2017 Condition-Specific Measures Updates and Specifications Report Hospital-Level 30-Day Risk-Standardized Excess Days in Acute Care Measures

Acute Myocardial Infarction – Version 2.0
Heart Failure – Version 2.0

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1. HOW TO USE THIS REPORT

This report describes the Centers for Medicare & Medicaid Services' (CMS's) condition-specific excess days in acute care (EDAC) measures used in the Hospital Inpatient Quality Reporting program and publicly reported on *Hospital Compare*. The measures report hospital-level 30-day risk-standardized EDAC following acute myocardial infarction (AMI) and heart failure (HF) admissions. This report serves as a single source of information about these measures for a wide range of readers. Reports describing other outcome measures can be found on *QualityNet*.

This report provides an overview of the measure methodology, methodology updates for 2017 public reporting, and the national results for 2017 public reporting. The appendices provide detailed specifications for each measure, including tables of codes used for cohort derivation and risk adjustment, as well as a history of annual updates.

Specifically, the report includes:

- **Section 2 – An overview of the AMI and HF EDAC measures:**
  - Background
  - Cohort inclusions and exclusions
    - Included and excluded hospitalizations
    - How transferred patients are handled
  - Outcome
  - Risk-adjustment variables
  - Data sources
  - EDAC calculation
  - Categorization of hospitals' performance score

- **Section 3 – 2017 measure updates**

- **Section 4 – 2017 measure results**

- **Section 5 - Glossary**

The Appendices contain detailed measure information, consisting of:

- Appendix A: Statistical approach to calculating EDACs;
- Appendix B: Data quality assurance (QA);
- Appendix C: Annual updates to the measures since measure development;
- Appendix D: Measure specifications including hyperlinks to certain ICD-10 code lists that are posted in supplemental Excel files on QualityNet, due to volume; and,
- Appendix E: Detailed overview of the planned readmission algorithm.

The original and updated measure methodology reports are available in the 'Measure Methodology' section under the claims-based EDAC measures page of *QualityNet*.[1-4]

2. BACKGROUND AND OVERVIEW OF MEASURE METHODOLOGY

2.1 Background on EDAC Measures

In 2016, CMS provided hospitals with their results on the AMI and HF EDAC measures. These results were made available in the hospital-specific reports. In July 2017, CMS will begin publicly reporting these measures on *Hospital Compare* for the nation's non-federal short-term acute care hospitals (including Indian Health Services hospitals) and critical access hospitals.

CMS contracted with the Yale New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (YNHHSC/CORE) to update the AMI and HF EDAC measures for 2017 public reporting through a process of measure reevaluation. The measures are reevaluated annually in order to improve them by responding to stakeholder input and incorporating advances in science or changes in coding.

2.2 Overview of Measure Methodology

The 2017 risk-adjusted EDAC measures use specifications from the initial and updated measure methodology reports with refinements to the measures, as listed in Appendix C.[1-4] An overview of the methodology is presented in this section.

2.2.1 Cohort

Index Admissions Included in the Measures

An index admission is the hospitalization to which the EDAC outcome is attributed and includes admissions for patients:

- Having a principal discharge diagnosis of AMI or HF for each respective measure;
- Enrolled in Medicare fee-for-service (FFS) Part A and Part B for the 12 months prior to the date of the admission, and enrolled in Part A during the index admission;
- Aged 65 or over;
- Discharged alive from a non-federal short-term acute care hospital; and,
- Not transferred to another acute care facility.

The International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) codes used to define the cohort inclusions for each measure for discharges on or after October 1, 2015 are listed in Appendix D, in Table D.1.1 and Table D.2.1, for AMI and HF, respectively. ICD-9 code lists for discharges prior to October 1, 2015 can be found in the 2016 updated measure methodology reports posted on *QualityNet*.

Index Admissions Excluded from the Measures

The EDAC measures exclude index admissions for patients:

- Without at least 30 days post-discharge enrollment in Medicare FFS; or,
- Discharged against medical advice.

An additional exclusion criterion for the AMI cohort is that patients admitted and discharged on the same calendar day are excluded as index admissions because it is unlikely that these patients had clinically significant AMIs.

An additional exclusion criterion for the HF cohort is that patients with a procedure code for left ventricular assist device (LVAD) implantation or heart transplantation either during the index admission or in the 12 months prior to the index admission are excluded as index admissions because these patients represent a clinically distinct group. The International Classification of Diseases, 10th Revision, Procedure Coding System (ICD-10-PCS) codes used to identify LVAD and heart transplant procedures in claims for discharges on or after October 1, 2015 are posted on *QualityNet* due to volume. ICD-9 code lists for discharges prior to October 1, 2015 can be found in the 2016 updated measure methodology reports also posted on *QualityNet*.

Admissions for a condition within 30 days of discharge from an index admission for that same condition are excluded as index admissions.

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, claims for patients not listed in the Medicare enrollment database, and records with invalid provider IDs.

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

Patients Transferred between Hospitals

The measures consider multiple contiguous hospitalizations as a single acute episode of care. Transfer patients are identified by tracking claims for inpatient short-term acute care hospitalizations over time. To qualify as a transfer, the second inpatient admission must occur on the same day or the next calendar day following discharge from the first inpatient admission at a short-term acute care hospital. Cases that meet this criterion are considered transfers regardless of whether or not the first institution indicates intent to transfer the patient in the discharge disposition code.

To include an admission in the measure cohort, the patient must ultimately be discharged to a non-acute care setting (for example, to home or a skilled nursing facility). Thus, for patients transferred from one short-term acute care hospital to another, only the last admission in the transfer chain is eligible for inclusion in the cohort. The previous admissions are not included. For example, if a patient is admitted to Hospital A, transferred to Hospital B, and then discharged from Hospital B to a non-acute care setting, the Hospital B admission would be included in the cohort, and all ED visits, observation stays, and unplanned readmissions within 30 days of discharge from the Hospital B admission would be captured in Hospital B's outcome.

2.2.2 Outcome

All-Cause Days in Acute Care

The measures assess the number of days the patient spends in acute care in the 30 days after discharge. Days in acute care are defined as days spent in an emergency department (ED), admitted to observation status, or admitted as an unplanned readmission for any cause to a short-term acute care hospital:

Each ED visit is counted as one half-day (0.5 days). See Table D.3.1 in Appendix D for the code definitions for ED visits.

Observation stays are recorded in terms of hours and converted for the measure into half-days (rounded up). See Table D.3.1 in Appendix D for the code definitions for observation stays. The codes capture all post-discharge observation stays using both facility and physician data.

A readmission is defined as any unplanned short-term acute care hospitalization within 30 days of the discharge date for the index admission. "Planned" readmissions are those planned by providers for anticipated medical treatment or procedures that must be provided in the inpatient setting. To exclude planned readmissions, the planned readmission algorithm previously developed for the publicly reported CMS 30-day AMI and HF readmission measures is used.[5] For more detail about how planned readmissions are defined, refer to Appendix E. Each unplanned readmission is counted according to the length of stay, which is calculated as the discharge date minus the admission date. Admissions that extend beyond the 30-day follow-up period are truncated on day 30.

When an ED visit, observation stay, or readmission overlaps with another event on the same day, only the most severe of the overlapping events is counted. For example, only a readmission day is counted if the readmission and either an observation stay or ED visit happens on the same day; only an observation day is counted if an observation stay and an ED visit happen on the same day.

In capturing the total amount of time patients spend in acute care, the EDAC measures include ED visits and observation stays, in addition to readmissions, for several reasons:

- Having to return to the ED or spend time in the hospital under observation matters to patients.
- Including all types of acute care will provide more detailed information to consumers on what to expect following discharge.
- By capturing a range of outcomes that are important to patients, a more complete picture of post-discharge outcomes can be produced that better informs consumers about care quality and incentivizes global improvement in transitional care.
- The increasing use of ED visits and observation stays have raised concerns that the current CMS 30-day readmission measures do not capture the full range of unplanned acute care in the post-discharge period. In particular, there exists concern that high use of observation stays could in some cases replace readmissions, and hospitals with high rates of observation stays in the post-

discharge period may therefore have low readmission rates that do not accurately reflect the quality of care.

- Current readmission measures report readmissions only as a binary outcome (that is, any versus no readmission). However, some readmissions reflect severe deterioration requiring prolonged hospitalization while others involve only a brief, less acute hospitalization. Some patients have multiple visits in 30 days. Additionally, binary metrics do not account for each patient's opportunity for readmission: Patients who die post-discharge have less opportunity for readmission, but are counted as being at the same risk for readmission as those who survive the full measurement period. The EDAC measures address all of these gaps by including other outcomes (that is, ED visits and observation stays), by capturing the total amount of time patients spend in acute care, and by accounting for time at risk of an event (that is, survival time).

All-cause acute care utilization is measured for several reasons as well. First, from the patient perspective, acute care utilization for any cause is undesirable. Second, limiting the measures to acute care utilization for recurrent AMI or HF may make them susceptible to gaming. Moreover, it is often hard to exclude quality concerns and accountability based on the documented cause of a hospital visit.

Multiple Events

All eligible outcomes occurring in the 30-day period are counted, even if they are repeat occurrences. For example, if a patient returns to the ED three times on three different days, we count each ED visit as a half-day. Similarly, if a patient has two hospitalizations within 30 days, the days spent in each are counted. This approach is taken in order to capture the full patient experience in the post-discharge period.

30-Day Time Frame

The measures assess eligible outcomes within a 30-day period from the date of discharge from an index admission. The 30-day time frame is considered a clinically reasonable time frame for two reasons:

1. A number of studies have demonstrated that improvements in care at the time of patient discharge can reduce 30-day readmission rates.[6-17] Hospitals, in collaboration with their medical communities, can take a number of actions to reduce readmissions: ensure patients are clinically ready at discharge; reduce risk of infection; reconcile medications; improve communications among providers involved in transition of care; encourage strategies that promote disease management principles; and educate patients about symptoms to monitor, whom to contact with questions, and where and when to seek follow-up care.[6-17] Studies also show that it can take more than 14 days for the benefits of these interventions to appear.[14]

2. The 30-day time frame is consistent with the existing CMS 30-day AMI and HF readmission measures approved by NQF and publicly reported by CMS. Note that if a readmission or observation stay extends beyond 30 days, only that portion of the stay that occurs during the 30 days is included in the outcome. In addition, note that

for patients who did not survive 30 days, their total exposure period is adjusted to reflect the number of days they survived (as discussed below).

Exposure Time

Because some patients do not survive 30 days, not all patients are at risk for an acute event for the same amount of time. 'Exposure time' is calculated as the number of days each patient survived after discharge, up to 30. This exposure time was incorporated as part of the outcome to reflect differential risk for EDAC after discharge. This differs from the existing CMS AMI and HF 30-day readmission measures, which consider all patients to be equally at risk for a hospital event regardless of survival time.

2.2.3 Risk-Adjustment Variables

In order to account for differences in case mix among hospitals, the measures adjust for variables (for example, age, comorbid diseases, and indicators of patient frailty) that are clinically relevant and have relationships with the outcome. For each patient, risk-adjustment variables are obtained from inpatient, outpatient, and physician Medicare administrative claims data extending 12 months prior to, and including, the index admission.

The measures 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 socioeconomic status (SES) because the association between SES and health outcomes can be due, in part, to differences in the quality of health care that groups of patients with varying SES receive. The intent is for the measures to adjust for patient demographic and clinical characteristics while illuminating important quality differences. As part of the NQF's endorsement process for these measures, we completed analyses for the two-year Sociodemographic Trial Period. Although univariate analyses found that the mean patient-level observed days in acute care is higher for dual-eligible patients (for patients living in lower AHRQ SES Index census block groups) and African-American patients compared with all other patients, analyses in the context of a multivariable model demonstrated that the effect size of these variables was small, and that the c-statistics for the logit part of the models and the deviance R^2 values for the Poisson part of the models are similar with and without the addition of these variables.

Refer to Table D.1.2 and Table D.2.2 in Appendix D of this report for the list of comorbidity risk-adjustment variables and the list of complications that are excluded from risk adjustment if they occur only during the index admission, for AMI and HF, respectively. The Condition Categories (CCs) outlined in these tables are used to identify risk variables in claims for discharges on or after October 1, 2015 as well as discharges prior to October 1, 2015. The ICD-10 code lists referenced in the tables that are used to identify certain risk variables (for example, history of PTCA) in discharges on or after

October 1, 2015 are posted on *QualityNet* due to volume. For a list of ICD-9 codes used to identify these variables in discharges prior to October 1, 2015, please refer to the 2016 updated measure methodology reports posted on *QualityNet*.

Note that CC mappings to ICD-10-CM codes (for discharges on or after October 1, 2015) and ICD-9 codes (for discharges prior to October 1, 2015) are available on the *QualityNet* website.

2.2.4 Data Sources

The data sources for these analyses are Medicare administrative claims and enrollment information for patients with hospitalizations between July 1, 2013 and June 30, 2016. The datasets also contain associated inpatient, outpatient, and physician Medicare administrative claims for the 12 months prior to the index admission and for the 30 days post-discharge for calculation of the ED visits and observation days. Refer to the original and updated measure methodology reports for further descriptions of these data sources and an explanation of the three-year measurement period.[1-4]

2.2.5 Measure Calculation

The measures estimate hospital-level 30-day all-cause EDAC for each condition using hierarchical generalized linear models. These models take into account risk-adjustment variables.

Specifically, CMS calculates EDAC, for each hospital, as the difference ("excess") between a hospital's predicted days and expected days per 100 discharges. "Predicted days" is the average number of days a hospital's patients spent in acute care after adjusting for the risk factors (Tables D.1.2 and Table D.2.2, for the AMI and HF measures, respectively). "Expected days" is the average number of risk-adjusted days in acute care a hospital's patients would have been expected to spend if discharged from an average performing hospital with the same case mix. To be consistent with the reporting of the CMS 30-day AMI and HF readmission measures, CMS multiplies the measure result by 100 such that the final EDAC measures represent EDAC per 100 discharges.

To assess hospital performance for each reporting period, we re-estimate the parameter estimates using the years of data in that period.

The hierarchical generalized linear models are described fully in Appendix A and in the original methodology reports.[1,2]

2.2.6 Categorizing Hospital Performance

To categorize hospital performance, CMS estimates each hospital's EDAC and the corresponding 95% credible interval (CI). CMS assigns hospitals to a performance category by comparing each hospital's EDAC credible interval to zero, which represents performance no different than expected. Comparative performance for hospitals with 25 or more eligible cases is classified as follows:

- "No different than expected" if the 95% CI surrounding the hospital's days includes zero.
- "More days than expected" if the entire 95% CI surrounding the hospital's days is above zero.
- "Fewer days than expected" if the entire 95% CI surrounding the hospital's days is below zero.

If a hospital has fewer than 25 eligible cases for a measure, CMS assigns the hospital to a separate category, "Number of cases too small". This category is used when 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 EDAC and parameter 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 reporting period.

3. UPDATES TO MEASURES FOR 2017 PUBLIC REPORTING

3.1 Rationale for Measure Updates

Annual measure reevaluation ensures that the risk-standardized days in acute care models are continually assessed and remain valid, given possible changes in clinical practice and coding standards over time. Modifications made to measure cohorts, risk models, and outcomes are informed by review of the most recent literature related to measure conditions or outcomes, feedback from various stakeholders, and empirical analyses including assessment of coding trends that reveal shifts in clinical practice or billing patterns. As this report describes, for 2017 public reporting, we made the following modifications to the measures:

- Revised the measure specifications to accommodate the implementation of ICD-10 coding:
  - Identified the ICD-10 codes used to define both of the measure cohorts for discharges on or after October 1, 2015.
  - Updated the planned readmission algorithm, by using the most recent (2016) version of the AHRQ ICD-10 Clinical Classification Software (CCS) and ICD-10 codes for certain "potentially planned procedures" and "acute diagnoses" to the algorithm specifications, for discharges on or after October 1, 2015.
  - Re-specified the risk models, updating the CC-based risk variables to the ICD-10-compatible Hierarchical Condition Categories (HCC) system version 22 and applying ICD-10 codes for certain risk variables (for example, history of PTCA) to the models.

As a part of annual reevaluation, we also undertook the following activities:

- Evaluated and validated model performance for the three years combined (July 2013-June 2016);
- Evaluated the stability of the risk-adjustment model over the three-year measurement period by examining the model variable frequencies in each year (July 2013-June 2014, July 2014-June 2015, and July 2015-June 2016); and,
- Updated the measures' SAS analytic package (SAS pack) and documentation.

3.2 Detailed Discussion of Measure Updates

3.2.1 Updates to ICD-10-Based Measure Specifications

Measure Re-specification

We re-specified the measures to accommodate the implementation of ICD-10 coding. Specifically:

- We expanded the cohort definitions to include ICD-10 codes for use with discharges on or after October 1, 2015. (Previously-specified ICD-9 codes continue to be used for discharges before October 1, 2015.)
- We updated the planned readmission algorithm for use with readmission claims for discharges on or after October 1, 2015:
  - The 2016 version of the AHRQ ICD-10 CCS was applied; and,

- Certain “potentially planned procedures” and “acute diagnoses” previously defined using ICD-9 codes were re-defined using ICD-10 codes.

- We re-specified the risk models:
  - The CC-based risk variables were updated to the ICD-10-compatible Hierarchical Condition Categories (HCC) system version 22, maintained by RTI International; and,
  - Certain risk variables (for example, history of PTCA) previously defined using ICD-9 codes were re-defined using ICD-10 codes, for use with inpatient, outpatient, and/or physician Medicare administrative claims on or after October 1, 2015.

Rationale for Measure Re-specification

On October 1, 2015, the ICD-9 code sets used to report medical diagnoses and inpatient procedures were replaced by ICD-10 code sets. The Department of Health and Human Services (HHS) has mandated that ICD-10 codes be used by all HIPAA-covered entities for medical coding, effective for October 1, 2015+ discharges. More information on ICD-10 coding can be found on the CMS website.

The condition-specific EDAC measures use Medicare FFS claims to define the measure cohorts, identify patient comorbidities for measure risk adjustment, and assess the outcome. In public reporting years prior to 2017, the measures exclusively used ICD-9 codes from claims. However, the measurement period for 2017 public reporting requires data from claims that include ICD-10 codes in addition to data from claims that include ICD-9 codes. Thus, re-specification of each of the above three components was warranted to accommodate ICD-10 coding.

The goal of this re-specification was to maintain the intent and validity of the measures.

The ICD-10 Transition Process

In developing the ICD-10 code lists that define the cohorts for the measures, we created cohort crosswalks using the General Equivalence Mappings (GEMs), a tool created by CMS and the Centers for Disease Control and Prevention (CDC) to assist with the conversion of ICD-9 codes to ICD-10 codes. To validate the cohort crosswalks, we compared cohort sizes using ICD-10 codes in a set of claims submitted between October 2015 and March 2016 with cohort sizes using previously-defined ICD-9 codes in a set of claims submitted between October 2014 and March 2015. We conducted clinical review to identify those codes appropriate for cohort definition.

In adopting the AHRQ ICD-10 CCS maps, experts examined both the condition and procedure code maps and created a crosswalk for the planned readmission algorithm. We subsequently examined frequencies of the “potentially planned procedures” and “acute diagnoses” re-defined using ICD-10 codes.

The risk variables were updated to the ICD-10-compatible HCC version 22 map. The intent was to keep the risk-adjustment model as similar as possible to the model previously defined using HCC version 12. Specifically:

- Experts examined the ICD-9 code-based HCC version 12 and version 22 maps and reviewed shifts that occurred (where an ICD-9 code had moved from one CC to another). Based on these examinations, they recommended new risk variables using version 22 CCs.
- Following re-specification of the risk variables using the HCC version 22 map, we ran risk-adjustment models on several outcome measures, to ensure testing of all variables where shifts in the ICD-9 codes included in the CCs had occurred.
- For each tested measure, we used the same claims dataset to calculate and compare two separate sets of measure results using two separate risk-adjustment models: One set using the previously-specified version 12 risk variables, and the other using the newly-specified version 22 risk variables. For this analysis we used the ICD-9-coded data from the 2016 measurement period.
  - We compared the frequencies and model coefficients of the two sets of risk-adjustment variables, to ensure that they were similar.
  - We compared the performance of each risk-adjustment model by calculating each model's c-statistic and predictive ability.
  - We examined the correlation in the risk-standardized outcome rates produced by the two risk-adjustment models, to ensure that they produced similar measure results.
  - We examined the degree to which the models produced similar risk-standardized outcome rates at the hospital level by assessing whether individual hospitals' risk-standardized rates fell into the same quintile in the distribution of risk-standardized rates calculated by each of the two models.
  - Based on the results of these analyses, we made minor modifications to the re-specified risk-adjustment variables to ensure that the performance of the risk-adjustment model was as similar as possible to the performance of the previously-specified model, and that the hospital-level results were as similar as possible.

The updated measure specifications can be found in Appendix D.

4. RESULTS FOR 2017 PUBLIC REPORTING

4.1 Assessment of Updated Models

The EDAC measures estimate hospital-specific 30-day all-cause EDAC using hierarchical generalized linear models. Refer to Section 2 for a summary of the measure methodology and model risk-adjustment variables. Refer to prior methodology reports for further details.[1-4]

We evaluated the performance of the models using the July 2013 to June 2016 data for the 2017 reporting period. We examined the differences in the frequencies of patient risk factors and the model parameter estimates.

For both of the conditions, we assessed the overall fit of the model using posterior predictive checking (PPC) for the three-year combined period. For the logit model of zero versus non-zero days, which includes all patients in the cohort, we calculated the c-statistic. For the truncated Poisson model of non-zero days, which includes only patients with some acute care, we calculated the deviance R^2. The deviance R^2 is computed from the difference in the log-likelihoods between the final model and an empty model (no covariates) attributed to each observation, averaged over all observations.[18]

The results of these analyses for the AMI and HF measures are presented in Section 4.2 and Section 4.3, respectively.

4.2 AMI EDAC 2017 Model Results

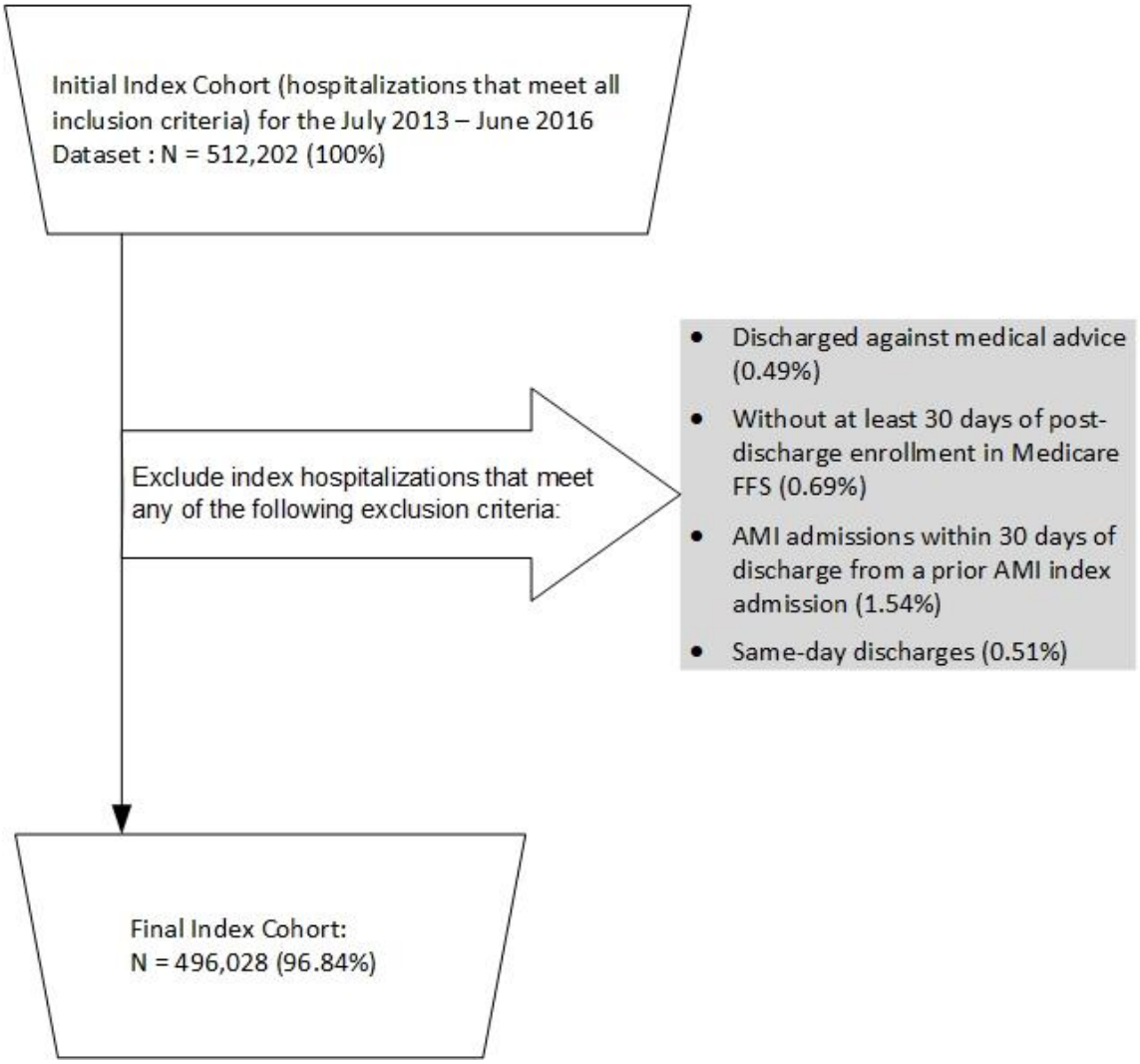
4.2.1 Index Cohort Exclusions

The exclusion criteria for this measure are presented in Section 2.2.1. The percentage of AMI admissions that met each exclusion criterion in the July 2013-June 2016 dataset is presented in Figure 4.2.1.

Admissions may have been counted in more than one exclusion category because they are not mutually exclusive. The index cohort includes short-term acute care hospitalizations for Medicare patients:

- Aged 65 or over;
- With a principal discharge diagnosis of AMI;
- Enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission;
- Who were not transferred to another acute care facility; and,
- Were alive at discharge.

Figure 4.2.1 - AMI Cohort Exclusions in the July 2013-June 2016 Dataset



4.2.2 Frequency of AMI Model Variables

We examined the change in the frequencies of clinical and demographic variables. Frequencies of model variables were quite stable over the measurement period. The largest changes in the frequencies (those greater than 2% absolute change) include:

- An increase in History of coronary artery bypass graft (CABG) surgery (11.9% to 14.1%)
- A decrease in Coronary atherosclerosis/other chronic ischemic heart disease (87.1% to 84.8%)

Refer to Table 4.2.1 for more detail. Note that the increases and decreases in some model variables may reflect not only changes in rates of comorbidities in the Medicare FFS population, but also changes due to ICD-10 code implementation effective with October 1, 2015+ discharges.

4.2.3 AMI Model Parameters and Performance

Table 4.2.2 shows the parameter estimates and 95% credible intervals (CIs) for the AMI days in acute care model for the combined three-year dataset. Table 4.2.3 shows the PPC results for the combined three-year dataset. The c-statistic for the logit part was 0.60 (Table 4.2.4). The deviance R^2 for the truncated Poisson part was 0.062.

4.2.4 Distribution of Hospital Volumes and EDAC for AMI

Between July 2013-June 2014 and July 2015-June 2016, the *observed* days in acute care decreased from 107.06 to 104.95.

Table 4.2.5 shows both unadjusted (observed) days of post-discharge events per 100 discharges and EDAC per 100 discharges for AMI. The median hospital EDAC in the combined three-year dataset was 0.015 (interquartile range [IQR]: -10.98 – 13.22). Figure 4.2.2 shows the overall distribution of the hospital EDAC for the three-year dataset.

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

Of 4,164 hospitals in the study cohort, 493 had ”More days than expected,” 1,436 were “No different than expected,” and 242 had ”Fewer days than expected.” 1,993 were classified as “Number of cases too small” (fewer than 25) to reliably tell how well the hospital is performing.

Table 4.2.1- Frequency of AMI Model Variables over Different Time Periods

Variable	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Total N	164,112	164,921	166,995	496,028
Mean age minus 65 (SD)	13.4 (8.4)	13.4 (8.4)	13.1 (8.3)	13.3 (8.3)
Male (%)	52.5	53.0	53.4	53.0
Anterior myocardial infarction	6.9	6.6	6.6	6.7
Other location of myocardial infarction	11.1	10.8	12.9	11.6

Variable	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
History of coronary artery bypass graft (CABG) surgery	11.9	12.2	14.1	12.8
History of percutaneous transluminal coronary angioplasty (PTCA)	18.9	20.0	20.5	19.8
Severe infection; other infectious diseases (CC 1, 3-7)	26.4	26.3	25.9	26.2
Metastatic cancer or acute leukemia (CC 8)	1.9	2.0	2.0	2.0
Cancer (CC 9-14)	18.9	18.9	18.7	18.8
Diabetes mellitus (DM) or DM complications (CC 17-19, 122-123)	47.6	47.6	47.9	47.7
Protein-calorie malnutrition (CC 21)	6.1	6.2	6.2	6.2
Other significant endocrine and metabolic disorders; disorders of fluid/electrolyte/acid-base balance (CC 23-24)	27.5	27.6	27.6	27.6
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	47.4	47.3	46.7	47.1
Dementia or other specified brain disorders (CC 51-53)	19.2	19.0	18.4	18.9
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	4.8	4.8	5.0	4.9
Congestive heart failure (CC 85)	30.9	30.5	30.5	30.6
Acute coronary syndrome (CC 86-87)	21.5	20.6	21.5	21.2
Angina pectoris (CC 88)	9.2	8.9	8.2	8.8
Coronary atherosclerosis/other chronic ischemic heart disease (CC 89)	87.1	87.0	84.8	86.3
Valvular and rheumatic heart disease (CC 91)	32.0	32.6	32.5	32.4
Specified arrhythmias and other heart rhythm disorders (CC 96-97)	35.5	35.6	35.8	35.7
Stroke (CC 99-100)	7.1	6.9	6.8	6.9
Cerebrovascular disease (CC 101-102, 105)	22.0	21.4	20.5	21.3
Vascular or circulatory disease (CC 106-109)	35.9	35.7	35.6	35.7
Chronic obstructive pulmonary disease (COPD) (CC 111)	30.2	30.1	29.4	29.9
Asthma (CC 113)	7.0	7.1	8.7	7.6
Pneumonia (CC 114-116)	22.0	22.1	20.9	21.6
Dialysis status (CC 134)	3.4	3.5	3.6	3.5
Renal failure (CC 135-140)	38.5	39.5	40.1	39.4
Other urinary tract disorders (CC 145)	20.0	19.6	18.9	19.5
Decubitus ulcer or chronic skin ulcer (CC 157-161)	7.7	7.5	7.4	7.5

Table 4.2.2 - Median Parameter Estimates and Credible Intervals (CIs) of Risk Variables from the Logit and Poisson Models for AMI (July 2013-June 2016)

Variable	Part 1: Logit Model		Part 2: Poisson Model	
	Median	CI	Median	CI
Age minus 65 (years above 65, continuous)	0.0058	(0.0048, 0.0066)	0.0031	(0.0027, 0.0036)
Male	-0.1052	(-0.1172, -0.0935)	0.0052	(0.0001, 0.0107)
Anterior myocardial infarction	0.1900	(0.1646, 0.2129)	0.1331	(0.1219, 0.1434)
Other location of myocardial infarction	-0.0030	(-0.0246, 0.0197)	-0.0503	(-0.0612, -0.0397)
History of coronary artery bypass graft (CABG) surgery	-0.0103	(-0.0306, 0.0071)	-0.0409	(-0.0494, -0.0319)

Variable	Part 1: Logit Model		Part 2: Poisson Model	
	Median	CI	Median	CI
History of percutaneous transluminal coronary angioplasty (PTCA)	-0.0470	(-0.0634, -0.0313)	-0.0308	(-0.0382, -0.0230)
Severe infection; other infectious diseases (CC 1, 3-7)	0.0435	(0.0288, 0.0595)	-0.0038	(-0.0104, 0.0033)
Metastatic cancer or acute leukemia (CC 8)	0.2670	(0.2218, 0.3136)	0.1074	(0.0896, 0.1274)
Cancer (CC 9-14)	0.0421	(0.0258, 0.0593)	-0.0115	(-0.0193, -0.0037)
Diabetes mellitus (DM) or DM complications (CC 17-19, 122-123)	0.0961	(0.0811, 0.1095)	0.0927	(0.0859, 0.0988)
Protein-calorie malnutrition (CC 21)	0.1284	(0.1052, 0.1546)	0.1538	(0.1441, 0.1645)
Other significant endocrine and metabolic disorders; disorders of fluid/electrolyte/acid-base balance (CC 23-24)	0.1275	(0.1109, 0.1436)	0.0285	(0.0204, 0.0362)
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	0.1452	(0.1288, 0.1587)	0.1777	(0.171, 0.1852)
Dementia or other specified brain disorders (CC 51-53)	0.0798	(0.0656, 0.0981)	-0.0208	(-0.0295, -0.0129)
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	0.1001	(0.0731, 0.1301)	0.0474	(0.0356, 0.0587)
Congestive heart failure (CC 85)	0.1349	(0.1185, 0.149)	0.0804	(0.073, 0.0889)
Acute coronary syndrome (CC 86-87)	0.0235	(0.006, 0.0409)	-0.0473	(-0.0534, -0.0401)
Angina pectoris (CC 88)	0.0660	(0.0428, 0.088)	-0.0404	(-0.0502, -0.0308)
Coronary atherosclerosis/other chronic ischemic heart disease (CC 89)	0.0326	(0.0117, 0.0526)	-0.0234	(-0.0324, -0.0129)
Valvular and rheumatic heart disease (CC 91)	0.0805	(0.0658, 0.0952)	0.0699	(0.0641, 0.0756)
Specified arrhythmias and other heart rhythm disorders (CC 96-97)	0.0953	(0.0822, 0.1103)	-0.0029	(-0.0104, 0.0038)
Stroke (CC 99-100)	0.0256	(-0.0027, 0.0488)	0.0033	(-0.0074, 0.0144)
Cerebrovascular disease (CC 101-102, 105)	0.0616	(0.0443, 0.0786)	-0.0028	(-0.01, 0.0045)
Vascular or circulatory disease (CC 106-109)	0.0919	(0.0757, 0.106)	0.0279	(0.0223, 0.0351)
Chronic obstructive pulmonary disease (COPD) (CC 111)	0.1982	(0.1833, 0.2131)	0.1114	(0.1051, 0.1182)
Asthma (CC 113)	0.0484	(0.0249, 0.0748)	-0.0582	(-0.0695, -0.0479)
Pneumonia (CC 114-116)	0.1202	(0.1026, 0.1383)	0.1161	(0.1087, 0.1233)
Dialysis status (CC 134)	0.3410	(0.3101, 0.3733)	-0.0644	(-0.0759, -0.0525)
Renal failure (CC 135-140)	0.1412	(0.1266, 0.1565)	0.1680	(0.1601, 0.1749)

Variable	Part 1: Logit Model		Part 2: Poisson Model	
	Median	CI	Median	CI
Other urinary tract disorders (CC 145)	0.1002	(0.0854, 0.1168)	0.0141	(0.0066, 0.0212)
Decubitus ulcer or chronic skin ulcer (CC 157-161)	0.0691	(0.0447, 0.0925)	0.1044	(0.0956, 0.1137)

Table 4.2.3 - Posterior Predictive Checking (PPC) Results for AMI (July 2013-June 2016)

Statistic	Observed Days in Acute Care	MCMC 95% Credible Interval (CI) for Predicted Days in Acute Care	P-Value
Variance	0.9287	(0.7262, 0.9571)	0.6230
Median	0.9500	(1.000, 1.007)	<0.0001
Interquartile range (IQR)	0.7911	(0.6783, 0.7314)	<0.0001
Coefficient of variation	0.9400	(0.7839, 0.8789)	<0.0001

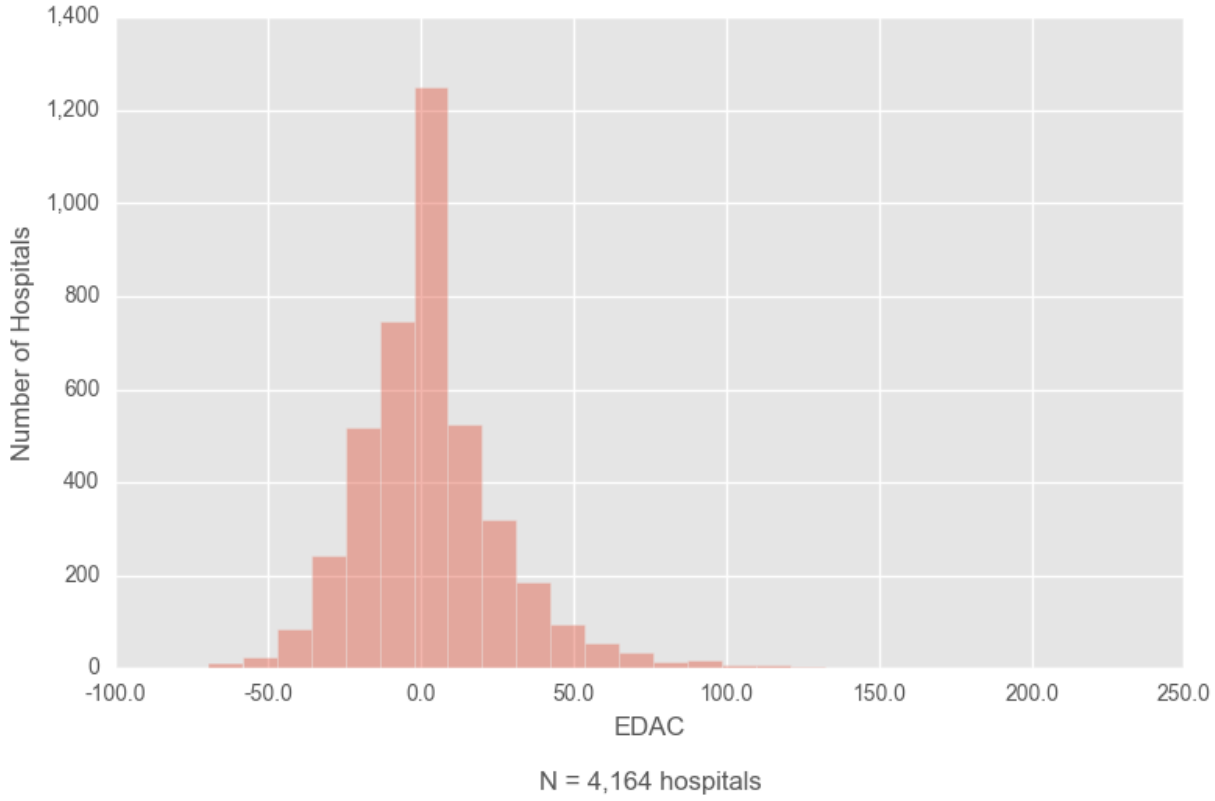
Table 4.2.4 - AMI Generalized Linear Modeling (Logistic Regression) Performance (July 2013-June 2016)

Characteristic	07/2013-06/2016
C-statistic (Logit part)	0.60
Deviance r-squared (Poisson part)	0.062

Table 4.2.5 - Hospital-Level Unadjusted Distribution of Overall Acute Care, ED Visits, Observation Stays, and Readmissions per 100 AMI Discharges, and Distribution of EDAC (July 2013-June 2016)

Description	Mean ± SD	Median (Q1, Q3)	Range
Observed days in acute care	102.53 (96.36)	95.00 (51.31, 130.38)	1650
Days of ED visits	9.96 (11.77)	8.14 (4.55, 11.78)	300
Days of observation stays	13.35 (23.36)	8.88 (0.00, 16.33)	450
Days of readmissions	83.66 (91.31)	75.76 (27.45, 110.15)	1400
EDAC	3.19 (24.76)	0.015 (-10.98, 13.22)	279.90
Days of predicted	108.29 (37.63)	103.76 (84.70, 126.52)	386.03
Days of expected	105.10 (28.20)	103.1 (91.61, 116.65)	317.45

Figure 4.2.2 - Hospital-Level EDAC per 100 Discharges for AMI for the July 2013-June 2016 Dataset



4.3 HF EDAC 2017 Model Results

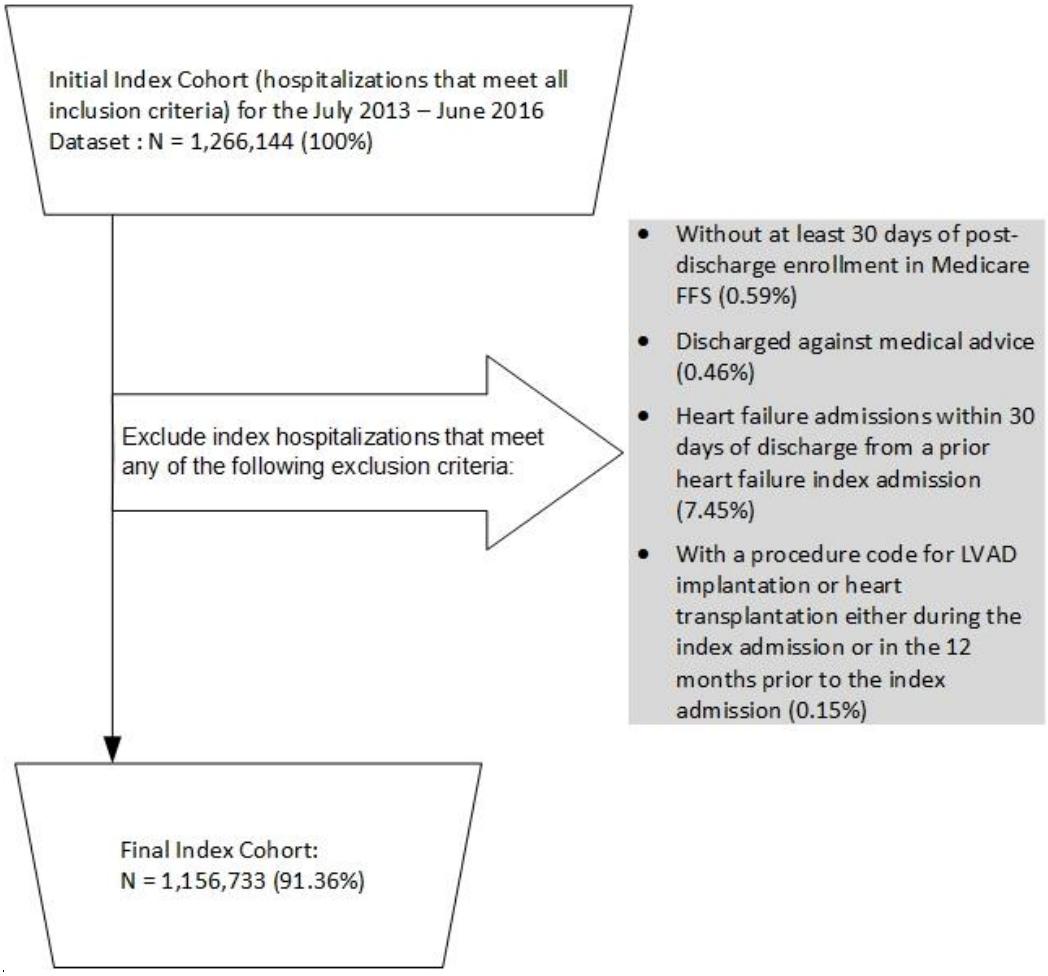
4.3.1 Index Cohort Exclusions

The exclusion criteria for this measure are presented in Section 2.2.1. The percentage of HF admissions that met each exclusion criterion in the July 2013-June 2016 dataset is presented in Figure 4.3.1.

Admissions may have been counted in more than one exclusion category because they are not mutually exclusive. The index cohort includes short-term acute care hospitalizations for Medicare patients:

- Aged 65 or over;
- With a principal discharge diagnosis of HF;
- Enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission;
- Who were not transferred to another acute care facility; and,
- Were alive at discharge.

Figure 4.3.1 - HF Cohort Exclusions in the July 2013-June 2016 Dataset



4.3.2 Frequency of HF Model Variables

We examined the change in the frequencies of clinical and demographic variables. Frequencies of model variables were quite stable over the measurement period. The largest changes in the frequencies (those greater than 2% absolute change) include:

- Increases in Asthma (10.1% to 13.3%), Cardio-respiratory failure and shock (29.9% to 33.7%), Other psychiatric disorders (21.1% to 23.6%), and Renal failure (62.8% to 65.0%)
- A decrease in Other urinary tract disorders (30.9% to 28.5%)

Refer to Table 4.3.1 for more detail. Note that the increases and decreases in some model variables may reflect not only changes in rates of comorbidities in the Medicare FFS population, but also changes due to ICD-10 code implementation effective with October 1, 2015+ discharges.

4.3.3 HF Model Parameters and Performance

Table 4.3.2 shows the parameter estimates and 95% CIs for the HF days in acute care model for the combined three-year dataset. Table 4.3.3 shows the PPC results for the combined three-year dataset. The c-statistic for the logit part was 0.60 (Table 4.3.4). The deviance R^2 for the truncated Poisson part was 0.029.

4.3.4 Distribution of Hospital Volumes and EDAC for HF

Between July 2013-June 2014 and July 2015-June 2016, the *observed* days in acute care increased from 142.86 to 144.36.

Table 4.3.5 shows both unadjusted (observed) days of post-discharge events per 100 discharges and EDAC per 100 discharges for HF. The median hospital EDAC in the combined three-year dataset was 0.28 (IQR: -14.19 – 18.1). Figure 4.3.2 shows the overall distribution of the hospital EDAC for the three-year dataset.

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

Of 4,606 hospitals in the study cohort, 803 had "More days than expected," 2,461 were "No different than expected," and 475 had "Fewer days than expected." 867 were classified as "Number of cases too small" (fewer than 25) to reliably tell how well the hospital is performing.

Table 4.3.1 - Frequency of HF Model Variables over Different Time Periods

Variable	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Total N	382,196	390,003	384,534	1,156,733
Mean age minus 65 (SD)	15.9 (8.4)	15.9 (8.4)	15.8 (8.5)	15.9 (8.4)
Male (%)	45.6	45.7	45.8	45.7
History of coronary artery bypass graft (CABG) surgery	19.7	19.4	19.4	19.5
Metastatic cancer or acute leukemia (CC 8)	2.2	2.1	2.3	2.2
Cancer (CC 9-14)	21.3	21.2	21.4	21.3

Variable	07/2013-06/2014	07/2014-06/2015	07/2015-06/2016	07/2013-06/2016
Diabetes mellitus (DM) or DM complications (CC 17-19, 122-123)	55.0	54.9	55.2	55.0
Protein-calorie malnutrition (CC 21)	10.0	10.0	10.5	10.2
Other significant endocrine and metabolic disorders; disorders of fluid/electrolyte/acid-base balance (CC 23-24)	49.6	49.7	50.3	49.9
Liver or biliary disease (CC 27-32)	11.2	11.4	11.8	11.5
Peptic ulcer, hemorrhage, other specified gastrointestinal disorders (CC 36)	16.9	16.6	16.6	16.7
Other gastrointestinal disorders (CC 38)	64.6	65.3	66.1	65.3
Severe hematological disorders (CC 46)	2.4	2.3	2.2	2.3
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	64.4	64.1	63.9	64.1
Dementia or other specified brain disorders (CC 51-53)	24.5	24.2	24.1	24.3
Drug/alcohol abuse/dependence/psychosis (CC 54-56)	14.4	15.1	15.6	15.0
Major psychiatric disorders (CC 57-59)	10.9	11.0	10.0	10.6
Depression (CC 61)	22.0	22.4	22.4	22.3
Other psychiatric disorders (CC 63)	21.1	22.3	23.6	22.3
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	6.4	6.4	6.9	6.6
Cardio-respiratory failure and shock (CC 84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	29.9	31.3	33.7	31.7
Congestive heart failure (CC 85)	75.9	75.3	75.4	75.5
Acute coronary syndrome (CC 86-87)	16.9	16.8	17.5	17.1
Coronary atherosclerosis or angina (CC 88-89)	73.6	72.5	71.9	72.7
Valvular and rheumatic heart disease (CC 91)	54.7	55.1	55.1	55.0
Specified arrhythmias and other heart rhythm disorders (CC 96-97)	69.0	69.4	69.7	69.4
Other and unspecified heart disease (CC 98)	33.4	33.8	34.3	33.9
Stroke (CC 99-100)	9.2	9.3	9.0	9.2
Vascular or circulatory disease (CC 106-109)	53.5	53.5	53.8	53.6
Chronic obstructive pulmonary disease (COPD) (CC 111)	49.0	48.8	49.0	49.0
Fibrosis of lung or other chronic lung disorders (CC 112)	9.8	9.5	9.2	9.5
Asthma (CC 113)	10.1	10.4	13.3	11.3
Pneumonia (CC 114-116)	45.8	46.0	45.1	45.7
Dialysis status (CC 134)	4.6	4.5	4.5	4.5
Renal failure (CC 135-140)	62.8	63.5	65.0	63.8
Nephritis (CC 141)	4.4	4.4	3.8	4.2
Other urinary tract disorders (CC 145)	30.9	29.6	28.5	29.7
Decubitus ulcer or chronic skin ulcer (CC 157-161)	14.7	14.7	14.6	14.7

Table 4.3.2 - Median Parameter Estimates and Credible Intervals (CIs) of Risk Variables from the Logit and Poisson Models for HF (July 2013-June 2016)

Risk Variable	Part 1: Logit Model		Part 2: Poisson Model	
	Median	CI	Median	CI
Age minus 65 (years above 65, continuous)	-0.001	(-0.0011, 0.0001)	-0.006	(-0.0059, -0.0055)
Male	0.016	(0.0078, 0.0243)	-0.001	(-0.0044, 0.0024)

Risk Variable	Part 1: Logit Model		Part 2: Poisson Model	
	Median	CI	Median	CI
History of coronary artery bypass graft (CABG) surgery	-0.010	(-0.0199, 0.0004)	-0.012	(-0.0164, -0.0076)
Metastatic cancer or acute leukemia (CC 8)	0.213	(0.1840, 0.2386)	0.035	(0.0250, 0.0436)
Cancer (CC 9-14)	0.015	(0.0054, 0.0259)	0.006	(0.0014, 0.0098)
Diabetes mellitus (DM) or DM complications (CC 17-19, 122-123)	0.067	(0.0575, 0.0743)	0.027	(0.0234, 0.0305)
Protein-calorie malnutrition (CC 21)	0.117	(0.1034, 0.1292)	0.093	(0.0887, 0.0985)
Other significant endocrine and metabolic disorders; disorders of fluid/electrolyte/acid-base balance (CC 23-24)	0.113	(0.1039, 0.1212)	0.033	(0.0294, 0.0368)
Liver or biliary disease (CC 27-32)	0.074	(0.0606, 0.0857)	0.032	(0.0277, 0.0367)
Peptic ulcer, hemorrhage, other specified gastrointestinal disorders (CC 36)	0.050	(0.038, 0.0616)	0.017	(0.0129, 0.0218)
Other gastrointestinal disorders (CC 38)	0.096	(0.0869, 0.1038)	-0.007	(-0.0112, -0.0031)
Severe hematological disorders (CC 46)	0.188	(0.1609, 0.2091)	0.060	(0.0506, 0.0680)
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	0.085	(0.0755, 0.0945)	0.074	(0.0700, 0.0791)
Dementia or other specified brain disorders (CC 51-53)	0.067	(0.0582, 0.0771)	-0.029	(-0.0326, -0.0251)
Drug/alcohol abuse/dependence/psychosis (CC 54-56)	0.110	(0.0986, 0.1210)	-0.024	(-0.0283, -0.0197)
Major psychiatric disorders (CC 57-59)	0.078	(0.0654, 0.0920)	0.010	(0.0043, 0.0151)
Depression (CC 61)	0.013	(0.0027, 0.0244)	-0.020	(-0.0235, -0.0163)
Other psychiatric disorders (CC 63)	0.116	(0.1052, 0.1272)	-0.013	(-0.0171, -0.0093)
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	0.058	(0.0420, 0.0758)	0.024	(0.0183, 0.0300)
Cardio-respiratory failure and shock (CC 84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	0.063	(0.0528, 0.0727)	0.052	(0.0480, 0.0560)
Congestive heart failure (CC 85)	0.104	(0.0923, 0.1155)	0.020	(0.0152, 0.0246)
Acute coronary syndrome (CC 86-87)	0.119	(0.1077, 0.1304)	-0.007	(-0.0116, -0.0033)
Coronary atherosclerosis or angina (CC 88-89)	0.079	(0.0698, 0.0900)	-0.021	(-0.0247, -0.0163)
Valvular and rheumatic heart disease (CC 91)	0.046	(0.0376, 0.0533)	0.036	(0.0328, 0.0392)
Specified arrhythmias and other heart rhythm disorders (CC 96-97)	0.059	(0.0496, 0.0695)	0.022	(0.0186, 0.0272)

Risk Variable	Part 1: Logit Model		Part 2: Poisson Model	
	Median	CI	Median	CI
Other and unspecified heart disease (CC 98)	0.055	(0.0461, 0.0637)	-0.011	(-0.0145, -0.0081)
Stroke (CC 99-100)	0.028	(0.0138, 0.0444)	-0.010	(-0.0145, -0.0045)
Vascular or circulatory disease (CC 106-109)	0.065	(0.0572, 0.0736)	0.010	(0.0063, 0.0134)
Chronic obstructive pulmonary disease (COPD) (CC 111)	0.120	(0.1118, 0.1279)	0.058	(0.0542, 0.0612)
Fibrosis of lung or other chronic lung disorders (CC 112)	0.061	(0.0480, 0.0741)	0.035	(0.0297, 0.0407)
Asthma (CC 113)	0.039	(0.0270, 0.0524)	-0.013	(-0.0176, -0.0085)
Pneumonia (CC 114-116)	0.054	(0.0469, 0.0640)	0.052	(0.0490, 0.0559)
Dialysis status (CC 134)	0.232	(0.2137, 0.2500)	-0.125	(-0.1313, -0.1186)
Renal failure (CC 135-140)	0.162	(0.1521, 0.1715)	0.130	(0.1262, 0.1338)
Nephritis (CC 141)	0.045	(0.0247, 0.0631)	0.043	(0.0367, 0.0508)
Other urinary tract disorders (CC 145)	0.063	(0.0554, 0.0717)	0.011	(0.0076, 0.0143)
Decubitus ulcer or chronic skin ulcer (CC 157-161)	0.087	(0.0758, 0.0982)	0.088	(0.0836, 0.0920)

Table 4.3.3 - Posterior Predictive Checking (PPC) Results for HF (July 2013-June 2016)

Statistic	Observed Days in Acute Care	MCMC 95% Credible Interval (CI) for Predicted Days in Acute Care	P-Value
Variance	0.3872	(0.2954, 0.3808)	0.0153
Median	1.3081	(1.3228, 1.3468)	<0.0001
Interquartile range (IQR)	0.6023	(0.5752, 0.6151)	0.2077
Coefficient of variation	0.4744	(0.4048, 0.4560)	0.0130

Table 4.3.4 - HF Generalized Linear Modeling (Logistic Regression) Performance (July 2013-June 2016)

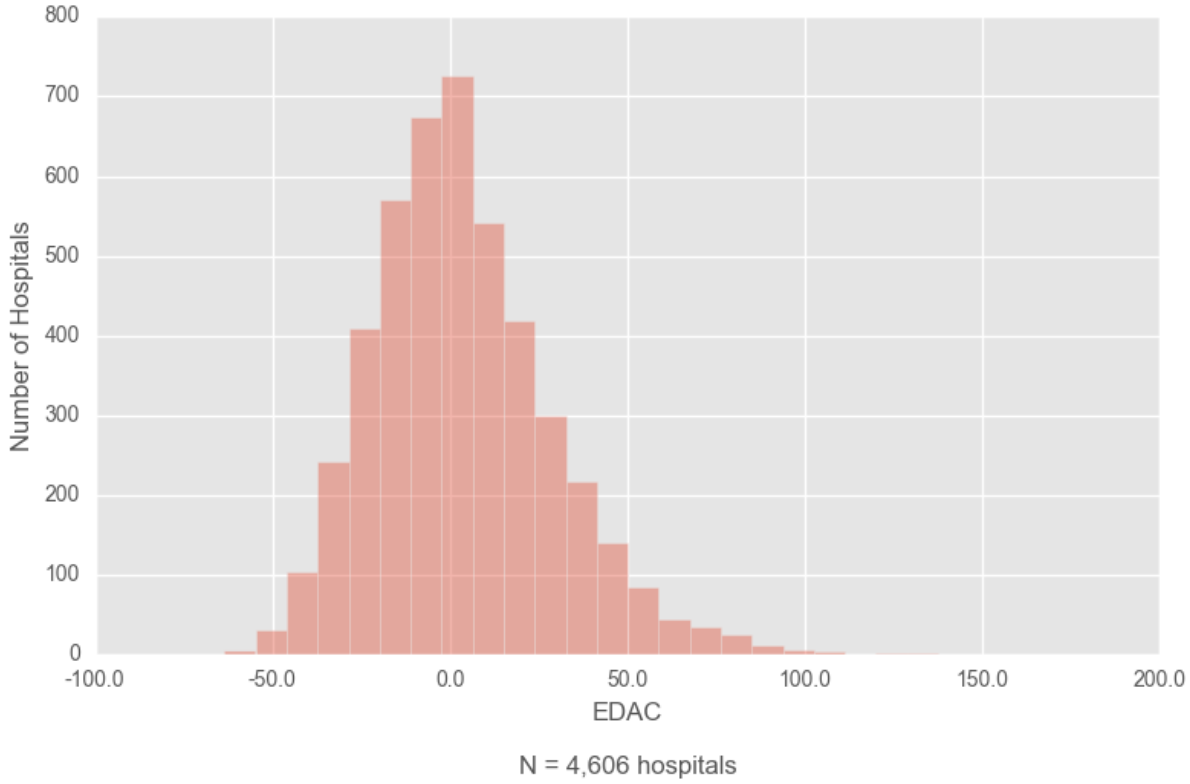
Characteristic	07/2013-06/2016
C-statistic (Logit part)	0.60
Deviance r-squared (Poisson part)	0.029

Table 4.3.5 - Hospital-Level Unadjusted Distribution of Overall Acute Care, ED Visits, Observation Stays, and Readmissions per 100 HF Discharges, and Distribution of EDAC (July 2013-June 2016)

Description	Mean ± SD	Median (Q1, Q3)	Range
Observed days in acute care	131.19 (62.22)	130.85 (99.72, 159.95)	1100
Days of ED visits	10.43 (7.03)	8.87 (6.52, 12.50)	100
Days of observation stays	10.04 (9.82)	8.45 (4.71, 13.10)	175
Days of readmissions	115.00 (60.86)	114.54 (83.20, 143.10)	1100
EDAC	3.58 (25.79)	0.28 (-14.19, 18.1)	218.34

Description	Mean ± SD	Median (Q1, Q3)	Range
Days of predicted	133.90 (33.78)	131.75 (109.31, 154.77)	268.08
Days of expected	130.22 (17.33)	131.80 (121.14, 140.79)	275.40

Figure 4.3.2 - Hospital-Level EDAC per 100 Discharges for HF for the July 2013-June 2016 Dataset



5. GLOSSARY

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

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

Clinical Classification Software (CCS): Software maintained by the AHRQ that groups thousands of individual procedure and diagnosis codes into clinically coherent, mutually exclusive procedure and diagnosis categories. AHRQ CCS categories are used to determine if a readmission is planned. AHRQ CCS procedure categories are used to define planned and potentially planned procedures. AHRQ CCS diagnosis categories are used to define acute diagnoses and complications of care that are considered unplanned, as well as a few specific types of care that are always considered planned (for example, maintenance chemotherapy). Mappings which show the assignment of ICD-9 and ICD-10 codes to the AHRQ CCS diagnosis and procedure categories are available on the AHRQ website.

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

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

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

Condition Categories (CCs): Groupings of ICD-9-CM/ICD-10-CM diagnosis codes in clinically relevant categories, from the Hierarchical Condition Categories (HCCs) system.[19,20] CMS uses the grouping but not the hierarchical logic of the system to create risk factor variables. Mappings which show the assignment of ICD-9 and ICD-10 codes to the CCs are available on the *QualityNet* website.

Credible interval (CI): Analogous to a confidence interval under Bayesian framework. We select a range of values from the posterior probability distribution that has 95% probability. This range is the 95% credible interval. Posterior probability distribution is described below.

Deviance R^2: A statistical tool used to evaluate the goodness-of-fit of logistic models.

Expected days: The average number of risk-adjusted days in acute care that a hospital's patients would have been expected to spend if discharged from an average performing hospital with the same case mix.

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

Log-likelihood: The logarithm of a likelihood function, which is defined as a function of the parameters of a statistical model given data.

Medicare fee-for-service (FFS): Original Medicare plan in which providers receive a fee or payment for each individual service provided directly from Medicare. Only beneficiaries in Medicare FFS, not in managed care (Medicare Advantage), are included in the measures.

Outcome: The result of a broad set of healthcare activities that affect patients' well-being. For the EDAC measures, the outcome is the number of days the patient spends in acute care in the 30 days after discharge.

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

Posterior predictive checking (PPC): To evaluate whether the model fits the data well, observations from the fitted model are simulated, followed by a comparison of the distribution of the simulation data to the observed data (that is, the real data). The aim is to investigate whether there is any discrepancy between the real data and the model-based simulated data.

Predicted days: The average number of risk-adjusted days a hospital's patients spent in acute care.

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

Truncated Poisson model (or Truncated Poisson distribution): Similar to the usual Poisson distribution, the zero-truncated Poisson (ZTP) distribution is a discrete probability distribution that only takes positive integers.

Unplanned readmissions: Acute clinical events a patient experienced that require urgent rehospitalization. Unplanned readmissions are captured in the outcomes of these measures.

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7. APPENDICES

Appendix A. Statistical Approach to EDAC for AMI and HF Measures

We estimate the hospital-specific EDAC using hierarchical generalized linear models. This consists of the two-part logit/truncated Poisson model specifications for days in acute care and includes two random effects for hospitals – one for the logit part and one for the truncated Poisson part – with a non-zero covariance between the two random effects. 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.

Hospital Performance Reporting

Explicitly, let Y_{ij} denote the number of days in acute care experienced by the *i*-th patient discharged from the *j*-th hospital, and ω_{ij} is the patient's exposure time (the number of days alive up to 30). At the first stage, whether a patient has non-zero days in acute care (that is, a binary outcome of $Y_{ij} > 0$ vs. $Y_{ij} = 0$) is modeled via a logistic regression model. At the second stage, if a patient utilizes acute care within 30 days after discharge ($Y_{ij} > 0$), Y_{ij} is made a variable of counts and is assumed to follow a ZTP distribution. Thus, we have the following "hurdle" model:

$$\begin{cases} \text{logit}(\pi_{ij}) = \log(\omega_{ij}) + X_{ij}C + v_j \text{ where } \pi_{ij} = \Pr\{Y_{ij} > 0\} \\ \log(\mu_{ij}) = \log(\omega_{ij}) + X_{ij}B + u_j \text{ where } Y_{ij} \mid Y_{ij} > 0 \sim \text{Truncated Poisson}(\mu_{ij}) \end{cases} \quad (1)$$

Note that $E(Y_{ij} \mid Y_{ij} > 0) = \mu_{ij}/(1 - \exp(-\mu_{ij}))$ and $E(Y_{ij}) = \pi_{ij}\mu_{ij}/(1 - \exp(-\mu_{ij}))$. $(v_j, u_j) \sim MVN(M, \Sigma)$, where v_j and u_j are random effects across hospitals with means $M = [C_0, B_0]$ and variance-covariance matrix Σ. The X_{ij} is a vector of patient risk factors, and B and C are vectors of covariate coefficients.

We estimated the model and used the coefficient vectors B and C and the random effects v_j and $u_j$to calculate the predicted (P_{ij}) and expected (E_{ij}) days in acute care for each index admission, respectively. Specifically, we calculate:

Predicted $$P_{ij} = \text{logit}^{-1}(X_{ij}C + v_j) * \frac{\exp(X_{ij}B + u_j)}{1 - \exp(-\exp(X_{ij}B + u_j))} \quad (2)$$

Expected $$E_{ij} = logit^{-1}(X_{ij}C + C_0) * \frac{\exp(X_{ij}B + B_0)}{1 - \exp(-\exp(X_{ij}B + B_0))} \quad (3)$$

where C_0 and B_0 are means of the random effects v_j and u_j.

We then calculated the EDAC for the hospital *j* as:

$$EDAC_j = 100 * \sum(P_{ij} - E_{ij})/m_j \quad (4)$$

where the sum is over all patients at hospital *j*, and m_j is the number of index admissions at hospital *j*. To be consistent with the reporting of the CMS 30-day AMI readmission measure, we have multiplied the final measure by 100 so that EDAC represents EDAC per 100 discharges.

Creating Credible Intervals

We use Bayesian Markov Chain Monte Carlo (MCMC) estimation to derive a CI.[21] MCMC estimation allows us to generate a large number of simulated values of P_{ij}, E_{ij}, v_j and u_j, from their posterior distribution (determined by both prior assumption for those quantities and the actual data), to base inferences; using these simulated values, we calculate a similar number of values of $EDAC_j$ for each hospital. The median value is taken as the hospital estimate, with the 2.5th and 97.5th percentile order statistics taken as the endpoints of a 95% CI.

Appendix B. Data QA

This production year required revision of all SAS packs to account for the ICD-10 code transition. In order to assure the quality of measure output, we utilized a multi-phase approach to QA of the EDAC measures.

This section represents QA for the subset of the work CORE conducted to maintain and report these EDAC 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 another contractor conducts that work.

Phase I

The first step in this year's QA process started prior to the SAS pack revisions. We tested the conversion of the HCC map from version 12 to version 22 to ensure that the risk variables were well-aligned in both coding schemes. Following risk variable testing, we tested the impact of ICD-10 coding on the cohort inclusion and exclusion criteria, outcomes, and risk factors. We drew comparisons between the first six months of data from the start of the ICD-10 transition and the same six months in the prior year for ICD-9.

In general, we used both manual scan and descriptive analyses to conduct data validity checks, including cross-checking EDAC information, distributions of ICD-9/ICD-10 codes, and frequencies of key variables.

Phase II

Using a finalized list of ICD-10 coding changes, we updated the existing SAS packs to accommodate the post-transition data. To assure accuracy in the SAS pack revisions, two to three analysts/programmers independently wrote SAS code for any changes made in calculating the EDAC measures: data preparation, cohort construction, hierarchical modeling, and calculation of EDAC. This process highlighted any programming errors in syntax or logic and checked that new ICD-10 codes had been properly applied. Once this parallel programming process was complete, the analysts cross-checked their codes by analyzing datasets in parallel, checking for consistency of output, and reconciling any discrepancies. Finally, an additional analyst reviewed the finalized SAS code and recommended changes to the coding and readability of the SAS pack, where appropriate.

Phase III

The last phase of QA involved reviewing the year-to-year changes in the risk variable frequencies, beta coefficients, and outcome rates for the measures. This was especially important this year as the final year of the three-year reporting period encompasses a large proportion of ICD-10 claims. This phase served as a final check, to ensure the ICD-10 code-based cohort, risk factor and outcome changes did not have an adverse impact on measure results.

Appendix C. Annual Updates

For convenience, we have listed all updates under the reporting year and corresponding report. In 2013, CMS began assigning version numbers to its measures. The measure specifications in the original and updated EDAC methodology reports are considered Version 1.0 and 1.1 for each measure, respectively. The measures receive a new version number for each subsequent year of public reporting.

2017

2017 Measures Updates and Specifications Report (Version 2.0 – AMI and HF)

1. Revised the measure specifications to accommodate the implementation of ICD-10 coding:
   - Identified the ICD-10 codes used to define each of the measure cohorts for discharges on or after October 1, 2015.
   - Updated the planned readmission algorithm, by using the most recent (2016) version of the AHRQ ICD-10 CCS and ICD-10 codes for certain "potentially planned procedures" and "acute diagnoses" to the algorithm specifications, for discharges on or after October 1, 2015.
   - Re-specified the risk models, updating the CC-based risk variables to the ICD-10-compatible HCC system version 22 and applying ICD-10 codes for certain risk variables (for example, history of PTCA) to the models.
     - Rationale: The ICD-9 code sets used to report medical diagnoses and inpatient procedures were replaced by ICD-10 code sets on October 1, 2015. HHS mandated that ICD-10 codes be used for medical coding, effective October 1, 2015 discharges. The measurement period for 2017 public reporting required data from claims that include ICD-10 codes in addition to data from claims that include ICD-9 codes. Thus, re-specification was warranted to accommodate ICD-10 coding.
2. Psychiatric and rehabilitation units within short-term acute care hospitals in Maryland have the same type of provider ID number (or CMS certification number [CCN]) as the acute care hospital in which they are housed. Transfers to these units can therefore look like readmissions. In order to accurately assess readmissions in Maryland and allow for public reporting of Maryland readmission rates, methodologies to identify these cases were needed, to ensure these transfers are not counted as readmissions for any hospital:
   - Identification of psychiatric admissions before and after October 1, 2015:
     (1) the admission being evaluated as a potential readmission has a psychiatric principal discharge diagnosis code (ICD-9-CM codes beginning with '29', '30' or '31', for discharges prior to October 1, 2015, or ICD-10-CM codes beginning with 'F', for discharges on or after October 1, 2015);
     (2) the index admission has a discharge disposition code to a psychiatric hospital or psychiatric unit from the index admission; and,
     (3) the admission being evaluated as a potential readmission occurred during the same day as or the day following the index discharge.
   - Identification of rehabilitation admissions prior to October 1, 2015:
     The admission being evaluated as a potential readmission has an ICD-9-CM principal discharge diagnosis code beginning with 'V57'.
   - Identification of rehabilitation admissions on or after October 1, 2015:
     (1) the index admission has a discharge disposition code to a rehabilitation hospital or rehabilitation unit from the index admission; and,
     (2) the admission being evaluated as a potential readmission occurred on the same day as or the day following the index discharge.

Psychiatric/rehabilitation admissions identified as described above are not counted as readmissions. Note that we do not expect to see rehabilitation claims in hospital data from states other than Maryland.

- Rationale: With the implementation of ICD-10 coding effective with October 1, 2015+ discharges, the criteria for Maryland hospitals had to be specified for both ICD-10 and ICD-9 code-based claims. For psychiatric admissions, defining "psychiatric diagnosis" with ICD-10-CM codes for October 1, 2015+ discharges was a simple solution, as mental health diagnosis codes all reside under the Category 'F' (Mental, Behavioral and Neurodevelopmental disorders). However, for rehabilitation admissions, rehabilitation diagnosis codes are no longer coded consistently. Thus, defining the V57.0 ICD-9-CM code criterion with ICD-10-CM codes was not a viable option, and a different strategy was warranted.

Appendix D. Measure Specifications

Appendix D.1 Hospital-Level 30-Day EDAC following AMI (NQF #2881)

Cohort

Inclusion Criteria for AMI Measure

1. **Principal discharge diagnosis of AMI**
   Rationale: AMI is the condition targeted for measurement (Table D.1.1).
2. **Enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission**
   Rationale: Claims data are consistently available only for Medicare FFS beneficiaries. The 12-month prior enrollment criterion ensures that patients were Medicare FFS beneficiaries and that their comorbidities are captured from claims for risk adjustment. Medicare Part A is required at the time of admission to ensure that no Medicare Advantage patients are included in the measure.
3. **Aged 65 or over**
   Rationale: Medicare patients younger than 65 usually qualify for the program due to severe disability. They are not included in the measure because they are considered to be too clinically distinct from Medicare patients 65 and over.
4. **Discharged alive from a non-federal short-term acute care hospital**
   Rationale: It is only possible for patients to be eligible for an ED visit, observation stay, or readmission if they are discharged alive.
5. **Not transferred to another acute care facility**
   Rationale: Hospitalizations that result in a transfer to another acute care facility are not included in the measure because the measure's focus is on admissions that result in discharge to a non-acute care setting (for example, to home or a skilled nursing facility).

Exclusion Criteria for AMI Measure

1. **Without at least 30 days of post-discharge enrollment in Medicare FFS**
   Rationale: The 30-day outcome cannot be assessed in this group since claims data are used to determine whether a patient visited the ED, was placed under observation, or was readmitted.
2. **Discharged against medical advice**
   Rationale: Providers did not have the opportunity to deliver full care and prepare the patient for discharge.
3. **Same-day discharges**
   Rationale: Patients admitted and then discharged on the same day are not included as an index admission because it is unlikely that these admissions are for clinically significant AMIs.
4. **AMI admissions within 30 days of discharge from a prior AMI index admission**
   Rationale: Additional AMI admissions within 30 days are excluded as index admissions because they are part of the outcome. A single admission does not count as both an index admission and a readmission for another index admission.

Table D.1.1 – ICD-10-CM Codes for AMI Cohort

Table D.1.1 below outlines the ICD-10-CM codes used to define the AMI cohort for discharges on or after October 1, 2015. ICD-9 code lists for discharges prior to October 1, 2015 can be found in the 2016 AMI EDAC updated measure methodology report posted on *QualityNet*.

ICD-10-CM Codes	Description
I21.01	ST elevation (STEMI) myocardial infarction involving left main coronary artery
I21.02	ST elevation (STEMI) myocardial infarction involving left anterior descending coronary artery
I21.09	ST elevation (STEMI) myocardial infarction involving other coronary artery of anterior wall
I21.11	ST elevation (STEMI) myocardial infarction involving right coronary artery
I21.19	ST elevation (STEMI) myocardial infarction involving other coronary artery of inferior wall
I21.21	ST elevation (STEMI) myocardial infarction involving left circumflex coronary artery
I21.29	ST elevation (STEMI) myocardial infarction involving other sites
I21.3	ST elevation (STEMI) myocardial infarction of unspecified site
I21.4	Non-ST elevation (NSTEMI) myocardial infarction

Risk Adjustment

Table D.1.2 – Risk Variables for AMI Measure

The CCs outlined in Table D.1.2 below are used to identify risk variables in claims for discharges on or after October 1, 2015 as well as discharges prior to October 1, 2015.

The ICD-10 codes used to identify certain risk variables (for example, history of PTCA) in discharges on or after October 1, 2015 are posted on *QualityNet* due to volume; hyperlinks to these lists are provided in the table. For a list of ICD-9 codes used to identify these variables in discharges prior to October 1, 2015, please refer to the 2016 AMI EDAC updated measure methodology report posted on *QualityNet*.

Description of Risk Variable	CCs and/or ICD-10 Codes Included	Variables Not Used in Risk Adjustment if Occurred Only during Index Admission (indicated by "X")
Age minus 65 (years above 65, continuous)	n/a	
Male	n/a	
Anterior myocardial infarction	ICD-10-CM code list	
Other location of myocardial infarction	ICD-10-CM code list	
History of coronary artery bypass graft (CABG) surgery	ICD-10-CM code list and ICD-10-PCS code list	
History of percutaneous transluminal coronary angioplasty (PTCA)	ICD-10-CM code list and ICD-10-PCS code list	
Severe infection; other infectious diseases (CC 1, 3-7)	HIV/AIDS (CC 1)	
	Bacterial, fungal, and parasitic central nervous system infections (CC 3)	
	Viral and late effects central nervous system infections (CC 4)	
	Tuberculosis (CC 5)	
	Opportunistic infections (CC 6)	
	Other infectious diseases (CC 7)	X
Metastatic cancer or acute leukemia (CC 8)	Metastatic cancer or acute leukemia (CC 8)	
Cancer (CC 9-14)	Lung and other severe cancers (CC 9)	
	Lymphoma and other cancers (CC 10)	

Description of Risk Variable	CCs and/or ICD-10 Codes Included	Variables Not Used in Risk Adjustment if Occurred Only during Index Admission (indicated by "X")
	Colorectal, bladder, and other cancers (CC 11)	
	Breast, prostate, and other cancers and tumors (CC 12)	
	Other respiratory and heart neoplasms (CC 13)	
	Other digestive and urinary neoplasms (CC 14)	
Diabetes mellitus (DM) or DM complications (CC 17-19, 122-123)	Diabetes with acute complications (CC 17)	X
	Diabetes with chronic complications (CC 18)	
	Diabetes without complications (CC 19)	
	Proliferative diabetic retinopathy and vitreous hemorrhage (CC 122)	
	Diabetic and other vascular retinopathies (CC 123)	
Protein-calorie malnutrition (CC 21)	Protein-calorie malnutrition (CC 21)	
Other significant endocrine and metabolic disorders; disorders of fluid/electrolyte/acid-base balance (CC 23-24)	Other significant endocrine and metabolic disorders (CC 23)	
	Disorders of fluid/electrolyte/acid-base balance (CC 24)	X
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	Iron deficiency or other/unspecified anemias and blood disease (CC 49)	
Dementia or other specified brain disorders (CC 51-53)	Dementia with complications (CC 51)	
	Dementia without complications (CC 52)	
	Nonpsychotic organic brain syndromes/conditions (CC 53)	
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	Quadriplegia (CC 70)	
	Paraplegia (CC 71)	
	Spinal cord disorders/injuries (CC 72)	
	Amyotrophic lateral sclerosis and other motor neuron disease (CC 73)	
	Cerebral palsy (CC 74)	
	Hemiplegia/hemiparesis (CC 103)	X
	Monoplegia, other paralytic syndromes (CC 104)	X
	Amputation status, lower limb/amputation complications (CC 189)	X
	Amputation status, upper limb (CC 190)	X
Congestive heart failure (CC 85)	Congestive heart failure (CC 85)	X
Acute coronary syndrome (CC 86-87)	Acute myocardial infarction (CC 86)	X
	Unstable angina and other acute ischemic heart disease (CC 87)	X
Angina pectoris (CC 88)	Angina pectoris (CC 88)	
Coronary atherosclerosis/other chronic ischemic heart disease (CC 89)	Coronary atherosclerosis/other chronic ischemic heart disease (CC 89)	
Valvular and rheumatic heart disease (CC 91)	Valvular and rheumatic heart disease (CC 91)	
Specified arrhythmias and other heart rhythm disorders (CC 96-97)	Specified heart arrhythmias (CC 96)	X
	Other heart rhythm and conduction disorders (CC 97)	X
Stroke (CC 99-100)	Cerebral hemorrhage (CC 99)	X
	Ischemic or unspecified stroke (CC 100)	X

Description of Risk Variable	CCs and/or ICD-10 Codes Included	Variables Not Used in Risk Adjustment if Occurred Only during Index Admission (indicated by "X")
Cerebrovascular disease (CC 101-102, 105)	Precerebral arterial occlusion and transient cerebral ischemia (CC 101)	X
	Cerebrovascular atherosclerosis, aneurysm, and other disease (CC 102)	
	Late effects of cerebrovascular disease, except paralysis (CC 105)	
Vascular or circulatory disease (CC 106-109)	Atherosclerosis of the extremities with ulceration or gangrene (CC 106)	X
	Vascular disease with complications (CC 107)	X
	Vascular disease (CC 108)	X
	Other circulatory disease (CC 109)	X
Chronic obstructive pulmonary disease (COPD) (CC 111)	Chronic obstructive pulmonary disease (COPD) (CC 111)	
Asthma (CC 113)	Asthma (CC 113)	
Pneumonia (CC 114-116)	Aspiration and specified bacterial pneumonias (CC 114)	X
	Pneumococcal pneumonia, empyema, lung abscess (CC 115)	X
	Viral and unspecified pneumonia, pleurisy (CC 116)	
Dialysis status (CC 134)	Dialysis status (CC 134)	X
Renal failure (CC 135-140)	Acute renal failure (CC 135)	X
	Chronic kidney disease, stage 5 (CC 136)	
	Chronic kidney disease, severe (stage 4) (CC 137)	
	Chronic kidney disease, moderate (stage 3) (CC 138)	
	Chronic kidney disease, mild or unspecified (stages 1-2 or unspecified) (CC 139)	
	Unspecified renal failure (CC 140)	X
Other urinary tract disorders (CC 145)	Other urinary tract disorders (CC 145)	
Decubitus ulcer or chronic skin ulcer (CC 157-161)	Pressure ulcer of skin with necrosis through to muscle, tendon, or bone (CC 157)	X
	Pressure ulcer of skin with full thickness skin loss (CC 158)	X
	Pressure ulcer of skin with partial thickness skin loss (CC 159)	X
	Pressure pre-ulcer skin changes or unspecified stage (CC 160)	X
	Chronic ulcer of skin, except pressure (CC 161)	

Outcome

Outcome Criteria for AMI Measure

All-cause days in acute care within 30 days from the date of discharge from an index admission. Rationale: Days in acute care are defined as days spent in an ED, admitted to observation status, or admitted as an unplanned readmission for any cause within 30 days from the date of discharge from

the index AMI hospitalization. From a patient perspective, days in acute care from any cause is an adverse event. Multiple events are counted in order to capture the full patient experience in the post-discharge period. Outcomes occurring within 30 days of discharge can be influenced by hospital care. The 30-day time frame is a clinically meaningful period for hospitals to collaborate with their communities to reduce days in acute care.

Appendix D.2 Hospital-Level 30-Day EDAC following HF (NQF #2880)

Cohort

Inclusion Criteria for HF Measure

1. **Principal discharge diagnosis of HF**
   Rationale: HF is the condition targeted for measurement (Table D.2.1).
2. **Enrolled in Medicare FFS Part A and Part B for the 12 months prior to the date of admission, and enrolled in Part A during the index admission**
   Rationale: Claims data are consistently available only for Medicare FFS beneficiaries. The 12-month prior enrollment criterion ensures that patients were Medicare FFS beneficiaries and that their comorbidities are captured from claims for risk adjustment. Medicare Part A is required at the time of admission to ensure that no Medicare Advantage patients are included in the measure.
3. **Aged 65 or over**
   Rationale: Medicare patients younger than 65 usually qualify for the program due to severe disability. They are not included in the measure because they are considered to be too clinically distinct from Medicare patients 65 and over.
4. **Discharged alive from a non-federal short-term acute care hospital**
   Rationale: It is only possible for patients to be eligible for an ED visit, observation stay, or readmission if they are discharged alive.
5. **Not transferred to another acute care facility**
   Rationale: Hospitalizations that result in a transfer to another acute care facility are not included in the measure because the measure's focus is on admissions that result in discharge to a non-acute care setting (for example, to home or a skilled nursing facility).

Exclusion Criteria for HF Measure

1. **Without at least 30 days of post-discharge enrollment in Medicare FFS**
   Rationale: The 30-day outcome cannot be assessed in this group since claims data are used to determine whether a patient visited the ED, was placed under observation, or was readmitted.

2. **Discharged against medical advice**
   Rationale: Providers did not have the opportunity to deliver full care and prepare the patient for discharge.

3. **HF admissions within 30 days of discharge from a prior HF index admission**
   Rationale: Additional HF admissions within 30 days are excluded as index admissions because they are part of the outcome. A single admission does not count as both an index admission and a readmission for another index admission.

4. **With a procedure code for LVAD implantation or heart transplantation either during the index admission or in the 12 months prior to the index admission**
   Rationale: These patients represent a clinically distinct group (ICD-10-PCS code list).

Table D.2.1 – ICD-10-CM Codes for HF Cohort

Table D.2.1 below outlines the ICD-10-CM codes used to define the HF cohort for discharges on or after October 1, 2015. ICD-9 code lists for discharges prior to October 1, 2015 can be found in the 2016 HF EDAC updated measure methodology report posted on *QualityNet*.

ICD-10-CM Codes	Description
I11.0	Hypertensive heart disease with heart failure
I13.0	Hypertensive heart and chronic kidney disease with heart failure and stage 1 through stage 4 chronic kidney disease, or unspecified chronic kidney disease
I13.2	Hypertensive heart and chronic kidney disease with heart failure and with stage 5 chronic kidney disease, or end stage renal disease
I50.1	Left ventricular failure
I50.20	Unspecified systolic (congestive) heart failure
I50.21	Acute systolic (congestive) heart failure
I50.22	Chronic systolic (congestive) heart failure
I50.23	Acute on chronic systolic (congestive) heart failure
I50.30	Unspecified diastolic (congestive) heart failure
I50.31	Acute diastolic (congestive) heart failure
I50.32	Chronic diastolic (congestive) heart failure
I50.33	Acute on chronic diastolic (congestive) heart failure
I50.40	Unspecified combined systolic (congestive) and diastolic (congestive) heart failure
I50.41	Acute combined systolic (congestive) and diastolic (congestive) heart failure
I50.42	Chronic combined systolic (congestive) and diastolic (congestive) heart failure
I50.43	Acute on chronic combined systolic (congestive) and diastolic (congestive) heart failure
I50.9	Heart failure, unspecified

Risk Adjustment

Table D.2.2 – Risk Variables for HF Measure

The CCs outlined in Table D.2.2 below are used to identify risk variables in claims for discharges on or after October 1, 2015 as well as discharges prior to October 1, 2015.

The ICD-10 codes used to identify History of CABG surgery in discharges on or after October 1, 2015 are posted on *QualityNet* due to volume; a hyperlink to this list is provided in the table. For a list of ICD-9 codes used to identify this variable in discharges prior to October 1, 2015, please refer to the 2016 HF EDAC updated measure methodology report posted on *QualityNet*.

Description of Risk Variable	CCs and/or ICD Codes Included	Variables Not Used in Risk Adjustment if Occurred Only during Index Admission (indicated by "X")
Age minus 65 (years above 65, continuous)	n/a	
Male	n/a	
History of coronary artery bypass graft (CABG) surgery	ICD-10-CM code list and ICD-10-PCS code list	
Metastatic cancer or acute leukemia (CC 8)	Metastatic cancer or acute leukemia (CC 8)	
Cancer (CC 9-14)	Lung and other severe cancers (CC 9)	
	Lymphoma and other cancers (CC 10)	
	Colorectal, bladder, and other cancers (CC 11)	

Description of Risk Variable	CCs and/or ICD Codes Included	Variables Not Used in Risk Adjustment if Occurred Only during Index Admission (indicated by "X")
	Breast, prostate, and other cancers and tumors (CC 12)	
	Other respiratory and heart neoplasms (CC 13)	
	Other digestive and urinary neoplasms (CC 14)	
Diabetes mellitus (DM) or DM complications (CC 17-19, 122-123)	Diabetes with acute complications (CC 17)	X
	Diabetes with chronic complications (CC 18)	
	Diabetes without complications (CC 19)	
	Proliferative diabetic retinopathy and vitreous hemorrhage (CC 122)	
	Diabetic and other vascular retinopathies (CC 123)	
Protein-calorie malnutrition (CC 21)	Protein-calorie malnutrition (CC 21)	
Other significant endocrine and metabolic disorders; disorders of fluid/electrolyte/acid-base balance (CC 23-24)	Other significant endocrine and metabolic disorders (CC 23)	
	Disorders of fluid/electrolyte/acid-base balance (CC 24)	X
Liver or biliary disease (CC 27-32)	End-stage liver disease (CC 27)	
	Cirrhosis of liver (CC 28)	
	Chronic hepatitis (CC 29)	
	Acute liver failure/disease (CC 30)	X
	Other hepatitis and liver disease (CC 31)	
	Gallbladder and biliary tract disorders (CC 32)	
Peptic ulcer, hemorrhage, other specified gastrointestinal disorders (CC 36)	Peptic ulcer, hemorrhage, other specified gastrointestinal disorders (CC 36)	X
Other gastrointestinal disorders (CC 38)	Other gastrointestinal disorders (CC 38)	
Severe hematological disorders (CC 46)	Severe hematological disorders (CC 46)	
Iron deficiency or other/unspecified anemias and blood disease (CC 49)	Iron deficiency or other/unspecified anemias and blood disease (CC 49)	
Dementia or other specified brain disorders (CC 51-53)	Dementia with complications (CC 51)	
	Dementia without complications (CC 52)	
	Nonpsychotic organic brain syndromes/conditions (CC 53)	
Drug/alcohol abuse/dependence/psychosis (CC 54-56)	Drug/alcohol psychosis (CC 54)	
	Drug/alcohol dependence (CC 55)	
	Drug/alcohol abuse, without dependence (CC 56)	
Major psychiatric disorders (CC 57-59)	Schizophrenia (CC 57)	
	Major depressive, bipolar, and paranoid disorders (CC 58)	
	Reactive and unspecified psychosis (CC 59)	
Depression (CC 61)	Depression (CC 61)	
Other psychiatric disorders (CC 63)	Other psychiatric disorders (CC 63)	
Hemiplegia, paraplegia, paralysis, functional disability (CC 70-74, 103-104, 189-190)	Quadriplegia (CC 70)	
	Paraplegia (CC 71)	
	Spinal cord disorders/injuries (CC 72)	
	Amyotrophic lateral sclerosis and other motor neuron disease (CC 73)	
	Cerebral palsy (CC 74)	

Description of Risk Variable	CCs and/or ICD Codes Included	Variables Not Used in Risk Adjustment if Occurred Only during Index Admission (indicated by "X")
	Hemiplegia/hemiparesis (CC 103)	X
	Monoplegia, other paralytic syndromes (CC 104)	X
	Amputation status, lower limb/amputation complications (CC 189)	X
	Amputation status, upper limb (CC 190)	X
Cardio-respiratory failure and shock	Cardio-respiratory failure and shock (CC 84 plus ICD-10-CM codes R09.01 and R09.02, for discharges on or after October 1, 2015; CC 84 plus ICD-9-CM codes 799.01 and 799.02, for discharges prior to October 1, 2015)	X
Congestive heart failure (CC 85)	Congestive heart failure (CC 85)	X
Acute coronary syndrome (CC 86-87)	Acute myocardial infarction (CC 86)	X
	Unstable angina and other acute ischemic heart disease (CC 87)	X
Coronary atherosclerosis or angina (CC 88-89)	Angina pectoris (CC 88)	
	Coronary atherosclerosis/other chronic ischemic heart disease (CC 89)	
Valvular and rheumatic heart disease (CC 91)	Valvular and rheumatic heart disease (CC 91)	
Specified arrhythmias and other heart rhythm disorders (CC 96-97)	Specified heart arrhythmias (CC 96)	X
	Other heart rhythm and conduction disorders (CC 97)	X
Other and unspecified heart disease (CC 98)	Other and unspecified heart disease (CC 98)	
Stroke (CC 99-100)	Cerebral hemorrhage (CC 99)	X
	Ischemic or unspecified stroke (CC 100)	X
Vascular or circulatory disease (CC 106-109)	Atherosclerosis of the extremities with ulceration or gangrene (CC 106)	X
	Vascular disease with complications (CC 107)	X
	Vascular disease (CC 108)	X
	Other circulatory disease (CC 109)	X
Chronic obstructive pulmonary disease (COPD) (CC 111)	Chronic obstructive pulmonary disease (COPD) (CC 111)	
Fibrosis of lung or other chronic lung disorders (CC 112)	Fibrosis of lung or other chronic lung disorders (CC 112)	
Asthma (CC 113)	Asthma (CC 113)	
Pneumonia (CC 114-116)	Aspiration and specified bacterial pneumonias (CC 114)	X
	Pneumococcal pneumonia, empyema, lung abscess (CC 115)	X
	Viral and unspecified pneumonia, pleurisy (CC 116)	
Dialysis status (CC 134)	Dialysis status (CC 134)	X
Renal failure (CC 135-140)	Acute renal failure (CC 135)	X
	Chronic kidney disease, stage 5 (CC 136)	
	Chronic kidney disease, severe (stage 4) (CC 137)	
	Chronic kidney disease, moderate (stage 3) (CC 138)	

Description of Risk Variable	CCs and/or ICD Codes Included	Variables Not Used in Risk Adjustment if Occurred Only during Index Admission (indicated by "X")
	Chronic kidney disease, mild or unspecified (stages 1-2 or unspecified) (CC 139)	
	Unspecified renal failure (CC 140)	X
Nephritis (CC 141)	Nephritis (CC 141)	X
Other urinary tract disorders (CC 145)	Other urinary tract disorders (CC 145)	
Decubitus ulcer or chronic skin ulcer (CC 157-161)	Pressure ulcer of skin with necrosis through to muscle, tendon, or bone (CC 157)	X
	Pressure ulcer of skin with full thickness skin loss (CC 158)	X
	Pressure ulcer of skin with partial thickness skin loss (CC 159)	X
	Pressure pre-ulcer skin changes or unspecified stage (CC 160)	X
	Chronic ulcer of skin, except pressure (CC 161)	

Outcome

Outcome Criteria for HF Measure

All-cause days in acute care within 30 days from the date of discharge from an index admission. Rationale: Days in acute care are defined as days spent in an ED, admitted to observation status, or admitted as an unplanned readmission for any cause within 30 days from the date of discharge from the index HF hospitalization. From a patient perspective, days in acute care from any cause is an adverse event. Multiple events are counted in order to capture the full patient experience in the post-discharge period. Outcomes occurring within 30 days of discharge can be influenced by hospital care. The 30-day time frame is a clinically meaningful period for hospitals to collaborate with their communities to reduce days in acute care.

Appendix D.3 Definition of Emergency Department Visits and Observation Stays

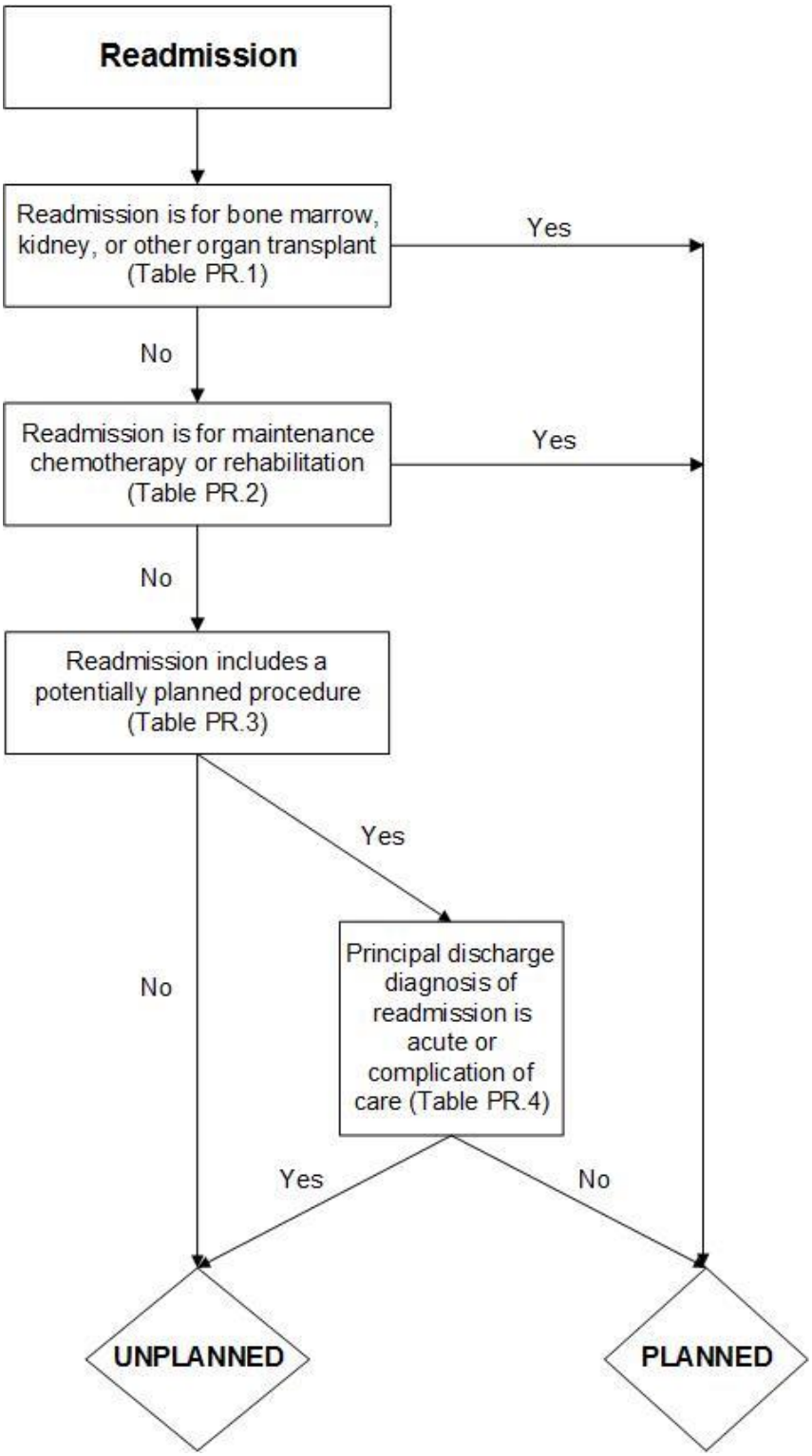
Table D.3.1. Codes Used to Define Emergency Department (ED) Visits and Observation Stays

Code (Code Type)	Description
Emergency Department (ED) Definition	
0450 (Revenue Center Code)	Emergency Room
0451 (Revenue Center Code)	Emergency Room: EM/EMTALA
0452 (Revenue Center Code)	Emergency Room: ER/Beyond EMTALA
0459 (Revenue Center Code)	Emergency Room: Other emergency room
0981 (Revenue Center Code)	Professional fees (096x) Emergency room
Observation Stay Definition	
0762 (Revenue Center Code)	Observation room
G0378 (Healthcare Common Procedure Coding System [HCPCS] Code)	Hospital observation service, per hour
99217 (Current Procedural Terminology [CPT] Code)	Hospital observation service, per hour
99218 (CPT Code)	Initial observation care, per day, for the evaluation and management of a patient which requires these three key components: a detailed or comprehensive history; a detailed or comprehensive examination; and medical decision making that is straightforward or of low complexity. Counseling and/or coordination of care with other providers or agencies are provided consistent with the nature of the problem(s) and the patient's and/or family's needs. Usually, the problem(s) requiring admission to observation status are of low severity
99219 (CPT Code)	Initial observation care, per day, for the evaluation and management of a patient, which requires these three key components: a comprehensive history; a comprehensive examination; and medical decision making of moderate complexity. Counseling and/or coordination of care with other providers or agencies are provided consistent with the nature of the problem(s) and the patient's and/or family's needs. Usually, the problem(s) requiring admission to observation status are of moderate severity.
99220 (CPT Code)	Initial observation care, per day, for the evaluation and management of a patient, which requires these three key components: a comprehensive history; a comprehensive examination; and medical decision making of high complexity. Counseling and/or coordination of care with other providers or agencies are provided consistent with the nature of the problem(s) and the patient's and/or family's needs. Usually, the problem(s) requiring admission to observation status are of high severity.
99234 (CPT Code)	Observation or inpatient hospital care, for the evaluation and management of a patient including admission and discharge on the same date which requires these three key components: a detailed or comprehensive history; a detailed or comprehensive examination; and medical decision making that is straightforward or of low complexity. Counseling and/or coordination of care with other providers or agencies are provided consistent with the nature of the problem(s) and the patient's and/or family's needs. Usually the presenting problem(s) requiring admission are of low severity.

Code (Code Type)	Description
99235 (CPT Code)	Observation or inpatient hospital care, for the evaluation and management of a patient including admission and discharge on the same date which requires these three key components: a comprehensive history; a comprehensive examination; and medical decision making of moderate complexity. Counseling and/or coordination of care with other providers or agencies are provided consistent with the nature of the problem(s) and the patient's and/or family's needs. Usually the presenting problem(s) requiring admission are of moderate severity.
99236 (CPT Code)	Observation or inpatient hospital care, for the evaluation and management of a patient including admission and discharge on the same date which requires these three key components: a comprehensive history; a comprehensive examination; and medical decision making of high complexity. Counseling and/or coordination of care with other providers or agencies are provided consistent with the nature of the problem(s) and the patient's and/or family's needs. Usually the presenting problem(s) requiring admission are of high severity.

Appendix E. Planned Readmission Algorithm

Figure PR.1. Planned Readmission Algorithm Version 4.0 (ICD-10) Flowchart



Planned Readmission Algorithm Version 4.0 (ICD-10) Tables – AMI and HF Measures

Note that the ICD-10-based AHRQ CCS categories listed in Tables PR.1 through PR.4 below and the singular ICD-10 codes listed in Tables PR.3 and Table PR.4 are used to identify planned readmissions in claims for discharges on or after October 1, 2015. The ICD-9-based AHRQ CCS categories and singular ICD-9 code lists for discharges prior to October 1, 2015 can be found in the 2016 AMI and HF EDAC updated measure methodology reports posted on *QualityNet*.

Table PR.1. Procedure Categories That Are Always Planned (Version 4.0 [ICD-10])

AHRQ CCS Procedure	Description
64	Bone marrow transplant
105	Kidney transplant
134	Cesarean section [Included only in all-payer population, not Medicare]
135	Forceps; vacuum; and breech delivery [Included only in all-payer population, not Medicare]
176	Other organ transplantation (other than bone marrow corneal or kidney)

Table PR.2. Diagnosis Categories That Are Always Planned (Version 4.0 [ICD-10])

AHRQ CCS Diagnosis	Description
45	Maintenance chemotherapy; radiotherapy
194	Forceps delivery [Included only in all-payer population, not Medicare]
196	Other pregnancy and delivery including normal [Included only in all-payer population, not Medicare]
254	Rehabilitation care; fitting of prostheses; and adjustment of devices

Table PR.1. Potentially Planned Procedures (Version 4.0 ICD-10])

Procedure Category/ICD-10-PCS Codes	Description
AHRQ CCS Procedure Categories	
1	Incision and excision of CNS
3	Excision destruction or resection of intervertebral disc
5	Insertion of catheter or spinal stimulator and injection into spinal canal
9	Other OR therapeutic nervous system procedures
10	Thyroidectomy; partial or complete
12	Therapeutic endocrine procedures
33	Other OR procedures on mouth and throat
36	Lobectomy or pneumonectomy
38	Other diagnostic procedures on lung and bronchus
40	Other diagnostic procedures on the respiratory system and mediastinum
43	Heart valve procedures
44	Coronary artery bypass graft (CABG)
45	Percutaneous transluminal coronary angioplasty (PTCA) with or without stent placement
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
66	Procedures on spleen
67	Other procedures; hemic and lymphatic systems
74	Gastrectomy; partial and total
78	Colorectal resection
79	Excision (partial) of large intestine (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)
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

Procedure Category/ICD-10-PCS Codes	Description
158	Spinal fusion
159	Other diagnostic procedures on musculoskeletal system
166	Lumpectomy; quadrantectomy of breast
167	Mastectomy
172	Skin graft
175	Other OR therapeutic procedures on skin subcutaneous tissue fascia and breast
0CBS4ZZ, 0CBS7ZZ, 0CBS8ZZ	Laryngectomy
0B5N0ZZ, 0B5N3ZZ, 0B5N4ZZ, 0B5P0ZZ, 0B5P3ZZ, 0B5P4ZZ, 0BW10FZ, 0BW13FZ, 0BW14FZ	Revision of tracheostomy, scarification of pleura
0TC03ZZ, 0TC04ZZ, 0TC13ZZ, 0TC14ZZ, 0TC33ZZ, 0TC34ZZ, 0TC43ZZ, 0TC44ZZ	Nephrostomy
0T9030Z, 0T9130Z	Kidney procedures
GZB0ZZZ, GZB1ZZZ, GZB2ZZZ, GZB3ZZZ, GZB4ZZZ	Electroshock therapy

Table PR.2. Acute Diagnoses (Version 4.0 [ICD-10])

Diagnosis Category/ICD-10-CM Codes	Description
AHRQ CCS Diagnosis Categories	
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
99	Hypertension with complications and secondary hypertension
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 tuberculosis or sexually transmitted disease)
123	Influenza
124	Acute and chronic tonsillitis
125	Acute bronchitis
126	Other upper respiratory infections
127	Chronic obstructive pulmonary disease and bronchiectasis
128	Asthma
129	Aspiration pneumonitis; food/vomitus
130	Pleurisy; pneumothorax; pulmonary collapse

Diagnosis Category/ICD-10-CM Codes	Description
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
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

Diagnosis Category/ICD-10-CM Codes	Description
652	Attention-deficit conduct and disruptive behavior disorders
653	Delirium dementia and amnestic and other cognitive disorders
656	Impulse 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 mental health disorders
ICD-10-CM Codes	
A36.81, A39.50, A39.51, A39.52, A39.53, B33.20, B33.21, B33.22, B33.23, B37.6, B58.81, I01.0, I01.1, I01.2, I01.8, I01.9, I02.0, I09.0, I09.89, I09.9, I30.0, I30.1, I30.8, I30.9, I31.0, I31.1, I31.2, I31.4, I32, I33.0, I33.9, I39, I40.0, I40.1, I40.8, I40.9, I41, I51.4	Peri-; endo-; and myocarditis; cardiomyopathy
I21.01, I21.02, I21.09, I21.11, I21.19, I21.21, I21.29, I21.3, I21.4	Acute myocardial infarction (without subsequent MI)
I44.0, I44.1, I44.2, I44.30, I44.39, I44.4, I44.5, I44.60, I44.69, I44.7, I45.0, I45.10, I45.19, I45.2, I45.3, I45.4, I45.5, I45.6, I45.81, I45.9	Conduction disorders
I47.9, I49.3, I49.49, I49.8, I49.9, R00.0, R00.1	Dysrhythmia
I09.81, I50.1, I50.20, I50.21, I50.23, I50.30, I50.31, I50.33, I50.40, I50.41, I50.43, I50.9	Congestive heart failure; nonhypertensive
K80.00, K80.01, K80.12, K80.13,	Biliary tract disease

Diagnosis Category/ICD-10-CM Codes	Description
K80.30, K80.31, K80.32, K80.33, K80.36, K80.37, K80.42, K80.43, K80.46, K80.47, K80.62, K80.63, K80.66, K80.67, K81.0, K81.2, K83.0	
K85.0, K85.1, K85.2, K85.3, K85.8, K85.9	Pancreatic disorders