2013 Measures Updates and Specifications Report: Hospital-Level 30-Day Risk-Standardized Readmission Measures for Acute Myocardial Infarction, Heart Failure, and Pneumonia (Version 6.0)

Submitted By:

Yale New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (YNHHSC/CORE)

Prepared For:

Centers for Medicare & Medicaid Services (CMS)

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Table of Contents

LIST OF TABLES **4**

LIST OF FIGURES **5**

1. HOW TO USE THIS REPORT **7**

2. BACKGROUND AND OVERVIEW OF MEASURE METHODOLOGY **9**

2.1 Background on Readmission Measures 9
2.2 Overview of Measure Methodology 9
2.2.1 Cohort 9
2.2.2 Outcome 11
2.2.3 Risk-Adjustment Variables 12
2.2.4 Data Sources 13
2.2.5 Measure Calculation 13
2.2.6 Categorizing Hospital Performance 14

3. UPDATES TO MEASURES FOR 2013 PUBLIC REPORTING **15**

3.1 Rationale for Measure Updates 15
3.2 Detailed Discussion of Measure Updates 15
3.2.1 Incorporation of Planned Readmission Algorithm 15
3.2.2 Updates to the Condition Category (CC) Map 18
3.3 Changes to SAS Analytic Package (SAS Pack) 18

4. RESULTS FOR 2013 PUBLIC REPORTING **19**

4.1 Assessment of Updated Models 19
4.2 AMI Readmission 2013 Model Results 20
4.2.1 Index Cohort Exclusions 20
4.2.2 Frequency of AMI Model Variables 21
4.2.3 AMI Model Parameters and Performance 21
4.2.4 Distribution of Hospital Volumes and RSRRs 21
4.2.5 Distribution of Hospitals by Performance Category in the Three-Year Dataset 21
4.3 HF Readmission 2013 Model Results 27
4.3.1 Index Cohort Exclusions 27
4.3.2 Frequency of HF Model Variables 28
4.3.3 HF Model Parameters and Performance 28
4.3.4 Distribution of Hospital Volumes and RSRRs 28
4.3.5 Distribution of Hospitals by Performance Category in the Three-Year Dataset 28
4.4 Pneumonia Readmission 2013 Model Results 33
4.4.1 Index Cohort Exclusions 33
4.4.2 Frequency of Pneumonia Model Variables 34
4.4.3 Pneumonia Model Parameters and Performance 34
4.4.4 Distribution of Hospital Volumes and RSRRs 34
4.4.5 Distribution of Hospitals by Performance Category in the Three-Year Dataset 34

5. DATA QUALITY ASSURANCE (QA) **39**

5.1 Phase I 39

5.2 Phase II 39

6. REFERENCES 42

7. APPENDICES 43

Appendix A. Measure Specifications 43
Appendix B. Annual Updates 52
Appendix C. Planned Readmission Algorithm 54
Appendix D. Common Terms 63
Appendix E. RTI Memorandum 65

LIST OF TABLES

Table 1 – Effect of Planned Readmission Algorithm on AMI Measure 17
Table 2 – Effect of Planned Readmission Algorithm on HF Measure 18
Table 3 – Effect of Planned Readmission Algorithm on Pneumonia Measure 18
Table 4 – Frequency of AMI Model Variables over Different Time Periods 23
Table 5 – Adjusted OR and 95% CIs for the AMI Hierarchical Logistic Regression Model over Different Time Periods 24
Table 6 – AMI Generalized Linear Modeling (Logistic Regression) Performance over Different Time 25
Table 7 – Distribution of Hospital AMI Admission Volumes over Different Time Periods 25
Table 8 – Distribution of Hospital AMI RSRRs over Different Time Periods 25
Table 9 – Frequency of HF Model Variables over Different Time Periods 29
Table 10 – Adjusted OR and 95% CIs for the HF Hierarchical Logistic Regression Model over Different Time Periods 30
Table 11 – HF Logistic Regression Model Performance over Different Time Periods 31
Table 12 – Distribution of Hospital Heart Failure Admission Volumes over Different Time Periods 31
Table 13 – Distribution of Hospital Heart Failure RSRRs over Different Time Periods 31
Table 14 – Frequency of Pneumonia Model Variables over Different Time Periods 35
Table 15 – Adjusted OR and 95% CIs for the Pneumonia Hierarchical Logistic Regression Model over Different Time Periods 36
Table 16 – Pneumonia Logistic Regression Model Performance over Different Time Periods 37
Table 17 – Distribution of Hospital Pneumonia Admission Volumes over Different Time Periods 37
Table 18 – Distribution of Hospital Pneumonia RSRRs over Different Time Periods 37

Table PR 1 - Procedure Categories that are Always Planned (Version 2.1 – General Population) 55
Table PR 2 - Diagnosis Categories that are Always Planned (Version 2.1 – General Population) 55
Table PR 3 - Potentially Planned Procedure Categories (Version 2.1 – General Population) 56
Table PR 4 - Acute Diagnosis Categories (Version 2.1 – General Population) 58

LIST OF FIGURES

Figure 1 – Index Cohort Sample for AMI in the July 2009-June 2012 Dataset 20
Figure 2 – Distribution of Hospital 30-Day AMI RSRRs between July 2009 and June 2012 26
Figure 3 – Index Cohort Sample for HF in the July 2009-June 2012 Dataset 27
Figure 4 – Distribution of Hospital 30-Day HF RSRRs between July 2009 and June 2012 32
Figure 5 – Index Cohort Sample for Pneumonia in the July 2009-June 2012 Dataset 33
Figure 6 – Distribution of Hospital 30-Day Pneumonia RSRRs between July 2009 and June 2012 38
Figure 7 – YNHHSC/CORE QA Phase I 40
Figure 8 – YNHHSC/CORE QA Phase II 41
Figure PR1: Planned Readmission Algorithm Version 2.1 – Flowchart 54

YNHHSC/CORE Project Team

Jacqueline N. Grady, M.S. – Lead
Zhenqiu Lin, Ph.D. – Analytic Director
Changqin Wang, M.D., M.S. – Lead Analyst
Megan Keenan, M.P.H. – Project Coordinator
Chinwe Nwosu, M.S. – Research Assistant
Kanchana R. Bhat, M.P.H. – Project Manager
Leora I. Horwitz, M.D., M.H.S. – Planned Readmission Lead
Elizabeth E. Drye, M.D., S.M.* – Planned Readmission Director
Harlan M. Krumholz, M.D., S.M.* - Principal Investigator
Susannah M. Bernheim, M.D., M.H.S. – Project Director

*Yale School of Medicine

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1. HOW TO USE THIS REPORT

This report describes three of the Centers for Medicare & Medicaid Services (CMS) readmission measures used in the Hospital Inpatient Quality Reporting (IQR) program and publicly reported on *Hospital Compare*: the hospital-level 30-day risk-standardized readmission rates (RSRRs) following acute myocardial infarction (AMI), heart failure (HF), and pneumonia measures.

This report is intended to provide a single source of information about the current measures for a wide range of readers. Within this report we provide an overview of the measure methodology, describe methodology updates to the measures and the national results for 2013 public reporting, and describe our quality assurance processes. The appendices provide further details, including concise tables of measure specifications and a list of the annual updates each year since public reporting began in 2009.

Specifically, the reader can find:

- **An overview of the AMI, HF, and pneumonia readmission measures (Section 2):**
  - History of the measures
  - Measure cohort
    - included and excluded hospitalizations
    - how transfers are handled
    - differences between IQR reporting and the Hospital Readmissions Reduction Program (Section 3025 of the Affordable Care Act)
  - Outcome (what counts as a readmission)
    - what is considered a planned readmission
  - Risk-adjustment specifications
  - Data sources
  - Readmission rate calculation
  - Categorization of hospitals' performance

- **2013 measure updates (Section 3):**
  - The most significant update for 2013 reporting is the addition of an algorithm to identify planned readmissions. Planned readmissions will not be counted in the measures.

- **2013 results (Section 4)**:
  - Results from the models that are used for the Hospital Inpatient Quality Reporting (IQR) program in 2013.

- **Quality assurance process (Section 5)**

The Appendices contain detailed measure information, including:

- Appendix A: Measure specifications;
- Appendix B: Annual updates to measures since measure development;
- Appendix C: Detailed overview of the Planned Readmission Algorithm;
- Appendix D: Definitions for common terms; and
- Appendix E: RTI's memorandum on updates to the Condition Category (CC) map.

For additional references, the original measure methodology and development technical reports, as well as prior updates and specifications reports (formerly called measure maintenance reports) are also available on the claims based readmission measure page of *QualityNet*:

- Hospital 30-Day Acute Myocardial Infarction Readmission Measure: Methodology (2008)[1]
- Hospital 30-Day Heart Failure Readmission Measure: Methodology (2008)[2]
- Hospital 30-Day Pneumonia Readmission Measure: Methodology (2008)[3]
- 2009-2012 Measure Maintenance Technical Reports: Acute Myocardial Infarction, Heart Failure, and Pneumonia 30-Day Risk-Standardized Readmission Measures[4-7]

The AMI, HF, and pneumonia readmission measure methodologies are also described in the peer-reviewed medical literature.[8-10]

2. BACKGROUND AND OVERVIEW OF MEASURE METHODOLOGY

2.1 Background on Readmission Measures

In July 2009, CMS began publicly reporting hospital 30-day RSRRs for AMI, HF, and pneumonia for the nation's non-federal* acute care hospitals, including critical access hospitals. In 2011, CMS and the Veterans Health Administration (VA) collaborated to update the readmission measures to include hospitalizations for patients admitted for AMI, HF, or pneumonia in VA hospitals. These three measures complement the 30-day mortality measures CMS reports for AMI, HF, and pneumonia.[11,12] The readmission measure results are posted on *Hospital Compare*, and CMS updates them annually. This year CMS plans to report two additional readmission measures, the Hospital-Wide All-Cause Unplanned Readmission Measure and the Hospital-Level 30-Day, All-Cause Risk-Standardized Readmission rate (RSRR) Following Elective Primary Total Hip Arthroplasty (THA) and/or Total Knee Arthroplasty (TKA). The updates and specifications reports for those measures can be found on *QualityNet*.

CMS contracted with YNHHSC/CORE to update the 30-day AMI, HF, and pneumonia readmission measures for 2013 public reporting through a process of measures maintenance. Measures maintenance is an annual process to improve the measures by responding to stakeholder input on the measures and incorporating advances in the science or changes in coding.

2.2 Overview of Measure Methodology

The 2013 risk-adjusted readmission measures use the National Quality Forum (NQF)-endorsed methodology set forth in the initial measure methodology reports[1-3] with slight refinements to the measures as listed in Appendix B and described in the prior measures maintenance reports.[4-7] Below, we provide an overview of the methodology.

The methodology for the IQR measures described in this report is the same methodology that will be used to calculate excess readmissions for the Hospitals Readmissions Reduction Program (HRRP), Section 3025 of the Affordable Care Act, with certain differences in the measures' application as noted below. These differences may make individual hospital's results for the two programs slightly different.

2.2.1 Cohort

Index Admissions Included in Measures

An *index admission* is the hospitalization considered for the readmission outcome.

The readmission measures include index admissions for patients:

- Who are enrolled in Medicare fee-for-service (FFS) or are VA beneficiaries;

* Note: Includes Indian Health Services hospitals

- Aged 65 years or over;
- Discharged from non-federal acute care hospitals or VA hospitals; and
- Having a principal discharge diagnosis of AMI, HF, or pneumonia for each respective measure. For specific International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes used to define the cohort for each condition, refer to Appendix A.
- Medicare FFS beneficiaries with an index admission within a non-federal hospital are included if they have been enrolled in Part A and Part B Medicare for the 12 months prior to and including the date of the index admission to ensure a full year of administrative data for risk adjustment. This requirement is dropped for patients with an index admission within a VA hospital.

Index Admissions Excluded from the Measures*

The readmission measures exclude index admissions for patients:

- With an in-hospital death;
- Without at least 30 days post-discharge enrollment in FFS Medicare because the 30-day readmission outcome cannot be assessed in this group. This exclusion applies only to patients who have index admissions in non-VA hospitals;
- Who were transferred to another acute care facility, as described further below, because the measure evaluates hospitalizations for patients discharged to non-acute care settings; or
- Who were discharged against medical advice (AMA), because providers did not have the opportunity to deliver full care and prepare the patient for discharge.

Admissions within 30 days of discharge from an index admission will not be considered index admissions. Thus, no hospitalization will be counted as both a readmission and an index admission within the same measure. However, because the cohorts for the readmission measures are determined independently of each other, a readmission in one measure may qualify as an index admission in the other CMS readmission measures.

An additional exclusion criterion for the AMI cohort is that patients admitted and then discharged on the same day are not included as an index admission because it is unlikely these are clinically significant AMIs.

The number of admissions excluded based on each criterion is shown in Section 4 in Figure 1, Figure 3, and Figure 5 for AMI, HF, and pneumonia, respectively.

Transferred Patients

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

The measures consider multiple contiguous hospitalizations as a single acute episode of care. Admissions to another hospital within one day of discharge are considered transfers, regardless of the disposition of the previous admission.

Readmissions for transferred patients are attributed to the hospital that ultimately discharges the patient to a non-acute care setting (e.g., to home or a skilled nursing facility). Thus, if a patient is admitted to Hospital A, transferred to Hospital B, and ultimately discharged from Hospital B to a non-acute care setting, a readmission within 30 days of discharge to any acute care hospital is attributed to Hospital B.

Please note that if a patient is readmitted to the same hospital on the same day of discharge for the same diagnosis as the index admission, the measure combines both stays. However, if the diagnosis of the readmission is different from the index admission, this is considered a readmission.

Hospital Readmissions Reduction Program

HRRP includes only Subsection(d) hospitals[†], and hospitals located in Maryland. This means that critical access hospitals, cancer hospitals, and hospitals located in U.S territories will not be included in the calculations. Admissions to such hospitals will not be included as index admissions nor are they counted as readmissions. Please note that the set of hospitals among which these measures are calculated for the HRRP differs from those used in calculations for the Hospital IQR Program.

More information about the HRRP can be found on *QualityNet's* Hospital Readmissions Reduction Program webpage and in the FY 2012, FY 2013 and FY 2014 IPPS Final Rules posted on the CMS website.

2.2.2 Outcome

All-Cause Unplanned Readmissions

The measures count all unplanned readmissions. They are designed to capture readmissions that arise from acute clinical events requiring urgent rehospitalization within 30 days of discharge. Planned readmissions, which are generally not a signal of quality of care, are not counted in the measures. For more details about how the planned readmissions are defined see Section 3 and Appendix C.

There are a number of reasons for counting unplanned readmissions for all causes in the CMS readmission measures. First, from a patient perspective, an unplanned readmission for any cause is an adverse event. In addition, it is difficult to make inferences about

[†] Subsection (d) hospital encompasses any acute care hospital located in one of the fifty States or the District of Columbia which does not meet any of the following exclusion criteria as defined by the Social Security Act: psychiatric, rehabilitation, children's, or long-term care hospitals, and cancer specialty centers. By definition, all other hospitals are considered subsection (d) hospitals.

quality issues and accountability based solely on the documented cause of readmission. For example, a patient with HF who develops a hospital-acquired infection may ultimately be readmitted for sepsis. In this context it would be inappropriate to consider the readmission to be unrelated to the care the patient received for HF during the index admission.

30-Day Time Frame

The measures assess unplanned readmissions within a 30-day period from the date of discharge from an index admission. This standard time period is necessary so that the outcome for each patient is measured uniformly. The measures use a 30-day time frame because outcomes occurring within 30 days of discharge can be influenced by hospital care and the early transition to the outpatient setting. The use of the 30-day time frame is a clinically meaningful period for hospitals to collaborate with their communities in an effort to reduce readmissions.[14]

Multiple Readmissions

If a patient has more than one unplanned admission within 30 days of discharge from the index admission, only the first one is counted as a readmission. The measure looks for a dichotomous yes or no outcome of whether each admitted patient has an unplanned readmission within 30 days. However, if the first readmission after discharge is planned, then no readmission is considered in the outcome, regardless of whether a subsequent unplanned readmission takes place because it would be unfair to attribute the unplanned readmission back to the care received during the index admission.

2.2.3 Risk-Adjustment Variables

The measures adjust for variables (i.e. age, sex, comorbid diseases, and indicators of patient frailty) that are clinically relevant and have strong relationships with the outcome. For each patient, risk-adjustment variables are obtained from inpatient, outpatient, and physician Medicare administrative claims and VA administrative data for patients with a VA index admission, extending 12 months prior to, and including, the index admission.

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

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

The measures also do not adjust for socioeconomic status (SES) because the association between SES and health outcomes can be due, in part, to differences in the quality of health care received by groups of patients with varying SES. Risk adjusting for patient SES would suggest that hospitals with low SES patients should be held to different standards for patient outcomes than hospitals treating higher SES patient populations. It could also mask important disparities and minimize incentives to improve outcomes for vulnerable populations. The intention is for the measures to adjust for patient demographic and clinical characteristics while illuminating important quality differences. This methodology is consistent with guidance from NQF. Additionally, recent analyses have shown that hospitals caring for high proportions of low SES patients perform similarly on the measures to hospitals caring for low proportions of low SES patients.[13]

Please refer to Table 4, Table 9, and Table 14 in Section 4 of this report for the list of risk-adjustment variables for AMI, HF, and pneumonia, respectively.

2.2.4 Data Sources

The data sources for these analyses are Medicare administrative claims data, VA administrative data, and enrollment information for patients with hospitalizations that occurred between July 1, 2009 and June 30, 2012. The datasets also contain associated inpatient, outpatient, and physician Medicare administrative claims for the 12 months prior to the index admission and one month subsequent to the index admission for patients admitted in this time period. Please see the original methodology reports[1-7] for further descriptions of these data sources and an explanation of the three-year measurement period.

2.2.5 Measure Calculation

The measures estimate hospital-level 30-day all-cause RSRRs for each condition using hierarchical logistic regression models (Appendix A). In brief, the approach simultaneously models data at the patient and hospital levels to account for the variance in patient outcomes within and between hospitals.[14] At the patient level, it models the log-odds of hospital readmission within 30 days of discharge using age, sex, selected clinical covariates, and a hospital-specific intercept. At the hospital level, it models the hospital-specific intercepts as arising from a normal distribution. The hospital intercept represents the underlying risk of a readmission at the hospital, after accounting for patient risk. The hospital-specific intercepts are given a distribution in order to account for the clustering (non-independence) of patients within the same hospital.[14] If there were no differences among hospitals, then after adjusting for patient risk, the hospital intercepts should be identical across all hospitals.

The RSRR is calculated as the ratio of the number of "predicted" readmissions to the number of "expected" readmissions at a given hospital, multiplied by the national observed readmission rate. For each hospital, the "numerator" of the ratio is the number of readmissions within 30 days predicted on the basis of the hospital's performance with its observed case mix, and the "denominator" is the number of readmissions expected on the basis of the nation's performance with that hospital's case mix. This approach is analogous to a ratio of "observed" to "expected" used in

other types of statistical analyses. It conceptually allows for a comparison of a particular hospital's performance given its case mix to an average hospital's performance with the same case mix. Thus, a lower ratio indicates lower-than-expected readmission rates or better quality, and a higher ratio indicates higher-than-expected readmission rates or worse quality.

The "predicted" number of readmissions (the numerator) is calculated by regressing the risk factors (found in Table 4, Table 9, and Table 14 for the AMI, HF, and pneumonia measures, respectively) and the hospital-specific intercept on the risk of readmission. The estimated regression coefficients are then multiplied by the patient characteristics in the hospital. The results are then transformed and summed over all patients attributed to the hospital to get a value. The "expected" number of readmissions (the denominator) is obtained by regressing the risk factors and a common intercept on the readmission outcome using all hospitals in our sample. The estimated regression coefficients are then multiplied by the patient characteristics in the hospital. The results are then transformed and summed over all patients in the hospital to get a value. To assess hospital performance for each reporting period, we re-estimate the model coefficients using the years of data in that period. This ratio is multiplied by the national rate to calculate the RSRR.

The hierarchical logistic regression models are described fully in the original methodology reports.[1-3]

2.2.6 Categorizing Hospital Performance

To categorize hospital performance, CMS estimates each hospital's RSRR and the corresponding 95% interval estimate. CMS assigns hospitals to a performance category by comparing each hospital's RSRR interval estimate to the national observed readmission rate. Comparative performance for hospitals with 25 or more eligible cases is classified as follows:

- "No different than U.S. national rate" if the 95% interval estimate surrounding the hospital's rate includes the national observed readmission rate.
- "Worse than U.S. national rate" if the entire 95% interval estimate surrounding the hospital's rate is higher than the national observed readmission rate.
- "Better than U.S. national rate" if the entire 95% interval estimate surrounding the hospital's rate is lower than the national observed readmission rate.

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

Section 4 describes the distribution of hospitals by performance category in the U.S. for this 2009-2012 reporting period.

3. UPDATES TO MEASURES FOR 2013 PUBLIC REPORTING

3.1 Rationale for Measure Updates

Measures maintenance ensures that the risk-standardized readmission models are continually assessed and remain valid given possible changes in the data over time and allows for model refinements. As described in this report, for 2013 public reporting, we undertook the following measures maintenance activities:

- Respecified the measures by adding a new planned readmission algorithm to identify and remove planned readmissions from the outcome;
- Incorporated ICD-9-CM coding updates for the Condition Categories;
- Validated the performance of each condition-specific model and its corresponding risk-adjustment variables in three recent one-year datasets (July 2009-June 2010, July 2010-June 2011, and July 2011-June2012);
- Evaluated and validated model performance in the three-year combined dataset (July 2009-June 2012); and
- Updated the measures SAS pack and documentation

3.2 Detailed Discussion of Measure Updates

3.2.1 Incorporation of Planned Readmission Algorithm

CMS has worked with experts in the medical community as well as other stakeholders to identify planned readmissions for procedures and treatments and not count them in readmission measures. Specifically, CMS contracted with YNHHSC/CORE to develop a Planned Readmission Algorithm that can be used to identify planned readmissions across its readmission measures, and has applied the algorithm to each of its measures. The algorithm is a set of criteria for classifying readmissions as planned using Medicare claims. The algorithm identifies admissions that are typically planned and may occur within 30 days of discharge from the hospital.

We based the Planned Readmission Algorithm on three principles:

1. A few specific, limited types of care are always considered planned (obstetric delivery, transplant surgery, maintenance chemotherapy/radiotherapy/ immunotherapy, rehabilitation);
2. Otherwise, a planned readmission is defined as a non-acute readmission for a scheduled procedure; and
3. Admissions for acute illness or for complications of care are never planned.

The *Planned Readmission Algorithm Version 2.1 – General Population* is a set of criteria for classifying readmissions as planned among the general Medicare population using Medicare administrative claims data. The algorithm identifies admissions that are typically planned and may occur within 30 days of discharge from the hospital. The details of the *index* admission (diagnosis or procedures) are not considered when

determining whether a readmission is planned. For more information on the development of the algorithm, please refer to the *Centers for Medicare & Medicaid Services Planned Readmission Algorithm Version 2.1: General Population* report.

CMS has modified its hospital-wide, condition-specific and procedure-specific readmission measures to incorporate Version 2.1 of the algorithm. The algorithm uses a more comprehensive definition of planned readmissions than the definitions of planned readmissions originally used in the development of CMS's readmission measures, several of which had no condition- or procedure-specific planned readmissions as originally specified.

During development of the AMI, HF, and pneumonia measures, CMS initially only identified planned procedures and conditions that were considered follow-up care for the specific condition that was the focus of the measure. For example, in previous years, the AMI readmission measure only considered readmissions planned if they included coronary artery bypass graft surgery (CABG) or percutaneous coronary intervention (PCI) and were not for one of five acute conditions (such as a second AMI). The readmission measures for HF and pneumonia did not previously identify any readmissions as follow up care for the specific condition, and therefore did not count any readmissions as planned in the outcome. The Planned Readmission Algorithm more generally identifies any likely planned readmission, not solely those related to follow-on care for the index condition or procedure.

In applying the algorithm to condition- and procedure-specific measures, teams of clinical experts reviewed the algorithm in the context of each measure-specific patient cohort and, where clinically indicated, adapted the content of the tables to better reflect the likely clinical experience of each measure's patient cohort. For CMS's AMI, HF, and pneumonia readmission measures, CMS used the *Planned Readmission Algorithm Version 2.1 - General Population* without making any changes. The algorithm fit patients admitted for these medical conditions well without revision.

Details of CMS's Planned Readmission Algorithm

The Planned Readmission Algorithm uses a flowchart and four tables of specific procedure categories and discharge diagnosis categories to classify readmissions as planned (Appendix C). As illustrated in the flowchart (Figure PR1), readmissions that include certain procedures (Table PR1) or are for certain diagnoses (Table PR2) are always considered planned.

If the readmission does not include a procedure or diagnosis in Table PR1 or Table PR2 that is always considered planned, the algorithm checks if the readmission has at least one procedure that is considered potentially planned (Table PR3). If the readmission has no procedures from Table PR3, the readmission is considered unplanned. Table PR3 includes 57 Agency for Healthcare Research and Quality (AHRQ) procedure Clinical

Classification Software (CCS) categories[‡] from among 231 AHRQ procedure CCS categories, plus 11 individual ICD-9-CM procedure codes. Two examples of potentially planned procedures are total hip replacement (Procedure CCS 153) and hernia repair (Procedure CCS 85).

If the readmission *does* have at least one potentially planned procedure from Table PR3, the algorithm checks for a primary discharge diagnosis that is considered acute (Table PR4). If the readmission has an acute primary discharge diagnosis from Table PR4, the readmission is considered unplanned. Otherwise, it is considered planned. The list of acute primary discharge diagnoses includes 100 diagnosis groups from among 285 AHRQ condition categories, plus 4 groupings of individual ICD-9-CM diagnosis codes that represent cardiac diagnoses that would not be associated with a planned readmission. Two examples of acute primary discharge diagnoses that identify readmissions with potentially planned procedures as unplanned are pneumonia (Diagnosis CCS 122) and cardiac arrest (Diagnosis CCS 107).

Change in Treatment of Unplanned Readmissions after a Planned Readmission

Under the new Planned Readmission Algorithm, unplanned readmissions within 30 days of discharge from an index admission that occur *after a planned readmission* will not be counted in the outcome. It would be unfair to attribute the unplanned readmission back to the care received during the index admission when there is an intervening planned readmission.

Effect on the Measures for 2013 Reporting Period

The impact of the Planned Readmission Algorithm on the AMI, HF, and pneumonia readmission measures is summarized in Table1, Table 2, and Table 3 respectively.

Table 1 – Effect of Planned Readmission Algorithm on AMI Measure

	Revised Measure	Original Measure
Number of Admissions	513,331	513,331
Number of Unplanned Readmissions	93,966	98,809
Readmission Rate	18.3%	19.2%
Number of Planned Readmissions	12,281	7,433
Planned Readmission Rate	2.4%	1.4%
% of Readmissions that are Planned	11.6%	7.0%

[‡] AHRQ CCS codes group thousands of individual procedure and diagnosis ICD-9-CM codes into clinically coherent, mutually exclusive procedure CCS categories and mutually exclusive diagnosis CCS categories.

Table 2 – Effect of Planned Readmission Algorithm on HF Measure

	Revised Measure	Original Measure
Number of Admissions	1,262,826	1,262,826
Number of Unplanned Readmissions	291,063	308,668
Readmission Rate	23.0%	24.4%
Number of Planned Readmissions	17,605	0
Planned Readmission Rate	1.4%	0.0%
% of Readmissions that are Planned	5.7%	0.0%

Table 3 – Effect of Planned Readmission Algorithm on Pneumonia Measure

	Revised Measure	Original Measure
Number of Admissions	1,089,758	1,089,758
Number of Unplanned Readmissions	191,766	199,292
Readmission Rate	17.6%	18.3%
Number of Planned Readmissions	7,526	0
Planned Readmission Rate	0.7%	0.0%
% of Readmissions that are Planned	3.8%	0.0%

3.2.2 Updates to the Condition Category (CC) Map

RTI International, contracted by CMS to maintain the CC system, assigns new ICD-9-CM codes to the existing CCs based on their clinical expertise and the historical assignment of related ICD-9-CM codes to the CCs. CCs are clinically relevant diagnostic groups of the more than 14,500 ICD-9 codes. The CCs group the ICD-9-CM codes into larger groups that are used in models to predict medical care utilization, spending, mortality, or other related measures.[15] CMS revises the ICD-9-CM CC map annually to reflect changes in ICD-9-CM codes so that the measures will capture all relevant comorbidities coded in patient claims data.

The assignment of new codes and the removal of retired codes had little impact on the model variables since RTI assigned the majority of new codes, which were more specific versions of retired codes, to the same CCs as retired codes. For more details on the CC changes, see Appendix E for RTI's memo to CMS detailing the map changes.

3.3 Changes to SAS Analytic Package (SAS Pack)

We revised the measure calculation SAS packs to reflect all changes to the index admission cohorts and models, including ad-hoc patches to address data issues. The primary changes this year were made to incorporate the Planned Readmission Algorithm. The new SAS packs and documentation are available upon request by emailing cmsreadmissionmeasures@yale.edu. **Do *NOT* submit patient-identifiable information (e.g., Date of Birth, Social Security Number, Health Insurance Claim Number, etc.) to this address.**

4. RESULTS FOR 2013 PUBLIC REPORTING

4.1 Assessment of Updated Models

The readmission measures estimate hospital-specific 30-day all-cause RSRRs using hierarchical logistic regression models. See Section 2 of this report for a summary of the measure methodology and model risk-adjustment variables. Refer to prior technical reports[1-7] for further details.

In this report we evaluate the performance of the models and provide national results using the data for 2013 reporting. This differs from previous reports where we provided national results using calendar year data. We fit the updated models to three single year datasets (July 2009-June 2010, July 2010-June 2011, and July 2011-June 2012) and to a combined three-year (July 2009-June 2012) dataset. We examined trends in the frequency of patient risk factors and the model variable coefficients, and compared the model performance between these datasets.

For each of the three conditions, we assessed logistic regression and hierarchical logistic regression model performance in terms of discriminant ability for each year of data and for the three-year combined period listed above. We computed two summary statistics for assessing model performance: the predictive ability and the area under the receiver operating characteristic (ROC) curve (c-statistic). The c-statistic is an indicator of the model's discriminant ability or ability to correctly classify those who have and have not been readmitted within 30 days of discharge. Potential values range from 0.5, meaning no better than chance, to 1.0, meaning perfect discrimination.

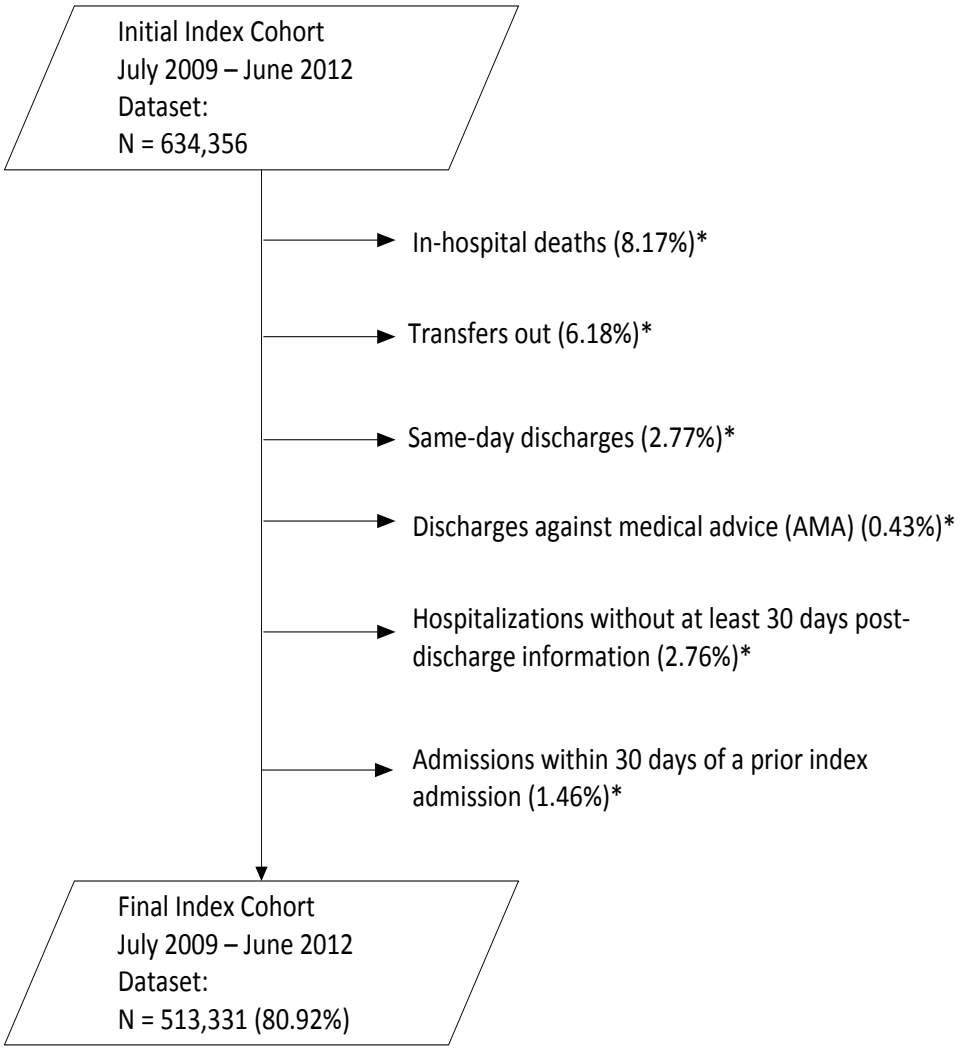
The results of these analyses for each of the three measures (AMI, HF, and pneumonia) are presented below in Sections 4.2, 4.3, and 4.4, respectively.

4.2 AMI Readmission 2013 Model Results

4.2.1 Index Cohort Exclusions

The exclusion criteria for the measures are presented in Section 2. The percentage of AMI patients meeting each exclusion criterion in the July 2009-June 2012 dataset is presented in Figure 1.

Figure 1 – Index Cohort Sample for AMI in the July 2009-June 2012 Dataset



* These categories are not mutually exclusive

4.2.2 Frequency of AMI Model Variables

We examined the change in both observed readmission rates and frequency of clinical and demographic variables. Between the year July 2009-June 2010 and the year July 2011-June 2012, the observed readmission rate decreased from 18.6% to 17.8%.

The frequency of some model variables increased. The increase may reflect an increased rate of comorbidity in the fee-for-service population, but is also due in part to increased hospital coding of comorbidities. In the 2012 update to the measures, we increased the number of diagnosis codes and procedure codes to align with the Version 5010 format changes required by the Department of Health and Human Services (DHHS). Hospitals could begin to submit up to 25 diagnosis and procedure codes starting in 2010. Over time, more hospitals have submitted increased numbers of codes which translate into increased frequencies for some model variables. Some notable changes include an increase in history of PCI from 9.1% to 17.3%, in history of CABG from 5.8% to 12.0%, in angina pectoris from 22.7% to 28.38%, in coronary atherosclerosis (CAD) from 80.7% to 86.5%, in valvular or rheumatic heart disease from 26.9% to 32.2%, and in iron deficiency from 40.5% to 48.6%.

4.2.3 AMI Model Parameters and Performance

Table 5 shows the risk-adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for the AMI readmission model by individual year and for the combined three-year dataset. Overall, the variable effect sizes were relatively constant across years. Between-hospital variance within the combined dataset was 0.02 (SE: 0.002). If there were no systematic differences between hospitals, the between-hospital variance would be 0. In addition, model performance was stable over the three-year time period; the area under the ROC curve (c-statistic) increased slightly to 0.64 (Table 6).

4.2.4 Distribution of Hospital Volumes and RSRRs

Table 7 shows the distribution of hospital admission volumes and Table 8 shows the distribution of hospital RSRRs. These tables show the between-hospital variance by individual year and for the combined three-year dataset. The mean RSRR decreased over the three-year period, from 18.6% between July 2009 and June 2010 to 17.8% between July 2011 and June 2012. The median hospital RSRR in the combined three-year dataset was 18.3% (IQR 17.9% - 18.7%).

Figure 2 shows the overall distribution of the hospital RSRRs for the combined dataset. The odds of all-cause readmission if treated at a hospital one standard deviation above the national rate were 1.34 times higher than the odds of all-cause readmission if treated at a hospital one standard deviation below the national rate. If there were no systematic differences between hospitals, the OR would be 1.0.[15]

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

Out of 4,464 number of hospitals in the U.S., 22 performed “better than the U.S. national rate,” 2,333 performed “no different from the U.S. national rate,” and 24

performed “worse than the U.S. national rate.” 2,085 were classified as “number of cases too small” (fewer than 25) to reliably tell how well the hospital is performing.

Table 4 – Frequency of AMI Model Variables over Different Time Periods

Variable	07/2009-06/2010	07/2010-06/2011	07/2011-06/2012	07/2009-06/2012
Total N	177,031	176,196	160,104	513,331
Observed readmission rate (%)	18.6	18.5	17.8	18.3
Mean age minus 65 (SD)	13.9 (8.2)	13.9 (8.3)	13.8 (8.3)	13.9 (8.3)
Male (%)	51.1	51.2	52.2	51.5
History of PTCA	9.1	13.1	17.3	13.0
History of CABG	5.8	9.0	12.0	8.8
Congestive heart failure (CC 80)	32.9	33.0	32.9	32.9
Acute coronary syndrome (CC 81-82)	22.5	22.8	22.6	22.7
Anterior myocardial infarction (ICD-9 codes 410.00-410.19)	8.0	7.6	7.2	7.6
Other location myocardial infarction (ICD-9 codes 410.20-410.69)	11.7	11.3	11.1	11.4
Angina pectoris, old MI (CC 83)	22.7	25.2	28.4	25.4
Coronary atherosclerosis (CC 84)	80.7	83.6	86.5	83.5
Valvular or rheumatic heart disease (CC 86)	26.9	29.4	32.2	29.4
Specified arrhythmias (CC 92-93)	34.3	34.9	35.8	35.0
History of infection (CC 1, 3-6)	26.6	26.7	27.1	26.8
Metastatic cancer or acute leukemia (CC 7)	2.1	2.0	2.1	2.1
Cancer (CC 8-12)	18.9	19.0	19.5	19.1
Diabetes mellitus (DM) or DM complications (CC 15-20, 119-120)	44.1	45.7	47.1	45.6
Protein-calorie malnutrition (CC 21)	5.2	5.9	6.4	5.8
Disorders of fluid, electrolyte, acid-base (CC 22-23)	25.9	27.5	28.9	27.4
Iron deficiency or other anemias and blood disease (CC 47)	40.5	44.9	48.6	44.5
Dementia or other specified brain disorders (CC 49-50)	17.7	19.0	20.2	18.9
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	6.0	6.1	6.6	6.2
Stroke (CC 95-96)	7.8	7.6	7.6	7.7
Cerebrovascular disease (CC 97-99, 103)	20.1	20.7	21.5	20.7
Vascular or circulatory disease (CC 104-106)	35.7	36.0	37.0	36.2
Chronic obstructive pulmonary disease (CC 108)	28.8	30.1	31.5	30.1
Asthma (CC 110)	6.0	6.3	6.8	6.3
Pneumonia (CC 111-113)	23.4	23.6	23.4	23.5
End stage renal disease or dialysis (CC 129-130)	2.5	2.9	3.2	2.9
Renal failure (CC 131)	23.9	25.6	27.4	25.6
Other urinary tract disorders (CC 136)	20.0	21.0	22.8	21.2
Decubitus ulcer or chronic skin ulcer (CC 148-149)	7.8	7.9	8.1	7.9

Table 5 – Adjusted OR and 95% CIs for the AMI Hierarchical Logistic Regression Model over Different Time Periods

Variable	07/2009-06/2010 OR (95% CI)	07/2010-06/2011 OR (95% CI)	07/2011-06/2012 OR (95% CI)	07/2009-06/2012 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.01 (1.01 - 1.01)	1.01 (1.01 - 1.01)	1.01 (1.01 - 1.01)	1.01 (1.01 - 1.01)
Male	0.92 (0.89 - 0.94)	0.92 (0.90 - 0.94)	0.91 (0.88 - 0.93)	0.91 (0.90 - 0.93)
History of PTCA	0.91 (0.87 - 0.96)	0.90 (0.87 - 0.94)	0.93 (0.90 - 0.97)	0.91 (0.89 - 0.93)
History of CABG	0.98 (0.93 - 1.03)	1.00 (0.96 - 1.05)	1.02 (0.98 - 1.07)	0.99 (0.97 - 1.02)
Congestive heart failure (CC 80)	1.27 (1.23 - 1.31)	1.24 (1.21 - 1.28)	1.2 (1.16 - 1.24)	1.24 (1.22 - 1.26)
Acute coronary syndrome (CC 81-82)	1.02 (0.99 - 1.05)	1.03 (1.00 - 1.06)	1.01 (0.98 - 1.04)	1.02 (1.01 - 1.04)
Anterior myocardial infarction (ICD-9 codes 410.00 410.19)	1.18 (1.13 - 1.24)	1.18 (1.13 - 1.24)	1.20 (1.14 - 1.26)	1.19 (1.16 - 1.23)
Other location myocardial infarction (ICD-9 codes 410.20-410.69)	0.94 (0.90 - 0.98)	0.95 (0.91 – 1.00)	0.92 (0.88 - 0.97)	0.94 (0.92 - 0.96)
Angina pectoris, old MI (CC 83)	1.03 (0.99 - 1.06)	1.01 (0.98 - 1.04)	1.02 (0.98 - 1.05)	1.01 (1.00 - 1.03)
Coronary atherosclerosis (CC 84)	0.91 (0.88 - 0.94)	0.96 (0.93 - 0.99)	1.02 (0.98 - 1.07)	0.95 (0.93 - 0.97)
Valvular or rheumatic heart disease (CC 86)	1.09 (1.06 - 1.12)	1.12 (1.09 - 1.15)	1.13 (1.10 - 1.17)	1.11 (1.09 - 1.13)
Specified arrhythmias (CC 92-93)	1.08 (1.05 - 1.11)	1.07 (1.04 - 1.10)	1.10 (1.07 - 1.14)	1.08 (1.06 - 1.10)
History of infection (CC 1, 3-6)	1.05 (1.02 - 1.08)	1.05 (1.02 - 1.08)	1.06 (1.02 - 1.09)	1.05 (1.03 - 1.07)
Metastatic cancer or acute leukemia (CC 7)	1.22 (1.13 - 1.32)	1.24 (1.15 - 1.35)	1.15 (1.05 - 1.25)	1.20 (1.15 - 1.26)
Cancer (CC 8-12)	1.05 (1.01 - 1.08)	1.01 (0.98 - 1.05)	1.03 (1.00 - 1.07)	1.03 (1.01 - 1.05)
Diabetes mellitus (DM) or DM complications (CC 15-20, 119-120)	1.20 (1.17 - 1.24)	1.22 (1.19 - 1.25)	1.20 (1.17 - 1.23)	1.20 (1.19 - 1.22)
Protein-calorie malnutrition (CC 21)	1.11 (1.06 - 1.17)	1.10 (1.05 - 1.15)	1.11 (1.06 - 1.17)	1.11 (1.08 - 1.14)
Disorders of fluid, electrolyte, acid-base (CC 22-23)	1.13 (1.09 - 1.16)	1.12 (1.09 - 1.16)	1.12 (1.08 - 1.15)	1.12 (1.10 - 1.14)
Iron deficiency or other anemias and blood disease (CC 47)	1.18 (1.15 - 1.21)	1.23 (1.20 - 1.27)	1.30 (1.26 - 1.34)	1.23 (1.21 - 1.24)
Dementia or other specified brain disorders (CC 49-50)	1.01 (0.98 - 1.04)	0.99 (0.96 - 1.02)	1.03 (1.00 - 1.06)	1.00 (0.98 - 1.02)
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	1.07 (1.02 - 1.12)	1.10 (1.05 - 1.16)	1.09 (1.04 - 1.15)	1.08 (1.05 - 1.12)
Stroke (CC 95-96)	1.05 (1.00 - 1.10)	1.02 (0.97 - 1.07)	1.05 (1.00 - 1.11)	1.04 (1.01 - 1.07)
Cerebrovascular disease (CC 97-99, 103)	1.06 (1.03 - 1.10)	1.05 (1.01 - 1.08)	1.04 (1.00 - 1.07)	1.05 (1.03 - 1.07)
Vascular or circulatory disease (CC 104-106)	1.09 (1.06 - 1.12)	1.08 (1.05 - 1.11)	1.11 (1.08 - 1.14)	1.09 (1.07 - 1.11)
Chronic obstructive pulmonary disease (CC 108)	1.24 (1.21 - 1.28)	1.28 (1.24 - 1.31)	1.28 (1.24 - 1.32)	1.26 (1.24 - 1.28)
Asthma (CC 110)	0.99 (0.94 - 1.04)	1.00 (0.95 - 1.05)	1.04 (0.99 - 1.10)	1.01 (0.98 - 1.04)
Pneumonia (CC 111-113)	1.22 (1.18 - 1.26)	1.23 (1.19 - 1.26)	1.15 (1.11 - 1.18)	1.20 (1.18 - 1.22)
End stage renal disease or dialysis (CC 129-130)	1.36 (1.27 - 1.45)	1.29 (1.21 - 1.38)	1.33 (1.25 - 1.42)	1.32 (1.27 - 1.37)
Renal failure (CC 131)	1.18 (1.14 - 1.22)	1.18 (1.15 - 1.22)	1.16 (1.12 - 1.2)	1.18 (1.15 - 1.20)
Other urinary tract disorders (CC 136)	1.10 (1.07 - 1.13)	1.07 (1.04 - 1.11)	1.08 (1.04 - 1.11)	1.08 (1.06 - 1.10)
Decubitus ulcer or chronic skin ulcer (CC 148-149)	1.12 (1.07 - 1.17)	1.07 (1.03 - 1.12)	1.12 (1.07 - 1.17)	1.10 (1.08 - 1.13)
Between-Hospital Variance (SE)	0.02(0.003)	0.03 (0.003)	0.02 (0.003)	0.02 (0.002)

Table 6 – AMI Generalized Linear Modeling (Logistic Regression) Performance over Different Time Periods

Characteristic	07/2009-06/2010	07/2010-06/2011	07/2011-06/2012	07/2009-06/2012
Predictive ability, % (lowest decile – highest decile)	7.4-32.5	7.0-32.5	5.9-31.7	6.8-32.1
c-statistic	0.64	0.64	0.65	0.64

Table 7 – Distribution of Hospital AMI Admission Volumes over Different Time Periods[§]

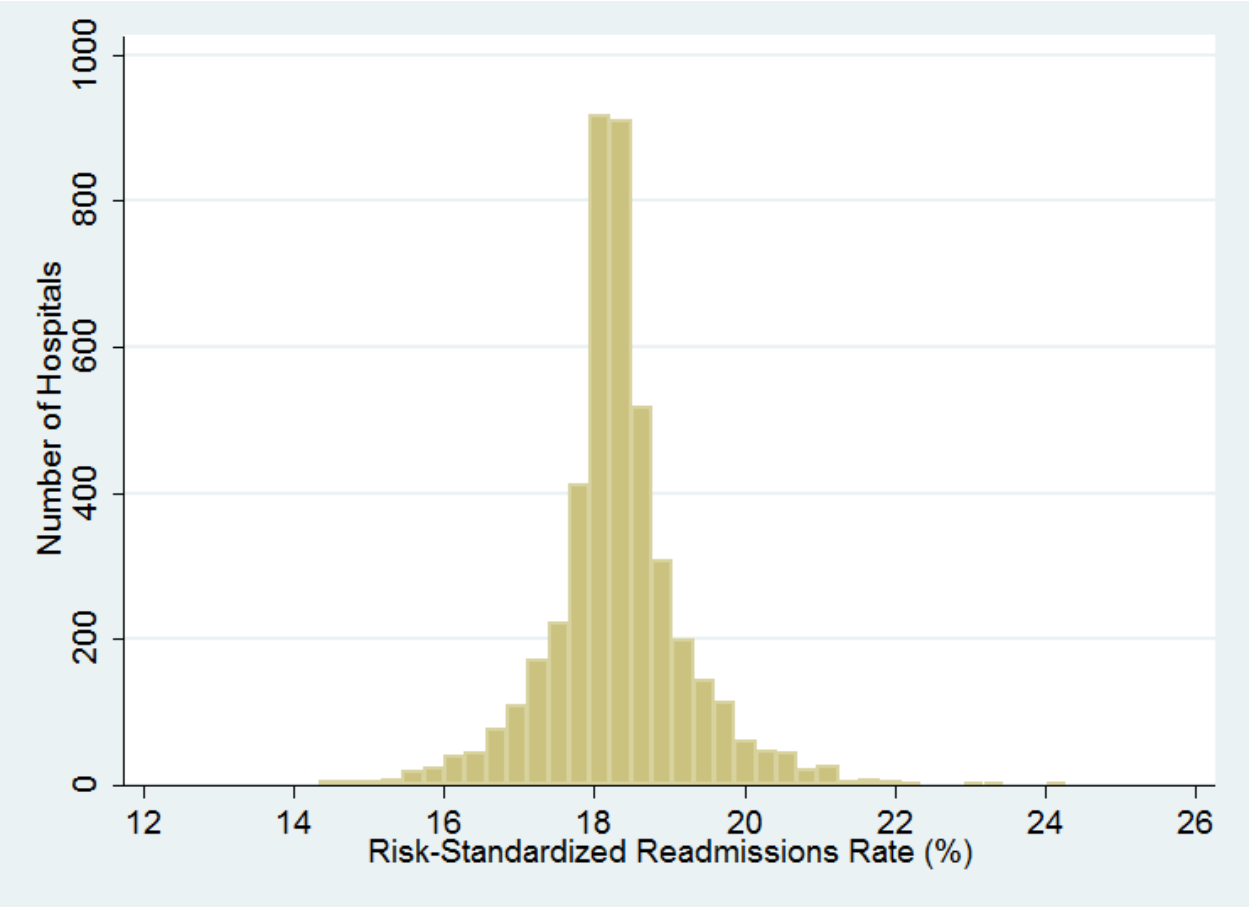
Characteristic	07/2009-06/2010	07/2010-06/2011	07/2011-06/2012	07/2009-06/2012
Number of Hospitals	4,120	4,048	3,959	4,464
Mean Number of Admissions (SD)	43.0 (66.0)	43.5 (65.3)	40.4 (59.4)	115.0 (183.8)
Range (min. – max.)	1-539	1-612	1-495	1-1646
25th percentile	4	4	3	7
50th percentile	14	14	14	30
75th percentile	55	59	56	148

Table 8 – Distribution of Hospital AMI RSRRs over Different Time Periods

Characteristic	07/2009-06/2010	07/2010-06/2011	07/2011-06/2012	07/2009-06/2012
Number of Hospitals	4,120	4,048	3,959	4,464
Mean (SD)	18.6 (0.7)	18.5 (0.8)	17.8 (0.5)	18.3 (0.9)
Range (min. – max.)	15.4-22.9	15.0-22.6	15.3-20.7	14.4-24.3
25th percentile	18.3	18.2	17.6	17.9
50th percentile	18.5	18.5	17.7	18.3
75th percentile	18.9	18.8	18.0	18.7

[§] Hospital volumes for third year of reporting (July 2011-2012) are lower in part due to incomplete enrollment data for discharges in June 2012.

Figure 2 – Distribution of Hospital 30-Day AMI RSRRs between July 2009 and June 2012



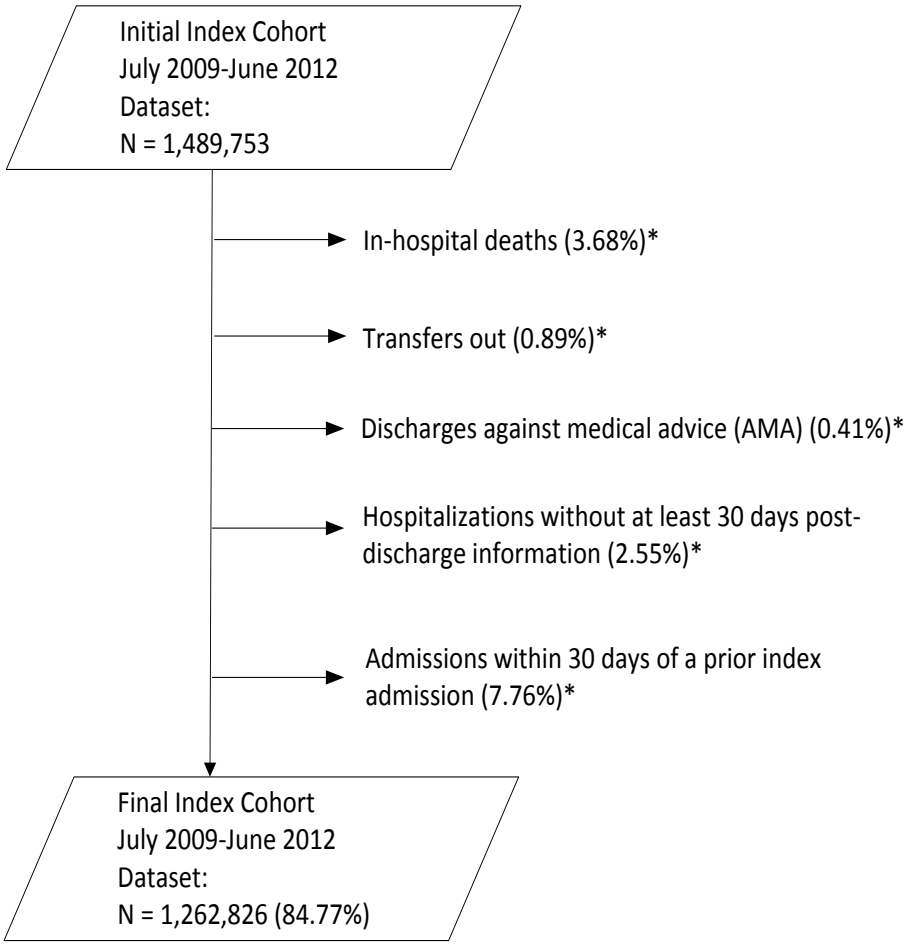
N= 4,464 hospitals

4.3 HF Readmission 2013 Model Results

4.3.1 Index Cohort Exclusions

The exclusion criteria for the measures are presented in Section 2. The percentage of HF patients meeting each exclusion criterion in the July 2009-June 2012 dataset is presented in Figure 3.

Figure 3 – Index Cohort Sample for HF in the July 2009-June 2012 Dataset



* These categories are not mutually exclusive

4.3.2 Frequency of HF Model Variables

We examined the change in both observed readmission rates and frequency of clinical and demographic variables. Between the year July 2009-June 2010 and the year July 2011-June 2012, the observed readmission rate decreased from 23.4% to 22.5% (Table 9).

As noted above, many hospitals are submitting up to 25 secondary diagnosis and procedure codes which may be translating into increased frequency of some risk variables. Some notable changes include an increase in history of CABG from 9.1% to 19.7%, in valvular or rheumatic heart disease from 46.6% to 53.7%, in disorders of fluid, electrolyte, or acid-base from 44.4% to 49.9%, in other gastrointestinal disorders from 54.3% to 63.7%, in iron deficiency from 55.3% to 64.4%, in drug and alcohol abuse from 9.3% to 13.5%, in depression from 13.5% to 21.1%, in other psychiatric disorders from 10.9% to 17.2%, and in renal failure from 45.2% to 50.9%.

4.3.3 HF Model Parameters and Performance

Table 10 shows the risk-adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for the HF readmission model by individual year and for the combined three-year dataset. Overall, the variable effect sizes were relatively constant across years. Between-hospital variance in the combined dataset was 0.02 (SE: 0.001). If there were no systematic differences between hospitals, the between-hospital variance would be 0. In addition, model performance was stable over the three-year time period; the area under the ROC curve (c-statistic) remained constant at 0.61 (Table 11).

4.3.4 Distribution of Hospital Volumes and RSRRs

Table 12 shows the distribution of hospital admission volumes and Table 13 shows the distribution of hospital RSRRs. These tables show the between-hospital variance by individual year and for the combined three-year dataset. The mean RSRR decreased over the three-year period, from 23.4% between July 2009 and June 2010 to 22.6% between July 2011 and June 2012. The median hospital RSRR in the combined three-year dataset was 23.0% (IQR: 22.1% - 24.1%).

Figure 4 shows the overall distribution of the hospital RSRRs for the combined three-year dataset. The odds of all-cause readmission if treated at a hospital one standard deviation above the national rate were 1.36 times higher than the odds of all-cause readmission if treated at a hospital one standard deviation below the national rate. If there were no systematic differences between hospitals, the OR would be 1.0.[15]

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

Out of 4,786 number of hospitals in the U.S., 105 performed “better than the U.S. national rate,” 3,904 performed “no different from the U.S. national rate,” and 146 performed “worse than the U.S. national rate.” 631 were classified as “number of cases too small” (fewer than 25) to reliably tell how well the hospital is performing.

Table 9 – Frequency of HF Model Variables over Different Time Periods

Variable	07/2009-06/2010	07/2010-06/2011	07/2011-06/2012	07/2009-06/2012
Total N	447,352	434,082	381,392	1,262,826
Observed readmission rate (%)	23.4	23.2	22.5	23.1
Mean Age minus 65 (SD)	15.8 (8.1)	15.8 (8.2)	15.9 (8.2)	15.8 (8.2)
Male (%)	45.4	45.5	46.1	45.7
History of CABG	9.1	14.7	19.7	14.2
Cardio-respiratory failure or shock (CC 79)	23.8	25.2	27.0	25.3
Congestive heart failure (CC 80)	76.7	76.9	77.2	77.0
Acute coronary syndrome (CC 81-82)	17.5	17.2	17.2	17.3
Coronary atherosclerosis or angina (CC 83-84)	72.4	73.6	75.3	73.7
Valvular or rheumatic heart disease (CC 86)	46.6	49.5	53.7	49.7
Specified arrhythmias (CC 92-93)	65.4	66.6	68.5	66.8
Other or unspecified heart disease (CC 94)	31.7	31.8	33.7	32.3
Vascular or circulatory disease (CC 104-106)	50.6	51.5	54.0	51.9
Metastatic cancer or acute leukemia (CC 7)	2.2	2.2	2.2	2.2
Cancer (CC 8-12)	20.8	20.9	21.6	21.1
Diabetes or DM complications (CC 15-20, 119-120)	52.4	53.5	54.9	53.5
Protein-calorie malnutrition (CC 21)	8.1	8.9	9.9	8.9
Disorders of fluid, electrolyte, acid-base (CC 22-23)	44.4	46.5	49.9	46.8
Liver or biliary disease (CC 25-30)	9.1	9.8	11.2	9.9
Peptic ulcer, hemorrhage, other specified gastrointestinal disorders (CC 34)	15.5	15.2	15.8	15.5
Other gastrointestinal disorders (CC 36)	54.3	58.1	63.7	58.4
Severe hematological disorders (CC 44)	4.3	4.5	3.9	4.2
Iron deficiency or other anemias and blood disease (CC 47)	55.3	59.5	64.4	59.5
Dementia or other specified brain disorders (CC 49-50)	21.1	22.8	24.8	22.8
Drug/alcohol abuse/dependence/psychosis (CC 51-53)	9.3	10.8	13.5	11.1
Major psychiatric disorders (CC 54-56)	9.5	10.1	10.8	10.1
Depression (CC 58)	13.5	16.6	21.1	16.9
Other psychiatric disorders (CC 60)	10.9	12.9	17.2	13.5
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	7.4	7.9	8.8	8.0
Stroke (CC 95-96)	10.0	9.8	9.7	9.9
Chronic obstructive pulmonary disease (CC 108)	46.5	47.9	49.6	47.9
Fibrosis of lung or other chronic lung disorders (CC 109)	11.9	12.1	11.7	11.9
Asthma (CC 110)	8.7	9.1	9.7	9.2
Pneumonia (CC 111-113)	44.0	44.6	45.4	44.6
End stage renal disease or dialysis (CC 129-130)	3.8	4.2	4.8	4.2
Renal failure (CC 131)	45.2	47.8	50.9	47.8
Nephritis (CC 132)	2.8	3.0	4.1	3.3
Other urinary tract disorders (CC 136)	30.7	31.7	34.0	32.0
Decubitus ulcer or chronic skin ulcer (CC 148-149)	13.7	14.2	14.8	14.2

Table 10 – Adjusted OR and 95% CIs for the HF Hierarchical Logistic Regression Model over Different Time Periods

Variable	07/2009-06/2010 OR (95% CI)	07/2010-06/2011 OR (95% CI)	07/2011-06/2012 OR (95% CI)	07/2009-06/2012 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.00 (1.00 – 1.00)	1.00 (1.00 – 1.00)	1.00 (1.00 – 1.00)	1.00 (1.00 – 1.00)
Male	1.00 (0.98 - 1.01)	1.01 (1.00 - 1.03)	1.01 (0.99 - 1.03)	1.01 (1.00 - 1.01)
History of CABG	0.93 (0.91 - 0.95)	0.95 (0.93 - 0.97)	0.97 (0.95 - 0.99)	0.94 (0.93 - 0.95)
Cardio-respiratory failure or shock (CC 79)	1.13 (1.11 - 1.15)	1.09 (1.07 - 1.11)	1.09 (1.07 - 1.11)	1.11 (1.10 - 1.12)
Congestive heart failure (CC 80)	1.13 (1.11 - 1.15)	1.12 (1.10 - 1.14)	1.13 (1.11 - 1.16)	1.13 (1.12 - 1.14)
Acute coronary syndrome (CC 81-82)	1.12 (1.10 - 1.14)	1.12 (1.10 - 1.14)	1.11 (1.09 - 1.13)	1.12 (1.11 - 1.13)
Coronary atherosclerosis or angina (CC 83-84)	1.06 (1.04 - 1.08)	1.06 (1.04 - 1.08)	1.06 (1.04 - 1.08)	1.06 (1.05 - 1.07)
Valvular or rheumatic heart disease (CC 86)	1.03 (1.02 - 1.05)	1.04 (1.03 - 1.06)	1.04 (1.03 - 1.06)	1.04 (1.03 - 1.05)
Specified arrhythmias (CC 92-93)	1.07 (1.05 - 1.09)	1.04 (1.02 - 1.06)	1.05 (1.03 - 1.07)	1.06 (1.04 - 1.07)
Other or unspecified heart disease (CC 94)	1.04 (1.02 - 1.06)	1.04 (1.02 - 1.06)	1.05 (1.03 - 1.06)	1.04 (1.03 - 1.05)
Vascular or circulatory disease (CC 104-106)	1.07 (1.05 - 1.08)	1.09 (1.07 - 1.11)	1.07 (1.05 - 1.09)	1.07 (1.06 - 1.08)
Metastatic cancer or acute leukemia (CC 7)	1.20 (1.14 - 1.25)	1.13 (1.08 - 1.19)	1.16 (1.10 - 1.22)	1.16 (1.13 - 1.19)
Cancer (CC 8-12)	0.99 (0.97 - 1.01)	1.01 (1.00 - 1.03)	1.01 (0.99 - 1.03)	1.00 (0.99 - 1.01)
Diabetes or DM complications (CC 15-20, 119-120)	1.10 (1.09 - 1.12)	1.11 (1.10 - 1.13)	1.09 (1.07 - 1.11)	1.10 (1.09 - 1.11)
Protein-calorie malnutrition (CC 21)	1.09 (1.07 - 1.12)	1.10 (1.07 - 1.12)	1.08 (1.06 - 1.11)	1.09 (1.08 - 1.11)
Disorders of fluid, electrolyte, acid-base (CC 22-23)	1.15 (1.13 - 1.16)	1.14 (1.12 - 1.16)	1.11 (1.09 - 1.14)	1.13 (1.12 - 1.14)
Liver or biliary disease (CC 25-30)	1.10 (1.07 - 1.12)	1.08 (1.05 - 1.10)	1.07 (1.04 - 1.09)	1.08 (1.06 - 1.09)
Peptic ulcer, hemorrhage, other specified gastrointestinal disorders (CC 34)	1.06 (1.04 - 1.08)	1.08 (1.06 - 1.10)	1.06 (1.04 - 1.09)	1.07 (1.06 - 1.08)
Other gastrointestinal disorders (CC 36)	1.05 (1.03 - 1.07)	1.06 (1.04 - 1.08)	1.07 (1.05 - 1.09)	1.05 (1.04 - 1.06)
Severe hematological disorders (CC 44)	1.18 (1.14 - 1.22)	1.18 (1.14 - 1.22)	1.16 (1.11 - 1.20)	1.18 (1.16 - 1.20)
Iron deficiency or other anemias and blood disease (CC 47)	1.09 (1.07 - 1.10)	1.11 (1.09 - 1.13)	1.13 (1.11 - 1.15)	1.10 (1.09 - 1.11)
Dementia or other specified brain disorders (CC 49-50)	1.01 (0.99 - 1.03)	1.03 (1.01 - 1.05)	1.04 (1.02 - 1.06)	1.02 (1.01 - 1.03)
Drug/alcohol abuse/dependence/psychosis (CC 51-53)	1.11 (1.09 - 1.14)	1.09 (1.06 - 1.11)	1.12 (1.09 - 1.14)	1.10 (1.08 - 1.11)
Major psychiatric disorders (CC 54-56)	1.07 (1.04 - 1.10)	1.06 (1.03 - 1.08)	1.05 (1.02 - 1.08)	1.06 (1.04 - 1.07)
Depression (CC 58)	1.03 (1.01 - 1.05)	1.03 (1.01 - 1.05)	1.03 (1.01 - 1.05)	1.02 (1.01 - 1.03)
Other psychiatric disorders (CC 60)	1.10 (1.07 - 1.12)	1.08 (1.06 - 1.10)	1.07 (1.05 - 1.09)	1.07 (1.06 - 1.08)
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	1.04 (1.01 - 1.07)	1.05 (1.02 - 1.08)	1.03 (1.00 - 1.06)	1.04 (1.02 - 1.05)
Stroke (CC 95-96)	1.03 (1.00 - 1.05)	1.03 (1.00 - 1.05)	1.02 (0.99 - 1.04)	1.03 (1.01 - 1.04)
Chronic obstructive pulmonary disease (CC 108)	1.17 (1.15 - 1.19)	1.18 (1.16 - 1.20)	1.17 (1.15 - 1.19)	1.17 (1.16 - 1.18)
Fibrosis of lung or other chronic lung disorders (CC 109)	1.06 (1.04 - 1.08)	1.04 (1.02 - 1.06)	1.05 (1.03 - 1.08)	1.05 (1.04 - 1.07)
Asthma (CC 110)	1.01 (0.99 - 1.04)	1.03 (1.00 - 1.05)	0.99 (0.97 - 1.02)	1.01 (0.99 - 1.02)
Pneumonia (CC 111-113)	1.12 (1.10 - 1.13)	1.11 (1.09 - 1.13)	1.09 (1.07 - 1.11)	1.11 (1.10 - 1.12)
End stage renal disease or dialysis (CC 129-130)	1.13 (1.09 - 1.17)	1.10 (1.07 - 1.14)	1.14 (1.10 - 1.18)	1.12 (1.10 - 1.14)
Renal failure (CC 131)	1.21 (1.19 - 1.23)	1.20 (1.18 - 1.22)	1.19 (1.17 - 1.21)	1.20 (1.19 - 1.21)
Nephritis (CC 132)	1.09 (1.05 - 1.13)	1.09 (1.05 - 1.13)	1.08 (1.04 - 1.12)	1.08 (1.05 - 1.10)
Other urinary tract disorders (CC 136)	1.06 (1.04 - 1.07)	1.07 (1.05 - 1.09)	1.08 (1.06 - 1.09)	1.07 (1.06 - 1.08)
Decubitus ulcer or chronic skin ulcer (CC 148-149)	1.09 (1.06 - 1.11)	1.10 (1.08 - 1.12)	1.09 (1.07 - 1.12)	1.09 (1.08 - 1.11)
Between-Hospital Variance (SE)	0.02 (0.002)	0.02 (0.002)	0.03 (0.002)	0.02 (0.001)

Table 11 – HF Logistic Regression Model Performance over Different Time Periods

Characteristic	07/2009-06/2010	07/2010-06/2011	07/2011-06/2012	07/2009-06/2012
Predictive ability, % (lowest decile – highest decile)	14.2-37.6	13.6-36.9	13.2-36.0	13.7-36.7
c-statistic	0.61	0.61	0.61	0.61

Table 12 – Distribution of Hospital Heart Failure Admission Volumes over Different Time Periods[**]

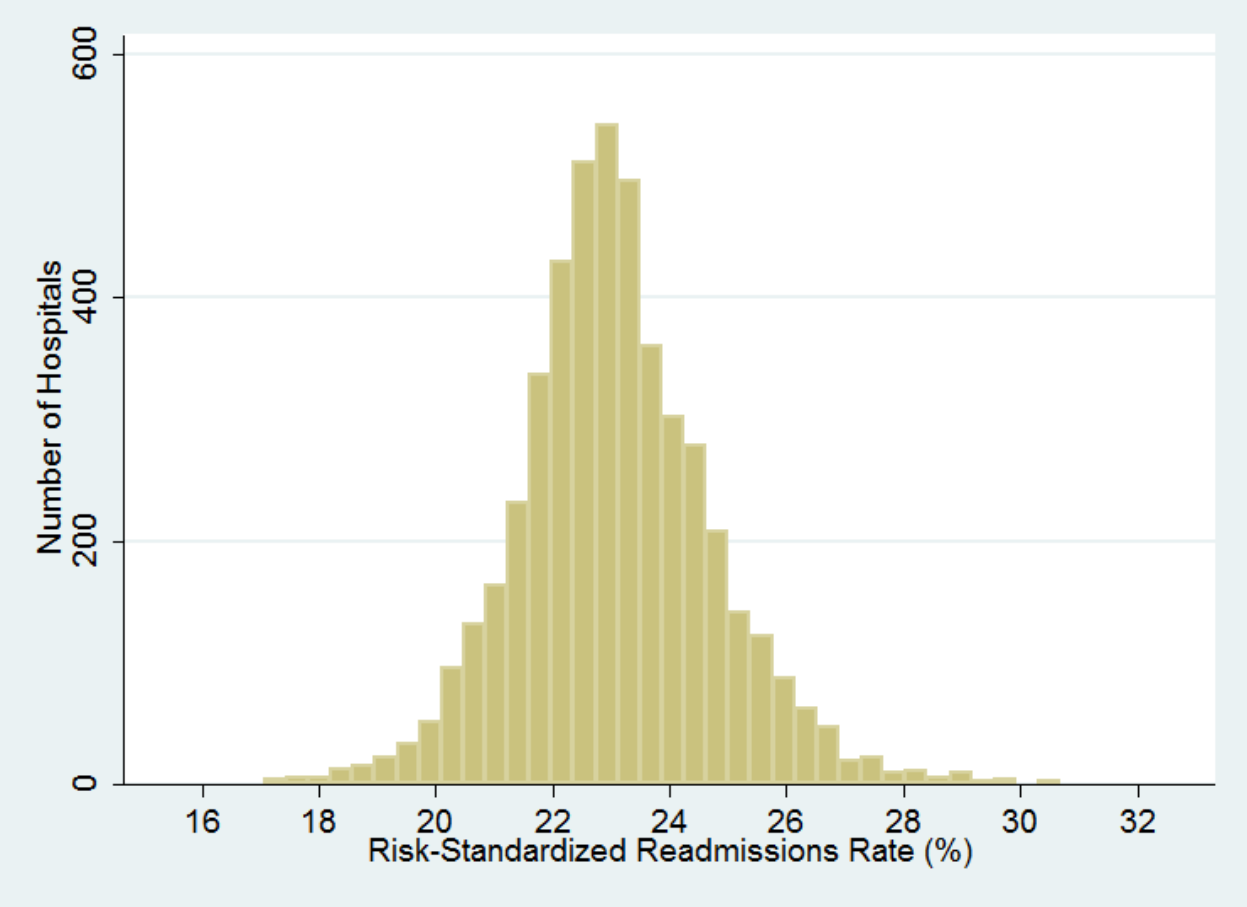
Characteristic	07/2009-06/2010	07/2010-06/2011	07/2011-06/2012	07/2009-06/2012
Number of Hospitals	4,701	4,679	4,673	4,786
Mean Number of Admissions (SD)	95.2 (113.2)	92.8 (111.7)	81.6 (99.4)	263.9 (321.1)
Range (min. – max.)	1-1,249	1-1,264	1-1,087	1-3,600
25th percentile	19	18	14	48
50th percentile	52	49	42	137
75th percentile	134	129	116	370

Table 13 – Distribution of Hospital Heart Failure RSRRs over Different Time Periods

Characteristic	07/2009-06/2010	07/2010-06/2011	07/2011-06/2012	07/2009-06/2012
Number of Hospitals	4,701	4,679	4,673	4,786
Mean (SD)	23.4 (1.3)	23.2 (1.1)	22.6 (1.2)	23.1 (1.7)
Range (min. – max.)	18.2-31.4	18.4-30.1	17.6-30.3	17.1-30.7
25th percentile	22.7	22.6	21.9	22.1
50th percentile	23.3	23.1	22.5	23.0
75th percentile	24.1	23.8	23.1	24.1

[**] Hospital volumes for third year of reporting (July 2011-2012) are lower in part due to incomplete enrollment data for discharges in June 2012.

Figure 4 – Distribution of Hospital 30-Day HF RSRRs between July 2009 and June 2012



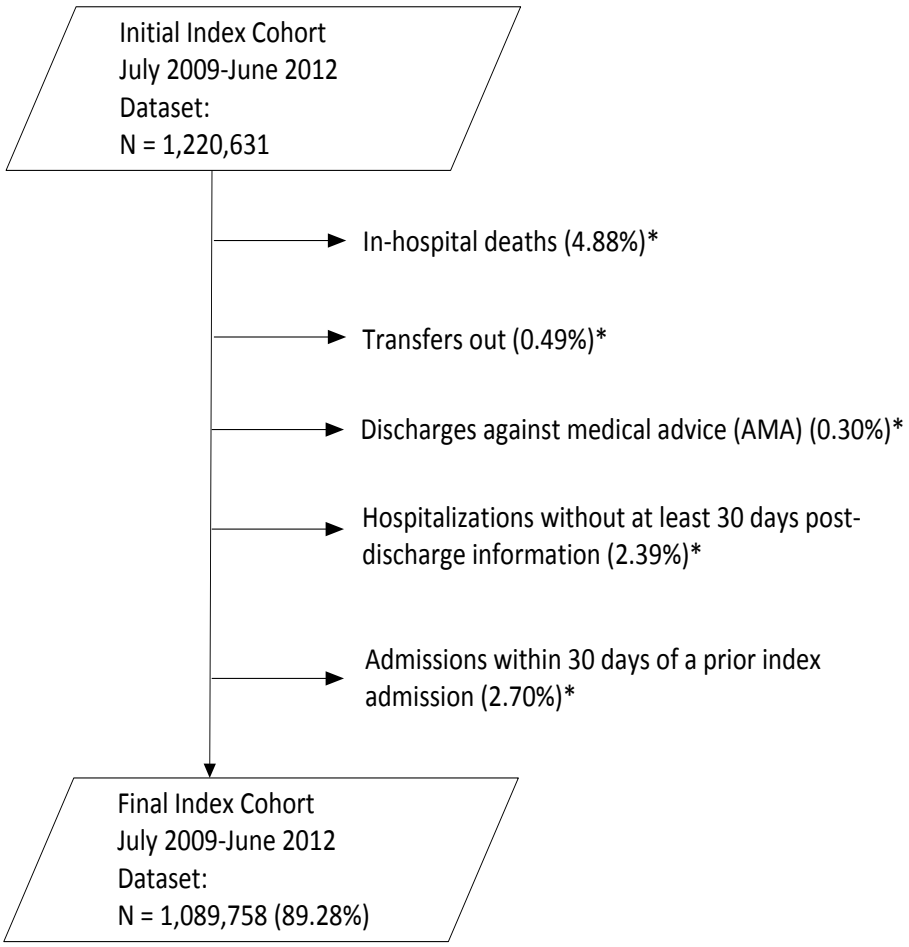
N=4,786 hospitals

4.4 Pneumonia Readmission 2013 Model Results

4.4.1 Index Cohort Exclusions

The exclusion criteria for the measures are presented in Section 2. The percentage of pneumonia patients meeting each exlcusion criterion in the July 2009-June 2012 dataset is presented in Figure 5.

Figure 5 – Index Cohort Sample for Pneumonia in the July 2009-June 2012 Dataset



* These categories are not mutually exclusive

4.4.2 Frequency of Pneumonia Model Variables

We examined the change in both observed readmission rates and frequency of clinical and demographic variables. Between the year July 2009-June 2010 and the year July 2011-June 2012, the observed readmission rate decreased from 17.7% to 17.4% (Table 14).

Some notable changes to variable frequencies include an increase in history of CABG from 4.3% to 9.3%, in other gastrointestinal disorders from 58.5% to 66.0%, and in iron deficiency from 51.6% to 58.7%.

4.4.3 Pneumonia Model Parameters and Performance

Table 15 shows the risk-adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for the pneumonia readmission model by individual year and for the combined three-year dataset. Overall, the variable effect sizes were relatively constant across years. Between-hospital variance win the combined dataset was 0.03 (SE: 0.001). If there were no systematic differences between hospitals, the between-hospital variance would be 0. In addition, model performance was stable over the three-year time period; the area under the ROC curve (c-statistic) increased slightly to 0.64 (Table 16).

4.4.4 Distribution of Hospital Volumes and RSRRs

Table 17 shows the distribution of hospital admission volumes and Table 18 shows the distribution of hospital RSRRs. These tables show the between-hospital variance by individual year and for the combined three-year dataset. The mean RSRR decreased over the three-year period, from 17.8% between July 2009 and June 2010 to 17.4% between July 2011 and June 2012. The median hospital RSRR in the combined three-year dataset was 17.5% (IQR: 16.8% - 18.4%).

Figure 6 shows the overall distribution of the hospital RSRRs for the combined three-year dataset. The odds of all-cause readmission if treated at a hospital one standard deviation above the national rate were 1.37 times higher than the odds of all-cause readmission if treated at a hospital one standard deviation below the national rate. If there were no systematic differences between hospitals, the OR would be 1.0.[15]

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

Out of 4,833 number of hospitals in the U.S., 25 performed “better than the U.S. national rate,” 4,331 performed “no different from the U.S. national rate,” and 101 performed “worse than the U.S. national rate.” 376 were classified as “number of cases too small” (fewer than 25) to reliably tell how well the hospital is performing.

Table 14 – Frequency of Pneumonia Model Variables over Different Time Periods

Variable	07/2009-06/2010	07/2010-06/2011	07/2011-06/2012	07/2009-06/2012
Total N	371,003	382,700	336,055	1,089,758
Observed readmission rate (%)	17.7	17.7	17.4	17.6
Mean Age minus 65 (SD)	15.1 (8.2)	15.3 (8.3)	15.3 (8.3)	15.2 (8.3)
Male (%)	46.3	46.4	46.8	46.5
History of CABG	4.3	7.2	9.3	6.9
History of infection (CC 1, 3-6)	37.3	37.9	38.8	38.0
Septicemia/shock (CC 2)	7.5	7.9	8.4	7.9
Metastatic cancer or acute leukemia (CC 7)	4.9	4.9	5.3	5.0
Lung or other severe cancers (CC 8)	6.9	6.9	7.2	7.0
Other major cancers (CC 9-10)	17.6	17.6	18.1	17.8
Diabetes mellitus (DM) or DM complications (CC 15-20, 119-120)	40.3	41.2	42.3	41.2
Protein-calorie malnutrition (CC 21)	11.3	12.1	12.8	12.1
Disorders of fluid, electrolyte, acid-base (CC 22-23)	37.3	38.8	41.1	39.0
Other gastrointestinal disorders (CC 36)	58.5	61.9	66.0	62.0
Severe hematological disorders (CC 44)	4.3	4.4	3.6	4.1
Iron deficiency or other anemias and blood disease (CC 47)	51.6	54.9	58.7	55.0
Dementia or other specified brain disorders (CC 49-50)	28.5	30.2	31.3	30.0
Drug/alcohol abuse/dependence/psychosis (CC 51-53)	12.5	14.1	16.4	14.3
Major psychiatric disorders (CC 54-56)	12.8	13.4	14.1	13.4
Other psychiatric disorders (CC 60)	13.2	15.3	19.4	15.8
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	8.2	8.5	9.0	8.5
Cardio-respiratory failure or shock (CC 79)	19.5	20.5	22.1	20.6
Congestive heart failure (CC 80)	38.9	39.0	39.5	39.1
Acute coronary syndrome (CC 81-82)	7.7	7.5	7.6	7.6
Coronary atherosclerosis or angina (CC 83-84)	47.5	48.7	50.3	48.8
Valvular or rheumatic heart disease (CC 86)	22.0	23.3	25.3	23.5
Specified arrhythmias (CC 92-93)	41.3	42.4	44.3	42.6
Stroke (CC 95-96)	9.7	9.5	9.3	9.5
Vascular or circulatory disease (CC 104-106)	41.1	41.9	43.3	42.0
Chronic obstructive pulmonary disease (CC 108)	54.6	55.0	55.8	55.1
Fibrosis of lung or other chronic lung disorders (CC 109)	16.6	16.5	16.2	16.5
Asthma (CC 110)	11.2	11.3	11.6	11.4
Pneumonia (CC 111-113)	43.5	43.7	43.6	43.6
Pleural effusion/pneumothorax (CC 114)	15.3	15.9	16.8	16.0
Other lung disorders (CC 115)	46.8	47.1	46.8	46.9
End stage renal disease or dialysis (CC 129-130)	2.5	2.8	3.2	2.8
Renal failure (CC 131)	25.3	27.2	29.3	27.2
Urinary tract infection (CC 135)	28.5	28.7	28.7	28.6
Other urinary tract disorders (CC 136)	23.1	23.9	25.5	24.1
Decubitus ulcer or chronic skin ulcer (CC 148-149)	10.9	11.2	11.5	11.2
Vertebral fractures (CC 157)	5.0	5.0	5.1	5.0
Other injuries (CC 162)	36.3	38.3	39.0	37.9

Table 15 – Adjusted OR and 95% CIs for the Pneumonia Hierarchical Logistic Regression Model over Different Time Periods

Variable	07/2009-06/2010 OR (95% CI)	07/2010-06/2011 OR (95% CI)	07/2011-06/2012 OR (95% CI)	07/2009-06/2012 OR (95% CI)
Age minus 65 (years above 65, continuous)	1.00 (1.00 – 1.00)	1.00 (1.00 – 1.00)	1.00 (1.00 – 1.00)	1.00 (1.00 – 1.00)
Male	1.06 (1.04 - 1.08)	1.07 (1.05 - 1.09)	1.05 (1.03 - 1.07)	1.06 (1.05 - 1.07)
History of CABG	0.86 (0.82 - 0.90)	0.89 (0.86 - 0.92)	0.95 (0.92 - 0.98)	0.90 (0.88 - 0.92)
History of infection (CC 1, 3-6)	1.05 (1.04 - 1.07)	1.04 (1.02 - 1.06)	1.06 (1.04 - 1.08)	1.05 (1.04 - 1.06)
Septicemia/shock (CC 2)	1.06 (1.03 - 1.09)	1.06 (1.03 - 1.09)	1.05 (1.02 - 1.09)	1.05 (1.03 - 1.07)
Metastatic cancer or acute leukemia (CC 7)	1.20 (1.15 - 1.25)	1.19 (1.14 - 1.24)	1.23 (1.18 - 1.28)	1.20 (1.17 - 1.23)
Lung or other severe cancers (CC 8)	1.19 (1.15 - 1.24)	1.19 (1.15 - 1.23)	1.16 (1.11 - 1.20)	1.18 (1.15 - 1.20)
Other major cancers (CC 9-10)	1.01 (0.98 - 1.03)	1.00 (0.98 - 1.03)	1.05 (1.02 - 1.07)	1.02 (1.00 - 1.03)
Diabetes mellitus (DM) or DM complications (CC 15-20, 119-120)	1.08 (1.06 - 1.10)	1.09 (1.07 - 1.11)	1.08 (1.06 - 1.10)	1.08 (1.07 - 1.09)
Protein-calorie malnutrition (CC 21)	1.19 (1.16 - 1.22)	1.16 (1.14 - 1.19)	1.14 (1.11 - 1.17)	1.17 (1.15 - 1.18)
Disorders of fluid, electrolyte, acid-base (CC 22-23)	1.15 (1.13 - 1.17)	1.16 (1.13 - 1.18)	1.16 (1.13 - 1.18)	1.15 (1.14 - 1.17)
Other gastrointestinal disorders (CC 36)	1.04 (1.02 - 1.06)	1.05 (1.03 - 1.07)	1.08 (1.06 - 1.11)	1.05 (1.04 - 1.06)
Severe hematological disorders (CC 44)	1.19 (1.15 - 1.24)	1.20 (1.15 - 1.25)	1.17 (1.12 - 1.23)	1.19 (1.17 - 1.22)
Iron deficiency or other anemias and blood disease (CC 47)	1.11 (1.09 - 1.13)	1.16 (1.13 - 1.18)	1.20 (1.17 - 1.22)	1.15 (1.13 - 1.16)
Dementia or other specified brain disorders (CC 49-50)	1.02 (1.00 - 1.05)	1.03 (1.01 - 1.05)	1.03 (1.01 - 1.06)	1.03 (1.01 - 1.04)
Drug/alcohol abuse/dependence/psychosis (CC 51-53)	1.08 (1.06 - 1.11)	1.09 (1.06 - 1.11)	1.10 (1.07 - 1.12)	1.08 (1.07 - 1.10)
Major psychiatric disorders (CC 54-56)	1.06 (1.03 - 1.08)	1.05 (1.03 - 1.08)	1.05 (1.02 - 1.08)	1.05 (1.04 - 1.07)
Other psychiatric disorders (CC 60)	1.10 (1.08 - 1.13)	1.10 (1.07 - 1.12)	1.08 (1.06 - 1.11)	1.09 (1.07 - 1.10)
Hemiplegia, paraplegia, paralysis, functional disability (CC 67-69, 100-102, 177-178)	1.09 (1.06 - 1.13)	1.09 (1.06 - 1.12)	1.06 (1.03 - 1.09)	1.08 (1.06 - 1.10)
Cardio-respiratory failure or shock (CC 79)	1.16 (1.13 - 1.18)	1.16 (1.13 - 1.19)	1.16 (1.13 - 1.18)	1.16 (1.14 - 1.17)
Congestive heart failure (CC 80)	1.20 (1.17 - 1.22)	1.19 (1.17 - 1.22)	1.18 (1.16 - 1.21)	1.19 (1.18 - 1.21)
Acute coronary syndrome (CC 81-82)	1.07 (1.04 - 1.11)	1.09 (1.06 - 1.12)	1.09 (1.05 - 1.12)	1.08 (1.06 - 1.10)
Coronary atherosclerosis or angina (CC 83-84)	1.06 (1.04 - 1.08)	1.06 (1.04 - 1.08)	1.06 (1.04 - 1.08)	1.06 (1.04 - 1.07)
Valvular or rheumatic heart disease (CC 86)	1.06 (1.04 - 1.08)	1.08 (1.06 - 1.10)	1.07 (1.04 - 1.09)	1.07 (1.05 - 1.08)
Specified arrhythmias (CC 92-93)	1.08 (1.06 - 1.10)	1.08 (1.06 - 1.10)	1.11 (1.09 - 1.13)	1.09 (1.08 - 1.10)
Stroke (CC 95-96)	1.06 (1.03 - 1.09)	1.05 (1.02 - 1.09)	1.03 (1.00 - 1.07)	1.05 (1.03 - 1.07)
Vascular or circulatory disease (CC 104-106)	1.07 (1.05 - 1.09)	1.06 (1.04 - 1.08)	1.05 (1.03 - 1.07)	1.06 (1.05 - 1.07)
Chronic obstructive pulmonary disease (CC 108)	1.19 (1.17 - 1.21)	1.19 (1.17 - 1.22)	1.18 (1.15 - 1.20)	1.19 (1.17 - 1.20)
Fibrosis of lung or other chronic lung disorders (CC 109)	1.10 (1.07 - 1.12)	1.08 (1.06 - 1.11)	1.08 (1.05 - 1.11)	1.09 (1.07 - 1.10)
Asthma (CC 110)	0.97 (0.94 - 0.99)	0.99 (0.96 - 1.02)	0.96 (0.94 - 0.99)	0.97 (0.96 - 0.99)
Pneumonia (CC 111-113)	1.09 (1.07 - 1.11)	1.06 (1.04 - 1.08)	1.05 (1.02 - 1.07)	1.07 (1.05 - 1.08)
Pleural effusion/pneumothorax (CC 114)	1.13 (1.10 - 1.16)	1.13 (1.10 - 1.15)	1.10 (1.08 - 1.13)	1.12 (1.10 - 1.13)
Other lung disorders (CC 115)	1.03 (1.01 - 1.05)	1.03 (1.01 - 1.05)	1.04 (1.02 - 1.06)	1.03 (1.02 - 1.05)
End stage renal disease or dialysis (CC 129-130)	1.25 (1.19 - 1.31)	1.18 (1.13 - 1.23)	1.26 (1.20 - 1.32)	1.22 (1.19 - 1.26)
Renal failure (CC 131)	1.16 (1.13 - 1.18)	1.19 (1.17 - 1.22)	1.14 (1.11 - 1.16)	1.16 (1.15 - 1.18)
Urinary tract infection (CC 135)	1.06 (1.04 - 1.09)	1.05 (1.02 - 1.07)	1.05 (1.02 - 1.07)	1.05 (1.04 - 1.07)
Other urinary tract disorders (CC 136)	1.04 (1.01 - 1.06)	1.04 (1.02 - 1.07)	1.06 (1.03 - 1.08)	1.05 (1.03 - 1.06)
Decubitus ulcer or chronic skin ulcer (CC 148-149)	1.11 (1.08 - 1.14)	1.08 (1.05 - 1.11)	1.08 (1.05 - 1.11)	1.09 (1.07 - 1.10)
Vertebral fractures (CC 157)	1.07 (1.03 - 1.11)	1.11 (1.07 - 1.15)	1.11 (1.06 - 1.15)	1.10 (1.08 - 1.12)
Other injuries (CC 162)	1.06 (1.04 - 1.08)	1.02 (1.01 - 1.04)	1.04 (1.02 - 1.06)	1.04 (1.03 - 1.05)
Between-Hospital Variance (SE)	0.03 (0.002)	0.03 (0.002)	0.02 (0.002)	0.03 (0.001)

Table 16 – Pneumonia Logistic Regression Model Performance over Different Time Periods

Characteristic	07/2009-06/2010	07/2010-06/2011	07/2011-06/2012	07/2009-06/2012
Predictive ability, % (lowest decile – highest decile)	8.7-32.3	8.5-32.2	8.2-32.5	8.5-32.2
c-statistic	0.63	0.64	0.64	0.64

Table 17 – Distribution of Hospital Pneumonia Admission Volumes over Different Time Periods[††]

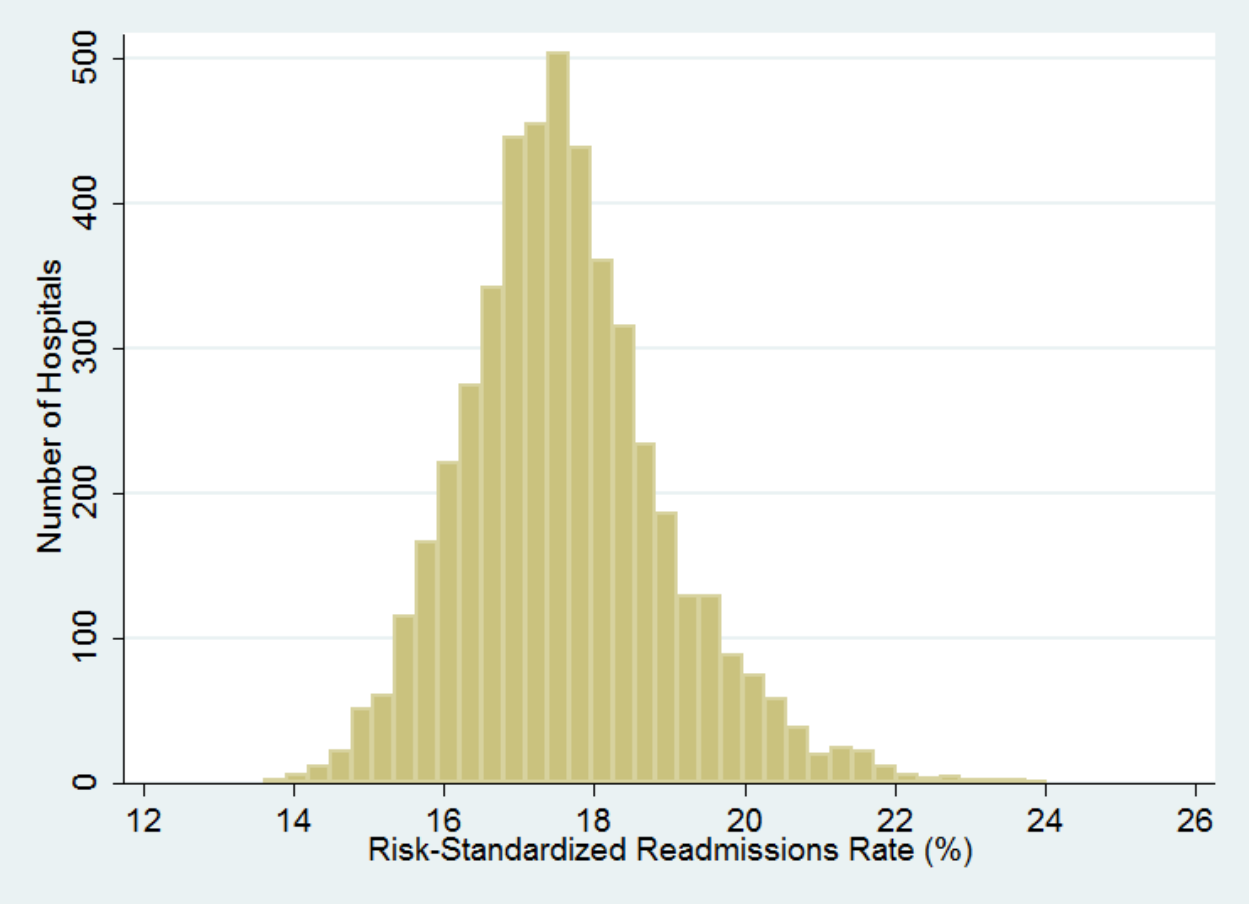
Characteristic	07/2009-06/2010	07/2010-06/2011	07/2011-06/2012	07/2009-06/2012
Number of Hospitals	4,759	4,750	4,734	4,833
Mean Number of Admissions (SD)	78.0 (74.0)	80.6 (77.4)	71.0 (69.5)	225.5 (218.7)
Range (min. – max.)	1-735	1-843	1-702	1-2,280
25th percentile	25	26	22	71
50th percentile	56	57	49	158
75th percentile	108	110	98	310

Table 18 – Distribution of Hospital Pneumonia RSRRs over Different Time Periods

Characteristic	07/2009-06/2010	07/2010-06/2011	07/2011-06/2012	07/2009-06/2012
Number of Hospitals	4,759	4,750	4,734	4,833
Mean (SD)	17.8 (1.0)	17.7 (1.1)	17.4 (0.8)	17.6 (1.4)
Range (min. – max.)	14.4-23.6	14.5-24.6	14.6-22.0	13.6-24.1
25th percentile	17.2	17.0	16.9	16.8
50th percentile	17.7	17.6	17.3	17.5
75th percentile	18.3	18.3	17.7	18.4

[††] Hospital volumes for third year of reporting (July 2011-2012) are lower in part due to incomplete enrollment data for discharges in June 2012.

Figure 6 – Distribution of Hospital 30-Day Pneumonia RSRRs between July 2009 and June 2012



N= 4,833 hospitals

5. DATA QUALITY ASSURANCE (QA)

We have a two-phase approach to internal QA for the readmission measures maintenance process. These phases are described below. Please refer to Figure 7 for a detailed outline of phase I and Figure 8 for a detailed outline of phase II.

Note that this section represents QA for the subset of the work conducted by YNHHSC/CORE to maintain and report these readmission measures. It does not describe the QA to process data and create the input files, nor does it include the QA for the final processing of production data for public reporting because that work is conducted by another contractor (Mathematica Policy Research Inc.).

5.1 Phase I

The first step in the QA process is to ensure the validity of the input data files. There were no substantial changes to the data input processing, and only one additional year of data was added to our existing datasets. Only one new field was added to support the production of another measure. There was minimal need for targeted quality checks this year, so the automated process we developed previously allowed for a thorough review of the new datasets.

In general, all condition-specific files for each reporting year are evaluated by comparing them to the prior year's QA results for the same condition/year. We conduct data validity checks, including crosschecking of readmission information, distributions of ICD-9-CM codes, and frequencies of key variables. We employ both manual scan and descriptive analyses to carry out these tasks. The results are reviewed for accuracy and changes over time compared to prior datasets. Any new variable constructs and other changes in formatting to the input files are also verified as part of this process. We share our QA findings with our data extraction contractor as needed.

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

5.2 Phase II

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

This phase also includes a comparison of prior years' risk-adjustment coefficients and variable frequencies. This enables us to check for potential inconsistencies in the data as well as the impact of any changes to the SAS pack.

Figure 7 – YNHHSC/CORE QA Phase I

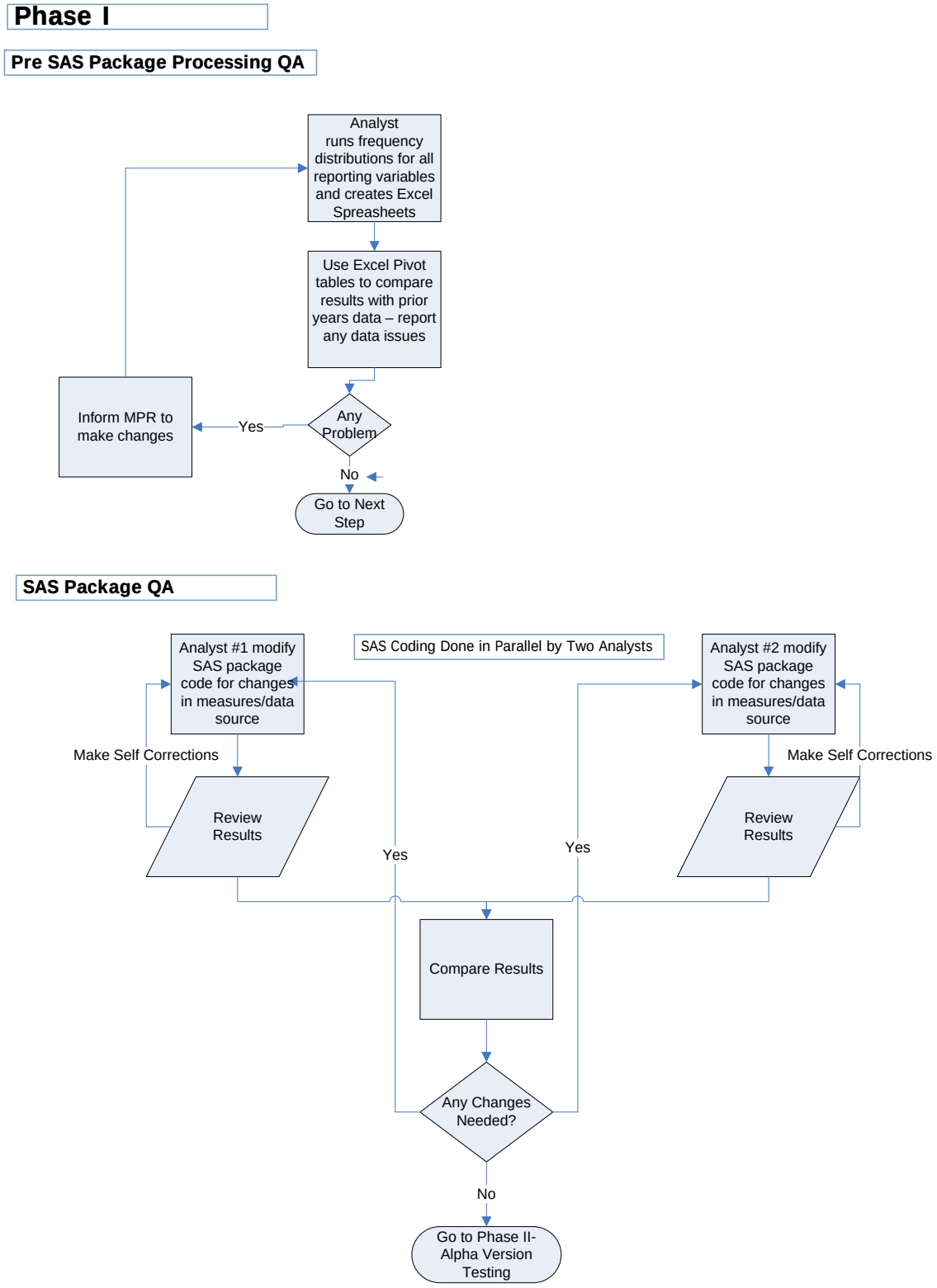
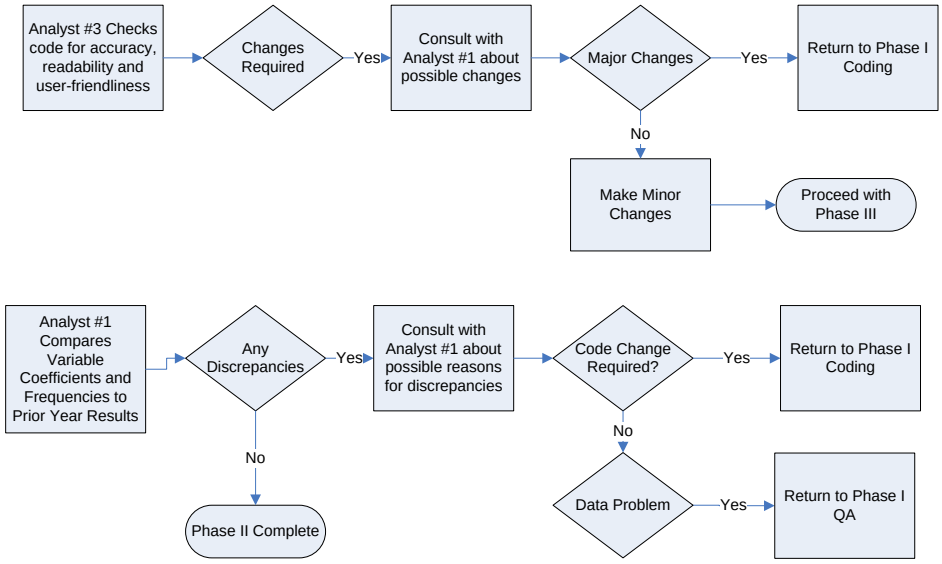


Figure 8 – YNHHSC/CORE QA Phase II

Phase II

Results Testing – Alpha Version



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7. APPENDICES

Appendix A. Measure Specifications

1. Cohort ICD-9-CM Codes by Measure

AMI Cohort Codes

410.00 AMI (anterolateral wall) – episode of care unspecified
410.01 AMI (anterolateral wall) – initial episode of care
410.10 AMI (other anterior wall) – episode of care unspecified
410.11 AMI (other anterior wall) – initial episode of care
410.20 AMI (inferolateral wall) – episode of care unspecified
410.21 AMI (inferolateral wall) – initial episode of care
410.30 AMI (inferoposterior wall) – episode of care unspecified
410.31 AMI (inferoposterior wall) – initial episode of care
410.40 AMI (other inferior wall) – episode of care unspecified
410.41 AMI (other inferior wall) – initial episode of care
410.50 AMI (other lateral wall) – episode of care unspecified
410.51 AMI (other lateral wall) – initial episode of care
410.60 AMI (true posterior wall) – episode of care unspecified
410.61 AMI (true posterior wall) – initial episode of care
410.70 AMI (subendocardial) – episode of care unspecified
410.71 AMI (subendocardial) – initial episode of care
410.80 AMI (other specified site) – episode of care unspecified
410.81 AMI (other specified site) – initial episode of care
410.90 AMI (unspecified site) – episode of care unspecified
410.91 AMI (unspecified site) – initial episode of care

Heart Failure Cohort Codes

402.01 Malignant hypertensive heart disease with congestive heart failure (CHF)
402.11 Benign hypertensive heart disease with CHF
402.91 Hypertensive heart disease with CHF
404.01 Malignant hypertensive heart and renal disease with CHF
404.03 Malignant hypertensive heart and renal disease with CHF & renal failure (RF)
404.11 Benign hypertensive heart and renal disease with CHF
404.13 Benign hypertensive heart and renal disease with CHF & RF
404.91 Unspecified hypertensive heart and renal disease with CHF
404.93 Hypertension and non-specified heart and renal disease with CHF & RF
428.0 Congestive heart failure, unspecified
428.1 Left heart failure
428.20 Systolic heart failure, unspecified
428.21 Systolic heart failure, acute
428.22 Systolic heart failure, chronic
428.23 Systolic heart failure, acute or chronic
428.30 Diastolic heart failure, unspecified
428.31 Diastolic heart failure, acute
428.32 Diastolic heart failure, chronic

428.33 Diastolic heart failure, acute or chronic
428.40 Combined systolic and diastolic heart failure, unspecified
428.41 Combined systolic and diastolic heart failure, acute
428.42 Combined systolic and diastolic heart failure, chronic
428.43 Combined systolic and diastolic heart failure, acute or chronic
428.9 Heart failure, unspecified

Pneumonia Cohort Codes

480.0 Pneumonia due to adenovirus
480.1 Pneumonia due to respiratory syncytial virus
480.2 Pneumonia due to parainfluenza virus
480.3 Pneumonia due to SARS-associated coronavirus
480.8 Viral pneumonia: pneumonia due to other virus not elsewhere classified
480.9 Viral pneumonia unspecified
481 Pneumococcal pneumonia [streptococcus pneumoniae pneumonia]
482.0 Pneumonia due to klebsiella pneumoniae
482.1 Pneumonia due to pseudomonas
482.2 Pneumonia due to hemophilus influenzae (h. influenzae)
482.30 Pneumonia due to streptococcus unspecified
482.31 Pneumonia due to streptococcus group a
482.32 Pneumonia due to streptococcus group b
482.39 Pneumonia due to other streptococcus
482.40 Pneumonia due to staphylococcus unspecified
482.41 Pneumonia due to staphylococcus aureus
482.42 Methicillin resistant pneumonia due to Staphylococcus aureus
482.49 Other staphylococcus pneumonia
482.81 Pneumonia due to anaerobes
482.82 Pneumonia due to escherichia coli [e.coli]
482.83 Pneumonia due to other gram-negative bacteria
482.84 Pneumonia due to legionnaires' disease
482.89 Pneumonia due to other specified bacteria
482.9 Bacterial pneumonia unspecified
483.0 Pneumonia due to mycoplasma pneumoniae
483.1 Pneumonia due to chlamydia
483.8 Pneumonia due to other specified organism
485 Bronchopneumonia organism unspecified
486 Pneumonia organism unspecified
487.0 Influenza with pneumonia
488.11 Influenza due to identified novel H1N1 influenza virus with pneumonia

2. Outcome Definition Criteria for AMI, HF, and Pneumonia Measures

30-day time frame

Rationale: Outcomes occurring within 30 days of discharge can be influenced by hospital care and the early transition to the outpatient setting. The use of the 30-day time frame is a clinically meaningful period for hospitals to collaborate with their communities in an effort to reduce readmissions.

All-cause unplanned readmission

Rationale: From a patient perspective, an unplanned readmission from any cause is an adverse event.

Unplanned readmission

Rationale: Planned readmissions are generally not a signal of quality of care. Including planned readmissions in a readmission measure could create a disincentive to provide appropriate care to patients who are scheduled for elective or necessary procedures within 30 days of discharge.

3. Cohort Inclusion Criteria for AMI, HF, and Pneumonia Measures

Principal discharge diagnosis of AMI, HF, or pneumonia

Rationale: AMI, HF, and pneumonia are the conditions targeted for measurement in this report.

Enrolled in Part A and Part B Medicare for the 12 months prior to the date of admission, and enrolled in Part A during the index admission

Rationale: The 12 month prior enrollment ensures a full year of administrative data for risk adjustment (requirement is dropped for patients with an index admission within a VA hospital). Part A is required during the index admission to ensure no Medicare Advantage patients are included in the measures.

Aged 65 or older

Rationale: Medicare patients younger than 65 are not included in the measure because they are considered to be too clinically different from patients 65 and over as they often qualify for Medicare at a younger age because of disabilities.

4. Cohort Exclusion Criteria for AMI, HF, and Pneumonia Measures

In-hospital deaths

Rationale: Patients are not eligible for readmission.

Without at least 30 days of post-discharge enrollment in FFS Medicare

Rationale: The 30-day readmission outcome cannot be assessed in this group since claims data are used to determine whether or not a patient was readmitted (exclusion applies only to patients with index admissions in non-VA hospitals).

Transfers to another acute care facility

Rationale: Readmission is attributed to the hospital that discharged the patient to the non-acute care setting. Transferred patients are still included in the measure cohort, but the initial admitting hospital is not accountable for the outcome (thus the "transfer-out" hospitalization is excluded as an index admission).

Discharged against medical advice (AMA)

Rationale: Providers did not have the opportunity to deliver full care and prepare the patient for discharge.

Table A1 – Risk Variables

Variable	Codes	AMI	HF	Pneumonia
Age-65 (years above 65, continuous)	n/a	x	x	x
Male	n/a	x	x	x
History of PTCA	ICD-9-CM V45.82,	x		

Variable	Codes	AMI	HF	Pneumonia
	00.66, 36.01, 36.02, 36.05, 36.06, 36.07			
History of CABG	ICD-9-CM V45.81, 36.10–36.16	x	x	x
Congestive heart failure	CC 80	x	x	x
Acute coronary syndrome	CC 81, 82	x	x	x
Angina pectoris/old myocardial infarction	CC 83	x	x	x
Coronary atherosclerosis/other chronic ischemic heart disease	CC 84	x	x	x
Valvular and rheumatic heart disease	CC 86	x	x	x
Arrhythmias	CC 92, 93	x	x	x
Vascular or circulatory disease	CC 104-106	x	x	x
Cardio-respiratory failure and shock	CC 79		x	x
Other and unspecified heart disease	CC 94		x	
Anterior myocardial infarction	ICD-9-CM 410.00-410.19	x		
Other location of myocardial infarction	ICD-9-CM 410.20-410.69	x		
Metastatic cancer and acute leukemia	CC 7	x	x	x
Lung, upper digestive tract, and other severe cancers	CC 8			x
Lymphatic, head and neck, brain, and other major cancers; breast, prostate, colorectal and other cancers and tumors	CC 9-10			x
Cancer	CC 8-12	x	x	
Diabetes and DM complications	CC 15-20, 119, 120	x	x	x
Protein-calorie malnutrition	CC 21	x	x	x
Disorders of fluid/electrolyte/acid-base	CC 22, 23	x	x	x
Iron deficiency and other/unspecified anemias and blood disease	CC 47	x	x	x
Dementia and senility	CC 49, 50	x	x	x
Hemiplegia, paraplegia, paralysis, functional disability	CC 67-69, 100-102, 177, 178	x	x	x
Stroke	CC 95, 96	x	x	x
COPD	CC 108	x	x	x
Asthma	CC 110	x	x	x
Pneumonia	CC 111-113	x	x	x
End-stage renal disease or dialysis	CC 129, 130	x	x	x
Renal failure	CC 131	x	x	x
Other urinary tract disorders	CC 136	x	x	x
Decubitus ulcer or chronic skin ulcer	CC 148, 149	x	x	x
History of infection	CC 1, 3-6	x		x
Other gastrointestinal disorders	CC 36		x	x
Drug/alcohol abuse/dependence/psychosis	CC 51-53		x	x
Major psychiatric disorders	CC 54-56		x	x

Variable	Codes	AMI	HF	Pneumonia
Other psychiatric disorders	CC 60		x	x
Fibrosis of lung and other chronic lung disorders	CC 109		x	x
Severe hematological disorders	CC 44		x	x
Cerebrovascular disease	CC 97-99, 103			
Peptic ulcer, hemorrhage, other specified gastrointestinal disorders	CC 34		x	
Nephritis	CC 132		x	
Liver and biliary disease	CC 25-30		x	
Depression	CC 58		x	
Septicemia/shock	CC 2			x
Pleural effusion/pneumothorax	CC 114			x
Other lung disorders	CC 115			x
Urinary tract infection	CC 135			x
Vertebral fractures	CC 157			x
Other injuries	CC 162			x

Table A2 – Risk Variables Considered Complications of Care During the Index Admission*

CC	Description	AMI	HF	Pneumonia
2	Septicemia/Shock			x
6	Other Infectious Diseases	x		x
17	Diabetes with Acute Complications	x	x	x
23	Disorders of Fluid/Electrolyte/Acid-Base	x	x	x
28	Acute Liver Failure/Disease		x	
34	Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders		x	
79	Cardio-Respiratory Failure and Shock		x	x
80	Congestive Heart Failure	x	x	x
81	Acute Myocardial Infarction	x	x	x
82	Other Acute/subacute forms of Ischemic Heart Disease	x	x	x
92	Specified Heart Arrhythmias	x	x	x
93	Other Heart Rhythm and Conduction Disorders	x	x	x
95	Cerebral Hemorrhage	x	x	x
96	Ischemic or Unspecified Stroke	x	x	x
97	Precerebral Arterial Occlusion and Transient Cerebral Ischemia	x		
100	Hemiplegia/Hemiparesis	x	x	x
101	Diplegia (Upper), Monoplegia, and Other Paralytic Syndromes	x	x	x
102	Speech, Language, Cognitive, Perceptual	x	x	x
104	Vascular Disease with Complications	x	x	x
105	Vascular Disease	x	x	x
106	Other Circulatory Disease	x	x	x
111	Aspiration and Specified Bacterial Pneumonias	x	x	x
112	Pneumococcal Pneumonia, Emphysema, Lung Abscess	x	x	x
114	Pleural Effusion/Pneumothorax			x
129	End Stage Renal Disease	x	x	x
130	Dialysis Status	x	x	x
131	Renal Failure	x	x	x
132	Nephritis		x	
135	Urinary Tract Infection			x
148	Decubitus Ulcer of Skin	x	x	x
177	Amputation Status, Lower Limb/Amputation	x	x	x
178	Amputation Status, Upper Limb	x	x	x

* The selected CCs are considered complications of care and are not risk-adjusted for if they only occur during the index admission.

5. Statistical Approach to Risk-Standardized Readmission Rates for AMI, HF, and Pneumonia Measures

We estimate the hospital-specific risk-standardized readmission rates using hierarchical generalized linear models. This strategy accounts for within-hospital correlation of the observed outcome and accommodates the assumption that underlying differences in quality across hospitals lead to systematic differences in outcomes. We model the probability of readmission as a function of patient age, clinically relevant comorbidities, and history of PCI and/or CABG with an intercept for the hospital-specific random effect.

We use the following strategy to calculate the hospital-specific readmission rates. We calculate these rates as the ratio of a hospital's "predicted" readmissions to "expected" readmissions multiplied by the national observed readmission rate. The expected number of readmissions for each hospital is estimated using its patient mix and the average hospital-specific intercept (i.e., the average intercept among all hospitals in the sample). The predicted number of readmissions for each hospital is estimated given the same patient mix but an estimated hospital-specific intercept. Operationally, the expected number of readmissions for each hospital is obtained by summing the expected probabilities of readmissions for all patients in the hospital. The expected probability of readmission for each patient is calculated via the hierarchical model which applies the estimated regression coefficients to the observed patient characteristics and adds the average of the hospital specific. The predicted number of readmissions for each hospital is calculated by summing the predicted probabilities for all patients in the hospital. The predicted probability for each patient is calculated through the hierarchical model which applies the estimated regression coefficients to the patient characteristics observed and adding the hospital-specific intercept.

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

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

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

Where h(.) is a logit link, Y_{ij} is whether the j^{th} patient in the i^{th} hospital was readmitted (1: readmitted, 0: otherwise); α_i represents the hospital-specific intercept, $\mathbf{Z}_{ij} = (Z_{1ij}, Z_{2ij}, \ldots, Z_{pij})$ the patient-specific covariates, μ is the average hospital intercept across all hospitals in the sample, and τ^2 is the between-hospital variance component[‡‡]. This model separates within-hospital variation from between-hospital variation. The hierarchical generalized linear models are estimated using the SAS software system (SAS 9.2 GLIMMIX).

5.1 Hospital performance reporting

Using the selected set of risk factors, we fit the hierarchical generalized linear model defined by Equations (1) - (2) and estimate the parameters, $\hat{\mu}$, $\{\hat{\alpha}_i, \hat{\alpha}_2, ..., \hat{\alpha}_I\}$, $\hat{\beta}$, and $\hat{\tau}^2$ where i is the

[‡‡] Daniels M, Gatsonic C. Hierarchical Generalized Linear Models in the Analysis of Variations in Health Care Utilization. *Journal of the American Statistical Association.* 1999;94(445):14

total number of hospitals. We calculate a standardized outcome measure, RSRR, for each hospital by computing the ratio of the predicted number of readmission to the expected number of readmissions, multiplied by the national observed readmission rate, $\bar{y}$. Specifically, we calculate

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

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

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

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

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

5.2 Creating Interval Estimates

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

Algorithm:

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

1. Sample *I* hospitals with replacement.

2. Fit the hierarchical generalized linear model using all patients within each sampled hospital. If some hospitals are selected more than once in a bootstrapped sample, we treat them as distinct so that we have *I* random effects to estimate the variance components. At the conclusion of Step 2, we have:
   a. $\hat{\beta}^{(b)}$ (the estimated regression coefficients of the risk factors).

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

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

3. We generate a hospital random effect by sampling from the distribution of the hospital-specific distribution obtained in Step 2c. We approximate the distribution for each random effect by a normal distribution. Thus, we draw $\alpha_i{}^{(b*)} \sim N(\hat{\alpha}_i{}^{(b)}, \widehat{var}(\hat{\alpha}_i{}^{(b)}))$ for the unique set of hospitals sampled in Step 1.

4. Within each unique hospital *i* sampled in Step 1, and for each case *j* in that hospital, we calculate $\hat{y}_{ij}^{(b)}$, $\hat{e}_{ij}^{(b)}$, and $\widehat{RSRR}_i(Z)^{(B)}$ where $\hat{\beta}^{(b)}$ and $\hat{\mu}^{(b)}$ are obtained from Step 2 and $\hat{\alpha}_i^{(b*)}$ is obtained from Step 3.

Ninety-five percent interval estimates (or alternative interval estimates) for the hospital-standardized outcome can be computed by identifying the 2.5th and 97.5th percentiles of the B estimates (or the percentiles corresponding to the alternative desired intervals)[§§].

[§§] Normand S, Wang Y, Krumholz H. Assessing surrogacy of data sources for institutional comparisons. *Health Services and Outcomes Research Methodology.* 2007;7:79-96.

Appendix B. Annual Updates

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

2009 Measures Maintenance Report (Version 2.0)

1. Used three years of claims and enrollment data for public reporting.
    a. Rationale: Three years of data increased the precision of the hospital RSRR estimates by increasing the number of admissions used to calculate the rates. CMS developed the measures using one year of data.
2. Excluded patients discharged against medical advice (AMA).
    a. Rationale: Providers are not able to deliver full care and prepare the patient for discharge when patients leave AMA.
3. Updated CC map.
    a. Rationale: The ICD-9-CM CC map is updated annually to capture all relevant comorbidities coded in patient administrative claims data.

2010 Measures Maintenance Report (Version 3.0)

1. Revised period for collecting comorbidities from claims codes.
    a. Rationale: The revised models use comorbidities coded within 365 days of admission rather than 365 days of discharge. This includes more clinical covariates for risk adjustment.
2. Updated handling of admissions to psychiatric and rehabilitation hospitals in Maryland.
    a. Rationale: Psych and rehab hospitals in Maryland have the same provider ID number as acute care hospitals. Therefore, readmissions to Maryland hospitals are not counted as readmissions if their principal diagnoses code begins within 30 days of the index discharge. The criteria for identifying such admissions are available in the 2010 Measures Maintenance Report.
3. Updated CC map.
    a. Rationale: The ICD-9-CM CC map is updated annually to capture all relevant comorbidities coded in patient administrative claims data.

2011 Measures Maintenance Report (Version 4.0)

1. Added two pneumonia codes (482.42 and 488.11).
    a. Rationale: CMS updated ICD-9 cohort codes to distinguish between Methicillin susceptible and resistant Staphylococcus aureus pneumonia(482.41 and 482.42), and added a new code for viral pneumonia cases (488.11) to reflect the emergence of H1N1 influenza virus.
2. Included VA hospitals.
    a. Rationale: Creates a more inclusive perspective of the relative quality of US hospitals.
3. Updated CC map.
    a. Rationale: The ICD-9-CM CC map is updated annually to capture all relevant comorbidities coded in patient administrative claims data.

2012 Measures Maintenance Report (Version 5.0)

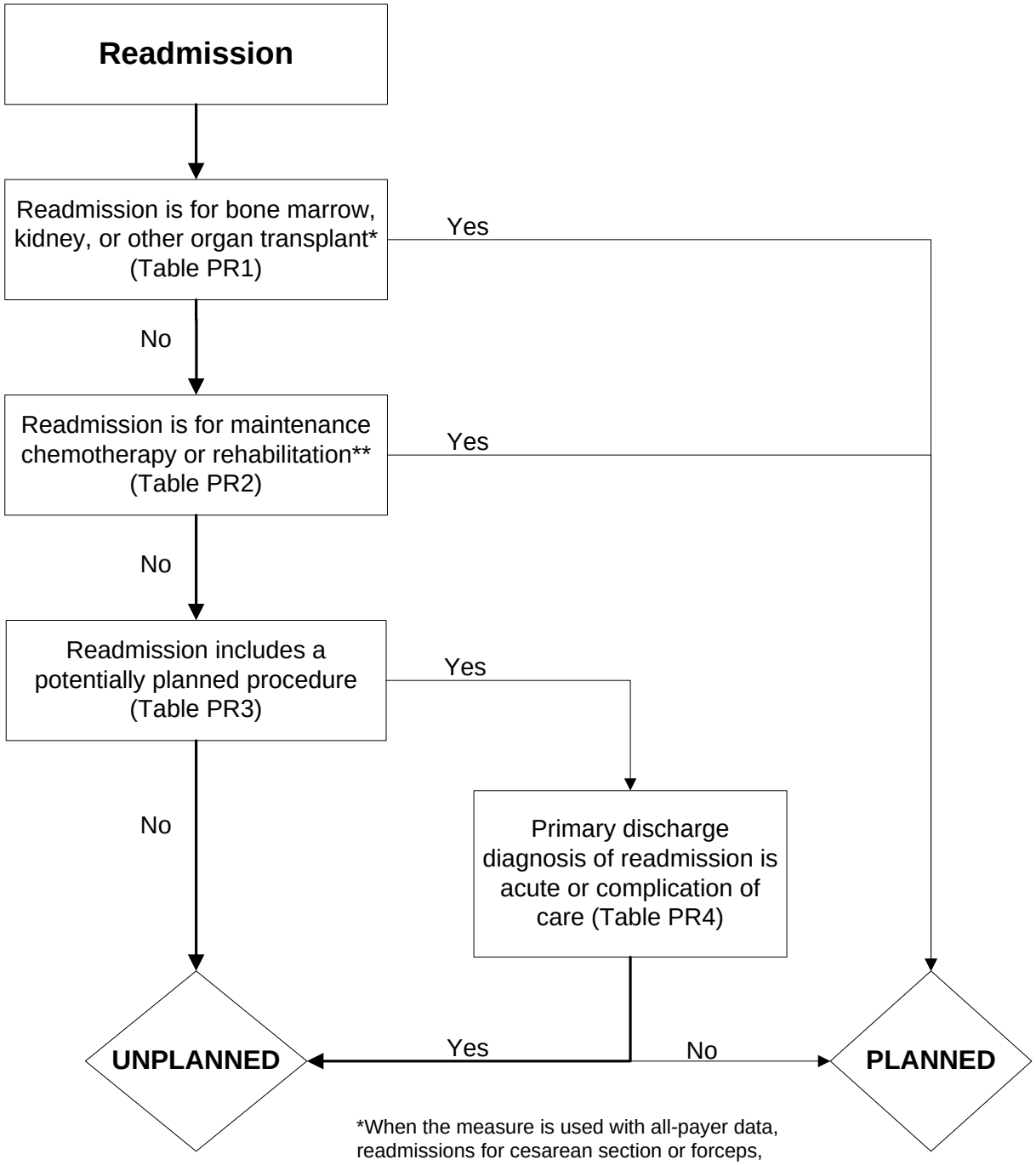
1. Included VA one-day stays.
    a. Rationale: Stays of less than 24 hours that result in death, discharge against medical advice, transfer (or follow a transfer) are not likely to be observation stays because the time frame of the admissions was determined not by clinical necessity but by other factors such as death or transfer. These stays had been previously excluded from the measure.
2. Incorporated Version 5010 format.
    a. Rationale: Version 5010 increased the number of diagnoses and procedures hospitals could code on Medicare claims. The inclusion of 15 additional codes for diagnoses and 19 additional codes for procedures allows us to identify additional comorbidities, thereby increasing the accuracy of risk adjustment.
3. Updated CC map.
    a. Rationale: The ICD-9-CM CC map is updated annually to capture all relevant comorbidities coded in patient administrative claims data.

2013 Measures Maintenance Report (Version 6.0)

1. Respecified the measures by adding the CMS Planned Readmission Algorithm (Version 2.1-General Population).
    a. Rationale: Unplanned readmissions are acute clinical events experienced by a patient that require urgent rehospitalization. In contrast, planned readmissions are generally not a signal of quality of care. Including planned readmissions in a readmission measure could create a disincentive to provide appropriate care to patients who are scheduled for elective or necessary procedures within 30 days of discharge.
2. Updated CC map.
    a. Rationale: The ICD-9-CM CC map is updated annually to capture all relevant comorbidities coded in patient administrative claims data.

Appendix C. Planned Readmission Algorithm

Figure PR1: Planned Readmission Algorithm Version 2.1 – Flowchart



*When the measure is used with all-payer data, readmissions for cesarean section or forceps, vacuum, or breech delivery are considered planned

**When the measure is used with all-payer data, readmissions for forceps or normal delivery are considered planned

Planned Readmission Algorithm Version 2.1 Tables – AMI, HF, Pneumonia Measures

Table PR 1 - Procedure Categories that are Always Planned (Version 2.1 – General Population)

Procedure CCS	Description
64	Bone marrow transplant
105	Kidney transplant
134	Cesarean section[***]
135	Forceps; vacuum; and breech delivery[†††]
176	Other organ transplantation

Table PR 2 - Diagnosis Categories that are Always Planned (Version 2.1 – General Population)

Diagnosis CCS	Description
45	Maintenance chemotherapy
194	Forceps delivery[‡‡‡]
196	Normal pregnancy and/or delivery[§§§]
254	Rehabilitation

[***] CCS to be included only in all-payer settings, not intended for inclusion in CMS' claims-based readmission measures for Medicare fee-for-service beneficiaries aged 65+ years

[†††] CCS to be included only in all-payer settings, not intended for inclusion in CMS' claims-based readmission measures for Medicare fee-for-service beneficiaries aged 65+ years

[‡‡‡] CCS to be included only in all-payer settings, not intended for inclusion in CMS' claims-based readmission measures for Medicare fee-for-service beneficiaries aged 65+ years

[§§§] CCS to be included only in all-payer settings, not intended for inclusion in CMS' claims-based readmission measures for Medicare fee-for-service beneficiaries aged 65+ years

Table PR 3 - Potentially Planned Procedure Categories (Version 2.1 – General Population)

Procedure CCS	Description
3	Laminectomy; excision intervertebral disc
5	Insertion of catheter or spinal stimulator and injection into spinal
9	Other OR therapeutic nervous system procedures
10	Thyroidectomy; partial or complete
12	Other therapeutic endocrine procedures
33	Other OR therapeutic procedures on nose; mouth and pharynx
36	Lobectomy or pneumonectomy
38	Other diagnostic procedures on lung and bronchus
40	Other diagnostic procedures of respiratory tract and mediastinum
43	Heart valve procedures
44	Coronary artery bypass graft (CABG)
45	Percutaneous transluminal coronary angioplasty (PTCA)
47	Diagnostic cardiac catheterization; coronary arteriography
48	Insertion; revision; replacement; removal of cardiac pacemaker or cardioverter/defibrillator
49	Other OR heart procedures
51	Endarterectomy; vessel of head and neck
52	Aortic resection; replacement or anastomosis
53	Varicose vein stripping; lower limb
55	Peripheral vascular bypass
56	Other vascular bypass and shunt; not heart
59	Other OR procedures on vessels of head and neck
62	Other diagnostic cardiovascular procedures
66	Procedures on spleen
67	Other therapeutic procedures; hemic and lymphatic system
74	Gastrectomy; partial and total
78	Colorectal resection
79	Local excision of large intestine lesion (not endoscopic)
84	Cholecystectomy and common duct exploration
85	Inguinal and femoral hernia repair
86	Other hernia repair
99	Other OR gastrointestinal therapeutic procedures
104	Nephrectomy; partial or complete
106	Genitourinary incontinence procedures
107	Extracorporeal lithotripsy; urinary
109	Procedures on the urethra
112	Other OR therapeutic procedures of urinary tract
113	Transurethral resection of prostate (TURP)

Procedure CCS	Description
114	Open prostatectomy
119	Oophorectomy; unilateral and bilateral
120	Other operations on ovary
124	Hysterectomy; abdominal and vaginal
129	Repair of cystocele and rectocele; obliteration of vaginal vault
132	Other OR therapeutic procedures; female organs
142	Partial excision bone
152	Arthroplasty knee
153	Hip replacement; total and partial
154	Arthroplasty other than hip or knee
157	Amputation of lower extremity
158	Spinal fusion
159	Other diagnostic procedures on musculoskeletal system
166	Lumpectomy; quadrantectomy of breast
167	Mastectomy
169	Debridement of wound; infection or burn
170	Excision of skin lesion
172	Skin graft
211	Therapeutic radiology for cancer treatment
224	Cancer chemotherapy
ICD-9 Codes	**Description**
30.1, 30.29, 30.3, 30.4, 31.74, 34.6	Laryngectomy, revision of tracheostomy, scarification of pleura (from Proc CCS 42- Other OR Rx procedures on respiratory system and mediastinum)
38.18	Endarterectomy leg vessel (from Proc CCS 60- Embolectomy and endarterectomy of lower limbs)
55.03, 55.04	Percutaneous nephrostomy with and without fragmentation (from Proc CCS 103- Nephrotomy and nephrostomy)
94.26, 94.27	Electroshock therapy (from Proc CCS 218- Psychological and psychiatric evaluation and therapy)

Table PR 4 - Acute Diagnosis Categories (Version 2.1 – General Population)

Diagnosis CCS	Description
1	Tuberculosis
2	Septicemia (except in labor)
3	Bacterial infection; unspecified site
4	Mycoses
5	HIV infection
7	Viral infection
8	Other infections; including parasitic
9	Sexually transmitted infections (not HIV or hepatitis)
54	Gout and other crystal arthropathies
55	Fluid and electrolyte disorders
60	Acute posthemorrhagic anemia
61	Sickle cell anemia
63	Diseases of white blood cells
76	Meningitis (except that caused by tuberculosis or sexually transmitted disease)
77	Encephalitis (except that caused by tuberculosis or sexually transmitted disease)
78	Other CNS infection and poliomyelitis
82	Paralysis
83	Epilepsy; convulsions
84	Headache; including migraine
85	Coma; stupor; and brain damage
87	Retinal detachments; defects; vascular occlusion; and retinopathy
89	Blindness and vision defects
90	Inflammation; infection of eye (except that caused by tuberculosis or sexually transmitted disease)
91	Other eye disorders
92	Otitis media and related conditions
93	Conditions associated with dizziness or vertigo
100	Acute myocardial infarction (with the exception of ICD-9 codes 410.x2)
102	Nonspecific chest pain
104	Other and ill-defined heart disease
107	Cardiac arrest and ventricular fibrillation
109	Acute cerebrovascular disease
112	Transient cerebral ischemia
116	Aortic and peripheral arterial embolism or thrombosis
118	Phlebitis; thrombophlebitis and thromboembolism
120	Hemorrhoids
122	Pneumonia (except that caused by TB or sexually transmitted disease)
123	Influenza
124	Acute and chronic tonsillitis
125	Acute bronchitis

Diagnosis CCS	Description
126	Other upper respiratory infections
127	Chronic obstructive pulmonary disease and bronchiectasis
128	Asthma
129	Aspiration pneumonitis; food/vomitus
130	Pleurisy; pneumothorax; pulmonary collapse
131	Respiratory failure; insufficiency; arrest (adult)
135	Intestinal infection
137	Diseases of mouth; excluding dental
139	Gastroduodenal ulcer (except hemorrhage)
140	Gastritis and duodenitis
142	Appendicitis and other appendiceal conditions
145	Intestinal obstruction without hernia
146	Diverticulosis and diverticulitis
148	Peritonitis and intestinal abscess
153	Gastrointestinal hemorrhage
154	Noninfectious gastroenteritis
157	Acute and unspecified renal failure
159	Urinary tract infections
165	Inflammatory conditions of male genital organs
168	Inflammatory diseases of female pelvic organs
172	Ovarian cyst
197	Skin and subcutaneous tissue infections
198	Other inflammatory condition of skin
225	Joint disorders and dislocations; trauma-related
226	Fracture of neck of femur (hip)
227	Spinal cord injury
228	Skull and face fractures
229	Fracture of upper limb
230	Fracture of lower limb
232	Sprains and strains
233	Intracranial injury
234	Crushing injury or internal injury
235	Open wounds of head; neck; and trunk
237	Complication of device; implant or graft
238	Complications of surgical procedures or medical care
239	Superficial injury; contusion
240	Burns
241	Poisoning by psychotropic agents
242	Poisoning by other medications and drugs
243	Poisoning by nonmedicinal substances

Diagnosis CCS	Description
244	Other injuries and conditions due to external causes
245	Syncope
246	Fever of unknown origin
247	Lymphadenitis
249	Shock
250	Nausea and vomiting
251	Abdominal pain
252	Malaise and fatigue
253	Allergic reactions
259	Residual codes; unclassified
650	Adjustment disorders
651	Anxiety disorders
652	Attention-deficit, conduct, and disruptive behavior disorders
653	Delirium, dementia, and amnestic and other cognitive disorders
656	Impluse control disorders, NEC
658	Personality disorders
660	Alcohol-related disorders
661	Substance-related disorders
662	Suicide and intentional self-inflicted injury
663	Screening and history of mental health and substance abuse codes
670	Miscellaneous disorders
ICD-9 codes	**Description**
Acute ICD-9 codes within Dx CCS 97: Peri-; endo-; and myocarditis; cardiomyopathy	
03282	Diphtheritic myocarditis
03640	Meningococcal carditis nos
03641	Meningococcal pericarditis
03642	Meningococcal endocarditis
03643	Meningococcal myocarditis
07420	Coxsackie carditis nos
07421	Coxsackie pericarditis
07422	Coxsackie endocarditis
07423	Coxsackie myocarditis
11281	Candidal endocarditis
11503	Histoplasma capsulatum pericarditis
11504	Histoplasma capssulatum endocarditis
11513	Histoplasma duboisii pericarditis
11514	Histoplasma duboisii endocarditis
11593	Histoplasmosis pericarditis
11594	Histoplasmosis endocarditis
1303	Toxoplasma myocarditis
3910	Acute rheumatic pericarditis
3911	Acute rheumatic endocarditis

Diagnosis CCS	Description
3912	Acute rheumatic myocarditis
3918	Acute rheumatic heart disease nec
3919	Acute rheumatic heart disease nos
3920	Rheumatic chorea w heart involvement
3980	Rheumatic myocarditis
39890	Rheumatic heart disease nos
39899	Rheumatic heart disease nec
4200	Acute pericarditis in other disease
42090	Acute pericarditis nos
42091	Acute idiopath pericarditis
42099	Acute pericarditis nec
4210	Acute/subacute bacterial endocarditis
4211	Acute endocarditis in other diseases
4219	Acute/subacute endocarditis nos
4220	Acute myocarditis in other diseases
42290	Acute myocarditis nos
42291	Idiopathic myocarditis
42292	Septic myocarditis
42293	Toxic myocarditis
42299	Acute myocarditis nec
4230	Hemopericardium
4231	Adhesive pericarditis
4232	Constrictive pericarditis
4233	Cardiac tamponade
4290	Myocarditis nos
Acute ICD-9 codes within Dx CCS 105: Conduction disorders	
4260	Atrioventricular
42610	Atrioventricular block nos
42611	Atrioventricular block-1st degree
42612	Atrioventricular block-mobitz ii
42613	Atrioventricular block-2nd degree nec
4262	Left bundle branch hemiblock
4263	Left bundle branch block nec
4264	Right bundle branch block
42650	Bundle branch block nos
42651	Right bundle branch block/left posterior fascicular block
42652	Right bundle branch block/left ant fascicular block
42653	Bilateral bundle branch block nec
42654	Trifascicular block
4266	Other heart block
4267	Anomalous atrioventricular excitation
42681	Lown-ganong-levine syndrome

Diagnosis CCS	Description
42682	Long qt syndrome
4269	Conduction disorder nos
Acute ICD-9 codes within Dx CCS 106: Dysrhythmia	
4272	Paroxysmal tachycardia nos
7850	Tachycardia nos
42789	Cardiac dysrhythmias nec
4279	Cardiac dysrhythmia nos
42769	Premature beats nec
Acute ICD-9 codes within Dx CCS 108: Congestive heart failure; nonhypertensive	
39891	Rheumatic heart failure
4280	Congestive heart failure
4281	Left heart failure
42820	Unspecified systolic heart failure
42821	Acute systolic heart failure
42823	Acute on chronic systolic heart failure
42830	Unspecified diastolic heart failure
42831	Acute diastolic heart failure
42833	Acute on chronic diastolic heart failure
42840	Unspec combined syst & dias heart failure
42841	Acute combined systolic & diastolic heart failure
42843	Acute on chronic combined systolic & diastolic heart failure
4289	Heart failure nos

Appendix D. Common Terms

Cohort: The index admissions included in the measure after the inclusion and exclusion criteria have been applied.

Complications: Medical conditions that likely occurred as a consequence of care rendered, rather than as an expected outcome of the patient's condition or a condition that the patient had upon presentation to the hospital.

Comorbidities: Medical conditions that the patient had in addition to their primary disease.

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

Expected readmissions: The number of readmissions expected on the basis of average hospital performance with a given hospital's case mix.

Hierarchical model: A widely accepted statistical method that enables fair evaluation of relative hospital performance by taking into account patient risk factors as well as the number of patients that a hospital treats. This statistical model accounts for the structure of the data (patients clustered within hospitals) and calculates: (1) how much variation in hospital readmission 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 readmission risk.

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

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

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

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

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

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

Planned readmissions: A readmission within 30 days of discharge from an acute care hospital that is a scheduled part of the patient's plan of care. Planned readmissions are not counted as outcomes in these measures.

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

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

Unplanned readmissions: Acute clinical events experienced by a patient that require urgent rehospitalization. Unplanned readmissions are counted as outcomes in these measures.

Appendix E. RTI Memorandum

MEMORANDUM

From: RTI International
To: CMS/CCSQ
Date: December 24, 2012

Subject: Overview of update of mappings of ICD-9-CM codes to CC groups for risk adjustment of hospital mortality and readmission models, changes related to FY2012 codes. This is in the context of creating a mapping covering FY2008 – FY2012 to the CC diagnosis clusters.

Overview

Each year the CDC National Center for Health Statistics and the Centers for Medicare & Medicaid Services oversee the changes and modifications to the ICD-9-CM system made through the Coordination and Maintenance Committee. The committee is a joint public-private effort to update and improve the coding system.

RTI has developed and supported a classification system that uses these codes as the basis for risk-adjustment systems. The Hierarchical Condition Category (HCC) system groups the ICD-9-CM codes into larger groups that are used in a model to predict medical care utilization, spending, mortality or other related measures. The condition categories (CCs) may also be used without applying the hierarchies that are used to categorize a person's medical conditions into the highest severity category of a set of related conditions. For this project the full set of 189 CCs in version 12 were updated for FY2012 changes and the changes were documented.

New ICD-9 codes generally become effective October 1 of each year, though there is a round of changes that may be made in an April announcement. Each calendar year of diagnosis data encompasses 2 years of codes. In the new mappings codes valid in FY2008 through FY2012 are all mapped to CCs. This allows the mapping to fully cover data from October 1, 2007 through September 30, 2012. These codes span CY2008 through CY2011 and the first nine months of 2012. The last three months of 2012 fall into FY2013.

Method

Additions and deletions

When the code changes are announced each year there may be both additions, deletions and changes to the descriptions of codes. We map only the valid codes, those of highest specificity, each year. ICD-9-CM codes have a minimum of three characters, mostly digits, and a maximum of five characters. The form is XXX, XXX.X or XXX.XX. [****] Code numbers after the decimal point are subclasses of the 3-digit main classes. An addition of new codes may be at any level from a new 3-digit class to new 4 and 5 digit subclasses. Deletions from ICD-9 may be explicit, the removal of a code from the code book. But

[****] In the Medicare data and our mappings the decimal points are omitted and all codes are left justified to remove ambiguity. The first character of a code may be an E or V as well as a digit.

deletions from our mapping occur more often because new, more specific, subcodes are introduced. Introduction of a new code of higher specificity than the code it sprang from does not remove the original 3- or 4- digit code from the ICD-9 book, but since coding is supposed to be done to the highest specificity, we remove the more general code from the mapping in the year it is superseded. If the new high specificity code is just an addition to an existing subset of codes of similar specificity, the new code is added but there would be no change in the status of the more general code. That code would have previously been superseded by higher specificity codes.

As an example, in 2012, code 0414, Bacterial infection in conditions classified elsewhere and of unspecified site, Escherichia coli [E.coli] was split into:

ICD-9	Short ICD-9 label
04141	Shiga txn-produce E.coli
04142	Shiga txn prod E.coli NEC
04143	Shiga txn prod E.coli NOS
04149	E.coli infection NEC/NOS

The new 5-digit codes were added to our mapping and were assigned to the same CC that 0414 was assigned to. The old 4-digit code would have been removed, except that 0414 was valid in 2008, 2009, 2010 and 2011. Since our mapping is intended to allow valid codes from those years, 0414 was retained.

In 2012 there were 168 codes added to ICD-9-CM. None were new 3-digit codes. Although there were a few 4-digit codes, the majority were of 5-digit specificity. The new 4-digit code groups were added with 5-digit detail. Among these there were 17 V-codes added but no E-codes. The V codes are for medical encounters but are not actual diagnoses of current conditions. The new 5-digit codes added more specificity within existing diagnostic code groups. In addition to the 0414 changes above another example is the 5 new codes in the ICD-9 code 5128 group, specifying particular types of pneumothorax. These were all mapped to the CC for "Pleural Effusion/Pneumothorax," where the nonspecific code was mapped previously. A more complicated situation is described in the *Mapping* section, below.

In FY 2012 there were 45 4-digit codes that were no longer at the highest specificity and are invalid starting that year. There was also one 3-digit code removed. However, the 46 codes are retained in our mapping because they were valid in the prior years covered by this mapping.

Mapping

Mapping of the new codes is done by review of the annual changes by RTI staff and clinical consultants. In most cases the codes of higher specificity are mapped to the same CC as the more general code that was split. This does not always occur. For example the ICD-9 code 9980 4-digit group was made invalid by the creation of 5-digit more specific codes. These are:

ICD-9	Short ICD-9 label	New CC	CC label
99800	Postoperative shock, NOS	164	Major Complications of Medical Care and Trauma
99801	Postop shock, cardiogenic	79	Cardio-Respiratory Failure and Shock
99802	Postop shock, septic	2	Septicemia/Shock
99809	Postop shock, other	164	Major Complications of Medical Care and Trauma

The original 4-digit code was assigned to CC 164. The more specific codes are not all assigned to that same CC. There is enough specificity to assign them to more specific CCs.

The general practice in maintaining the mappings for this work has been to maintain the existing structure of the CCs and to map the new codes to the location they would have gone to in prior years. However, sometimes the new specificity makes clear enough distinctions that new related codes do not all logically go to one place. Some new codes require judgment calls to be made. Our decision committee brings together both the people who maintain the integrity of the system and the people who provide the clinical expertise. The changes for FY2012 did not create a need for major changes but there were a few new 5-digit splits that did not all get assigned to the same CC.