varied slightly for development and testing of the hybrid HWM measure, we anticipate the hybrid HWM measure will be specified and implemented as described in the claims-only HWM measure report. The results in this report were calculated using the following minor modifications:

- Uses SAS GLIMMIX instead of SAS MCMC for risk model calculation of the SMR for each division, which was shown to have similar results when both approaches were used to calculate RSMRs in the claims-only HWM measure development dataset;
- Uses volume weighted mean to calculate the RSMR, rather than inverse variance weighted mean, which is a similar method and shows similar results; and
- Removed the risk variable MCC80 from consideration for all divisions and the risk variable MCC27 from consideration for surgical divisions due to their low prevalence and low or zero mortality rates in some divisions, causing model convergence issues.

### Models for each service-line division

For model development, we used logistic regression models with a logistic link function, with outcome  $Y_{ij}$  for the  $i^{\text{th}}$  patient in  $j^{\text{th}}$  hospital which is equal to 1 if the patient died within 30 days of admission and 0 otherwise. In contrast with the modeling approached proposed for implementation that is described in detail in the claims-only HWM measure report, logistic regression models are substantially less computationally intensive, and using models with fully specific error structures would have taken prohibitively long in the hybrid HWM measure development. Also, by using logistic regression models, we could assess risk factors and model performance without reference to the variation in performance across hospitals.

To calculate a hospital-level RSMR for the hybrid HWM measure in the Clinical Hybrid Dataset, we included an additional error term to the logistic regression models. Due to the natural clustering of observations within hospitals, we used hierarchical logistic regression to model the log-odds of mortality for each of the 12 cohorts; this will include all 13 proposed service-line divisions in the final measure when implemented. Death within 30 days was modeled as a function of patient-level demographic and clinical characteristics and a random hospital-level intercept. This model specification 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 estimated a separate hierarchical logistic regression model for each service-line division.

Specifically, for a given service-line division, we estimated a hierarchical logistic regression model as follows: Let  $Y_{ij}$  denote the outcome (equal to 1 if patient  $i$  dies within 30 days, zero otherwise) for the patient  $i$  in division  $D \subseteq \{1, \dots, 12\}$  at hospital  $j$ ;  $\mathbf{Z}_{ij}$  denotes a set of risk factors. Let  $M$  denote the total number of hospitals and  $m_j$  the number of index patient stays in hospital  $j$ . We assumed the outcome is related linearly to the covariates via a logit function with dispersion:

$$\text{logit}(\text{Prob}(Y_i = 1)) = \alpha_j + \boldsymbol{\beta}^* \mathbf{Z}_{ij} + \varepsilon_i \quad (1)$$

$$\alpha_j = \mu + \omega_j ; \omega_j \sim N(0, \tau^2)$$

where  $\mathbf{Z}_{ij} = (Z_1, Z_2, \dots, Z_k)$  is a set of  $k$  patient-level covariates.  $\alpha_j$  represents the hospital-specific intercept;  $\mu$  is the adjusted average outcome over all hospitals; and  $\tau^2$  is the between hospital variance component and  $\varepsilon \sim N(0, \sigma^2)$  captures any over- or under-dispersion. We estimated the hierarchical logistic regression model for each cohort using the SAS software system (GLIMMIX procedure).

#### Standardized mortality ratio for each service-line division

We used the results of each hierarchical logistic regression model to calculate the predicted number of deaths and the expected number of deaths at each hospital. We calculated the predicted number of deaths in each division, using the corresponding hierarchical logistic regression model, as the sum of the predicted probability of death for each patient, including the hospital-specific (random) effect. We similarly calculated the expected number of deaths in each division for each hospital as the sum of the predicted probability of death for each patient, ignoring the hospital-specific (random) effect. Using the notation of the previous section, the model specific risk-standardized mortality ratio (SMR) was calculated as follows: To calculate the predicted number of deaths  $\text{pred}_{Dj}$  for index admissions in each division  $D=1, \dots, 12$  at hospital  $j$ , we use

$$\text{pred}_{Dj} = \sum \text{logit}^{-1}(\alpha_j + \boldsymbol{\beta}^* \mathbf{Z}_{ij}) \quad (2)$$

where the sum is over all  $m_{Dj}$  index admissions in division  $D$  with index admissions at hospital  $j$ . To calculate the expected number  $\text{exp}_{Dj}$  we use

$$\text{exp}_{Dj} = \sum \text{logit}^{-1}(\mu + \boldsymbol{\beta}^* \mathbf{Z}_{ij}) \quad (3)$$

Then, as a measure of excess or reduced deaths among index admissions in cohort  $D$  at hospital  $j$ , we calculate the standardized risk ratio  $\text{SMR}_{Dj}$  as

$$\text{SMR}_{Dj} = \text{pred}_{Dj} / \text{exp}_{Dj} \quad (4)$$

#### Hospital-Wide 30-day Risk-Standardized Mortality Rate (RSMR) Calculation

To report a single mortality score for a hospital, the separate service-line division SMRs were combined into a single value. We created a single score as follows.

For a given hospital,  $j$ , which has patients in some subset of divisions  $D \subseteq \{1, \dots, 12\}$ , we calculate the SMR as described above for each division for which the hospital discharged patients. If the hospital does not have index admissions in a given division  $d$ , then  $m_{dj} = 0$  and we take  $\text{SMR}_{dj} = 1$ . Then, we calculate the volume-weighted logarithmic mean:

$$\text{SMR}_j = \exp((\sum m_{dj} \log(\text{SMR}_{dj})) / \sum m_{dj}) \quad (5)$$

where the sums are over all service-line divisions; note that if a hospital does not have index admissions in a given division ( $m_{dj} = 0$ ), then that cohort contributes nothing to the overall score  $\text{SMR}_j$ . **This value,  $\text{SMR}_j$ , is the hospital-wide risk-standardized mortality ratio** for hospital  $j$ . To aid interpretation, this ratio is then multiplied by the overall national observed mortality rate for all index admissions in all cohorts,  $\bar{Y}$ , to produce **the hospital-wide risk-standardized mortality rate (RSMR<sub>j</sub>)**.

$$\text{RSMR}_j = \text{SMR}_j * \bar{Y} \quad (6)$$

## APPENDIX J – Hospital-Level Service-Line Division-Level Final Model

The tables below represent the hospital-level service-line division-level results with the number of patients, and the mean, standard deviation, and median SMR and RSMR for each of the 12 divisions for which we were able to calculate the SMR.

**Table 26. Non-Surgical Cancer Division Hospital-Level Volume, SMR, RSMR, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014) (N = 22 hospitals; 5,764 patients)**

Description	Volume	SMR	RSMR
Mean	262.00	1.04	3.8%
Standard Deviation	144.32	0.20	0.7%
100% Max	575	1.45	5.3%
95%	521	1.45	5.3%
75% Q3	375	1.20	4.4%
50% Median	238	1.03	3.8%
25% Q1	170	0.89	3.2%
5%	56	0.75	2.7%
0% Min	11	0.71	2.6%

**Table 27. Non-Surgical Cardiac Division Hospital-Level Volume, SMR, RSMR, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014) (N = 22 hospitals; 57,090 patients)**

Description	Volume	SMR	RSMR
Mean	2595.00	1.00	4.0%
Standard Deviation	1470.19	0.17	0.7%
100% Max	5998	1.45	5.8%
95%	5159	1.26	5.1%
75% Q3	3239	1.10	4.4%
50% Median	2401	1.00	4.0%
25% Q1	1546	0.86	3.5%
5%	795	0.70	2.8%
0% Min	173	0.70	2.8%

**Table 28. Non-Surgical Gastrointestinal Division Hospital-Level Volume, SMR, RSMR, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014) (N = 22 hospitals; 34,366 patients)**

Description	Volume	SMR	RSMR
Mean	1562.09	1.03	2.7%
Standard Deviation	720.13	0.21	0.5%
100% Max	2972	1.42	3.7%
95%	2781	1.34	3.5%
75% Q3	1870	1.19	3.1%
50% Median	1564.5	1.02	2.7%



Description	Volume	SMR	RSMR
25% Q1	1110	0.87	2.3%
5%	338	0.61	1.6%
0% Min	131	0.61	1.6%

**Table 29. Non-Surgical Infectious Disease Division Hospital-Level Volume, SMR, RSMR, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014) (N = 22 hospitals; 52,627 patients)**

Description	Volume	SMR	RSMR
Mean	2392.14	1.00	10.1%
Standard Deviation	1158.04	0.10	1.0%
100% Max	4754	1.29	12.9%
95%	4690	1.17	11.7%
75% Q3	3022	1.05	10.5%
50% Median	2123	0.98	9.9%
25% Q1	1823	0.92	9.3%
5%	848	0.87	8.8%
0% Min	178	0.85	8.6%

**Table 30. Non-Surgical Neurology Division Hospital-Level Volume, SMR, RSMR, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014) (N = 22 hospitals; 19,425 patients)**

Description	Volume	SMR	RSMR
Mean	882.95	1.00	6.9%
Standard Deviation	424.45	0.10	0.7%
100% Max	1634	1.25	8.6%
95%	1579	1.25	8.6%
75% Q3	1211	1.07	7.3%
50% Median	873	0.98	6.7%
25% Q1	571	0.94	6.4%
5%	204	0.90	6.1%
0% Min	51	0.87	6.0%

**Table 31. Non-Surgical Orthopedic Division Hospital-Level Volume, SMR, RSMR, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014) (N = 22 hospitals; 11,497 patients)**

Description	Volume	SMR	RSMR
Mean	522.59	1.01	2.4%
Standard Deviation	296.25	0.12	0.3%
100% Max	1048	1.31	3.0%
95%	1028	1.20	2.8%
75% Q3	821	1.11	2.6%
50% Median	455	1.00	2.3%

Description	Volume	SMR	RSMR
25% Q1	308	0.92	2.1%
5%	98	0.84	2.0%
0% Min	36	0.84	2.0%

**Table 32. Surgical Pulmonary Division Hospital-Level Volume, SMR, RSMR, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014) (N = 22 hospitals; 25,057 patients)**

Description	Volume	SMR	RSMR
Mean	1138.95	1.02	8.4%
Standard Deviation	511.17	0.12	1.0%
100% Max	2089	1.34	11.1%
95%	1952	1.34	11.1%
75% Q3	1489	1.08	8.9%
50% Median	1140	0.98	8.1%
25% Q1	787	0.94	7.7%
5%	509	0.89	7.3%
0% Min	95	0.78	6.4%

**Table 33. Non-Surgical Renal Division Hospital-Level Volume, SMR, RSMR, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014) (N = 22 hospitals; 12,116 patients)**

Description	Volume	SMR	RSMR
Mean	550.73	1.00	6.9%
Standard Deviation	241.99	0.10	0.7%
100% Max	1070	1.25	8.7%
95%	859	1.25	8.7%
75% Q3	690	1.04	7.2%
50% Median	571	1.00	6.9%
25% Q1	358	0.94	6.5%
5%	230	0.82	5.7%
0% Min	57	0.82	5.7%

**Table 34. Surgical Cancer Division Hospital-Level Volume, SMR, RSMR, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014) (N = 22 hospitals; 15,506 patients)**

Description	Volume	SMR	RSMR
Mean	704.82	1.01	0.6%
Standard Deviation	636.14	0.18	0.1%
100% Max	2278	1.51	0.8%
95%	2196	1.23	0.7%
75% Q3	1153	1.17	0.6%
50% Median	454	1.02	0.6%

Description	Volume	SMR	RSMR
25% Q1	323	0.82	0.5%
5%	130	0.79	0.4%
0% Min	19	0.79	0.4%

**Table 35. Surgical Cardiothoracic Division Hospital-Level Volume, SMR, RSMR, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014) (N = 22 hospitals; 7,800 patients)**

Description	Volume	SMR	RSMR
Mean	354.55	1.02	4.2%
Standard Deviation	627.53	0.09	0.4%
100% Max	2464	1.24	5.1%
95%	2032	1.12	4.6%
75% Q3	237	1.12	4.6%
50% Median	139.5	1.00	4.1%
25% Q1	83	0.95	3.9%
5%	27	0.87	3.6%
0% Min	13	0.87	3.6%

**Table 36. General Surgery Division Hospital-Level Volume, SMR, RSMR, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014) (N = 22 hospitals; 34,159 patients)**

Description	Volume	SMR	RSMR
Mean	1552.68	1.00	1.6%
Standard Deviation	712.73	0.02	0.0%
100% Max	3006	1.03	1.7%
95%	2790	1.03	1.7%
75% Q3	1936	1.02	1.6%
50% Median	1539	0.99	1.6%
25% Q1	1071	0.99	1.6%
5%	469	0.96	1.6%
0% Min	95	0.96	1.6%

**Table 37. Surgical Orthopedic Division Hospital-Level Volume, SMR, RSMR, Clinical Hybrid Dataset (January 1, 2010 – December 31, 2014) (N = 22 hospitals; 2,787 patients)**

Description	Volume	SMR	RSMR
Mean	132.71	0.99	4.8%
Standard Deviation	326.00	0.02	0.1%
100% Max	1292	1.02	5.0%
95%	873	1.02	5.0%
75% Q3	48	1.02	5.0%
50% Median	15	0.99	4.8%

Description	Volume	SMR	RSMR
<b>25% Q1</b>	8	0.96	4.7%
<b>5%</b>	4	0.96	4.7%
<b>0% Min</b>	1	0.96	4.7%