

**Measure Methodology Report:  
Clinician and Clinician Group Hospital-wide All-cause Unplanned  
Readmission Measure**

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(YNHHSC/CORE)

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## Executive Summary

In 2017, the Centers for Medicare & Medicaid Services contracted with Yale New Haven Health Services Corporation – Center for Outcomes Research and Evaluation (CORE) to develop an eligible clinician, or eligible clinician group-level outcome measure that reflects the quality of care for patients discharged from acute care hospital stays. Specifically, CMS asked CORE to adapt its existing hospital-level measure, “Hospital-wide All-cause Unplanned Readmission Measure,” which is currently publicly reported, for use in assessing individual eligible clinicians or groups of eligible clinicians participating in the Merit-based Incentive Payment System (MIPS). Measure development has benefited from close stakeholder engagement, including a nationally convened Technical Expert Panel (TEP) and a public comment period. This measure fills an important gap by creating a mechanism for shared accountability across healthcare providers for readmitted patients. It will provide clinicians and patients with greater information and transparency to continue to improve patient care quality and outcomes.

The outcome is readmission within 30 days of discharge from an admission; planned readmissions are excluded from this outcome. In the measure proposed here, each admission is attributed to up to 3 eligible clinicians or eligible clinician groups. One is the eligible clinician who filed a claim for the ‘discharge procedure’ for the patient; conceptually, this clinician is measured because they have some responsibility for the transition of the patient to non-acute settings. Second is the eligible clinician who, during the inpatient stay, billed the most patient-facing charges; conceptually, this clinician has the most responsibility for the care of patients during their stay, and may also be the Discharge Clinician. A third eligible clinician is one that provides the plurality of outpatient primary care during the 12 months prior to the admission, as measured by plurality of primary care services; conceptually, a primary care provider may manage the transition from acute to non-acute care and participate in decisions to return to acute care. All admissions assigned to an eligible clinician are used to construct a single measure score for that clinician, regardless of the reason the admission was attributed. The measure has also been tested for eligible clinician groups, defined here by eligible clinicians who use the same Taxpayer Identification Number.

To compare readmission performance across eligible clinicians or eligible clinician groups, the measure accounts for differences in patient characteristics (i.e., patient case mix) as well as differences in the services and procedures offered by clinicians or clinician groups (i.e., provider service mix). The overall risk-adjusted readmission rate (RARR) is derived from the weighted geometric mean of 5 statistical models built for groups of admissions that are clinically related: cardiorespiratory, cardiovascular, medicine, neurology, and surgery/gynecology. We did not reselect risk variables used in the hospital-level measure, as the patient-level risk prediction is the same regardless of the attribution.

Using our development data, we found 170,755 eligible clinicians and 55,593 eligible clinician groups had at least 25 admissions attributed by 1 or more attribution rule. The RARRs for these sets of providers had a mean [range] of 15.2% [5.0% - 38.2%] for eligible clinicians and 15.4% [7.0% - 25.1%] for eligible clinician groups; 11.2% eligible clinicians and 11.6% of eligible clinician groups were statistically significantly better or worse than the national observed readmission rate.

In summary, this report details the approach and methods for re-specifying the hospital-level hospital-wide readmission (HWR) measure for use among MIPS eligible clinicians or eligible clinician groups. It presents a conceptual framework for the 3 attribution rules and provides a revised methodology for constructing risk-adjusted scores for the providers measured by these rules. Finally, it demonstrates the

feasibility, variability, reliability, and validity of measuring MIPS eligible clinicians or clinician groups. MIPS HWR measure has the potential to illuminate differences in quality, inform patient choice, drive quality improvement, and enhance care coordination. In a formal survey of the Technical Expert Panel, 70% agreed the measure scores were valid and useful measures of quality of care.

# 1. INTRODUCTION

## 1.1 Overview of Measure Development

In 2017, the Centers for Medicare & Medicaid Services (CMS) contracted with Yale New Haven Health Services Corporation – Center for Outcomes Research and Evaluation (CORE) to develop an eligible clinician outcome measure that reflects the quality of care for patients discharged from acute care hospital stays. Specifically, CMS asked CORE to adapt its existing publicly-reported hospital-level measure, “Hospital-wide All-cause Unplanned Readmission Measure,”<sup>1</sup> for use in assessing individual or groups of eligible clinicians participating in the Merit-based Incentive Payment System (hereinafter, MIPS HWR measure).

Readmission after discharge has been recognized for over a decade as both a quality and a resource concern. We detail the evidence supporting readmission as a quality indicator below. Jencks et. al. estimated that readmissions within 30 days of discharge cost Medicare more than \$17 billion annually.<sup>2</sup> A 2006 Commonwealth Fund report estimated if national readmission rates were lowered to the levels achieved by the top-performing regions, Medicare would save \$1.9 billion annually.<sup>3</sup> Consequently, there has been a national effort to address rates of readmission for patients of all ages and conditions. As a part of this effort, CMS publicly reports risk-standardized hospital-wide, all cause readmission rates using a measure which includes most hospital discharges.<sup>1</sup>

This existing hospital-level HWR measure, which provides a broad assessment of the quality of care at hospitals, reflects in part the quality of clinician care in the hospital, in that inpatient clinicians are integral to inpatient care and the transition to an outpatient setting. This measure also may reflect the quality of primary care, in that primary care clinicians may influence whether patients return to an acute care setting. It is thus meaningful to adapt the hospital-level hospital-wide, all-cause readmission measure for use in assessing the quality of individual clinician or clinician group care. The adapted measure is intended for use in MIPS, part of the Quality Payment Program, to assess the performance of eligible clinicians (ECs) or EC groups. There is currently a version of the hospital-level HWR measure in use under MIPS, referred to as the All-Cause Readmission measure. Where relevant, we drew from this measure. However, we used the original hospital-level measure as the foundation for our development work because that version has been most rigorously tested and vetted. Our measure development work focused on redefining the attribution approach for an EC- or EC group-level measure.

In this technical report, we provide detailed information on development of MIPS HWR measure. Briefly, we re-specified the hospital-level HWR measure, which was designed to capture unplanned readmissions within 30 days of discharge, to assign outcomes to inpatient and outpatient ECs or EC groups. In alignment with the hospital-level HWR measure, MIPS HWR measure complies with accepted standards for outcome measure development, including appropriate risk adjustment, testing, and transparency of specifications. From the cohort, we exclude admissions for which we have insufficient data for risk adjustment, admissions for patients who leave against medical advice, admissions for medical cancer treatment or for conditions that are not typically cared for in short-stay acute care hospitals, and admissions to PPS-exempt cancer hospitals. Consistent with the hospital-level HWR measure, MIPS HWR measure does not count planned readmissions in the measure outcome, since they do not represent a quality signal. Consistent with the hospital measure, admissions are assigned to 1 of 5 specialty cohorts: 1) cardiorespiratory, 2) cardiovascular, 3) medicine 4) neurology and 5) surgery/gynecology. Separate risk adjusted models are estimated for each specialty cohort. To

accommodate attribution of each admission to multiple ECs, we modified the statistical model and construction of the summary score used in the original hospital-level measure. Specifically, instead of using mixed-effects models to directly estimate EC or EC group effects, we used logistic regression models to construct standardized readmission ratios (SRRs) for each specialty cohort and applied a post-estimation method to adjust these for between-provider variation. These adjusted SRRs are then combined across specialty cohorts to produce a single risk-adjusted readmission rate (RARR). We did not reselect risk variables used in the hospital-level measure, as the patient-level risk prediction is the same regardless of the attribution.

## 1.2 Hospital-Wide Readmission as a Clinician Quality Indicator

Hospital readmission, for any reason, is disruptive to patients and caregivers, costly to the healthcare system, and puts patients at additional risk of hospital-acquired infections and complications. Readmissions are also a major source of patient and family stress and may contribute substantially to loss of functional ability, particularly in older patients. Some readmissions are unavoidable and result from inevitable progression of disease or worsening of chronic conditions. However, readmissions may also result from poor quality of care or inadequate transitional or post-discharge care. Transitional care includes effective discharge planning, transfer of information at the time of discharge, patient assessment and education, and coordination of care and monitoring in the post-discharge period. Numerous studies have found an association between quality of inpatient or transitional care and early (typically 30-day) readmission rates for a wide range of conditions.<sup>4-11</sup>

Randomized controlled trials have shown that improvement in the following areas can directly reduce readmission rates: quality of care during the initial admission; improvement in communication with patients, their caregivers, and their clinicians; patient education; pre-discharge assessment; and coordination of care after discharge.<sup>12-20</sup> Successful randomized trials have reduced 30-day readmission rates by 20-40%.<sup>21</sup> Widespread application of these clinical trial interventions to general practice has also been encouraging. Since 2008, 14 Medicare Quality Improvement Organizations have been funded to focus on care transitions by applying lessons learned from clinical trials. Several have been notably successful in reducing readmissions within 30 days.<sup>22</sup> Many of these study interventions involved enhanced clinician involvement and indicate a key role for clinicians in reducing readmissions. Further, analyses CORE performed pre-development of this measure support variation in clinician- and clinician group-level performance on 30-day readmissions for patients with acute myocardial infarction.

Despite these demonstrated successful interventions, the overall national readmission rate remains high, with a 30-day readmission following over 15% of discharges. Readmission rates also vary widely across institutions.<sup>23-25</sup> Moreover, we show below that RARRs vary from 5%-38% for ECs and 7%-25% for EC groups for 2015-16. Both the high baseline rate and the variability across ECs and EC groups speak to the need for a quality measure to prompt greater care improvement. Given that studies have shown readmissions within 30 days to be related to quality of care, that interventions, including those utilizing clinicians, have been able to reduce 30-day readmission rates for a variety of specific conditions, and that high and variable clinician-level readmission rates indicate opportunity for improvement, we sought to develop EC- or E group-level measure of all-cause, all-condition 30-day unplanned readmission.

### 1.3 Quality Payment Program Background

In April 2015, Congress passed the Medicare Access and CHIP Reauthorization Act (MACRA), which marked a milestone in moving from paying clinicians based on volume of services towards paying clinicians for value of care. MACRA laid forth 2 pathways for physicians and other clinicians participating in CMS's Quality Payment Program (QPP): (1) the Merit-based Incentive Payment System (MIPS) or (2) an Advanced Alternative Payment Model (APM). This work is informed by and focuses on several aspects of MIPS requirements.

#### 1.3.1 Eligible Clinicians and Eligible Clinician Groups

The first aspect of MIPS which informs this work involves defining eligible clinicians (ECs). CMS has identified a set of clinicians based on Medicare provider specialty codes and Medicare Part B volume requirements for participation under MIPS. The types of MIPS ECs include physicians, physician assistants, nurse practitioners, clinical nurse specialists, and certified registered nurse anesthetists who bill under Medicare Part B (81 FR 77036).<sup>26</sup> CMS describes clinicians who participate in MIPS as MIPS ECs. MIPS ECs may participate as a single clinician (identified by a unique combination of Taxpayer Identification Number [TIN] and National Provider Identifier [NPI] numbers), as a group (TIN with 2 or more clinicians), or as a virtual group (2 or more TINs of solo practitioners and small groups of fewer than 10 clinicians). CMS intends to use at least 1 outcome measure (or other high priority measure) to assess the quality of care provided by MIPS ECs who choose full participation in MIPS to achieve higher payment adjustments (82 FR 30028).<sup>27</sup>

#### 1.3.2 Outcome Measures

As part of MIPS, clinicians fully participating in MIPS must report at least 6 quality measures. Of these 6, one measure must be an outcome measure. If no outcome measure is available, clinicians must select another high-priority measure in its place. If fewer than 6 outcome measures are available, clinicians must report on those available. Placing importance on outcome measures and in alignment with statutory requirements, CMS indicated its plans to increase the requirements for outcome measure reporting over time as more outcome measures become available for MIPS reporting (81 FR 77101, 82 FR 30097).<sup>28,29 29,30</sup> While CMS has not indicated whether some or all future risk-adjusted outcome measures developed for use under MIPS would be optional or required for reporting, CMS will automatically calculate the first risk-adjusted outcome measure finalized for MIPS, called the all-cause readmission measure, for groups of 16 or more eligible clinicians and score measure performance using a decile distribution (81 FR 77282 through 77284).<sup>31</sup> This development of an EC- or EC group-level measure further modifies the all-cause readmission measure, also based on the hospital-level HWR measure, to align with stakeholder input.

#### 1.3.3 Existing MIPS Attribution Approaches

An important consideration for measure development is the attribution used by existing outcome measures under MIPS. CMS has published beneficiary assignment methods for MIPS all-cause readmission and total per capita cost measures. The attribution methodology is adopted from the Value Modifier (VM) program, which uses outpatient claims to identify a primary outpatient provider during a 12-month performance period. Specifically, the 2-step attribution methodology for the VM all-cause readmission measure assigns beneficiaries first to clinicians based on a plurality of charges for delivery

of primary care services by primary care physicians or, secondly, to the specialist with plurality of charges for such services if no primary care physicians provided such services in the 12-month performance period. For the total per capita cost measure in MIPS, CMS modified the algorithm by removing the skilled nursing facility codes from the list of qualifying primary care services used for attribution (79 FR 67960 through 67964, 81 FR 77131).<sup>32</sup> The current measure builds on this precedent by attributing the readmission outcome to, among other eligible clinicians, the outpatient primary care clinician. However, the measure detailed in this report revises the VM approach to identify the outpatient primary care clinician who has billed the plurality of primary care services during the 12 months prior to the index admission that qualifies for measure inclusion.

#### Hospital Quality as a Proxy for Clinician Quality in MIPS

The current clinician-level measure is in contrast to facility-based measures that have been considered for the program. In the program's first year (2019 MIPS payment year), CMS introduced its consideration to allow facility-based clinicians to use their institutions' quality and/or cost scores as a proxy for MIPS EC's quality and/or cost performance scores (81 FR 77127).<sup>33</sup> CMS believes providing this option to clinicians will allow for clinicians to be assessed along the lines of the facilities in which they work and minimize reporting burden (82 FR 53753).<sup>34</sup> For the 2021 MIPS payment year, CMS has proposed adopting measures from the Fiscal Year 2020 Hospital Value-based Purchasing Program for facility-based measurement under MIPS (83 FR 35960).<sup>35</sup> Attribution of a facility-based clinician would be to the hospital at which the facility-based clinician provides services to the most Medicare patients, and attribution of facility-based groups would be the hospital at which the plurality of facility-based clinicians were attributed. In contrast to facility-based measures, the current work created an EC- or EC group-level measure that is aligned with, but not identical to, the original hospital-level measure. The current measure was developed with input from a diverse Technical Expert Panel that included patients and clinicians to ensure the resulting measure is as meaningful as possible to all stakeholders.

#### 1.3.4 Measure Alignment

Finally, one of CMS's priorities in implementing MACRA is to align quality measures across federal programs, such as MIPS and Advanced APMs, settings, and payers. In November 2017, CMS finalized using benchmarks for MIPS quality measures for calculation of APMs (82 FR 53698).<sup>36</sup> CMS' future policies in this area will be important in guiding the attribution of patient health outcomes to clinicians participating in the QPP via MIPS or Advanced APM pathways. In consideration of these aspects of MIPS, we applied a formal strategy, outlined below, for adapting hospital-level inpatient measures for use in measuring eligible clinicians or EC groups.

#### 1.4 Approach to Measure Development

The CORE Project Team consists of a multidisciplinary group of individuals with expertise in measure development, health services research, clinical medicine, statistics, and measurement methodology. We developed this measure in consultation with national guidelines for publicly reported outcome measures, followed guidance set forth by the CMS Measure Management System Guidance, the NQF, and articulated in the American Heart Association scientific statement, "Standards for Statistical Models Used for Public Reporting of Health Outcomes."<sup>37,38</sup> Following these standards has ensured a transparent process and comprehensive expert input throughout development.

The development process relied on the input of a Technical Expert Panel (TEP) and other external stakeholders. As part of the process, we identified 5 key principles to guide re-specification of hospital measures for measuring clinician quality; a sixth principal was added by the TEP. We formulated a strategy for identifying and evaluating attribution rules that aligned with these principals. Below we review to the key aspects of our EC- and EC group-level measure development approach.

#### 1.4.1 Expert and Stakeholder Input

As part of measure development, CORE obtained input on measure development from persons and families, clinical and technical experts, and other stakeholders. As part of CMS's commitment to incorporating views of persons and families, CORE hosted 2 listening sessions to obtain feedback from persons and families about clinician quality measurement. The goal of the sessions was to obtain input from persons and families regarding quality measurement at the clinician level and attribution of selected outcomes to clinicians. We provided participants with the project's background and presented 3 scenarios for discussion. As part of these sessions, participants provided input for various scenarios, including to whom patient readmission should be attributed for patients discharged from the hospital. Feedback focused on concerns about holding clinicians accountable for events beyond their control and about identifying the true causes of adverse outcomes. As is standard with all measure development processes, CORE also convened, through a public process, and obtained input from a national Technical Expert Panel (TEP) throughout measure development. The TEP consists of clinicians, patient advocates, and other stakeholders. The TEP has provided input on approaches to measure re-specification including attribution and risk-adjustment methodology (see [Acknowledgements](#) for roster).

Finally, as part of the measure development process and in alignment with CMS Measure Management System guidance<sup>39</sup>, we sought comments from the public on the measure concept and all specifications as outlined in this report. We also sought input specifically on the following questions:

1. Does the measure identify the appropriate eligible clinicians or eligible clinician groups responsible for 30-day unplanned readmissions following discharge from an acute care setting? Please explain your response as needed.
2. Do you agree with the recommendation to report this measure at the level of eligible clinician groups with at least 100 patients in this measure? Please explain your response as needed.
3. What, if any, additional validity testing would be meaningful for this measure?

We received 29 comments for this measure. Comments received addressed the general utility of the measure, the extent to which face validity results sufficiently validate the measure, the attribution of multiple clinicians, and the risk adjustment approach including the addition of social risk factors to the risk model. No changes were made to this report based on the comments received.

#### 1.4.2 Key Principles Driving Attribution Identification and Evaluation

As part of this development process, we identified 5 key principles to guide re-specification of hospital measures for measuring clinician quality and added a sixth identified by the TEP. Our approach to identifying and evaluating attribution rules reflects a set of principles that we derived from prior work on hospital measurement, policy goals, consultation with our TEP, the context of adapting existing measures, and the common features of those measures. Notably, these principles are specific to

hospital measure re-specification and may not be applicable to attribution in general. In this section, we state these six principles explicitly and describe how they proscribed and informed our choices and findings.

#### Principle #1: Attribution is Specific to the Measure Outcome

Throughout this document, attribution refers to the assignment of the outcome of a patient episode of care to 1 or more clinicians for the purpose of assessing clinician quality. Attribution therefore is specific to the outcome. For example, when a patient is admitted for elective surgery, it may be most sensible to attribute any complications of that surgery to the surgeon, but any post-discharge readmission to the clinician who discharged the patient. For the HWR measure, we considered attribution to ECs (or EC groups) who might plausibly influence the transition of care from hospital to the outpatient setting, or who might influence the decision of patients to return to the hospital within 30 days.

#### Principle #2: Adapted Measures Should Align with Original Hospital-Level Measures

Our goal was to adapt the patient cohort, outcome, and risk-adjustment strategy that had been previously specified for hospital measurement for use in measuring clinicians. We took as a principle, then, that an adapted measure should align, to the degree practical, with the existing measure. We only considered attribution approaches that could be implemented using the same data sources that are used to measure hospitals, with the same cohort and outcome definitions. The risk-adjustment variables and models would be, when practical, similar to those used for hospital-level measures. Thus, for the current measure we adopted the original outcome, the 5 ‘specialty cohorts’ for classifying patients, and the existing set of risk factors from the hospital-level measure. We verified model performance using this approach.

#### Principle #3: Clinician Quality Reflects Hospital Quality

This measure was originally developed to measure hospital quality. When measuring performance, it may be possible (if technically challenging) to isolate the components of quality at the clinician, group, and hospital levels. However, just as hospital quality measurement inherently reflects contributions from clinical staff, hospital systems, and community resources, we adopted the analogous principle here, that clinician performance measurement also reflects other factors, including hospital quality. Therefore, just as with CMS’s hospital measures, we did not try to separate these effects when measuring clinician performance. From the perspective of the patient, this means that when comparing providers, the performance reflects the hospital or outpatient environment in which the clinician practices. From the perspective of the policymaker, this principle means that clinicians are held accountable in part for the quality of the hospital environment in which they treat patients. Since these individuals are perhaps best placed to identify systemic opportunities for improvement, this approach can drive improvement throughout the system of care.

#### Principle #4: Inpatient Outcomes may be Most Reasonably Attributed to Inpatient Clinicians

We identified candidate attribution rules using 4 sources: 1) a literature review/environmental scan; 2) current CMS policies; 3) TEP and other expert input; and 4) claims patterns for measured patients. A hierarchy that arose from TEP input allowed us to identify key candidate attribution rules:

- Hospital clinicians generally play the most important role in outcomes after admission.
- The most central hospital clinicians depends in large part on the condition/procedure and outcome.

- Clinicians caring for patients before and after an admission may also play a role in post-admission outcomes.

Finally, we only considered attribution to the types of clinicians that are eligible for the QPP. Currently, the types of clinicians who qualify for participation are physicians, physician assistants, nurse practitioners, clinical nurse specialists, and certified registered nurse anesthetists; this list may be expanded over time as directed by MACRA. However, based upon strong TEP input regarding the role of the outpatient primary care provider in supporting the transition to the outpatient setting, we did not limit ourselves to inpatient providers. The measure presented here attributes the readmission outcome to 2 inpatient providers and an outpatient provider; these provider categories, especially the inpatient provider categories, may overlap.

#### Principle # 5: Attribution Should Align with Policy Goals

Consistent with guidelines on attribution published by the National Quality Forum (NQF), we adopted the principle that the choice of attribution rule should be ultimately determined by policy goals and informed by clinical sensibility and empirical findings.<sup>40</sup> Thus, while empirical findings may illuminate what is feasible and practical, they cannot determine what is “right” or “appropriate.” For example, empirical results may indicate that a readmission outcome after a surgical procedure can be feasibly attributed to either the surgeon or the Discharge Clinician but cannot determine that one is “better” or “more sensible” than the other. The choice between the 2 attribution rules will need to be based on clinical and policy considerations.

#### Principle #6: Attribution Should Consider the Potential for Unintended Consequences

We prioritize the goal of improving patient care. One implication of prioritizing patient care is that we considered the incentives created or modified by each candidate attribution rule. An attribution rule could conceivably create lines of responsibility that result in a tradeoff between better patient care and better clinician scores. For example, any rule that can be manipulated after admission, allowing clinicians to avoid attribution of a patient’s outcome once they have provided care for that patient, could create incentives for a clinician to ‘shift’ patients with poorer prognoses to another clinician, resulting in perhaps worse care for the patient but better measure scores for the first clinician. Therefore, we articulate potential unintended consequences for each candidate attribution rule.

These 6 principles provide a framework for thinking about attribution of inpatient outcomes in a way consistent with CMS’s policies and goals. They are broad enough to identify all candidate attribution rules that are plausible and clinically meaningful, while narrow enough to avoid spurious analyses and findings.

### 1.4.3 Strategy for Adapting Inpatient Outcome Measures to Apply to Eligible Clinicians

Prior to adapting the HWR measure, we developed a general strategy for re-specifying existing hospital-level inpatient outcome measures to apply to ECs or EC groups. This strategy consists of: 1) systematically identifying candidate attribution rules; 2) evaluating the candidate attribution rules using standardized criteria; and 3) reviewing the findings with the TEP and CMS to inform the choice of final attribution rules. The overall process for identifying, testing, and selecting algorithms (“attribution rules”) for assigning patient outcomes to clinicians consists of 3 key steps:

1. Identify candidate attribution rules: Use literature and related publications, existing policies, claims patterns, and stakeholder (clinician, patient and other expert) input to identify a preliminary set of candidate attribution rules for the measure under consideration. Descriptive data on claims patterns may also inform this set of candidate attribution rules. The aim of this step is to identify a set of attribution rules that are feasible, meaningful and policy relevant.
2. Implement candidate attribution rules on a common dataset and evaluate key characteristics of each: For each candidate attribution rule, empirically evaluate the face validity, ability to differentiate among providers, reliability and sample size, and overlap with other candidate attribution rules. We compared results to that of a random attribution as an additional validity check.
3. Use TEP input and policy considerations to select a final attribution rule: We presented the results of the evaluation to stakeholders for their input. Specifically, we held an in-person meeting of our nationally convened Technical Expert Panel (TEP) that includes representation from a broad group of providers and patients. We presented the candidate attribution rules and results to the TEP to obtain their input. We then obtained CMS input and brought the final attribution rules back to the TEP for their assessment.

### 1.5 Aims of the Measure

The primary objective of this work was to develop a hospital wide, all-condition, 30-day readmission measure for clinicians that:

- Captures differences in readmissions experienced by patients who were discharged alive from an inpatient stay.
- Adjusts for clinician case mix.
- Assesses for relative performance of clinicians.
- Aligns with CMS's existing hospital-level hospital-wide readmission measure, as appropriate.
- Provide targets to clinicians for efforts to improve the quality of care.

## 2. METHODS

### 2.1 Overview

This measure reports the clinician-level or clinician group-level risk-adjusted readmission rate (RARR) of unplanned readmission within 30 days of hospital discharge for any condition. The measure comprises a single summary score, derived from the results of 5 different models, 1 for each of the following specialty cohorts (groups of discharge condition categories [CC] or procedure categories): medicine, surgery/gynecology, cardiorespiratory, cardiovascular, and neurology, each of which will be described in greater detail below. The measure uses one year of data to assess clinician and clinician group performance, as well as 1 prior year of data to determine risk factors and attribution.

Consistent with the hospital-level HWR measure, we created 5 major specialty cohorts based on organization of care and assigned each admission to a specialty cohort using principal discharge diagnosis and procedure codes. First, admissions that included major surgical procedures (regardless of diagnosis code) were assigned to the surgery/gynecology cohort. Then, we assigned the remaining patients to the other 4 specialty cohorts. We built a separate model for each of the 5 specialty cohorts. As risk adjustment relates to the patient-level risk of the measure outcome, we adopted the risk factors in the hospital model and evaluated the resulting risk model performance.

To accommodate attribution of each admission to multiple eligible clinicians, we modified the statistical modeling approach and construction of the summary score used in the original hospital measure. Specifically, instead of using mixed-effects models to estimate clinician or clinician group effects directly, we used logistic regression models to construct standardized readmission ratios (SRRs) for each specialty cohort and applied a post-estimation method to adjust these for between provider variation. These adjusted SRRs are then combined across specialty cohorts to produce a single risk-adjusted readmission rate (RARR).

We summarized the RARRs for ECs and EC groups, and evaluated the reliability and validity of the measure results. We also assessed the reliability and performance of the 5 specialty cohort models.

### 2.2 Data Sources

For measure development and testing, we used Medicare administrative claims and enrollment information for patients with admissions between July 1, 2015 and June 30, 2017.

- *Medicare Part A inpatient data* - contain final action claims data submitted by inpatient hospital providers for Medicare fee-for-service (FFS) beneficiaries for reimbursement of facility costs. Information in this file includes ICD-9/10 diagnosis codes, ICD-9/10 procedure codes, dates of service, hospital provider ID, and beneficiary demographic information. These data are used to identify index admissions, readmissions, and comorbidities for risk adjustment. These data also are used for identifying inpatient providers. MIPS HWR risk-adjustment models use only inpatient claims data (historical and current). Primarily this is to align with the existing hospital-level HWR measure. Outpatient data are used for attribution, which is done separately from risk adjustment.

- *Medicare Enrollment Database* - contains Medicare beneficiary demographic, benefit/coverage, and vital status information. These data were used to determine FFS enrollment and post-discharge mortality status.
- *Medicare Part B claim line data from Integrated Data Repository (IDR)* - contain final action claims data for the physician services (regardless of setting) during the index admission, outpatient care, services, and supplies for Medicare FFS beneficiaries. Each claim line in the file includes details of services rendered, the identity of the rendering clinician, and the payment the clinician received for each line of service. These data are used to identify clinicians who billed for care of the patient during the index inpatient stay and 12 months prior the admission date.
- *Provider Enrollment, Chain and Ownership System (PECOS) file for clinician specialty from Integrated Data Repository (IDR)* – contains physician and non-physician specialties for NPIs. We used the PECOS file to match the specialties for NPIs in outpatient facilities (Federally Qualified Health Center [FQHC], Critical access hospital [CAH], Rural Health Clinic [RHC]).
- *Electing Teaching Amendment (ETA) hospital-related files and Accountable Care Organization attestation file* - provide information related to identify eligible outpatient facility and clinicians for Outpatient Primary Care Provider (PCP).
- *Medicare outpatient data from FQHCs, CAHs, RHCs, and ETAs* – contain 100% Part B claims for each calendar year from institutional outpatient providers. Examples of institutional outpatient providers include hospital outpatient departments, rural health clinics, renal dialysis facilities, outpatient rehabilitation facilities, comprehensive outpatient rehabilitation facilities, community mental health centers. The file includes facility charge amounts. We use these data to identify the PCP facility and clinician. The eligible facility is treated as an EC group, and their CMS Certification Number (CCN) is treated as same as identification number for the EC groups.

For measure development and testing, we created and used datasets from the July 1, 2015 to June 30, 2017 data as follows:

- To test patient-level model reliability, we used multiple datasets, covering data from July 1, 2015 to June 30, 2016. We randomly split the 1 year of data into 2 equal samples (Development Sample and Validation Sample) and compared model performance in both samples.
- To test patient-level model validity/reliability from a temporal perspective, we used data from July 1, 2016 to June 30, 2017 (Temporal Validation Sample).
- To test measure score reliability, we used multiple datasets:
  - For test-retest reliability, we used data from July 1, 2015 to June 30, 2017. We randomly split the 2 years of data into 2 equal samples (Reliability Split Sample 1 and Reliability Split Sample 2). We compared EC- and EC group-level measure scores calculated using the 2 split samples.
  - For signal-to-noise reliability, we used a 1-year sample from July 1, 2015 to June 30, 2016 (Medicare Full Sample).

- To assess model performance, calculate measure scores, and calculate performance category results for ECs and EC groups, we used a 1-year sample (July 1, 2015 to June 30, 2016, or Medicare Full Sample). This reflects the amount of data (1 year) that would be used to calculate the measure under MIPS.

## 2.3 Cohort Definition

In general, we adopted the same cohort definition as the hospital-level HWR measure.<sup>41</sup> Our guiding principle for defining eligible admissions remained that the measure should capture unplanned readmissions for as many admissions as possible across a maximum number of eligible clinicians. Therefore, we included all admissions except those for which full data were not available or for which 30-day readmission cannot reasonably be considered a signal of quality of care.

### 2.3.1 Grouping Patients into Clinically Coherent Discharge Condition Categories

We adopted the approach of the hospital-level HWR measure, and aggregated ICD-10 codes into clinically coherent condition categories using the Agency for Healthcare Research and Quality (AHRQ) Clinical Classification Software (CCS). The CCS grouping system is well-known and widely used; it is based on the principal diagnosis and not on complications or events that occur during admission (unlike the Medicare Severity Diagnosis Related Groups [MS-DRGs]); and it was developed using Healthcare Cost and Utilization Project data (unlike CMS Condition Category groups [CMS-CCs]), making it more applicable to all-payer data.<sup>42</sup> The AHRQ CCS has been used by managed care plans, insurers and researchers for a variety of functions, such as assessing resource use, predicting future expenses, comparing procedure or condition rates among payers or hospitals, or profiling patients. There are a total of 285 mutually exclusive AHRQ condition categories, most of which are single, homogenous diseases such as pneumonia or acute myocardial infarction. Some are aggregates of conditions, such as “other bacterial infections.” Mental health and substance abuse categories are included. In addition, AHRQ provides 231 mutually exclusive procedure categories to group procedures a patient might have had during admission; these procedure groups are used to identify patients with major procedures for assignment to the surgery/gynecology cohort, and to risk adjust outcomes for the patients in that specialty cohort.

### 2.3.2 Inclusion Criteria

Admissions are eligible for inclusion in the measure if:

1. Patient is 65 or older  
**Rationale:** Younger Medicare patients represent a distinct population with dissimilar characteristics and outcomes.
2. Patient survives admission  
**Rationale:** Patients who die during the initial admission cannot be readmitted.
3. Patient is discharged home or to a non-acute setting  
**Rationale:** In an episode of care in which patient is transferred among hospitals, responsibility for the readmission is assigned to the final discharging hospital. Therefore, intermediate admissions within a single episode of care are not eligible for inclusion.

4. Patient is continuously enrolled in FFS Medicare for the 12 months prior to the index admission and 30 days after discharge  
**Rationale:** This is necessary to ensure full data for risk adjustment, attribution, and outcome determination.

These inclusion criteria are consistent with existing CMS publicly reported measures for readmission.

### 2.3.3 Exclusion Criteria

We then applied several exclusion criteria to the measure population (“starting cohort”).

1. Patients discharged against medical advice (AMA) are excluded  
**Rationale:** Clinicians have limited opportunity to implement high quality care
2. Admissions for patients to a PPS-exempt cancer hospital are excluded  
**Rationale:** These hospitals care for a unique population of patients that cannot reasonably be compared to the patients admitted to other hospitals.
3. Admissions primarily for medical treatment of cancer are excluded  
**Rationale:** These admissions have a very different mortality and readmission profile than the rest of the Medicare population (higher rates of planned readmissions and higher rates of competing mortality), and outcomes for these admissions do not correlate well with outcomes for other admissions. Patients with cancer who are admitted for other diagnoses or for surgical treatment of their cancer remain in the measure. See [Appendix B](#) for excluded CCS.
4. Admissions primarily for psychiatric disease are excluded  
**Rationale:** Patients admitted principally for psychiatric treatment are typically cared for in separate psychiatric centers which are not comparable to acute care hospitals. See [Appendix B](#) for excluded CCSs:
5. Admissions for “rehabilitation care; fitting of prostheses and adjustment devices” (CCS 254) are excluded  
**Rationale:** These admissions are not typically admitted to an acute care hospital for acute care.
6. Patient cannot be attributed to a clinician.  
**Rationale:** Only patients with adequate claims for attribution should be included in the measure.

Note that a readmission within 30-days will also be eligible as an index admission if it meets all other eligibility criteria. This allows our measure to capture repeated readmissions for the same patient, whether with the same clinician(s) or not. Since there are few patients with multiple admissions in the same year in the same specialty cohort, it is difficult to model the within patient variance; thus, we chose to treat these multiple admissions as statistically independent.

### 2.3.4 Specialty Cohorts

Consistent with the hospital-level measure, we organized admissions in the total cohort into 5 mutually exclusive specialty cohorts: 1) cardiorespiratory, 2) cardiovascular, 3) medicine, 4) neurology, and 5) surgery/gynecology. By grouping patients with similar conditions, we are able to improve risk

adjustment. We refer to these specialty cohorts as “specialty cohorts,” a term which refers to the principle discharge diagnosis, not the specialty of the clinicians caring for the patients. We estimated a separate risk model for each specialty cohort. We used the same approach to define the specialty cohorts as the hospital-level HWR measure; please refer to that measure methodology report for additional information regarding measure development decisions and details. (See [Appendix C, Table C2](#), for specific list of conditions in each specialty cohort).<sup>43</sup>

Logically, admissions are first assigned to the surgery/gynecology specialty cohort, according to whether a major procedure is performed. Those not assigned to this specialty cohort are then assigned to 1 of the other 4 specialty cohorts based on the primary discharge diagnosis. Thus, we describe the surgery/gynecology specialty cohort first, followed by the others.

#### Surgery/Gynecology

This cohort includes admissions likely cared for by surgical or gynecologic teams. To be confident that these patients were cared for by surgical or gynecologic teams, we used AHRQ *procedure* categories (rather than AHRQ condition categories) to identify these patients. A patient could only be assigned to the surgery/gynecology specialty cohort if s/he underwent a major surgical procedure. We reviewed the list of AHRQ procedure categories and identified those which could typically result in surgical or gynecological teams caring for the patient. Minor procedures that would not have required a patient to be on the surgical service were not included in the list (for example: breast biopsy). Procedures that would generally accompany other, more major, procedures were also not included in the list on the assumption that patients undergoing these procedures would also undergo another procedure on the list (for example, intraoperative cholangiogram). The full list of procedures assigned to the surgery/gynecology specialty cohort is summarized in [Appendix C, Table C1](#). Any eligible admission during which a major surgical procedure from the final list was performed was assigned to the surgery/gynecology specialty cohort.

After assigning patients to the surgery/gynecology specialty cohort, we then used the principal discharge diagnosis AHRQ CCS to assign each index admission to one of the remaining specialty cohorts, as described below. This approach is consistent with the hospital-level measure. The AHRQ discharge condition categories for the non-surgical groups are shown in [Appendix C, Table C2](#).

#### Cardiorespiratory

This cohort includes several conditions with very high readmission rates – pneumonia, chronic obstructive pulmonary disease, and heart failure – as well as admissions for other condition categories related to these 3 (asthma, acute bronchitis, pulmonary heart disease, cystic fibrosis and respiratory failure). We combined these patients into a single specialty cohort because patients with these diseases are often clinically indistinguishable, are typically treated by the same care teams, and are often simultaneously treated for several of these diagnoses. Although patients with heart failure may be cared for by a separate cardiac or cardiovascular team, they are also often cared for by general medicine teams.

#### Cardiovascular

This cohort includes cardiovascular condition categories, such as acute myocardial infarction, that in large hospitals might be cared for by a separate cardiac or cardiovascular team.

#### Neurology

This cohort includes neurologic condition categories such as stroke that in large hospitals might be cared for by a separate neurology team.

#### Medicine

This cohort includes all non-surgical patients who were not assigned to any of the specialty cohorts above.

## 2.4 Outcome Definition

The outcome for this measure is unplanned all-cause 30-day readmission. We define a readmission as a subsequent inpatient admission to any acute care facility which occurs within 30 days of the discharge date of an eligible index admission. Any readmission is eligible to be counted as an outcome, except those that are considered planned.

### 2.4.1 Planned Readmissions

Only unplanned readmissions were counted as outcomes. To align with our data years we used the planned readmission algorithm version 4.0 to classify readmissions as planned or unplanned.<sup>44</sup> Implementation with more recent data would use the most recent version 4.0.<sup>44</sup>

### 2.4.2 All-cause Readmission

As with the hospital-level HWR measure, we defined the outcome as “all-cause” unplanned readmissions rather than readmissions related to the previous admission for multiple reasons. First, from the patient perspective, readmission for any reason is likely to be an undesirable outcome of care. Furthermore, readmission for any reason exposes the patient to risks associated with admission, such as iatrogenic errors. Second, there is no reliable way to determine whether a readmission is related to the previous admission based on the documented cause of readmission. For example, a stroke patient who develops aspiration pneumonia may ultimately be readmitted for respiratory distress. It would be inappropriate to treat this readmission as unrelated to the care the patient received for stroke. Third, the range of potentially avoidable readmissions also includes those not directly related to the index condition category, such as those resulting from medication reconciliation errors, poor communication at discharge, or inadequate follow-up post-discharge. Creating a comprehensive list of potentially avoidable readmissions related to the previous admission’s condition category would be arbitrary and, ultimately, challenging to implement. Fourth, all existing CMS readmission measures report all-cause readmission, making this approach consistent with existing measures. Fifth, research shows that readmission reduction interventions can reduce all-cause readmission, not only condition-specific readmission. Finally, defining the outcome as all-cause readmissions may encourage hospitals to implement broader initiatives aimed at improving the overall care within the hospital and transitions from the hospital setting instead of limiting the focus to a narrow set of condition-specific approaches.

## 2.5 Attribution

Attribution of the outcome is the critical difference between MIPS HWR measure and the hospital-level HWR measure. While a hospital discharge can be unambiguously assigned to the facility which bills for the discharge, there is more uncertainty when assigning a discharge to a clinician. A critical and novel aspect of MIPS HWR measure is that it attributes each outcome to potentially 3 distinct EC or EC groups

(Section 2.5.2). Conceptually, this “multiple attribution” is consistent with the recognition that patient readmission can be influenced by multiple key providers; attribution to multiple providers was strongly endorsed by a large majority of the TEP.

We used the key principles, TEP input, and internal clinical experience to develop a set of potential candidates for attribution. These included eligible clinicians identified on the hospital claim (e.g., the Attending clinician), those identified through carrier claims and outpatient claims (Section 2.2). All candidate approaches were identified using claims data, and all were identified using the principles outlined above. We then used the strategy described in Section 1.4.3 to finalize the set of attribution rules. Appendix D documents attribution rules that were evaluated and ultimately excluded, along with the reason they were not adopted.

### 2.5.1 Eligible Clinician (TIN/NPI) and Eligible Clinician Group (TIN)

For the purposes of development and testing we have defined ‘eligible clinicians’ (ECs) as unique combinations of NPI and TIN. Thus, a single clinician may be measured 2 or more times if they file Medicare claims under 2 or more TINs. Each attribution rule includes an algorithm for identifying a unique TIN/NPI combination.

The unique TIN/NPI combinations can be directly aggregated into groups of clinicians with the same TIN. We refer to these as MIPS EC groups. It should be noted that these only approximately align with practice groups. Note also that patients can only be assigned to groups by way of an EC (a TIN/NPI combination), and thus these are by default groups with at least 1 EC. Within MIPS, an EC “group” must include 2 or more ECs, at least 1 of which participates in MIPS. Because we cannot identify non-attributed ECs at each TIN, we report all TINs regardless of the number of attributed ECs.

### 2.5.2 Attributed Eligible Clinicians

#### Discharge Clinician

The Discharge Clinician is intended to capture the clinician responsible for discharging the patient and thus a key individual responsible for readmission outcomes. The TEP agreed that the Discharge Clinician is both a key individual facilitating the transition from inpatient to outpatient care and is the main point of contact for post-discharge providers, such as home health providers and visiting nurses. They also prioritized this attribution approach over the Attending of Record, as the Attending is designated by the hospital, while the Discharge Clinician is identified through clinician claims and thus is more under the control of the clinician.

The Discharge Clinician is determined by identifying a claim for a discharge procedure code which occurred within the last 3 days of the hospital stay. Attribution to the Discharge Clinician reinforces the notion that readmission is a signal of quality during a care transition. Practically, the Discharge Clinician is often, but not always, also the attending of record on the inpatient claim. The Discharge Clinician is determined using the outpatient (Carrier) claims, as for most patients discharged from acute care there should be a corresponding claim for a discharge procedure (Current Procedural Terminology [CPT®] code 99238 or 99239). In the case of multiple claims with a discharge procedure code, the last claim was used. If no discharge procedure code was found, the last day of the stay was searched for a subsequent care code (CPTs 99231, 99232, and 99233), and, if found, the EC on this claim was assigned the

admission. If no EC is identified at this step, no Discharge Clinician was assigned. The complete algorithm is documented in [Figure D.2](#) in [Appendix D](#).

#### Primary Inpatient Care Provider

The Primary Inpatient Provider is the EC who billed the most charges for the patient during their hospital stay. Only patient-facing claims are counted. Conceptually, it may be reasonable that the provider who charged the most for the patient's care during the admission is most responsible for that patient's outcomes. Practically, charges are readily available from the Carrier claims file. This attribution approach was added based upon TEP input. As with the Discharge Clinician, it is identified using clinician claims and thus is more under the control of the individual clinician.

We explored using both the number of claims billed by each clinician as well as the total cost of charges per clinician to identify this provider. Using the greatest charges billed provides greater clinical sensibility and better reflects the different ways surgeons and non-surgical providers bill for inpatient care. While non-surgical providers frequently bill for each individual (often daily) patient encounter, surgeons often bill for the procedure but not for each daily patient encounter. Therefore, using the greatest number of claims produced clinician assignments that lacked face validity for surgical patients. Using the greatest charges billed identified similar non-surgical providers as the greatest number of claims approach, while more accurately identifying surgical providers for patients in the surgery/gynecology specialty cohort.

All patient-facing claims for the patient filed during the stay are identified and totaled over EC values on each claim; the admission is attributed to the EC with the greatest charges billed. This may often be the same as the EC identified as the Discharge Clinician, but in cases where the Discharge Clinician provided care for only a small part of the stay, the [Primary Inpatient Care Provider](#) attribution captures an alternate EC who provided most of the care. The complete algorithm is documented in [Figure D.1](#) in [Appendix D](#).

#### Outpatient PCP

The [Outpatient PCP](#) is the eligible clinician who provides the greatest number of claims for primary care services during the 12 months prior to the hospital admission date. Conceptually, if a patient has a primary care provider, this clinician could plausibly be aware of any admission and provide post-discharge follow-up care that would reduce the need for a readmission. The TEP strongly supported attributing the measure outcome to multiple providers, including outpatient providers, to incentivize shared accountability for readmissions. Of note, CMS is also developing outcome measures intended for evaluating outpatient provider performance in MIPS, some of which may overlap with this measure. CMS may therefore evolve the attribution of its MIPS measures over time to avoid duplication, while still encouraging shared accountability for comprehensive patient care.

In keeping with our principle to align the identified PCP with the way this is done in other measures, this rule is a modification of the attribution used by the current MIPS all-cause readmission or ACR measure. That measure uses an algorithm to assign inpatient admissions to primary care providers by identifying a clinician using the greatest number of claims of primary care codes during the calendar year of admission. The original MIPS ACR algorithm is documented elsewhere.<sup>45</sup> Our only modification was to use a different window for each admission, rather than a fixed calendar year.<sup>46</sup> The revised approach uses the 12 months of clinician claims prior to the index admission included in the measure to identify

the Outpatient PCP. This ensures the clinician has seen the patient prior to admission and is therefore more likely to be able to meaningfully contribute to the patient's post-discharge care.

#### Multiplicity, Overlap, and Reporting

Though an admission may be attributed to 3 distinct ECs (or EC groups), it will often be the case that 2 or even all 3 of the above listed roles for a given patient are filled by the same clinician. In the case of multiple assignments to the same EC or EC group, each admission is included only once when measuring the EC or EC group.

Importantly, this implies that while there are 3 different rules for attribution, these are not distinguished when measuring clinician performance. While a clinician can have admissions attributed to them in multiple capacities – for instance, a clinician may be both a Discharge Clinician for some patients and a Primary Inpatient Care Provider for others – all attributed admissions are used to construct a single score for that eligible clinician. Thus, while we report some results by attribution role, we report measure scores only for “unique ECs” and “unique EC groups”.

### 2.5.3 Volume Requirements

It is impractical to measure outcomes for eligible clinicians or clinician groups which are assigned a small number of patients; though technically it is feasible to construct estimates based on as few as 1 patient, practically we would want to measure only those entities with adequate volume to construct moderately reliable estimates. For the purposes of this report, we include ECs and EC groups with at least 25 attributed patients for reporting results; in the reliability section ([Section 4.4](#)), we suggest this reporting threshold be revised based on final measure reliability results.

## 2.6 Risk Adjustment

### 2.6.1 Overview

The goal of risk adjustment is to account for differences across hospitals in patient demographic and clinical characteristics that might be related to the outcome but are unrelated to quality of care. Risk adjustment for this measure is complicated by the fact that it includes many different principal discharge diagnosis condition categories. We must therefore adjust both for case mix differences (clinical status of the patient, accounted for by adjusting for comorbidities) and service mix differences (the types of conditions/procedures, accounted for by adjusting for the principal discharge diagnosis condition category). In keeping with our key principle regarding alignment with the hospital-level measure, and because the hospital-level risk model was developed and validated at the patient level using the same cohort adopted for MIPS HWR measure, we used the same risk factors as used by the HWR model. We then tested the model performance.

Consistent with the original hospital-level HWR measure, we 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 measure to adjust for age and clinical characteristics while illuminating important quality differences. The hospital-level HWR measure was recently re-endorsed by the National Quality Forum (NQF) without adjustment for patient-level SES factors. For more information about this decision, please refer to the [NQF website](#).

Because MIPS HWR measure assigns each admission to multiple eligible clinicians, we could not adapt the hierarchical logistic regression methods of the HWR to adjust for differences in eligible clinician case mix and to account for the clustering of patients within a provider. Instead, we used a method which uses the results of each specialty cohort model to construct a standardized readmission rate for each clinician or clinician group which is corrected for clustering and between provider variance after estimation. Each cohort model adjusts for case mix differences among providers by risk-adjusting for patients' comorbid conditions identified in inpatient episodes of care for the 12 months prior to the index admission as well as those present at admission. We did not risk-adjust for diagnoses that may have been a complication of care during the index admission. We used CMS-CCs, the grouper used in previous CMS risk-standardized outcome measures, to define the comorbid risk adjusters and used a fixed set of comorbid risk variables across models. We risk-adjusted for service mix differences among eligible clinicians within each specialty cohort by including indicator variables for principal discharge diagnosis condition categories (as defined by AHRQ CCS) in each model.

Finally, we used each of the 5 specialty cohort models to calculate the ratio of observed to expected numbers of readmissions (as defined below in Section 2.6.2 for each clinician or clinician group in each specialty cohort. These standardized readmission ratios (SRRs) are then used to estimate the between provider variance, and this parameter is then used to adjust each SRR, creating a 'smoothed rate' (SR). We then derived a single summary score from the results of the 5 specialty cohort models by calculating the volume-weighted log average (that is, the geometric mean) of the SRRs from each model and multiplying the resulting ratio by the average national observed readmission rate. This approach allowed us to take into account the variation in specialty cohort mix across ECs or EC groups.

#### Service-mix Grouping

For all CMS-CCs with sufficient volume (defined as those with more than 1,000 admissions nationally each year), we included a condition-specific indicator in the model. Condition categories differ in their baseline readmission risks and ECs and EC groups will differ in their relative distribution of these condition categories (service mix) within each specialty cohort. Therefore, adjusting for condition categories levels the playing field across ECs and EC groups with different service mixes. This was to align with the hospital-level HWR measure. These are listed in the tables of Appendix F.

#### Complications of Admission

Complications occurring during admission are not comorbid illnesses, may reflect clinician quality of care, and therefore should not be used for risk adjustment. Although adverse events during admission may increase the risk of readmission, including them as covariates in a risk-adjusted model could attenuate the measure's ability to characterize the quality of care delivered by ECs and EC groups. We used the previously vetted approach from the hospital-level HWR measure to classify CMS-CCs that are plausibly complications of care; we augmented these with Present on Admission (POA) codes and omitted any potential complications of care lacking a POA flag as risk adjusters. See Appendix E.

#### Case-mix Adjustment: Comorbid Risk Variables

We used CMS-CCs to group ICD-9-CM/ICD-10-CM codes into comorbid risk adjustment variables. Multiple CMS condition-specific claims-based readmission models that use this grouper method to define variables for risk adjustment have been validated against models that use medical record-abstracted data for risk adjustment.<sup>23-25</sup>

### 2.6.2 Statistical Approach to Calculating Risk-Adjusted Readmission Rates

Because the same admission may be attributed to more than 1 unique EC or unique EC group, we could not apply the method used by the existing hospital-level HWR measure to construct risk standardized readmission rates. Instead, we adopted method that, while requiring an assumption independence across entities, allowed us to account for correlation within entity.

Let

- $Y_i$  be the observed (0, 1) outcome for patient  $i$
- $\bar{Y}$  be the observed rate for all discharges in the reference population
- $H$  be the total number of providers
- $\hat{E}_i$  be the expected (predicted) patient level probability;
- $n_h$  be the number of discharges at provider  $h$

We define the observed rate at provider  $h$  as

$$O_h = \frac{1}{n_h} \sum_{i=1}^{n_h} Y_i$$

The expected rate at provider  $h$  as

$$\hat{E}_h = \frac{1}{n_h} \sum_{i=1}^{n_h} \hat{E}_i$$

The Standardized Readmission Ratio (SRR) as

$$SRR_h = \frac{O_h}{\hat{E}_h}$$

Then the formula for the smoothed rate is:

$$SR_k = (SRR_k \times \text{Shrinkage Weight}) + (1 - \text{Shrinkage Weight}) \quad (1)$$

Where

$$\text{Shrinkage Weight} = \frac{\text{Signal Variance}}{\text{Signal Variance} + \text{Noise Variance}}$$

$$\text{Noise Variance } \hat{\sigma}_h^2 = \left( \frac{1}{n_h \hat{E}_h} \right)^2 \sum_{i \in A_h} \hat{E}_i (1 - \hat{E}_i)$$

$$\text{Signal Variance } \hat{t}^2 = \frac{\sum_{h=1}^H \frac{1}{(\hat{t}^2 + \hat{\sigma}_h^2)^2} \max(0, \{(SRR_h - \overline{SRR})^2 - \hat{\sigma}_h^2\})}{\sum_{h=1}^H \frac{1}{(\hat{t}^2 + \hat{\sigma}_h^2)^2}} \quad (2)$$

Note that  $\hat{t}^2$  appears on both sides of the signal variance equation.

For calculating the physician RARR using SR scores from 5 specialty cohorts, we combined the SRs using volume-weighted logarithmic mean as following:

$$\begin{aligned} SR_j &= \exp( \sum m_{cj} \log(SR_{cj}) ) / \sum m_{cj} \\ RARR_j &= SRR_j * \bar{Y} \end{aligned} \quad (3)$$

where  $\bar{Y}$  = overall national observed readmission rate for all index admissions in all cohort,  $m_{cj}$  = the number of discharges for provider j in cohort c,  $SR_{cj}$  = the calculated smoothed rate score for provider j in cohort c.

#### Creating Credible Interval Estimates

For purposes of estimating confidence intervals, we used bootstrapping. Because of overlapping assignment of patients, bootstrapping was at the specialty cohort level. Specifically, we select  $m=1, \dots, M$  random samples of discharges with replacement from each specialty cohort. Using the existing attribution, we calculated (1), (2) and (3) above for each EC and EC group. The 95% credible interval estimate of the  $RARR_j$  for each EC or EC group was used as the estimated 95% confidence interval.

#### Performance Categories

After bootstrapping the RARRs, we used the estimated 95% confidence intervals to identify ECs and EC groups which have RARRs that are statistically significantly different than the national rate. Those significantly above (worse than) the national rate had 95% confidence intervals above and wholly exclusive of the national rate; those significantly below (better than) the national rate had 95% confidence intervals below and wholly exclusive of the national rate.

## 3. METHODS

### 3.1 Evaluation

We used a full year of admission data from 2015-2016, with 12 months history data, to create the specialty cohorts and select risk variables. To assess reliability of the models' performance, we also created a full year cohort for 2016-2017 and then combined 2015-2016 and 2016-2017 data, randomly split this dataset and ran the models on each split sample.

#### 3.1.1 Cohorts and Outcomes

For each specialty cohort we report the number of admissions, number of readmissions, rate of planned and unplanned readmissions, and proportion of all readmissions that are planned.

#### 3.1.2 Attributed Eligible Clinicians and Eligible Clinician Groups

For each attribution rule, as well as for unique ECs, we report the distribution of admissions assigned across ECs. We also report the percent of admissions that could not be assigned, and the total number of distinct ECs in that role. We replicate this for EC groups. Then, for unique ECs and unique EC groups, we report the number of specialty cohorts assigned and the distribution of unadjusted outcome rates across specialty cohorts.

#### 3.1.3 Unadjusted Outcome Rates

We report distribution of unadjusted readmission rates for ECs and EC groups with at least 25 patients assigned, both by attribution rule and overall.

#### 3.1.4 Risk-Adjustment Variables

We report the frequency of each risk variable for all datasets. This provides a description of the patients included in the different samples, informing both face validity and reliability considerations.

#### 3.1.5 Models for Each Specialty Cohort

For each of the 5 specialty cohorts, we estimated a patient-level logistic regression model. These models included the risk factors listed in [Appendix E](#), with the dependent variable being the outcome, readmission within 30 days after discharge. We report the coefficient and variance estimates for the models. Direction and magnitude of these provide face validity for the risk adjustment.

#### 3.1.6 Risk Adjusted Readmission Rates

We report the distribution of RARRs across ECs and EC groups with at least 25 patients. We also report the distribution of high and low outliers for the same ECs and EC groups.

### 3.2 Model Performance

We assessed the reliability of the patient-level models by comparing coefficients from logistic regression models in the Development Sample to both the Validation and Temporal Validation Samples ([Section 2.2](#)). For each logistic regression model, we computed 5 summary statistics to assess model performance: calibration (a measure of over-fitting), discrimination in terms of predictive ability, discrimination in terms of area under the receiver operating curve (ROC), distribution of residuals, and model chi-square.

Over-fitting refers to the phenomenon in which a model describes the relationship between predictive variables and outcome well in the development dataset but fails to provide valid predictions in new patients. If the  $\gamma_0$  in the validation sample is close to zero and the  $\gamma_1$  is close to 1 in each of the models, there is little evidence of over-fitting.

Discrimination in predictive ability measures the ability to distinguish high-risk subjects from low-risk subjects. Therefore, we would hope to see a wide range between the lowest decile and highest decile, which these models show.

The C-statistic is a measure of how accurately a statistical model is able to distinguish between a patient with and without an outcome. A C-statistic of 0.50 indicates random prediction, implying all patient risk factors are useless; a value of 1 indicates perfect prediction, implying patients' outcomes can be predicted completely by their risk factors, and clinicians play no role in patients' outcomes. While higher C-statistic is desirable, we do not want to maximize C-statistic by adjusting for factors that should not be adjusted for; for example, we do not want to include complications of care as risk factors, even if it produces a higher C-statistic.

The model residuals are the difference between what the model predicts for each patient and the observed outcome. If they are not distributed symmetrically around zero, or if most values are not near zero, this indicates that the model assumptions are not met.

The model chi-square is a statistic which represents the degree to which the model explains the observed data.

### 3.3 Internal Consistency

Because this measure is comprised of 5 component specialty cohort models, we assessed whether the component scores – the SRs for each specialty cohort – were consistent with each other across providers. To assess the overall internal consistency of the specialty cohort SRs, we report the correlations for unique ECs and EC groups, as well as Cronbach's coefficient  $\alpha$ . We do this those specialty cohorts for which the EC or EC group has at least 25 patients attributed.

Cronbach's  $\alpha$  reflects the proportion of total variance in the summated scale composite score that is accounted for by a common source among the condition measures. Theoretically Cronbach's  $\alpha$  varies from 0 to 1;  $\alpha$  generally increases as the intercorrelations among components increase, although it is also affected by factors such as the number of contributing items. Though internal consistency provides some measure of overall validity, we take a formative perspective in combining the SRs across providers

– that the overall RARR serves as an average of perhaps distinct metrics rather than as a measure of a latent trait underlying them.

### 3.4 Reliability

#### 3.4.1 Data Element Reliability

In constructing MIPS HWR measure we utilized only those data elements from claims that have both face validity and reliability. We also assessed the reliability of the data elements by comparing risk factor frequencies and ORs in the Split Sample Datasets.

#### 3.4.2 Measure Score Reliability

We considered 2 notions of reliability when evaluating MIPS HWR measure. The ‘test-retest’ reliability is the degree to which repeated measurements of the same entity at the same time agree with each other. For measures of EC or EC group performance, the measured entity is naturally the EC or EC group, and reliability is the extent to which repeated measurements of the same entity give similar results. In line with this thinking, our approach to assessing reliability is to measure each EC or EC group once using a random subset of patients, then measure the same entity again using a second random subset, exclusive of the first, and finally compare the agreement between the 2 resulting performance measures across all entities.<sup>47</sup>

For test-retest reliability, we combined index admissions from two 12-month periods into 1 dataset, randomly sampled half of the patients within each EC, calculated the measure for each EC, and repeated the calculation using the second half. Thus, each EC is measured twice, but each measurement is made using an entirely distinct set of patients. To the extent that the calculated measures of these 2 subsets agree, we have evidence that the measure is assessing an attribute of the EC, not of the patients. We compared the frequency of providers between each test-retest dataset and assessed the overlap/agreement between Reliability Split Sample 1 and 2, at both EC and EC group level. As a metric of agreement, we calculated the intra-class correlation coefficient (ICC[2,1]) (Shrout and Fleiss, 1979).<sup>48</sup> We assessed the values according to conventional standards (Landis and Koch, 1977).<sup>49</sup> We report ICC[2,1] for a range of minimum volume thresholds.

The other notion of reliability that we considered was ‘signal-to-noise’ reliability. This is the degree to which the variation between entities (‘signal’) comprises the total variation (‘noise’ + ‘signal’) in the outcome. To estimate the overall signal and noise, we used the bootstrap estimates of RARR variance (Section 2.6.2 above) as the within-entity variance  $\sigma_j^2$  for each entity (EC or EC group)  $j$ . We used equation (2) above to estimate the signal  $\tau^2$ , and then for each entity calculate  $\rho_j = \tau^2 / (\tau^2 + \sigma_j^2)$ . We then used the equation

$$R_j = n_j \rho_j / (1 + (n_j - 1) \rho_j)$$

to calculate the reliability of each entity measurement; we report the mean  $R_j$  over all entities for different minimum volumes  $n_j$ .<sup>50</sup>

### 3.5 Validity

#### 3.5.1 Data Element Validity

For validity of the data elements, the CORE Project Team has already demonstrated for a number of prior measures the validity of claims-only measures for profiling hospitals by comparing either the measure results or individual data elements against medical records, as discussed further in the Results ([Section 4](#)).

#### 3.5.2 Measure Score Validity

##### Validity of Attribution Rules

Prior to developing a list of attribution rules, we conducted literature review and environmental scans to evaluate the attribution used by existing outcome measures under MIPS, as well as those that have been implemented and evaluated. We reviewed the methodology from the CMS Value Modifier (VM) program measures, the report on attribution rules proposed for use in or implemented in healthcare delivery models published by the NQF in December 2016, and medical literature published after the NQF compiled its report. After we compiled this comprehensive list of attribution rules, we held 2 TEP meetings to review the rules with clinical and patient experts and establish an approach to identifying and testing candidate attribution rules.

##### Face Validity of Measure Scores

Following presentation and review of the final measure specifications, results, and testing, we systematically assessed the face validity of the measure score as an indicator of quality by confidentially soliciting the TEP members' agreement with the following statements (via an online survey):

The risk-standardized readmission rates obtained from the MIPS HWR measure as specified:

1. Are valid and useful measures of MIPS EC and MIPS EC group quality of care.
2. Will provide MIPS ECs and MIPS EC groups with information that can be used to improve their quality of care.

TEP members were asked to report their agreement with each statement on a 6-point scale, representing a range from "strongly disagree" to "strongly agree."

## 4. RESULTS

### 4.1 Evaluation

#### 4.1.1 Cohorts and Outcomes

Figure 1 illustrates the cohort selection and exclusions.

**Figure 1. Hospital-wide readmission (HWR) cohort exclusions (dataset: Medicare full sample [July 2015-June 2016])**

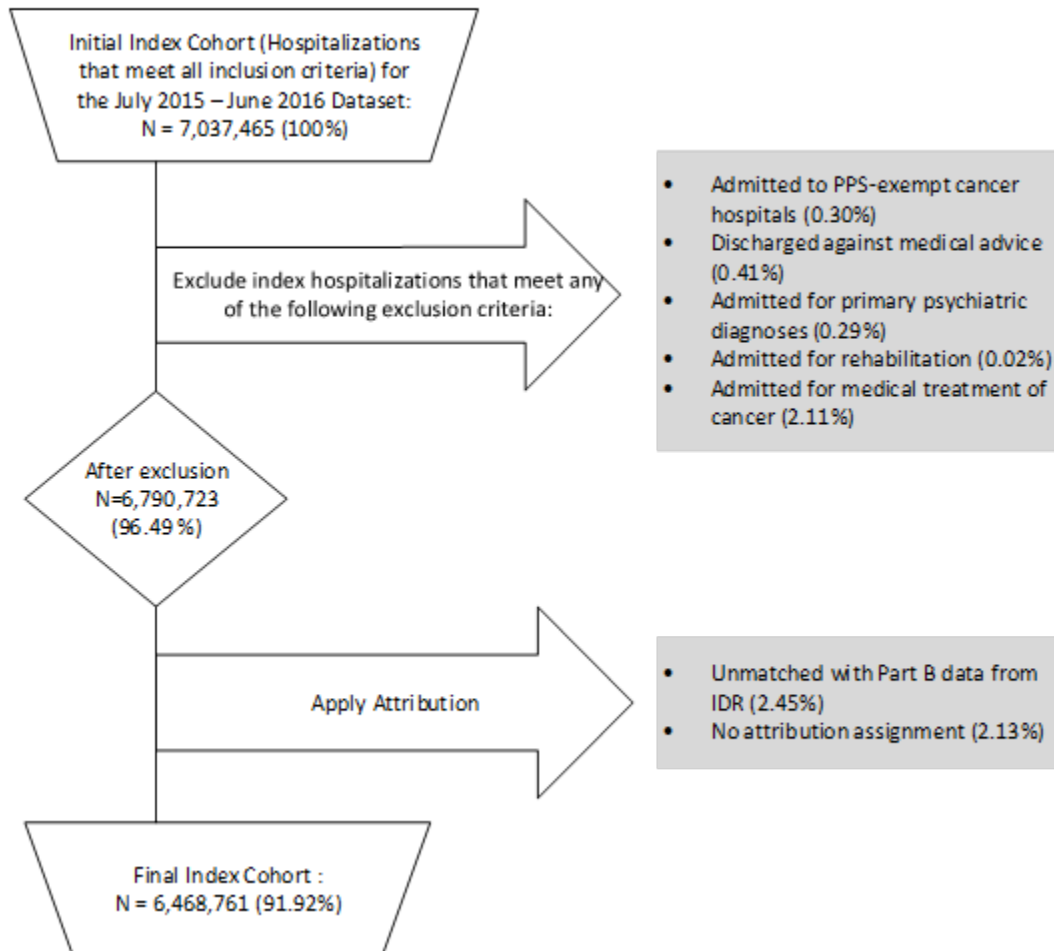


Table 1 reports the number of admissions, number of readmissions, rate of planned and unplanned readmissions, and proportion of all readmissions that are planned.

**Table 1. Admissions, readmissions for the 5 specialty cohorts (dataset: Medicare Full Sample)**

Specialty cohort	# of admissions	# of unplanned readmissions	30-day readmission rates	# of planned readmissions	30-day planned readmission rates	Planned to unplanned readmission ratio
Cardiorespiratory	1,041,507	203,182	19.5%	6,307	0.6%	3.1%
Cardiovascular	640,081	92,567	14.5%	10,919	1.7%	11.8%
Medicine	2,719,822	459,304	16.9%	23,799	0.9%	5.2%
Neurology	402,319	52,692	13.1%	3,503	0.9%	6.6%
Surgical	1,665,032	189,667	11.4%	11,470	0.7%	6.0%
Total	6,468,761	997,412	15.4%	55,998	0.9%	5.6%

#### 4.1.2 Attributed Eligible Clinicians and Eligible Clinician Groups

For each attribution role, as well as for unique ECs, Table 2 reports the distribution of admissions assigned across ECs. We also report the percent of admissions that could not be assigned, and the total number of distinct ECs in that role. Table 3 replicates this for EC groups.

**Table 2. Distribution of admissions assigned to eligible clinicians for each attribution rule and to any eligible clinician (dataset: Medicare Full Sample)**

Statistic	Discharge clinician	Primary inpatient care provider	Outpatient PCP	All eligible clinicians (unique ECs)
# of total admissions	6,468,761	6,468,761	6,468,761	6,468,761
# of admissions in each attribution	6,417,534	6,417,534	6,290,391	6,468,761

Statistic	Discharge clinician	Primary inpatient care provider	Outpatient PCP	All eligible clinicians (unique ECs)
% of admissions in each attribution	99.2%	99.2%	97.2%	100.0%
Minimum	1	1	1	1
10 <sup>th</sup> percentile	1	1	1	1
25 <sup>th</sup> percentile	2	2	1	2
50 <sup>th</sup> percentile	5	8	4	8
75 <sup>th</sup> percentile	20	23	18	27
90 <sup>th</sup> percentile	61	51	47	66
Maximum	1217	680	824	1223
Mean (standard deviation [SD])	21.3 (41.6)	18.8 (29.2)	16.2 (28.1)	24.1 (41.5)
Number of eligible clinicians	301,352	341,727	388,659	629,951

**Table 3. Distribution of admissions assigned to eligible clinician groups for each attribution, and to any eligible clinician (dataset: Medicare Full Sample)**

Statistic	Discharge Clinician	Primary inpatient care provider	Outpatient PCP	All eligible clinician groups (unique TINs)
# of admissions in each attribution	6,417,534	6,417,534	6,290,391	6,468,761
% of admissions in each attribution	99.2%	99.2%	97.2%	100.0%

Statistic	Discharge Clinician	Primary inpatient care provider	Outpatient PCP	All eligible clinician groups (unique TINs)
Minimum	1	1	1	1
10 <sup>th</sup> percentile	1	1	1	1
25 <sup>th</sup> percentile	3	3	2	3
50 <sup>th</sup> percentile	12	16	10	16
75 <sup>th</sup> percentile	48	57	40	59
90 <sup>th</sup> percentile	151	161	103	158
Maximum	31136	16988	12133	35528
Mean (standard deviation [SD])	114.7 (620.6)	100.1 (466.5)	57.5 (272.0)	99.6 (535.6)
Number of eligible clinician groups	55,957	64,081	109,312	130,671

Table 4 reports, for unique ECs and unique EC groups, the number of specialty cohorts assigned and the distribution of unadjusted outcome rates across specialty cohorts.

**Table 4. Number of eligible clinicians and eligible clinician groups by number of specialty cohorts attributed (dataset: Medicare Full Sample)**

Number of specialty cohorts	All entities		Entities with 25+ admissions attributed	
	# (%) eligible clinicians	# (%) eligible clinician groups	# (%) eligible clinicians	# (%) eligible clinician groups
1	163,995 (26.0%)	26,180 (20.0%)	3,282 (1.9%)	334 (0.6%)
2	124,007 (19.7%)	19,225 (14.7%)	9,896 (5.8%)	1,645 (3.0%)
3	96,651 (15.3%)	15,613 (11.9%)	10,993 (6.4%)	2,471 (4.4%)

Number of specialty cohorts	All entities		Entities with 25+ admissions attributed	
	# (%) eligible clinicians	# (%) eligible clinician groups	# (%) eligible clinicians	# (%) eligible clinician groups
4	92,593 (14.7%)	18,050 (13.8%)	25,881 (15.2%)	6,433 (11.6%)
5	152,705 (24.2%)	51,603 (39.5%)	120,703 (70.7%)	44,710 (80.4%)

Accordingly, the final measure score for over 70% of ECs and over 80% of EC groups with at least 25 admissions are based on all 5 specialty cohorts. Fewer than 15% and 10% of ECs and EC groups with at least 25 admissions, respectively have measure results reports based upon 3 or fewer specialty cohorts.

#### 4.1.3 Unadjusted Outcome Rates

Below we report the unadjusted unplanned readmission rates for EC and EC groups, Tables [5](#) and [6](#)).

**Table 5. Unadjusted rates for eligible clinicians with at least 25 admissions (dataset: Medicare Full Sample)**

Statistic	Cardio-respiratory	Cardio-vascular	Medicine	Neurology	Surgical	Overall HWR cohort
# of admissions in each attribution with 25 admission cutoff	1,011,595	620,320	2,618,659	386,429	1,580,876	6,217,879
% of admissions in each attribution with 25 admission cutoff	97.1%	96.9%	96.3%	96.1%	94.9%	96.1%
Minimum	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10 <sup>th</sup> percentile	0.0%	0.0%	0.0%	0.0%	0.0%	7.1%
25 <sup>th</sup> percentile	6.3%	0.0%	9.5%	0.0%	2.7%	10.9%
50 <sup>th</sup> percentile	17.4%	10.5%	15.8%	0.0%	11.1%	15.2%
75 <sup>th</sup> percentile	27.3%	23.5%	22.2%	20.0%	20.0%	19.5%
90 <sup>th</sup> percentile	40.0%	37.5%	29.2%	40.0%	30.0%	24.1%

Statistic	Cardio-respiratory	Cardio-vascular	Medicine	Neurology	Surgical	Overall HWR cohort
Maximum	100%	100%	100%	100%	100%	64.3%
Mean (standard deviation [SD])	19.2% (17.1%)	15.1% (19.5%)	16.5% (11.7%)	13.3% (21.5%)	13.7% (14.2%)	15.5% (6.8%)
# of eligible clinicians with 25 admission cutoff	337,308	298,663	507,115	255,791	436,982	629,951

**Table 6. Unadjusted rates for eligible clinician groups with at least 25 patients (dataset: Medicare Full Sample)**

Statistic	Cardio-respiratory	Cardio-vascular	Medicine	Neurology	Surgical	Overall HWR cohort
# of admissions in each attribution with 25 admission cutoff	1,038,422	638,171	2,709,870	400,984	1,657,704	6,445,151
% of admissions in each attribution with 25 admission cutoff	99.7%	99.7%	99.6%	99.7%	99.6%	99.6%
Minimum	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10 <sup>th</sup> percentile	0.0%	0.0%	5.6%	0.0%	0.0%	7.7%
25 <sup>th</sup> percentile	8.3%	0.0%	11.1%	0.0%	5.7%	11.5%
50 <sup>th</sup> percentile	18.2%	12.5%	16.2%	6.3%	11.5%	15.3%
75 <sup>th</sup> percentile	26.4%	22.2%	21.4%	20.0%	18.2%	19.3%
90 <sup>th</sup> percentile	37.5%	33.3%	27.3%	33.3%	27.3%	23.8%
Maximum	100%	100%	100%	100%	100%	64.3%

Statistic	Cardio-respiratory	Cardio-vascular	Medicine	Neurology	Surgical	Overall HWR cohort
Mean (standard deviation [SD])	19.3% (16.2%)	15.0% (17.7%)	16.6% (9.4%)	13.3% (19.3%)	13.4% (12.2%)	15.6% (6.4%)
# of eligible clinician groups with 25 admission cutoff	81,177	77,068	110,396	68,689	104,354	130,671

#### 4.1.4 Risk-Adjustment Variables

The prevalence of the risk factors for each specialty cohort are in [Appendix F](#)

#### 4.1.5 Models for Each Specialty Cohort

The results of the model estimation for the development and validation cohorts are reported in detail in [Appendix F](#).

#### 4.1.6 Risk-adjusted Readmission Rates

After estimating the models reported in [Appendix F](#), we used the results to construct risk-adjusted readmission rates for individual ECs and EC groups. In the following 3 tables (Tables [7](#), [8](#), and [9](#)), [Figure 2](#), and [Figure 3](#), we report the distributions of SRs and RARRs for each entity. These data provide supportive evidence of performance variation.

**Table 7. Distribution of standardized risk ratios (SRs) by cohort and overall, for eligible clinicians with at least 25 admissions (dataset: Medicare Full Sample)**

Statistic	Cardio-respiratory	Cardio-vascular	Medicine	Neurology	Surgical	Overall HWR SRRs	RARR
Signal variance	0.1860	0.3511	0.1242	0.6568	0.2503	-	
Minimum	0.37	0.26	0.42	0.22	0.27	0.32	5.0%
10 <sup>th</sup> percentile	0.77	0.72	0.80	0.65	0.74	0.82	12.6%
25 <sup>th</sup> percentile	0.87	0.83	0.89	0.77	0.84	0.89	13.8%
50 <sup>th</sup> percentile	0.97	0.95	0.98	0.90	0.97	0.98	15.1%

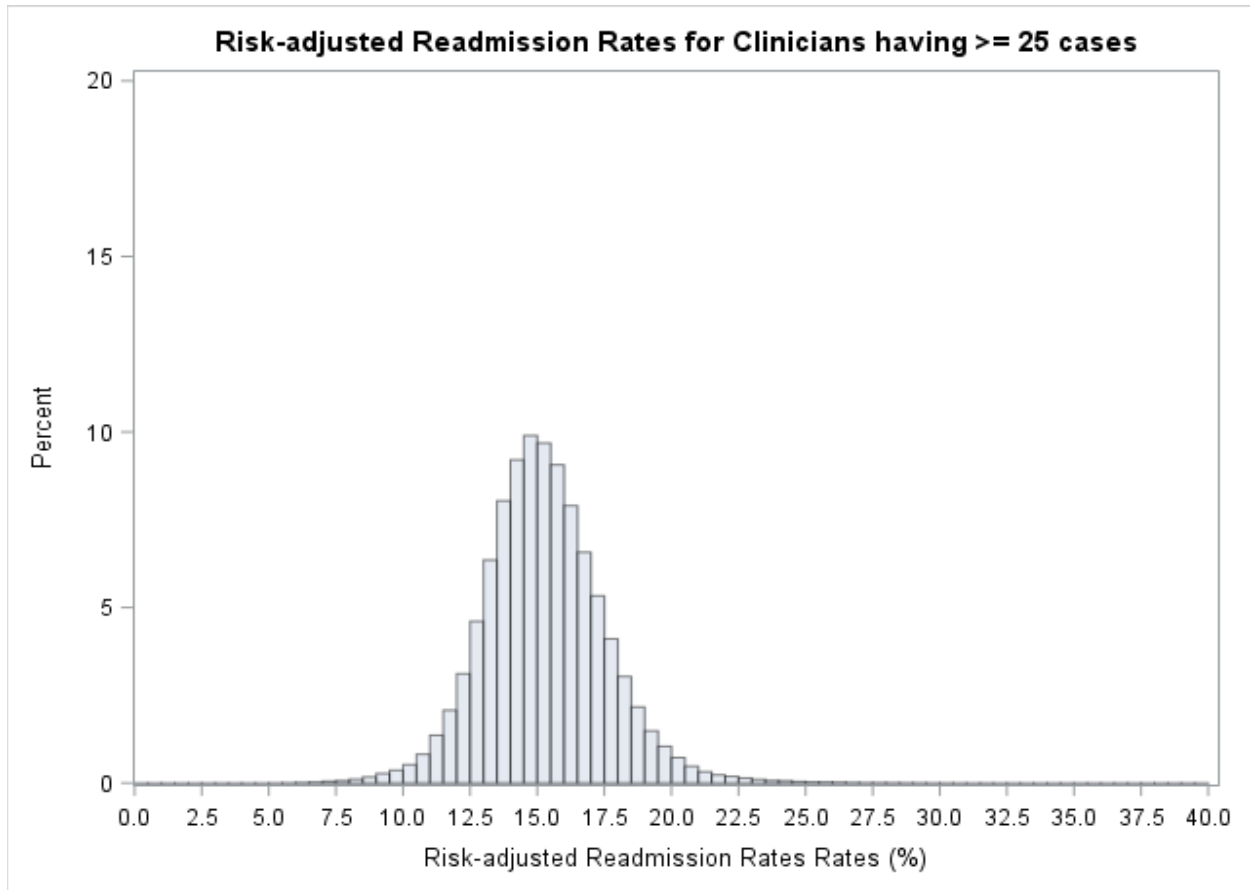
Statistic	Cardio-respiratory	Cardio-vascular	Medicine	Neurology	Surgical	Overall HWR SRRs	RARR
75 <sup>th</sup> percentile	1.12	1.16	1.10	1.22	1.15	1.07	16.5%
90 <sup>th</sup> percentile	1.26	1.34	1.22	1.50	1.32	1.17	18.0%
Maximum	2.12	2.93	2.40	3.39	2.78	2.50	38.5%
Mean (standard deviation [SD])	1.00 (0.19)	1.00 (0.25)	1.00 (0.17)	1.00 (0.35)	1.01 (0.23)	0.99 (0.15)	15.2% (2.3%)
Number of eligible clinicians	148,441	146,833	166,207	134,579	167,032	170,755	170,755

**Table 8. Distribution of standardized risk ratios (SRs) by cohort and overall, for eligible clinician groups with at least 25 admissions (dataset: Medicare Full Sample)**

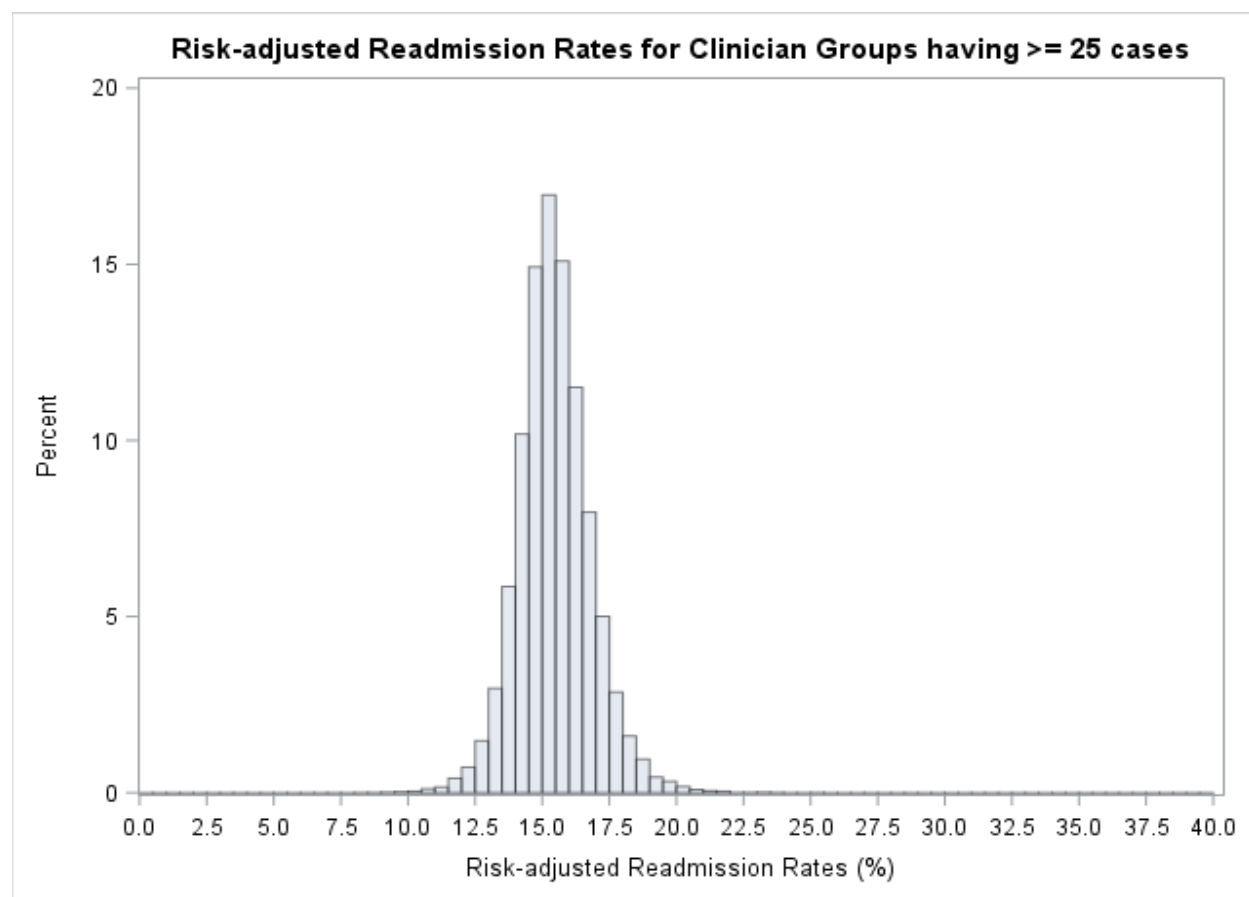
Statistic	Cardio-respiratory	Cardio-vascular	Medicine	Neurology	Surgical	Overall HWR SRR	RARR
Signal variance	0.0812	0.1206	0.0612	0.2077	0.0901	-	-
Minimum	0.52	0.45	0.57	0.38	0.43	0.45	7.0%
10 <sup>th</sup> percentile	0.87	0.87	0.87	0.83	0.86	0.90	13.8%
25 <sup>th</sup> percentile	0.93	0.93	0.93	0.90	0.92	0.94	14.6%
50 <sup>th</sup> percentile	0.99	0.98	0.99	0.97	0.99	0.99	15.3%
75 <sup>th</sup> percentile	1.07	1.07	1.07	1.10	1.08	1.05	16.2%
90 <sup>th</sup> percentile	1.16	1.17	1.15	1.21	1.17	1.11	17.1%
Maximum	1.81	1.98	1.73	2.17	1.75	1.63	25.1%
Mean (standard deviation [SD])	1.00 (0.12)	1.00 (0.13)	1.00 (0.11)	1.00 (0.16)	1.01 (0.12)	1.00 (0.09)	15.4% (1.4%)

Statistic	Cardio-respiratory	Cardio-vascular	Medicine	Neurology	Surgical	Overall HWR SRR	RARR
Number of eligible clinician groups	51,372	50,909	55,127	48,132	54,779	55,593	55,593

**Figure 2. Distribution of risk-adjusted readmission rates (RARRs) for eligible clinicians with at least 25 cases (dataset: Medicare Full Sample)**



**Figure 3. Distribution of risk-adjusted readmission rates (RARRs) for eligible clinician groups with at least 25 cases (dataset: Medicare Full Sample)**



From [Table 7](#), [Table 8](#), [Figure 2](#), and [Figure 3](#), we can see that the distributions of SRs and RARRs for ECs and EC groups with at least 25 patients are meaningfully dispersed.

After bootstrapping the RARRs we used the 95% confidence intervals to identify ECs and EC groups which have RARRs that are statistically better and worse than the national rate.

**Table 9. MIPS HWR outliers, at least 25 admissions (dataset: Medicare Full Sample)**

Performance Category	Eligible clinicians		Eligible clinician groups	
	Number	Percent	Number	Percent
Better than the national rate (estimated 95% CI wholly below national rate)	15,502	9.1%	4,318	7.8%
No different than the national rate (estimated 95% CI includes national rate)	151,636	88.8%	49,146	88.4%

Performance Category	Eligible clinicians		Eligible clinician groups	
	Number	Percent	Number	Percent
Worse than the national rate (estimated 95% CI wholly above national rate)	3,617	2.1%	2,129	3.8%
Number of cases too small (<25 admissions)	459,196	-	75,078	-

## 4.2 Model Performance

For each dataset and specialty cohort we report the volume of admissions, ECs and EC groups, overall readmission rate, calibration statistics (relative to the 2015-2016 development sample), discrimination, distribution of residuals, and Wald test of residuals; results for each specialty cohort are in a separate table.

**Table 10. Testing and calibration results for cardiorespiratory cohort model**

Cardiorespiratory	2015-2016 Development Sample	2015-2016 Validation Sample	2016-2017 Temporal Validation Sample
Number of admissions	520,629	520,878	840,343
Number of eligible clinicians	268,842	268,380	328,892
Number of eligible clinician groups	69,062	69,077	77,102
Unadjusted readmission rate	19.6%	19.4%	18.8%
Calibration (r0, r1)	0 - 1	-0.023 - 0.988	-0.023 - 1.002
Discrimination -predictive ability§ (lowest decile %, highest decile %)	9.76 - 35.94	9.78 - 35.68	9.43 - 35.3
Discrimination – area under receiver operator curve (ROC) or C-statistic	0.64	0.64	0.64
Distribution of residuals	-	-	-
%: < -2	0%	0%	0%

<b>Cardiorespiratory</b>	<b>2015-2016 Development Sample</b>	<b>2015-2016 Validation Sample</b>	<b>2016-2017 Temporal Validation Sample</b>
%: [-2, 0)	80.4%	80.6%	81.2%
%: [0, 2)	11.2%	11.0%	10.0%
%: [2 +)	8.4%	8.5%	8.7%
Model Wald X2 [DF]	19,851 (39)	19,491 (39)	32,279 (39)

**Table 11. Testing and calibration results for cardiovascular cohort model**

<b>Cardiovascular</b>	<b>2015-2016 Development Sample</b>	<b>2015-2016 Validation Sample</b>	<b>2016-2017 Temporal Validation Sample</b>
Number of admissions	320,256	319,825	611,740
Number of eligible clinicians	227,437	226,958	302,524
Number of eligible clinician groups	63,201	63,007	74,776
Unadjusted readmission rate	14.5%	14.4%	14.4%
Calibration (r0, r1)	0 – 1	-0.015 - 0.997	-0.018 - 1.001
Discrimination -predictive ability§ (lowest decile %, highest decile %)	6.86 - 31.81	6.8 - 31.72	6.74 - 31.79
Discrimination – area under receiver operator curve (ROC)	0.66	0.66	0.66
Distribution of residuals	-	-	-
%: < -2	0%	0%	0%
%: [-2, 0)	85.5%	85.6%	85.6%

<b>Cardiovascular</b>	<b>2015-2016 Development Sample</b>	<b>2015-2016 Validation Sample</b>	<b>2016-2017 Temporal Validation Sample</b>
%: [0, 2)	4.9%	4.9%	4.9%
%: [2 +)	9.6%	9.5%	9.5%
Model Wald X2 [DF]	12,883 (45)	12,929 (45)	24,890 (45)

**Table 12. Testing and calibration results for medicine cohort model**

<b>Medicine</b>	<b>2015-2016 Development Sample</b>	<b>2015-2016 Validation Sample</b>	<b>2016-2017 Temporal Validation Sample</b>
Number of admissions	1,360,000	1,359,822	2,917,076
Number of eligible clinicians	423,727	423,965	530,054
Number of eligible clinician groups	97,210	97,258	108,989
Unadjusted readmission rate	16.9%	16.9%	17.4%
Calibration (r0, r1)	0 – 1	0 - 1.003	-0.006 - 0.994
Discrimination -predictive ability§ (lowest decile %, highest decile %)	8.48 - 33.69	8.44 - 33.73	8.66 - 34.13
Discrimination – area under receiver operator curve (ROC)	0.65	0.65	0.65
Distribution of residuals	-	-	-
%: < -2	0%	0	0
%: [-2, 0)	83.1%	83.1%	82.6%
%: [0, 2)	7.4%	7.4%	8.1%

<b>Medicine</b>	<b>2015-2016 Development Sample</b>	<b>2015-2016 Validation Sample</b>	<b>2016-2017 Temporal Validation Sample</b>
%. [2 +)	9.5%	9.5%	9.3%
Model Wald X2 [DF]	51,325 (144)	51,689 (144)	111,196 (143)

**Table 13. Testing and calibration results for neurology cohort model**

Neurology	2015-2016 Development Sample	2015-2016 Validation Sample	2016-2017 Temporal Validation Sample
Number of admissions	201,286	201,033	390,971
Number of eligible clinicians	185,854	185,497	258,959
Number of eligible clinician groups	54,113	54,189	66,570
Unadjusted readmission rate	13.1%	13.1%	13.1%
Calibration (r0, r1)	0 - 1	-0.085 - 0.951	-0.047 - 0.978
Discrimination -predictive ability§ (lowest decile %, highest decile %)	7.31 - 26.67	7.53 - 26.16	7.46 - 26.55
Discrimination – area under receiver operator curve (ROC)	0.63	0.63	0.63
Distribution of residuals	-	-	-
%: < -2	0%	0%	0%
%: [-2, 0)	86.9%	86.9%	86.9%
%: [0, 2)	2.9%	2.8%	2.8%
%: [2 +)	10.2%	10.4%	10.3%
Model Wald X2 [DF]	5,426 (45)	5,014 (45)	10,279 (44)

**Table 14. Testing and calibration results for surgery/gynecology cohort model**

<b>Surgical</b>	<b>2015-2016 Development Sample</b>	<b>2015-2016 Validation Sample</b>	<b>2016-2017 Temporal Validation Sample</b>
Number of admissions	832,665	832,367	1,662,884
Number of eligible clinicians	357,052	357,246	449,470
Number of eligible clinician groups	90,349	90,253	101,738
Unadjusted readmission rate	11.4%	11.4%	11.2%
Calibration (r0, r1)	0 - 1	0.007 - 1.002	0.004 - 1.012
Discrimination -predictive ability§ (lowest decile %, highest decile %)	3.18% - 28.21%	3.21% - 28.3%	3.03% - 28.34%
Discrimination – area under receiver operator curve (ROC)	0.70	0.70	0.71
Distribution of residuals	-	-	-
%: < -2	0%	0%	0%
%: [-2, 0)	88.6%	88.6%	88.8%
%: [0, 2)	3.2%	3.2%	3.2%
%: [2 +)	8.2%	8.2%	8.0%
Model Wald X2 [DF]	38,737 (140)	38,952 (140)	80,052 (137)

### 4.3 Internal Consistency

We calculated the weighted correlation among the specialty cohort SRs. As case volume influences the stability of performance estimates, we performed these analyses using a minimum EC- or EC group-level volume of 25 admissions per specialty cohort. This enabled us to assess internal consistency without having to correct for variation due to small volumes. We also calculated the Cronbach's alpha for ECs and EC groups, excluding specialty cohorts with fewer than 25 patients.

As noted in [Section 3.3](#), we take the perspective that the overall RARR is a formative rather than reflective scale – that is, that it is meaningful to combine the specialty cohorts SRs because they capture the same outcome, even if they do so along different directions.

These results ([Tables 15- 18](#)) indicate modest internal consistency among the 5 specialty cohort SRs. This is consistent with the expectation that individual ECs or EC groups may have greater influence over specific conditions and procedures, compared to hospitals that are able to influence a greater diversity of care.

**Table 15. Correlations of SRs across cohorts for eligible clinicians (dataset: Medicare Full Sample); cohorts with at least 25 admissions only**

Pearson correlation	Cardiorespiratory	Cardiovascular	Medicine	Neurology	Surgery
Cardiorespiratory	1.00			0.04	
				0.23	
Cardiovascular	0.14	1.00		-0.04	0.04
	<.0001	–		0.38	0.03
Medicine	0.16	0.11	1.00	0.05	0.11
	<.0001	<.0001	–	0.06	<.0001
Neurology				1.00	
				–	
Surgery	0.08			0.10	1.00
	<.0001			0.00	

**Table 16. Correlations of SRs across cohorts for eligible clinician groups (dataset: Medicare Full Sample); SRs with at least 25 admissions only**

Pearson correlation	Cardiorespiratory	Cardiovascular	Medicine	Neurology	Surgery
Cardiorespiratory	1.00			0.26	
				<.0001	
Cardiovascular	0.27	1.00		0.18	0.23
	<.0001	–		<.0001	<.0001
Medicine	0.36	0.29	1.00	0.32	0.31
	<.0001	<.0001	–	<.0001	<.0001
Neurology				1.00	
Surgery	0.27			0.28	1.00
	<.0001			<.0001	–

**Table 17. Cronbach's alpha for 5 specialty cohorts, eligible clinicians with at least 25 admissions; cohorts with at least 25 admissions only**

Cohort	Correlation with overall composite score	Cronbach's alpha of overall composite score without this cohort
Cardiorespiratory	0.56	0.26
Cardiovascular	0.76	0.30
Medicine	0.78	0.23
Neurology	0.72	0.31
Surgery	0.82	0.38
Total	Not applicable	0.35

**Table 18. Cronbach's alpha for 5 specialty cohorts, eligible clinician groups with at least 25 admissions; cohorts with at least 25 admissions only**

Cohort	Correlation with overall composite score	Cronbach's alpha of overall composite score without this cohort
Cardiorespiratory	0.56	0.42
Cardiovascular	0.47	0.46
Medicine	0.79	0.40
Neurology	0.47	0.44
Surgery	0.71	0.48
Total	Not applicable	0.50

#### 4.4 Reliability

##### 4.4.1 Data Element Reliability

In constructing MIPS HWR measure we utilized only those data elements from the claims that have both face validity and reliability. To ensure that we use data elements that are reliable, we avoid the use of fields that are thought to be coded inconsistently across hospitals or providers. Additionally, CMS has in place several hospital auditing programs used to assess overall claims code accuracy, to ensure appropriate billing, and for overpayment recoupment. CMS routinely conducts data analysis to identify potential problem areas and detect fraud, and audits important data fields used in our measures.

We assessed the reliability of the data elements by comparing risk factor frequencies and ORs in the Split Sample Dataset, with results in [Appendix F](#).

##### 4.4.2 Measure Score Reliability

###### Test-Retest Reliability

This reliability is calculated by splitting each entity (e.g., EC or EC group) in half, constructing a measure for each half, and comparing how these 2 'tests' agree. As expected, measure result reliability is influenced by case volume; the more patients included in the measure, the more reliable the measure results. The results below indicate fair reliability for individuals ECs at a cut off of 150 patients per year and moderate reliability at a cut off of 200 patients. These reliability ratings are similar to CMS's hospital-level claims-based outcome measures, most of which have moderate or greater reliability. EC groups achieve similar reliability levels at lower cut offs (50 patients per year for fair and 100 patients for moderate).

Using a conventionally acceptable minimal value of 0.40 for test-retest reliability, these results suggest that a minimum threshold volume of 100 patients for EC groups and 200 for ECs be applied when using

this measure. Given that a minimum cut off of 200 patients for ECs retains only 0.7% of all ECs and 21.0% of patients, while an EC group-level cut off of 100 patients per year still captures 96% of patients, we recommend that this measure be reported for EC groups with at least 100 patients.

**Table 19. Test-retest reliabilities for eligible clinicians and eligible clinician groups for a range of minimum case volumes (datasets: Reliability Split Sample 1 and Reliability Sample 2)**

Annual admission cutoff	Number of entities		ICC[2,1] for overall RARR		Percent of patients included		Percent of providers included	
	Eligible clinicians	Eligible clinician groups	Eligible clinicians	Eligible clinician groups	Eligible clinicians	Eligible clinician groups	Eligible clinicians	Eligible clinician groups
25	168,995	54,869	0.16	0.30	95.2%	99.6%	21.2%	37.3%
50	86,890	37,015	0.21	0.34	84.5%	98.8%	10.9%	25.2%
100	30,699	20,692	0.28	0.40	58.5%	96.4%	3.8%	14.1%
150	12,790	13,670	0.35	0.45	36.3%	93.6%	1.6%	9.3%
200	5,580	9,933	0.41	0.49	21.0%	91.1%	0.7%	6.8%

#### Signal-to-Noise Ratio Reliability

We also assessed measure result reliability using the signal-to-noise ratio method. This approach produces a measure of reliability for each EC or EC group. All case volume cut offs produce high reliability using this approach.

**Table 20. Signal-to-noise ratio results for eligible clinicians and eligible clinician groups (dataset: Medicare Full Sample)**

Admission cutoff	Number of entities		Mean signal-to-noise reliability	
	Eligible clinicians	Eligible clinician groups	Eligible clinicians	Eligible clinician groups
25	170,755	55,593	0.967	0.996
50	89,442	37,443	0.986	0.996
100	33,256	20,863	0.991	0.997
150	14,516	13,832	0.993	0.998

Admission cutoff	Number of entities		Mean signal-to-noise reliability	
	Eligible clinicians	Eligible clinician groups	Eligible clinicians	Eligible clinician groups
200	6,488	10,096	0.995	0.998

## 4.5 Validity

### 4.5.1 Data Elements

For validity of the data elements, CORE has already demonstrated for a number of prior measures the validity of claims-based measures for profiling hospitals by comparing either the measure results or individual data elements against medical records. CMS validated the 6 NQF-endorsed claims-based measures currently in public reporting (AMI, heart failure, and pneumonia mortality and readmission) with models that used medical record-abstracted data for risk-adjustment. Specifically, claims model validation was conducted by building comparable models using abstracted medical record data for risk-adjustment for heart failure patients (National Heart Failure data), AMI patients (Cooperative Cardiovascular Project data) and pneumonia patients (National Pneumonia Project dataset). When both models were applied to the same patient population, the hospital risk-standardized rates estimated using the claims-based risk-adjustment models had a high level of agreement with the results based on the medical record model, thus supporting the use of the claims-based models for public reporting.

We have also completed 2 national, multi-site validation efforts for 2 procedure-based complications measures (for primary elective hip/knee arthroplasty and implantable cardioverter defibrillator [ICD]). Both projects demonstrated strong agreement between complications coded in claims and abstracted medical record data.

Comparison of hospital-level measure results obtained using a claims-based measure of mortality after isolated coronary artery bypass graft surgery compared to a registry-based measure also demonstrated high correlation.

These validation efforts suggest that such claims data variables are valid across a variety of conditions, procedures, and outcomes.

### 4.5.2 Measure Score

#### Face Validity of Final Attribution Rules

The TEP strongly supported attribution to multiple providers, including at least 1 inpatient and 1 outpatient provider.

#### Face Validity of MIPS Eligible Clinician or Eligible Clinician Group Measure Scores

Of 19 TEP members asked to complete a survey regarding validity and usability of the measure, 17 responded. Their responses are reported in [Table 21](#).

**Table 21. Results of Technical Expert Panel survey of validity and usability**

The HWR:	Disagree			Agree		
	Strongly	Moderately	Somewhat	Somewhat	Moderately	Strongly
Measure scores are valid and useful	1	3	1	4	6	2
Measure will provide info to be used for quality improvement	1	2	2	5	3	4

As shown in [Table 21](#), the majority of the respondents, 12/17 or 70%, agreed that the HWR measure scores were valid and useful, and the same proportion agreed that the measure would provide information that could be used to improve the quality of care.

Among those who disagreed, the primary concern was that factors which led to increased risk of readmission were beyond the control of any single eligible clinician or clinician group. This concern drove the adoption of ‘multiple’ attribution, in which no single eligible clinician is solely responsible for a readmission outcome; this attribution approach also has the potential to incentivize collaboration within the hospital and across the care system, further aligning the measure with the attribution.

Overall, the survey indicates support of the validity and usability of the measure.

## 5. SUMMARY

In this report we describe an approach to re-specifying the hospital HWR measure for use in measuring ECs and EC groups on the outcome of unplanned readmission within 30 days of discharge. Developed with input from a nationally convened TEP, the re-specified measure attributes admissions to up to 3 ECs or EC groups. To compare readmission performance across ECs or EC groups, the measure accounts for differences in patient characteristics (i.e., patient case mix) as well as differences in mixes of services and procedures offered by clinicians (i.e. service mix). Using our development data, we found 170,755 ECs and 55,593 EC groups had at least 25 admissions attributed by 1 or more attribution rule. The RARRs for these sets of providers had a mean [range] of 15.2% [5.0%-38.2%] and 15.4% [7.0%-25.1%] respectively; 11.2% eligible clinicians and 11.6% of EC groups were statistically significant performance outliers, with RARR 95% confidence intervals excluding the national average. These results indicate meaningful variation in performance across both EC or EC groups. Testing demonstrated acceptable measure result reliability for higher volumes and acceptable face validity. Based upon the results of reliability testing and TEP input, we recommend reporting results for EC groups with at least 100 patients.

In summary, this report demonstrates the feasibility of measuring ECs or EC groups on the outcome of readmission within 30 days and finds meaningful variation in risk-adjusted readmission rates. Measure development has benefited from close stakeholder engagement, including an engaged TEP that represents clinicians and patients, and a public comment period. This measure fills an important gap by creating a mechanism for shared accountability across health providers for readmitted patients. It will provide clinicians and patients with greater information and transparency to continue to improve patient care quality and outcomes. MIPS HWR measure has the potential to illuminate differences in quality, inform patient choice, drive quality improvement, and enhance care coordination.

## 6. GLOSSARY

**Acute care hospital:** A hospital that provides inpatient medical care for surgery and acute medical conditions or injuries. Short-term acute care hospitals provide care for short-term illnesses and conditions.

**Bootstrapping:** The bootstrap is a computer-based method for estimating the standard error of an estimate when the estimate is based on a sample with an unknown probability distribution. Bootstrap methods depend on the bootstrap sample, which is a random sample of size  $n$  drawn with replacement from the population of  $n$  objects. The bootstrap algorithm works by drawing many independent bootstrap samples, evaluating the corresponding bootstrap replications, and estimating the standard error of the statistic by the empirical standard deviation of the replications.

**C-statistic:** An indicator of the model's discriminant ability or ability to correctly classify those who have and have not been readmitted within 30 days of discharge. Potential values range from 0.5, meaning no better than chance, to 1.0, 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 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 procedure and diagnosis categories are used to define specialty cohorts and risk adjust. Additionally, 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-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 that 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 admission.

**Condition Categories (CCs):** Groupings of ICD-9-CM/ICD-10-CM diagnosis codes in clinically relevant categories, from the HCCs system.<sup>51,52</sup> 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.

**Confidence interval (CI):** A CI is a range of values that describes the uncertainty surrounding an estimate. It is indicated by its endpoints; for example, a 95% CI for the odds ratio (OR) associated with protein-calorie malnutrition noted as “1.09 – 1.15” would indicate that there is 95% confidence that the OR lies between 1.09 and 1.15.

**Discharge Clinician:** The eligible clinician that bills for 1 of the discharge procedure codes or, if a patient does not have such a code during the last 3 days of their stay, a subsequent care code.

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

**Hierarchical regression model:** A widely accepted statistical method that enables evaluation of relative hospital performance by accounting for patient risk factors. This statistical model accounts for the hierarchical structure of the data (patients clustered within hospitals are assumed to be correlated) and accommodates modeling of the association between outcomes and patient characteristics. Based on the hierarchical model, we can evaluate (1) how much variation in hospital readmission rates overall is accounted for by patients’ individual risk factors (such as age and other medical conditions), and (2) how much variation is accounted for by hospital contribution to readmission risk.

**Hospital-specific effect:** A measure of the hospital quality of care that is calculated through hierarchical logistic regression, taking into consideration how many patients were eligible for the cohort, these patients’ risk factors, and how many were readmitted. The hospital-specific effect is the calculated random effect for each hospital. The hospital-specific effect will be negative for a better-than-average hospital, positive for a worse-than-average hospital, and close to zero for an average hospital. The hospital-specific effect is used in the numerator to calculate “predicted” readmissions.

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

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

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

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

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

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

**Outpatient PCP:** The eligible clinician that files the most outpatient primary care claims for hospitalized patient during the 12 months prior to their admission date.

**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 outcome of this measure.

**Predicted readmissions:** The number of readmissions within 30 days predicted based on the hospital's observed case mix and service mix.

**Predictive ability:** An indicator of the model's discriminant ability or ability to distinguish high-risk subjects from low-risk subjects. A wide range between the lowest decile and highest decile suggests better discrimination.

**Primary Inpatient Care Provider:** The eligible clinician that files the most patient-facing charges during the patient inpatient stay.

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

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

**Specialty cohort:** A group of index admissions for patients with related AHRQ CCS diagnosis or procedure categories (or related ICD-10-PCS codes, in the case of the surgery/gynecology cohort) that are likely treated by similar care teams. This measure includes 5 cohorts, each with its own risk model.

**Unplanned readmissions:** Acute clinical events a patient experiences that require urgent readmission. Unplanned readmissions are the outcomes of the measure.

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## 8. APPENDICES

### Appendix A. External Stakeholder Engagement

Table A1. Technical Expert Panel members

Name, credentials, and professional role	Organizational affiliation	Location
<b>Kathleen Blake, MD, MPH;</b> Vice President, Healthcare Quality (cardiology)	American Medical Association	Washington, DC
<b>John Birkmeyer, MD;</b> Chief Clinical Officer (general surgery)	Sound Physicians	Tacoma, WA
<b>Dale Bratzler, DO, MPH;</b> Chief Quality Officer (internal medicine)	University of Oklahoma Physicians: Chickasaw Nation Department of Public Health	Oklahoma City, OK; Ada, OK
<b>Daniel Brotman, MD, SFM, FACP;</b> Professor of Medicine, Johns Hopkins University Director of Hospitalist Program, (internal medicine)	Johns Hopkins University School of Medicine; Johns Hopkins Hospital	Baltimore, MD
<b>Tracy Cardin, ACNP-BC, SFHM;</b> Director of Nurse Practitioner/Physician Assistant Services (nursing - inpatient)	University of Chicago Hospital Medicine	Chicago, IL
Cathy Castillo, BA	Patient or caregiver representative	Redwood City, CA
<b>Bruce Chernof, MD;</b> President and Chief Executive Officer (internal medicine)	The SCAN Foundation	Long Beach, CA
<b>Donna Cryer, JD;</b> President and Chief Executive Officer	Global Liver Institute	Washington, DC

Name, credentials, and professional role	Organizational affiliation	Location
<b>Sherrie H. Kaplan, PhD, MPH;</b> Assistant Vice Chancellor, Healthcare Measurement and Evaluation School of Medicine, Professor of Medicine and Anesthesiology & Perioperative Care	University of California, Irvine	Irvine, CA
<b>Timothy Kresowik, MD, MS;</b> Professor of Surgery - Vascular Surgery (vascular surgery)	University of Iowa Hospitals & Clinics	Iowa City, IA
<b>Joshua Lapps, MA;</b> Government Relations Manager	Society of Hospital Medicine	Philadelphia, PA
<b>Frederick Masoudi, MD, MSPH;</b> Professor of Medicine and Staff Cardiologist (cardiology)	University of Colorado Denver	Aurora, CO
<b>Brian McCardel, MD;</b> Orthopedic Surgeon/Board Member (orthopedics)	Sparrow Health System	Lansing, MI
<b>James Moore, MD;</b> Clinical Professor of Anesthesiology and Perioperative Medicine (anesthesiology)	University of California Los Angeles Health	Los Angeles, CA
<b>Michelle Mourad, MD;</b> Vice Chair for Clinical Affairs and Value, Medicine (internal medicine - hospital medicine)	University of California, San Francisco Health	San Francisco, CA
<b>Juan Quintana, DNP, MHS, CRNA;</b> Certified Registered Nurse Anesthetist (nursing - anesthesia)	American Association of Nurse Anesthetists	Winnsboro, TX
Carol Raphael, MA, MPH; Senior Advisor	Manatt Health Solutions	New York, NY
Charlene Setlow	Patient representative	Salinas, CA

Name, credentials, and professional role	Organizational affiliation	Location
<b>Heidi L. Wald, MD, MSPH;</b> Vice President for Clinical Performance (internal medicine-geriatrics)	SCL Health	Aurora, CO

**Disclaimer:** The views, thoughts, and opinions expressed in this report belong solely to the author and do not represent endorsement by any entity or individual, including the and Technical Expert Panel members and the organizations those members are affiliated with, as well as other contributors and consultants. Acknowledgment of input does not imply endorsement of the methodology and policy decisions.

## Appendix B. Exclusions

**Table B1. Cancer discharge condition categories excluded from the measure**

AHRQ CCS	Description of AHRQ CCS	Admits* (Total = 182,213)
42	Secondary malignancies	45,319
19	Cancer of bronchus; lung	30,292
45	Maintenance chemotherapy; radiotherapy	21,522
44	Neoplasms of unspecified nature or uncertain behavior	10,160
17	Cancer of pancreas	8,462
38	Non-Hodgkin`s lymphoma	7,977
39	Leukemias	7,809
14	Cancer of colon	6,121
40	Multiple myeloma	4,624
35	Cancer of brain and nervous system	3,561
16	Cancer of liver and intrahepatic bile duct	3,491
13	Cancer of stomach	3,467
29	Cancer of prostate	3,100
15	Cancer of rectum and anus	3,030
18	Cancer of other GI organs; peritoneum	2,974
12	Cancer of esophagus	2,533
11	Cancer of head and neck	2,515
27	Cancer of ovary	2,081

AHRQ CCS	Description of AHRQ CCS	Admits* (Total = 182,213)
33	Cancer of kidney and renal pelvis	1,863
32	Cancer of bladder	1,807
24	Cancer of breast	1,682
43	Malignant neoplasm without specification of site	1,451
25	Cancer of uterus	1,132
36	Cancer of thyroid	879
21	Cancer of bone and connective tissue	763
41	Cancer; other and unspecified primary	674
20	Cancer; other respiratory and intrathoracic	632
23	Other non-epithelial cancer of skin	593
26	Cancer of cervix	586
28	Cancer of other female genital organs	326
34	Cancer of other urinary organs	301
37	Hodgkin's disease	236
22	Melanomas of skin	212
31	Cancer of other male genital organs	34
30	Cancer of testis	4

\*After all other exclusions applied

**Table B2. Psychiatric discharge condition categories excluded from the measure**

<b>AHRQ CCS</b>	<b>Description of AHRQ CCS</b>	<b>Admits* (Total=21,483)</b>
657	Mood disorders	7,874
659	Schizophrenia and other psychotic disorders	7,849
651	Anxiety disorders	3,153
670	Miscellaneous disorders	1,315
654	Developmental disorders	594
650	Adjustment disorders	399
658	Personality disorders	127
652	Attention-deficit, conduct, and disruptive behavior disorders	119
656	Impulse control disorders, NEC	27
655	Disorders usually diagnosed in infancy, childhood, or adolescence	16
662	Suicide and intentional self-inflicted injury	10

\*After all other exclusions applied

## Appendix C. Specialty Cohort Definitions

**Table C1. Procedure categories defining the surgical/gynecology cohort**

AHRQ CCS	Description of AHRQ CCS	Number of procedures*	Number of readmissions with this procedure*	Readmission rate
1	Incision and excision of CNS	28,261	5,753	20.4%
2	Insertion; replacement; or removal of extracranial ventricular shunt	7,270	1,304	17.9%
3	Laminectomy; excision intervertebral disc	79,631	6,619	8.3%
9	Other OR therapeutic nervous system procedures	16,275	2,817	17.3%
10	Thyroidectomy; partial or complete	12,989	862	6.6%
12	Other therapeutic endocrine procedures	10,415	1,340	12.9%
13	Corneal transplant	157	16	10.2%
14	Glaucoma procedures	130	18	13.8%
15	Lens and cataract procedures	633	97	15.3%
16	Repair of retinal tear; detachment	292	33	11.3%
17	Destruction of lesion of retina and choroid	127	9	7.1%
20	Other intraocular therapeutic procedures	1,107	138	12.5%
21	Other extraocular muscle and orbit therapeutic procedures	1,163	150	12.9%
22	Tympanoplasty	140	14	10.0%
23	Myringotomy	450	99	22.0%
24	Mastoidectomy	273	29	10.6%

AHRQ CCS	Description of AHRQ CCS	Number of procedures*	Number of readmissions with this procedure*	Readmission rate
26	Other therapeutic ear procedures	2,002	263	13.1%
28	Plastic procedures on nose	1,790	213	11.9%
30	Tonsillectomy and/or adenoidectomy	333	43	12.9%
33	Other OR therapeutic procedures on nose; mouth and pharynx	8,040	913	11.4%
36	Lobectomy or pneumonectomy	32,065	4,350	13.6%
42	Other OR Rx procedures on respiratory system and mediastinum	16,452	3,453	21.0%
43	Heart valve procedures	45,477	10,398	22.9%
44	Coronary artery bypass graft (CABG)	82,527	14,548	17.6%
49	Other OR heart procedures	41,585	8,125	19.5%
51	Endarterectomy; vessel of head and neck	63,024	6,288	10.0%
52	Aortic resection; replacement or anastomosis	27,967	3,765	13.5%
53	'Varicose vein stripping; lower limb	245	33	13.5%
55	Peripheral vascular bypass	28,972	6,163	21.3%
56	Other vascular bypass and shunt; not heart	2,387	763	32.0%
59	Other OR procedures on vessels of head and neck	14,335	1,771	12.4%
60	Embolectomy and endarterectomy of lower limbs	9,770	2,292	23.5%
61	Other OR procedures on vessels other than head and neck	178,209	37,411	21.0%

<b>AHRQ CCS</b>	<b>Description of AHRQ CCS</b>	<b>Number of procedures*</b>	<b>Number of readmissions with this procedure*</b>	<b>Readmission rate</b>
66	Procedures on spleen	2,903	548	18.9%
67	Other therapeutic procedures; hemic and lymphatic system	42,288	5,557	13.1%
72	Colostomy; temporary and permanent	10,365	1,970	19.0%
73	Ileostomy and other enterostomy	5,592	1,805	32.3%
74	Gastrectomy; partial and total	6,507	1,305	20.1%
75	Small bowel resection	21,833	4,255	19.5%
78	Colorectal resection	105,467	16,702	15.8%
79	Local excision of large intestine lesion (not endoscopic)	368	50	13.6%
80	Appendectomy	19,326	1,851	9.6%
84	Cholecystectomy and common duct exploration	102,698	13,143	12.8%
85	Inguinal and femoral hernia repair	14,656	1,683	11.5%
86	Other hernia repair	33,253	3,887	11.7%
89	Exploratory laparotomy	2,981	611	20.5%
90	Excision; lysis peritoneal adhesions	36,415	6,278	17.2%
94	Other OR upper GI therapeutic procedures	31,731	4,334	13.7%
96	Other OR lower GI therapeutic procedures	33,387	5,846	17.5%
99	Other OR gastrointestinal therapeutic procedures	29,873	6,478	21.7%

<b>AHRQ CCS</b>	<b>Description of AHRQ CCS</b>	<b>Number of procedures*</b>	<b>Number of readmissions with this procedure*</b>	<b>Readmission rate</b>
101	Transurethral excision; drainage; or removal urinary obstruction	33,225	6,075	18.3%
103	Nephrotomy and nephrostomy	13,530	3,649	27.0%
104	Nephrectomy; partial or complete	19,504	2,338	12.0%
105	Kidney transplant	10,873	3,175	29.2%
106	Genitourinary incontinence procedures	8,819	351	4.0%
112	Other OR therapeutic procedures of urinary tract	17,650	3,688	20.9%
113	Transurethral resection of prostate (TURP)	42,523	4,259	10.0%
114	Open prostatectomy	23,965	1,158	4.8%
118	Other OR therapeutic procedures; male genital	6,005	835	13.9%
142	Partial excision bone	37,930	5,070	13.4%
143	Bunionectomy or repair of toe deformities	931	84	9.0%
144	Treatment; facial fracture or dislocation	1,968	204	10.4%
145	Treatment; fracture or dislocation of radius and ulna	14,471	1,466	10.1%
146	Treatment; fracture or dislocation of hip and femur	149,336	22,795	15.3%
147	Treatment; fracture or dislocation of lower extremity (other than hip or femur)	39,901	5,000	12.5%
148	Other fracture and dislocation procedure	23,019	2,900	12.6%

<b>AHRQ CCS</b>	<b>Description of AHRQ CCS</b>	<b>Number of procedures*</b>	<b>Number of readmissions with this procedure*</b>	<b>Readmission rate</b>
150	Division of joint capsule; ligament or cartilage	3,002	230	7.7%
151	Excision of semilunar cartilage of knee	1,381	181	13.1%
152	Arthroplasty knee	292,149	17,995	6.2%
153	Hip replacement; total and partial	207,011	23,096	11.2%
154	Arthroplasty other than hip or knee	32,597	1,772	5.4%
157	Amputation of lower extremity	51,213	13,548	26.5%
158	Spinal fusion	106,703	10,307	9.7%
160	Other therapeutic procedures on muscles and tendons	32,254	4,998	15.5%
161	Other OR therapeutic procedures on bone	29,314	5,611	19.1%
162	Other OR therapeutic procedures on joints	25,661	4,125	16.1%
164	Other OR therapeutic procedures on musculoskeletal system	5,963	1,346	22.6%
166	Lumpectomy; quadrantectomy of breast	2,994	311	10.4%
167	Mastectomy	16,333	1,102	6.7%
172	Skin graft	13,987	2,508	17.9%
175	Other OR therapeutic procedures on skin and breast	6,626	879	13.3%
176	Other organ transplantation	2,483	855	34.4%
119	Oophorectomy; unilateral and bilateral	33,667	2,856	8.5%

AHRQ CCS	Description of AHRQ CCS	Number of procedures*	Number of readmissions with this procedure*	Readmission rate
120	Other operations on ovary	906	111	12.3%
121	Ligation or occlusion of fallopian tubes	228	13	5.7%
122	Removal of ectopic pregnancy	143	6	4.2%
123	Other operations on fallopian tubes	937	82	8.8%
124	Hysterectomy; abdominal and vaginal	48,236	3,515	7.3%
125	Other excision of cervix and uterus	1,062	131	12.3%
126	Abortion (termination of pregnancy)	39	10	25.6%
127	Dilatation and curettage (D&C); aspiration after delivery or abortion	298	26	8.7%
129	Repair of cystocele and rectocele; obliteration of vaginal vault	14,446	476	3.3%
131	Other non-OR therapeutic procedures; female organs	509	115	22.6%
132	Other OR therapeutic procedures; female organs	13,796	996	7.2%
133	Episiotomy	372	7	1.9%
134	Cesarean section	6,226	280	4.5%
135	Forceps; vacuum; and breech delivery	535	15	2.8%
136	Artificial rupture of membranes to assist delivery	1,510	37	2.5%
137	Other procedures to assist delivery	5,131	162	3.2%
139	Fetal monitoring	1,488	179	12.0%

AHRQ CCS	Description of AHRQ CCS	Number of procedures*	Number of readmissions with this procedure*	Readmission rate
140	Repair of current obstetric laceration	1,387	38	2.7%
141	Other therapeutic obstetrical procedures	166	10	6.0%

**Table C2. Condition codes assigned to each cohort**

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Medicine	2	Septicemia (except in labor)	236,993	50,554	21.3%
Medicine	159	Urinary tract infections	232,590	41,421	17.8%
Medicine	55	Fluid and electrolyte disorders	178,808	32,670	18.3%
Medicine	157	Acute and unspecified renal failure	163,356	36,226	22.2%
Medicine	153	Gastrointestinal hemorrhage	135,891	22,873	16.8%
Medicine	197	Skin and subcutaneous tissue infections	111,669	17,020	15.2%
Medicine	245	Syncope	107,933	10,924	10.1%
Medicine	129	Aspiration pneumonitis; food/vomit	88,296	19,311	21.9%
Medicine	145	Intestinal obstruction without hernia	88,193	14,712	16.7%
Medicine	146	Diverticulosis and diverticulitis	85,920	11,864	13.8%
Medicine	237	Complication of device; implant or graft	81,549	18,771	23.0%
Medicine	238	Complications of surgical procedures or medical care	81,398	14,856	18.3%
Medicine	59	Deficiency and other anemia	79,516	17,683	22.2%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Medicine	50	Diabetes mellitus with complications	74,976	14,274	19.0%
Medicine	135	Intestinal infection	70,077	16,192	23.1%
Medicine	231	Other fractures	69,105	10,186	14.7%
Medicine	99	Hypertension with complications and secondary hypertension	67,337	14,808	22.0%
Medicine	118	Phlebitis; thrombophlebitis and thromboembolism	48,254	7,038	14.6%
Medicine	205	Spondylosis; intervertebral disc disorders; other back problems	46,916	7,395	15.8%
Medicine	653	Delirium, dementia, and amnestic and other cognitive disorders	44,266	6,489	14.7%
Medicine	155	Other gastrointestinal disorders	44,151	8,915	20.2%
Medicine	133	Other lower respiratory disease	36,203	6,414	17.7%
Medicine	152	Pancreatic disorders (not diabetes)	34,779	5,378	15.5%
Medicine	149	Biliary tract disease	33,718	5,443	16.1%
Medicine	138	Esophageal disorders	33,354	4,733	14.2%
Medicine	154	Noninfectious gastroenteritis	33,236	4,721	14.2%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Medicine	259	Residual codes; unclassified	32,960	5,853	17.8%
Medicine	93	Conditions associated with dizziness or vertigo	30,934	2,296	7.4%
Medicine	130	Pleurisy; pneumothorax; pulmonary collapse	29,482	7,463	25.3%
Medicine	140	Gastritis and duodenitis	29,329	4,953	16.9%
Medicine	211	Other connective tissue disease	28,565	4,106	14.4%
Medicine	251	Abdominal pain	27,091	4,425	16.3%
Medicine	151	Other liver diseases	20,612	6,282	30.5%
Medicine	244	Other injuries and conditions due to external causes	20,470	3,071	15.0%
Medicine	98	Essential hypertension	18,409	2,104	11.4%
Medicine	207	Pathological fracture	18,040	3,800	21.1%
Medicine	239	Superficial injury; contusion	17,651	2,670	15.1%
Medicine	141	Other disorders of stomach and duodenum	17,168	3,586	20.9%
Medicine	58	Other nutritional; endocrine; and metabolic disorders	16,379	3,394	20.7%
Medicine	199	Chronic ulcer of skin	16,350	3,408	20.8%
Medicine	51	Other endocrine disorders	16,343	3,160	19.3%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Medicine	229	Fracture of upper limb	15,309	2,477	16.2%
Medicine	252	Malaise and fatigue	14,677	2,414	16.4%
Medicine	63	Diseases of white blood cells	14,138	3,387	24.0%
Medicine	123	Influenza	14,096	1,672	11.9%
Medicine	7	Viral infection	13,805	2,178	15.8%
Medicine	230	Fracture of lower limb	13,448	2,039	15.2%
Medicine	246	Fever of unknown origin	13,079	2,304	17.6%
Medicine	242	Poisoning by other medications and drugs	12,394	1,915	15.5%
Medicine	160	Calculus of urinary tract	12,195	1,562	12.8%
Medicine	163	Genitourinary symptoms and ill-defined conditions	11,122	1,933	17.4%
Medicine	661	Substance-related disorders	11,050	1,924	17.4%
Medicine	204	Other non-traumatic joint disorders	10,891	1,556	14.3%
Medicine	250	Nausea and vomiting	10,795	2,148	19.9%
Medicine	120	Hemorrhoids	10,365	1,616	15.6%
Medicine	62	Coagulation and hemorrhagic disorders	9,534	2,477	26.0%
Medicine	134	Other upper respiratory disease	9,068	1,569	17.3%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Medicine	226	Fracture of neck of femur (hip)	8,585	1,303	15.2%
Medicine	660	Alcohol-related disorders	8,578	1,257	14.7%
Medicine	234	Crushing injury or internal injury	8,329	1,216	14.6%
Medicine	201	Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted di	8,105	1,683	20.8%
Medicine	203	Osteoarthritis	7,984	1,049	13.1%
Medicine	144	Regional enteritis and ulcerative colitis	7,954	1,586	19.9%
Medicine	60	Acute posthemorrhagic anemia	7,768	1,577	20.3%
Medicine	4	Mycoses	7,739	2,135	27.6%
Medicine	126	Other upper respiratory infections	7,663	961	12.5%
Medicine	143	Abdominal hernia	7,410	1,397	18.9%
Medicine	139	Gastroduodenal ulcer (except hemorrhage)	7,378	1,105	15.0%
Medicine	47	Other and unspecified benign neoplasm	7,123	1,104	15.5%
Medicine	161	Other diseases of kidney and ureters	7,057	1,299	18.4%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Medicine	121	Other diseases of veins and lymphatics	6,969	1,249	17.9%
Medicine	232	Sprains and strains	6,531	885	13.6%
Medicine	54	Gout and other crystal arthropathies	6,150	995	16.2%
Medicine	84	Headache; including migraine	5,839	677	11.6%
Medicine	147	Anal and rectal conditions	5,116	1,002	19.6%
Medicine	212	Other bone disease and musculoskeletal deformities	4,926	744	15.1%
Medicine	158	Chronic renal failure	4,886	1,186	24.3%
Medicine	228	Skull and face fractures	4,632	587	12.7%
Medicine	663	Screening and history of mental health and substance abuse codes	4,482	1,134	25.3%
Medicine	165	Inflammatory conditions of male genital organs	4,222	465	11.0%
Medicine	52	Nutritional deficiencies	4,003	972	24.3%
Medicine	253	Allergic reactions	3,885	565	14.5%
Medicine	162	Other diseases of bladder and urethra	3,850	698	18.1%
Medicine	137	Diseases of mouth; excluding dental	3,821	609	15.9%
Medicine	164	Hyperplasia of prostate	3,734	675	18.1%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Medicine	148	Peritonitis and intestinal abscess	3,663	896	24.5%
Medicine	48	Thyroid disorders	3,634	663	18.2%
Medicine	235	Open wounds of head; neck; and trunk	3,631	453	12.5%
Medicine	241	Poisoning by psychotropic agents	3,191	406	12.7%
Medicine	6	Hepatitis	3,042	827	27.2%
Medicine	202	Rheumatoid arthritis and related disease	2,806	480	17.1%
Medicine	8	Other infections; including parasitic	2,381	293	12.3%
Medicine	236	Open wounds of extremities	2,253	353	15.7%
Medicine	49	Diabetes mellitus without complication	2,198	308	14.0%
Medicine	198	Other inflammatory condition of skin	2,028	418	20.6%
Medicine	76	Meningitis (except that caused by tuberculosis or sexually transmitted disease)	2,003	332	16.6%
Medicine	248	Gangrene	1,996	435	21.8%
Medicine	90	Inflammation; infection of eye (except that caused by tuberculosis or sexually transmitted disease)	1,994	272	13.6%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Medicine	132	Lung disease due to external agents	1,866	376	20.2%
Medicine	136	Disorders of teeth and jaw	1,602	192	12.0%
Medicine	89	Blindness and vision defects	1,550	163	10.5%
Medicine	210	Systemic lupus erythematosus and connective tissue disorders	1,466	351	23.9%
Medicine	243	Poisoning by nonmedicinal substances	1,424	112	7.9%
Medicine	3	Bacterial infection; unspecified site	1,386	260	18.8%
Medicine	240	Burns	1,373	222	16.2%
Medicine	77	Encephalitis (except that caused by tuberculosis or sexually transmitted disease)	1,361	242	17.8%
Medicine	91	Other eye disorders	1,344	144	10.7%
Medicine	175	Other female genital disorders	1,119	203	18.1%
Medicine	225	Joint disorders and dislocations; trauma-related	1,104	129	11.7%
Medicine	94	Other ear and sense organ disorders	1,005	117	11.6%
Medicine	119	Varicose veins of lower extremity	991	138	13.9%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Medicine	200	Other skin disorders	985	148	15.0%
Medicine	167	Nonmalignant breast conditions	977	123	12.6%
Medicine	257	Other aftercare	894	141	15.8%
Medicine	168	Inflammatory diseases of female pelvic organs	852	137	16.1%
Medicine	87	Retinal detachments; defects; vascular occlusion; and retinopathy	852	83	9.7%
Medicine	142	Appendicitis and other appendiceal conditions	803	98	12.2%
Medicine	209	Other acquired deformities	760	108	14.2%
Medicine	156	Nephritis; nephrosis; renal sclerosis	756	200	26.5%
Medicine	173	Menopausal disorders	748	116	15.5%
Medicine	1	Tuberculosis	735	135	18.4%
Medicine	64	Other hematologic conditions	730	146	20.0%
Medicine	92	Otitis media and related conditions	724	104	14.4%
Medicine	166	Other male genital disorders	714	149	20.9%
Medicine	5	HIV infection	611	175	28.6%
Medicine	247	Lymphadenitis	456	87	19.1%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Medicine	249	Shock	451	109	24.2%
Medicine	9	Sexually transmitted infections (not HIV or hepatitis)	366	55	15.0%
Medicine	258	Other screening for suspected conditions (not mental disorders or infectious disease)	328	41	12.5%
Medicine	217	Other congenital anomalies	312	58	18.6%
Medicine	214	Digestive congenital anomalies	305	49	16.1%
Medicine	170	Prolapse of female genital organs	257	52	20.2%
Medicine	215	Genitourinary congenital anomalies	239	42	17.6%
Medicine	124	Acute and chronic tonsillitis	221	10	4.5%
Medicine	61	Sickle cell anemia	203	49	24.1%
Medicine	57	Immunity disorders	158	54	34.2%
Medicine	206	Osteoporosis	148	22	14.9%
Medicine	10	Immunizations and screening for infectious disease	127	16	12.6%
Medicine	88	Glaucoma	124	20	16.1%
Medicine	172	Ovarian cyst	114	14	12.3%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Medicine	208	Acquired foot deformities	103	17	16.5%
Medicine	46	Benign neoplasm of uterus	102	15	14.7%
Medicine	53	Disorders of lipid metabolism	98	16	16.3%
Medicine	171	Menstrual disorders	68	11	16.2%
Medicine	86	Cataract	37	6	16.2%
Medicine	256	Medical examination/evaluation	30	5	0.0%
Medicine	255	Administrative/social admission	14	2	0.0%
Medicine	56	Cystic fibrosis	14	3	0.0%
Medicine	169	Endometriosis	13	2	0.0%
Medicine		Total	3,086,792	556,131	18.0%
Surgery/ gynecology	203	Osteoarthritis	316,437	17,171	5.4%
Surgery/ gynecology	101	Coronary atherosclerosis and other heart disease	176,014	20,772	11.8%
Surgery/ gynecology	226	Fracture of neck of femur (hip)	174,221	25,570	14.7%
Surgery/ gynecology	237	Complication of device; implant or graft	108,171	17,096	15.8%
Surgery/ gynecology	205	Spondylosis; intervertebral disc disorders; other back problems	103,542	7,693	7.4%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	100	Acute myocardial infarction	80,208	13,197	16.5%
Surgery/ gynecology	149	Biliary tract disease	66,034	7,444	11.3%
Surgery/ gynecology	110	Occlusion or stenosis of precerebral arteries	59,540	4,223	7.1%
Surgery/ gynecology	114	Peripheral and visceral atherosclerosis	54,232	8,629	15.9%
Surgery/ gynecology	143	Abdominal hernia	44,379	4,918	11.1%
Surgery/ gynecology	230	Fracture of lower limb	37,222	4,754	12.8%
Surgery/ gynecology	14	Cancer of colon	35,852	4,847	13.5%
Surgery/ gynecology	238	Complications of surgical procedures or medical care	34,110	6,328	18.6%
Surgery/ gynecology	170	Prolapse of female genital organs	32,935	1,085	3.3%
Surgery/ gynecology	115	Aortic; peripheral; and visceral artery aneurysms	32,714	4,300	13.1%
Surgery/ gynecology	96	Heart valve disorders	31,286	6,631	21.2%
Surgery/ gynecology	164	Hyperplasia of prostate	30,171	2,245	7.4%
Surgery/ gynecology	47	Other and unspecified benign neoplasm	27,845	2,704	9.7%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	229	Fracture of upper limb	27,214	2,687	9.9%
Surgery/ gynecology	106	Cardiac dysrhythmias	26,198	4,055	15.5%
Surgery/ gynecology	145	Intestinal obstruction without hernia	25,829	4,152	16.1%
Surgery/ gynecology	207	Pathological fracture	25,176	4,305	17.1%
Surgery/ gynecology	19	Cancer of bronchus; lung	21,281	2,981	14.0%
Surgery/ gynecology	2	Septicemia (except in labor)	21,158	5,327	25.2%
Surgery/ gynecology	29	Cancer of prostate	21,069	1,207	5.7%
Surgery/ gynecology	24	Cancer of breast	20,936	1,224	5.8%
Surgery/ gynecology	50	Diabetes mellitus with complications	19,556	4,311	22.0%
Surgery/ gynecology	42	Secondary malignancies	19,132	3,352	17.5%
Surgery/ gynecology	231	Other fractures	18,928	2,983	15.8%
Surgery/ gynecology	146	Diverticulosis and diverticulitis	17,044	2,475	14.5%
Surgery/ gynecology	32	Cancer of bladder	16,392	3,142	19.2%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	155	Other gastrointestinal disorders	15,109	2,489	16.5%
Surgery/ gynecology	109	Acute cerebrovascular disease	14,296	2,688	18.8%
Surgery/ gynecology	142	Appendicitis and other appendiceal conditions	13,863	1,194	8.6%
Surgery/ gynecology	248	Gangrene	13,724	3,593	26.2%
Surgery/ gynecology	209	Other acquired deformities	11,837	1,093	9.2%
Surgery/ gynecology	108	Congestive heart failure; non-hypertensive	11,641	3,294	28.3%
Surgery/ gynecology	33	Cancer of kidney and renal pelvis	11,385	1,125	9.9%
Surgery/ gynecology	212	Other bone disease and musculoskeletal deformities	11,331	1,155	10.2%
Surgery/ gynecology	118	Phlebitis; thrombophlebitis and thromboembolism	11,273	2,297	20.4%
Surgery/ gynecology	160	Calculus of urinary tract	11,052	1,334	12.1%
Surgery/ gynecology	15	Cancer of rectum and anus	10,360	1,794	17.3%
Surgery/ gynecology	211	Other connective tissue disease	9,959	805	8.1%
Surgery/ gynecology	233	Intracranial injury	9,148	1,762	19.3%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	25	Cancer of uterus	9,129	903	9.9%
Surgery/ gynecology	201	Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted di	9,080	1,624	17.9%
Surgery/ gynecology	116	Aortic and peripheral arterial embolism or thrombosis	8,582	1,701	19.8%
Surgery/ gynecology	103	Pulmonary heart disease	8,316	1,832	22.0%
Surgery/ gynecology	152	Pancreatic disorders (not diabetes)	7,891	1,051	13.3%
Surgery/ gynecology	159	Urinary tract infections	6,278	1,441	23.0%
Surgery/ gynecology	147	Anal and rectal conditions	5,848	726	12.4%
Surgery/ gynecology	175	Other female genital disorders	5,700	422	7.4%
Surgery/ gynecology	122	Pneumonia (except that caused by tuberculosis or sexually transmitted disease)	5,684	1,367	24.0%
Surgery/ gynecology	81	Other hereditary and degenerative nervous system conditions	5,624	892	15.9%
Surgery/ gynecology	162	Other diseases of bladder and urethra	5,449	726	13.3%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	157	Acute and unspecified renal failure	5,364	1,469	27.4%
Surgery/ gynecology	197	Skin and subcutaneous tissue infections	5,359	897	16.7%
Surgery/ gynecology	44	Neoplasms of unspecified nature or uncertain behavior	5,159	654	12.7%
Surgery/ gynecology	199	Chronic ulcer of skin	5,144	1,099	21.4%
Surgery/ gynecology	11	Cancer of head and neck	5,027	765	15.2%
Surgery/ gynecology	48	Thyroid disorders	4,948	203	4.1%
Surgery/ gynecology	153	Gastrointestinal hemorrhage	4,871	1,199	24.6%
Surgery/ gynecology	204	Other non-traumatic joint disorders	4,804	296	6.2%
Surgery/ gynecology	130	Pleurisy; pneumothorax; pulmonary collapse	4,383	849	19.4%
Surgery/ gynecology	38	Non-Hodgkin's lymphoma	4,182	1,080	25.8%
Surgery/ gynecology	117	Other circulatory disease	4,155	721	17.4%
Surgery/ gynecology	27	Cancer of ovary	4,080	738	18.1%
Surgery/ gynecology	225	Joint disorders and dislocations; trauma-related	4,040	409	10.1%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	232	Sprains and strains	3,980	210	5.3%
Surgery/ gynecology	95	Other nervous system disorders	3,945	562	14.2%
Surgery/ gynecology	58	Other nutritional; endocrine; and metabolic disorders	3,856	349	9.1%
Surgery/ gynecology	17	Cancer of pancreas	3,808	876	23.0%
Surgery/ gynecology	131	Respiratory failure; insufficiency; arrest (adult)	3,739	966	25.8%
Surgery/ gynecology	18	Cancer of other GI organs; peritoneum	3,727	716	19.2%
Surgery/ gynecology	13	Cancer of stomach	3,673	757	20.6%
Surgery/ gynecology	163	Genitourinary symptoms and ill-defined conditions	3,654	543	14.9%
Surgery/ gynecology	99	Hypertension with complications and secondary hypertension	3,624	931	25.7%
Surgery/ gynecology	133	Other lower respiratory disease	3,611	434	12.0%
Surgery/ gynecology	97	Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transmitted	3,551	788	22.2%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	161	Other diseases of kidney and ureters	3,518	519	14.8%
Surgery/ gynecology	138	Esophageal disorders	3,387	405	12.0%
Surgery/ gynecology	127	Chronic obstructive pulmonary disease and bronchiectasis	3,321	968	29.1%
Surgery/ gynecology	217	Other congenital anomalies	3,148	241	7.7%
Surgery/ gynecology	139	Gastroduodenal ulcer (except hemorrhage)	2,879	532	18.5%
Surgery/ gynecology	35	Cancer of brain and nervous system	2,834	494	17.4%
Surgery/ gynecology	55	Fluid and electrolyte disorders	2,723	643	23.6%
Surgery/ gynecology	36	Cancer of thyroid	2,704	170	6.3%
Surgery/ gynecology	234	Crushing injury or internal injury	2,179	389	17.9%
Surgery/ gynecology	21	Cancer of bone and connective tissue	2,110	319	15.1%
Surgery/ gynecology	51	Other endocrine disorders	2,093	185	8.8%
Surgery/ gynecology	202	Rheumatoid arthritis and related disease	2,070	139	6.7%
Surgery/ gynecology	111	Other and ill-defined cerebrovascular disease	2,067	225	10.9%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	23	Other non-epithelial cancer of skin	2,029	235	11.6%
Surgery/ gynecology	236	Open wounds of extremities	1,819	187	10.3%
Surgery/ gynecology	28	Cancer of other female genital organs	1,816	246	13.5%
Surgery/ gynecology	166	Other male genital disorders	1,797	167	9.3%
Surgery/ gynecology	245	Syncope	1,779	257	14.4%
Surgery/ gynecology	129	Aspiration pneumonitis; food/vomit	1,612	464	28.8%
Surgery/ gynecology	172	Ovarian cyst	1,562	92	5.9%
Surgery/ gynecology	46	Benign neoplasm of uterus	1,558	75	4.8%
Surgery/ gynecology	141	Other disorders of stomach and duodenum	1,557	332	21.3%
Surgery/ gynecology	134	Other upper respiratory disease	1,514	223	14.7%
Surgery/ gynecology	59	Deficiency and other anemia	1,460	363	24.9%
Surgery/ gynecology	34	Cancer of other urinary organs	1,412	184	13.0%
Surgery/ gynecology	228	Skull and face fractures	1,387	127	9.2%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	144	Regional enteritis and ulcerative colitis	1,378	309	22.4%
Surgery/ gynecology	213	Cardiac and circulatory congenital anomalies	1,358	155	11.4%
Surgery/ gynecology	121	Other diseases of veins and lymphatics	1,305	260	19.9%
Surgery/ gynecology	135	Intestinal infection	1,294	408	31.5%
Surgery/ gynecology	151	Other liver diseases	1,244	372	29.9%
Surgery/ gynecology	244	Other injuries and conditions due to external causes	1,229	214	17.4%
Surgery/ gynecology	208	Acquired foot deformities	1,223	50	4.1%
Surgery/ gynecology	16	Cancer of liver and intrahepatic bile duct	1,170	220	18.8%
Surgery/ gynecology	102	Nonspecific chest pain	1,144	176	15.4%
Surgery/ gynecology	12	Cancer of esophagus	1,143	266	23.3%
Surgery/ gynecology	112	Transient cerebral ischemia	1,124	162	14.4%
Surgery/ gynecology	173	Menopausal disorders	1,099	68	6.2%
Surgery/ gynecology	259	Residual codes; unclassified	1,089	128	11.8%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	105	Conduction disorders	1,023	156	15.2%
Surgery/ gynecology	235	Open wounds of head; neck; and trunk	1,000	117	11.7%
Surgery/ gynecology	148	Peritonitis and intestinal abscess	999	178	17.8%
Surgery/ gynecology	79	Parkinson`s disease	969	200	20.6%
Surgery/ gynecology	227	Spinal cord injury	943	190	20.1%
Surgery/ gynecology	22	Melanomas of skin	940	109	11.6%
Surgery/ gynecology	240	Burns	912	164	18.0%
Surgery/ gynecology	26	Cancer of cervix	841	86	10.2%
Surgery/ gynecology	168	Inflammatory diseases of female pelvic organs	775	81	10.5%
Surgery/ gynecology	41	Cancer; other and unspecified primary	723	92	12.7%
Surgery/ gynecology	62	Coagulation and hemorrhagic disorders	649	144	22.2%
Surgery/ gynecology	165	Inflammatory conditions of male genital organs	643	100	15.6%
Surgery/ gynecology	239	Superficial injury; contusion	629	120	19.1%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	167	Nonmalignant breast conditions	614	53	8.6%
Surgery/ gynecology	137	Diseases of mouth; excluding dental	602	65	10.8%
Surgery/ gynecology	247	Lymphadenitis	590	90	15.3%
Surgery/ gynecology	78	Other CNS infection and poliomyelitis	579	112	19.3%
Surgery/ gynecology	83	Epilepsy; convulsions	579	97	16.8%
Surgery/ gynecology	128	Asthma	566	146	25.8%
Surgery/ gynecology	140	Gastritis and duodenitis	559	125	22.4%
Surgery/ gynecology	257	Other aftercare	519	65	12.5%
Surgery/ gynecology	158	Chronic renal failure	488	121	24.8%
Surgery/ gynecology	251	Abdominal pain	478	79	16.5%
Surgery/ gynecology	4	Mycoses	476	105	22.1%
Surgery/ gynecology	40	Multiple myeloma	469	123	26.2%
Surgery/ gynecology	98	Essential hypertension	456	50	11.0%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	136	Disorders of teeth and jaw	441	39	8.8%
Surgery/ gynecology	126	Other upper respiratory infections	424	51	12.0%
Surgery/ gynecology	54	Gout and other crystal arthropathies	416	72	17.3%
Surgery/ gynecology	154	Noninfectious gastroenteritis	381	74	19.4%
Surgery/ gynecology	39	Leukemias	73	123	33.0%
Surgery/ gynecology	653	Delirium, dementia, and amnesic and other cognitive disorders	372	65	17.5%
Surgery/ gynecology	87	Retinal detachments; defects; vascular occlusion; and retinopathy	352	20	5.7%
Surgery/ gynecology	60	Acute post hemorrhagic anemia	337	69	20.5%
Surgery/ gynecology	20	Cancer; other respiratory and intrathoracic	334	56	16.8%
Surgery/ gynecology	91	Other eye disorders	328	42	12.8%
Surgery/ gynecology	200	Other skin disorders	317	41	12.9%
Surgery/ gynecology	93	Conditions associated with dizziness or vertigo	315	34	10.8%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	120	Hemorrhoids	312	64	20.5%
Surgery/ gynecology	215	Genitourinary congenital anomalies	301	32	10.6%
Surgery/ gynecology	94	Other ear and sense organ disorders	294	20	6.8%
Surgery/ gynecology	250	Nausea and vomiting	283	46	16.3%
Surgery/ gynecology	214	Digestive congenital anomalies	282	33	11.7%
Surgery/ gynecology	64	Other hematologic conditions	282	57	20.2%
Surgery/ gynecology	104	Other and ill-defined heart disease	274	39	14.2%
Surgery/ gynecology	90	Inflammation; infection of eye (except that caused by tuberculosis or sexually transmitted disease)	273	39	14.3%
Surgery/ gynecology	43	Malignant neoplasm without specification of site	269	52	19.3%
Surgery/ gynecology	31	Cancer of other male genital organs	263	20	7.6%
Surgery/ gynecology	661	Substance-related disorders	262	55	21.0%
Surgery/ gynecology	45	Maintenance chemotherapy; radiotherapy	257	71	27.6%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	119	Varicose veins of lower extremity	247	31	12.6%
Surgery/ gynecology	52	Nutritional deficiencies	237	74	31.2%
Surgery/ gynecology	107	Cardiac arrest and ventricular fibrillation	227	43	18.9%
Surgery/ gynecology	37	Hodgkin`s disease	211	62	29.4%
Surgery/ gynecology	242	Poisoning by other medications and drugs	206	33	16.0%
Surgery/ gynecology	92	Otitis media and related conditions	198	35	17.7%
Surgery/ gynecology	8	Other infections; including parasitic	197	24	12.2%
Surgery/ gynecology	663	Screening and history of mental health and substance abuse codes	196	64	32.7%
Surgery/ gynecology	169	Endometriosis	183	11	6.0%
Surgery/ gynecology	246	Fever of unknown origin	180	49	27.2%
Surgery/ gynecology	113	Late effects of cerebrovascular disease	169	39	23.1%
Surgery/ gynecology	7	Viral infection	168	42	25.0%
Surgery/ gynecology	124	Acute and chronic tonsillitis	154	7	4.5%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	3	Bacterial infection; unspecified site	152	34	22.4%
Surgery/ gynecology	125	Acute bronchitis	144	34	23.6%
Surgery/ gynecology	63	Diseases of white blood cells	144	39	27.1%
Surgery/ gynecology	82	Paralysis	131	25	19.1%
Surgery/ gynecology	1	Tuberculosis	125	23	18.4%
Surgery/ gynecology	76	Meningitis (except that caused by tuberculosis or sexually transmitted disease)	118	22	18.6%
Surgery/ gynecology	9	Sexually transmitted infections (not HIV or hepatitis)	117	17	14.5%
Surgery/ gynecology	216	Nervous system congenital anomalies	114	20	17.5%
Surgery/ gynecology	132	Lung disease due to external agents	113	15	13.3%
Surgery/ gynecology	660	Alcohol-related disorders	110	7	6.4%
Surgery/ gynecology	88	Glaucoma	108	8	7.4%
Surgery/ gynecology	123	Influenza	107	27	25.2%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	252	Malaise and fatigue	106	25	23.6%
Surgery/ gynecology	206	Osteoporosis	103	22	21.4%
Surgery/ gynecology	6	Hepatitis	88	34	38.6%
Surgery/ gynecology	253	Allergic reactions	83	16	19.3%
Surgery/ gynecology	85	Coma; stupor; and brain damage	82	17	20.7%
Surgery/ gynecology	156	Nephritis; nephrosis; renal sclerosis	81	20	24.7%
Surgery/ gynecology	198	Other inflammatory condition of skin	79	12	15.2%
Surgery/ gynecology	86	Cataract	76	8	10.5%
Surgery/ gynecology	210	Systemic lupus erythematosus and connective tissue disorders	74	18	24.3%
Surgery/ gynecology	49	Diabetes mellitus without complication	59	10	16.9%
Surgery/ gynecology	171	Menstrual disorders	53	2	3.8%
Surgery/ gynecology	77	Encephalitis (except that caused by tuberculosis or sexually transmitted disease)	53	12	22.6%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	84	Headache; including migraine	47	8	17.0%
Surgery/ gynecology	80	Multiple sclerosis	42	10	23.8%
Surgery/ gynecology	249	Shock	35	10	28.6%
Surgery/ gynecology	243	Poisoning by nonmedicinal substances	34	3	8.8%
Surgery/ gynecology	5	HIV infection	31	12	38.7%
Surgery/ gynecology	241	Poisoning by psychotropic agents	29	12	41.4%
Surgery/ gynecology	53	Disorders of lipid metabolism	27	3	11.1%
Surgery/ gynecology	89	Blindness and vision defects	24	5	20.8%
Surgery/ gynecology	30	Cancer of testis	18	3	16.7%
Surgery/ gynecology	256	Medical examination/evaluation	16	5	31.3%
Surgery/ gynecology	258	Other screening for suspected conditions (not mental disorders or infectious disease)	9	-	0.0%
Surgery/ gynecology	61	Sickle cell anemia	3	-	0.0%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Surgery/ gynecology	10	Immunizations and screening for infectious disease	1	-	0.0%
Surgery/ gynecology	193	OB-related trauma to perineum and vulva	1	-	0.0%
Surgery/ gynecology	56	Cystic fibrosis	1	-	0.0%
Surgery/ gynecology	57	Immunity disorders	1	-	0.0%
Surgery/ gynecology		Total	2,163,279	272,830	12.6%
Cardio-respiratory	108	Congestive heart failure; nonhypertensive	453,340	111,720	24.6%
Cardio-respiratory	122	Pneumonia (except that caused by tuberculosis or sexually transmitted disease)	403,972	71,538	17.7%
Cardio-respiratory	127	Chronic obstructive pulmonary disease and bronchiectasis	297,735	64,132	21.5%
Cardio-respiratory	131	Respiratory failure; insufficiency; arrest (adult)	117,569	28,597	24.3%
Cardio-respiratory	128	Asthma	61,696	11,066	17.9%
Cardio-respiratory	103	Pulmonary heart disease	45,122	7,432	16.5%
Cardio-respiratory	125	Acute bronchitis	25,833	3,264	12.6%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Cardio-respiratory		Total	1,405,267	297,749	21.2%
Cardiovascular	106	Cardiac dysrhythmias	315,298	49,471	15.7%
Cardiovascular	102	Nonspecific chest pain	142,883	15,241	10.7%
Cardiovascular	100	Acute myocardial infarction	116,810	25,035	21.4%
Cardiovascular	101	Coronary atherosclerosis and other heart disease	116,147	15,040	12.9%
Cardiovascular	117	Other circulatory disease	56,016	8,998	16.1%
Cardiovascular	105	Conduction disorders	33,899	3,704	10.9%
Cardiovascular	114	Peripheral and visceral atherosclerosis	27,169	4,262	15.7%
Cardiovascular	97	Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transmitted)	13,241	2,735	20.7%
Cardiovascular	96	Heart valve disorders	9,920	1,803	18.2%
Cardiovascular	115	Aortic; peripheral; and visceral artery aneurysms	5,010	767	15.3%
Cardiovascular	116	Aortic and peripheral arterial embolism or thrombosis	2,570	444	17.3%
Cardiovascular	107	Cardiac arrest and ventricular fibrillation	2,009	360	17.9%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Cardiovascular	104	Other and ill-defined heart disease	1,749	247	14.1%
Cardiovascular	213	Cardiac and circulatory congenital anomalies	652	117	17.9%
Cardiovascular		Total	843,373	128,224	15.2%
Neurology	109	Acute cerebrovascular disease	197,598	28,620	14.5%
Neurology	112	Transient cerebral ischemia	82,499	9,073	11.0%
Neurology	95	Other nervous system disorders	58,486	10,172	17.4%
Neurology	83	Epilepsy; convulsions	38,034	6,013	15.8%
Neurology	233	Intracranial injury	35,366	5,890	16.7%
Neurology	81	Other hereditary and degenerative nervous system conditions	10,075	1,760	17.5%
Neurology	110	Occlusion or stenosis of precerebral arteries	9,091	1,273	14.0%
Neurology	79	Parkinson's disease	6,651	907	13.6%
Neurology	113	Late effects of cerebrovascular disease	6,396	1,044	16.3%
Neurology	85	Coma; stupor; and brain damage	6,092	975	16.0%
Neurology	111	Other and ill-defined cerebrovascular disease	5,316	621	11.7%

Specialty cohort	AHRQ CCS	Description of AHRQ CCS	Admissions	30-day unplanned readmissions	30-day unplanned readmission rate
Neurology	80	Multiple sclerosis	1,036	147	14.2%
Neurology	82	Paralysis	883	131	14.8%
Neurology	227	Spinal cord injury	832	144	17.3%
Neurology	78	Other CNS infection and poliomyelitis	786	135	17.2%
Neurology	216	Nervous system congenital anomalies	48	12	25.0%
Neurology		Total	459,189	66,917	14.6%
All Cohorts		Grand Total	7,957,901	1,321,851	16.6%

## Appendix D. Additional Details on Identification and Evaluation of Candidate Attribution Rules

### D1. Identification of Candidate Attribution Rules

Our approach to identifying attribution rules was guided by historical, analytic, policy, and clinical considerations. This includes prior work by the NQF, existing CMS programs, the Environmental Scan/Literature Review described below, input from the TEP, and descriptive analyses of claims patterns. This appendix describes the attribution rules evaluated for use in MIPS HWR measure: how they were identified and why they were or were not adopted.

#### NQF Recommendations

Consistent with the NQF Attribution Committee's recommendations, we considered multiple approaches determined by measure cohort and outcome. We also were attentive to the minimum standards for any attribution rule proposed by the NQF Attribution Committee:

- *Use transparent, clearly articulated methods that produce consistent and reproducible results.* Consistent with this standard, we developed attribution rules that were reproducible and straightforward to implement.
- *Ensure that accountable units can meaningfully influence measured outcomes.* We met this standard by obtaining clinical input on all candidate attribution rules.

#### Existing Centers for Medicare & Medicaid Services Programs

We considered attribution approaches that had been used or were currently in use for attributed hospital outcomes to individual clinicians or their practice groups. These included:

- Value-based Payment Modifier: 2-step attribution methodology based on plurality of primary care service delivery, first assigning to primary care provider and secondly to a specialist who provides primary care service.<sup>53</sup>
- Medicare Accountable Care Organizations (Medicare Shared Savings Program, Pioneer ACO Model, Next Generation ACOs): 2-step attribution method for beneficiaries who receive at least one primary care service from physician within an ACO, first assigning them to the primary care physician who provides the plurality of services and secondly to an ACO professional who provides primary care services.<sup>54</sup>
- Comprehensive Primary Care Plus (CPC+): attribution primarily based on billings for complex care management services and secondarily based on plurality of primary care visits, if not assigned in first step.<sup>55</sup>
- Medicare Multi-Payer Advanced Primary Care Practice (MAPCP) Demonstration: attribution to provider with most primary care visits and break tie with most recent visit.<sup>56</sup>

### Environmental Scan/Literature Review

We performed an environmental scan and literature review to identify approaches to attribution. First, we reviewed work completed by the NQF under contract to the Department of Health and Human Services in 2016.<sup>57</sup> As part of its work, the NQF convened a researcher and clinician-based team to conduct a comprehensive literature review and environmental scan to identify attribution rules proposed for use in or implemented in healthcare delivery models. The NQF also convened a multi-stakeholder committee that reviewed the research team's findings, developed principles of fair attribution models, and developed a guide to assist measure developers and those designing payment models in selecting attribution rules.<sup>57</sup>

Second, we updated the findings of the NQF Attribution Committee's literature review, which evaluated medical literature through October 2016. We searched PubMed (January 1, 2016 to January 4, 2017) and EMBASE (January 1, 2016 to January 4, 2017) to identify any new attribution methods not captured in the NQF's 2016 report. We adopted the NQF's search strategy, and supplemented the search by consulting content experts to include additional studies focused on assigning beneficiaries to clinicians.<sup>58</sup>

Our literature search identified several attribution approaches that were used in high-impact or multiple studies; we considered these as candidates for the current assessment. These included:

- Plurality of charges or claims during a fixed time frame.
- Most recent charges/claims/visits prior to an event.
- Procedure claim for patients undergoing a procedure.

### Claims Patterns

To better understand patterns of care that could help identify or exclude from consideration different attribution rules, we examined for each measure cohort, the patterns of claims around each inpatient stay, focusing specifically and separately on the 365 days prior to admission and during the inpatient stay. This included both institutional and outpatient claims. For example, by examining the claims distributions during and before an inpatient stay for acute myocardial infarction (AMI), we could identify for a given cohort the proportion of patients who saw a cardiologist during or prior to a hospitalization, which would in turn indicate the feasibility of attributing an outcome to cardiologist. We also examined the distribution in numbers and types of eligible clinicians seen by patients during their hospitalization, and the completeness of institutional claims with respect to clinician National Provider Identifiers (NPIs). These kind of data, while not used for evaluation of the attribution approaches, provided a profile of the kinds of clinician contact patients in a given measure cohort had prior to and during their hospitalization to help identify feasible attribution rules.

### Clinical Input

For initial clinical input, we organized a group of clinician researchers at CORE. We gave them background information on the objectives of the project, the candidate measures, and our initial list of candidate attribution approaches. We then solicited their thoughts or concerns about the candidate attribution rules, and their input on any additional attribution rules we should consider.

### Stakeholder Input

In the context of measure re-specification, we solicited input from a national TEP. This panel, listed in the [Acknowledgements](#) section provided iterative feedback, through 3 meetings, including 1 in-person

meeting, and through written commentary. At each meeting CORE presented proposals for attribution along with relevant results and obtained suggestions for additional analyses or additional attributions to be considered. The TEP also considered and endorsed the importance of attributing the readmission outcome to multiple ECs or EC groups.

## D2. Candidate Attribution Rules Considered

The following attribution rules were considered and evaluated during this process.

- *Attending*: Assigns the patient/outcome to the attending physician. Conceptually, the attending physician guides the patient's overall care, and thus it is reasonable to hold them responsible for the care transition at discharge. To apply this concept, we use the attending physician on the inpatient claim for the inpatient stay, entered as an NPI. Practically, this is an unambiguous assignment available for nearly all patients in an inpatient cohort.
- *Discharge Clinician*: Assigns the patient to the clinician who billed for discharging the patient. Consistent with the concept of the attending, it is aligned with the conceptual basis of readmission as a signal of quality during a care transition to assign to the Discharge Clinician. Practically, this will often, but not always, be the attending of record on the inpatient claim. The Discharge Clinician can be determined using the outpatient claims, as for any patient discharged from acute care there should be a corresponding claim for a discharge procedure (Current Procedural Terminology [CPT®] code 99238 or 99239).
- *Primary Inpatient Care Provider (charges)*: Assigns the patient to the clinician with the plurality of charges billed during the dates of the index hospitalization. Conceptually, it may be reasonable that the provider who charged the most for the patient's care during the hospitalization is most responsible for that patient's outcomes. Practically, charges are readily available from the Carrier claims file.
- *Primary Inpatient Care Provider (claims)*: Assigns the patient to the clinician with the plurality of claims billed during the dates of the index hospitalization. Conceptually, this is analogous to the 'most charges' assignment (3), using the same set of claims and clinicians but counting number of claims rather than charges on those claims, but may be less biased towards certain specialties. Practically, claim counts are readily available from the Carrier claims file.
- *Value Modifier (VM) Approach*: Used in CMS's VM program to assign inpatient admissions to providers. Assigns the patient to the clinician who provides the most primary care services during the 12 calendar months of the measurement period. Conceptually, if a patient has a primary care provider, this clinician could plausibly be aware of any hospitalization and provide post discharge care that would reduce the need for a rehospitalization. The existing algorithm identifies a primary care physician if possible, a specialist if not, using plurality of charges for primary care codes during the reporting calendar year.
- *Outpatient PCP*: We wanted to rule out the possibility that a patient would be attributed to a clinician they cared for only after discharge, so we modified the VM approach to count only those codes during the 365 days prior to admission.

- *Outpatient PCP+:* In a variation on the previous rule, we dropped the precedence given to primary care physicians.

Our empirical evaluation of the selected attribution methods for each test measure was comprised of analyses that would allow us to understand the implications of each approach with regards to feasibility, validity, reliability, and sample size. Our analytic evaluation was attentive to the minimum standards for any attribution rule proposed by the NQF Attribution Committee:

- Use adequate sample sizes, outlier exclusion, and/or risk adjustment to fairly compare the performance of attributed units. We examined sample size distribution and outlier patterns and used original hospital risk-adjustment models.
- *Conduct sufficient testing with scientific rigor at the level of accountability being measured.* Though additional testing would be necessary before adoption, we undertook implementation consistent with the hospital-level measures, which have been rigorously tested.

The analytic evaluation of each attribution method focused on the following aspects of each:

- *Face validity:* For each approach, we assessed face validity by summarizing the number and percent of unattributed patients as well as rates of missing clinician or TIN information. The distribution also provides face validity in that an attribution rule which leads to unexpected or senseless results is unlikely to be accepted by stakeholders. Implementation also provided a measure of feasibility; if an approach led to a high proportion of unattributed patients, then it was considered less valid. Thus, we examined the patterns of volume for ECs and EC groups overall and by specialty.
- *Differentiation among providers:* The greater the variation in entity performance, the more evidence that the attribution is aligned with some underlying true quality signal. Therefore, for each attribution method, we examined: the distribution of unadjusted outcome rates across physicians and EC groups; the between-clinician and between-TIN variance estimated from a hierarchical generalized linear model (HGLM) for different volume cut-offs; distribution of RARR; and the impact of risk adjustment on these variances.
- *Reliability and sample size:* Reliability relates the accuracy of measurement to the sample size of the measured entities. For each approach, we calculated the estimated average unit (clinician [NPI] or group [TIN]) reliability for a volume cut-off of 25 as well as the minimum volume for an average reliability of 0.40.
- *Overlap with other attribution rules:* As recommended by the NQF report, we examined the overlap between the different candidate attribution rules. If several different attribution rules are consistent (have high overlap), then it suggests there is little practical difference in choosing among them. For all attribution rules assigned to a single entity, we summarized how much pairwise overlap there was in their assignments.

For all attribution rules, we evaluated implementation of the rule at the individual EC level and at the EC group level.

**Table D1. Attribution rules evaluated**

Attribution rule	Definition	Justification for inclusion as candidate attribution rule	Reason for exclusion
Attending	Identified as the “attending provider” on the inpatient claim	Logically responsible for patient care and discharge transition.	Concern that ECs had little control over whether they were listed on an inpatient claim as the Attending.
Discharge clinician	Identified by claim with ‘discharge procedure’ codes	Logically responsible for discharge transition.	Not applicable; rule not excluded
Primary inpatient care provider (greatest number of claims)	Identified by plurality of Part B patient-facing claim lines during inpatient stay	Logically responsible for patient care during inpatient stay.	Analyses found that the ECs identified by charges had specialties that were more aligned with clinical expectations.
Primary Inpatient Care Provider (greatest total charges)	Identified by plurality of Part B patient-facing claim charges during inpatient stay	Logically responsible for patient care during inpatient stay.	Not applicable; rule not excluded
Outpatient PCP	identified by plurality of outpatient primary care during 12 months prior to admissions, precedence given to primary care specialties	Logically responsible for patient care in the outpatient setting.	Not applicable; rule not excluded
Outpatient PCP+	identified by plurality of outpatient primary care during 12 months prior to admissions, no precedence given to primary care specialties	Logically responsible for patient care in the outpatient setting.	Compared with Outpatient PCP, more often identified specialties that were unlikely to be responsible for admission decisions.

### D3. Final Attributions

CORE sought consensus from a national TEP around which of the rules should be used for MIPS HWR measure. The TEP strongly supported attributing readmissions to more than 1 EC and identified combinations of preferences for the Discharge Clinician, Outpatient PCP, and some version of the Primary Inpatient care clinician.

Figure D1. Hospital-wide readmission: Primary inpatient care clinician attribution (EC level)

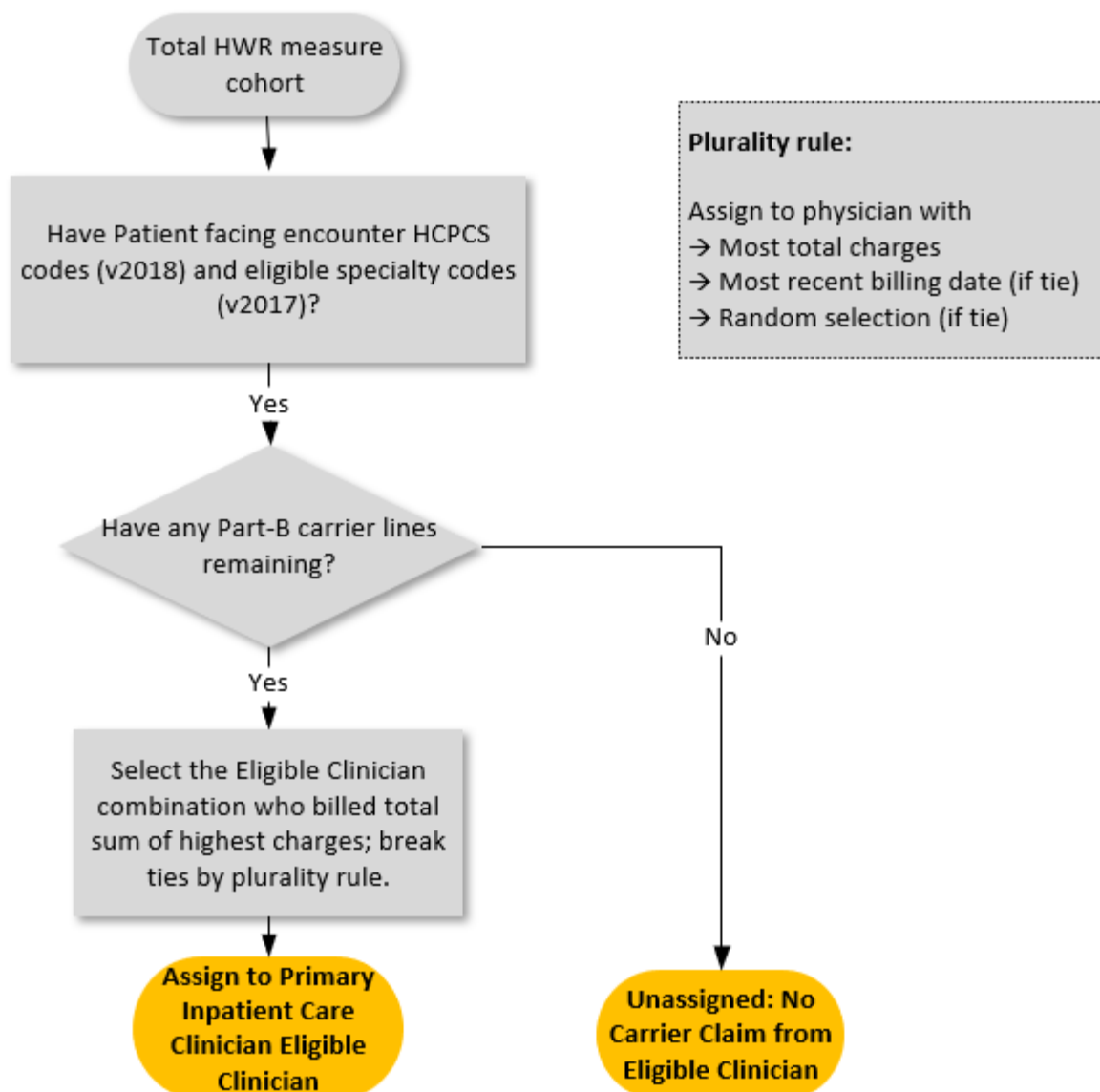
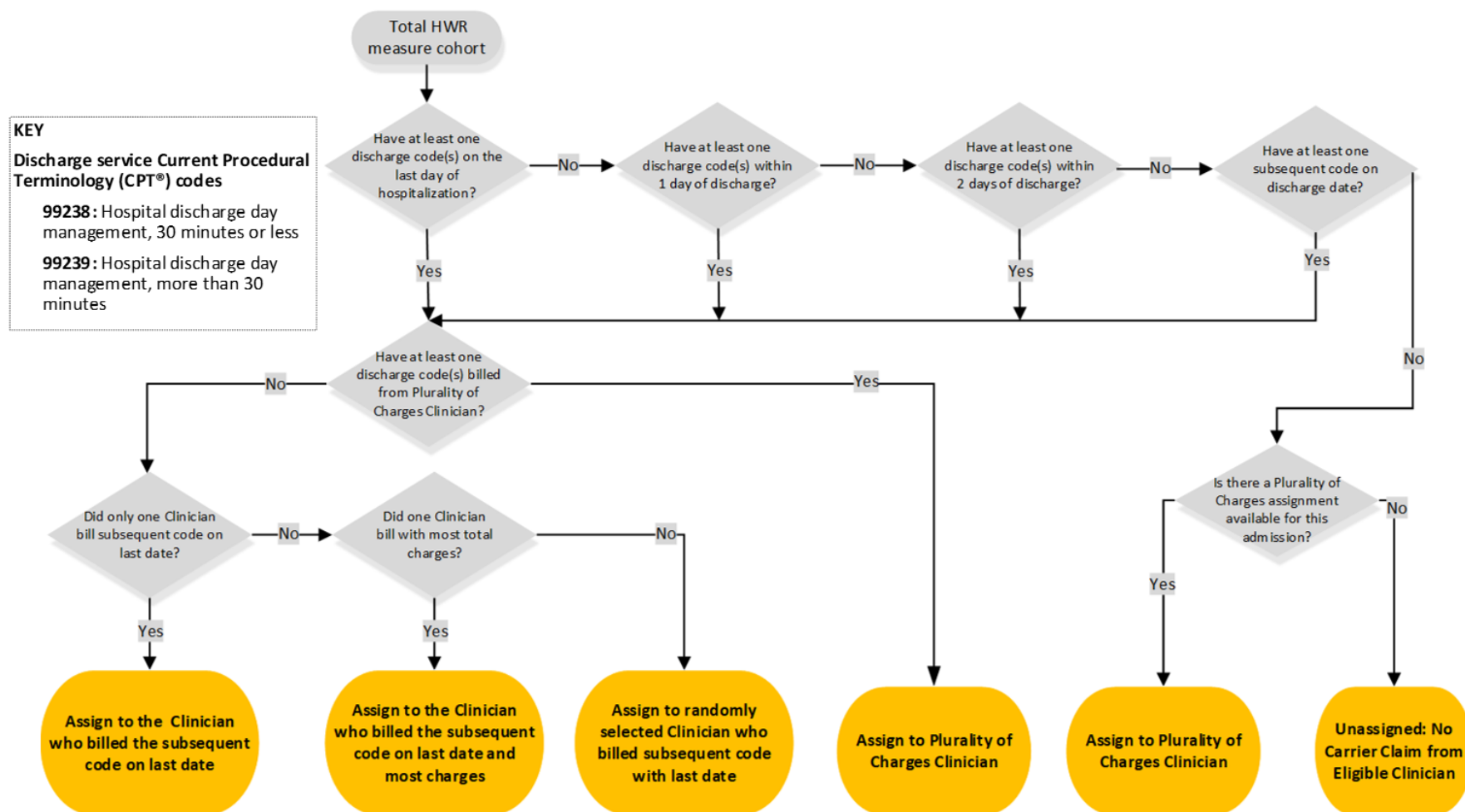


Figure D.2 Hospital-wide readmission: Greatest Total Charges Attribution (EC level)



#### D4. Excluded Attribution Rules

CORE sought consensus from the TEP around which of these rules should be used for MIPS HWR measure. These rules were excluded for the following reasons:

*Attending:* The TEP and other stakeholders were concerned that ECs had little control over whether they were listed on an inpatient claim as the Attending. This would dilute responsibility and raised concerns about validity.

*Primary Inpatient Care Provider (claims):* While closely related to the adopted attribution rule, “Primary Inpatient Care Provider (Charges),” analyses found the ECs identified by charges had specialties more closely aligned with clinical expectations. Specifically, for the surgery/gynecology cohort, using charges typically identified a surgeon, while the number of claims typically identified other specialties. For non-surgical cohorts, the same EC was often identified using both methods. Thus, attribution based on number of claims was dropped in favor of an approach that could be more accurately applied across all specialty cohorts.

*Outpatient PCP+:* While very similar to the Outpatient PCP that was ultimately adopted, the modification to ignore specialty unsurprisingly identified specialties that were unlikely to be responsible for admission decisions. Feedback from the TEP also indicated greater face validity for the Outpatient PCP approach finally adopted.

## Appendix E. Potential Complications of Care Excluded from Risk Adjustment

Table E1. Conditions that are treated as potential complications of care if occurring during index admission

CMS-CC <sup>59</sup>	Label	Potential complication
2	Septicemia/Shock	Yes
6	Other Infectious Diseases	Yes
17	Diabetes with Acute Complications	Yes
23	Disorders of Fluid/Electrolyte/Acid-Base	Yes
24	Other Endocrine/Metabolic/ Nutritional Disorders	No
28	Acute Liver Failure/Disease	Yes
31	Intestinal Obstruction/Perforation	Yes
34	Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders	Yes
36	Other Gastrointestinal Disorders	No
37	Bone/Joint/Muscle Infections/Necrosis	No
43	Other Musculoskeletal and Connective Tissue Disorders	No
46	Coagulation Defects and Other Specified Hematological Disorders	Yes
47	Iron Deficiency and Other/ Unspecified Anemias and Blood Disease	No
48	Delirium and Encephalopathy	Yes
51	Drug/Alcohol Psychosis	No

<b>CMS-CC<sup>59</sup></b>	<b>Label</b>	<b>Potential complication</b>
75	Coma, Brain Compression/Anoxic Damage	Yes
76	Mononeuropathy, Other Neurological Conditions/Injuries	No
77	Respirator Dependence/Tracheostomy Status	Yes
78	Respiratory Arrest	Yes
79	Cardio-Respiratory Failure and Shock	Yes
80	Congestive Heart Failure	Yes
81	Acute Myocardial Infarction	Yes
82	Unstable Angina and Other Acute Ischemic Heart Disease	Yes
85	Heart Infection/Inflammation, Except Rheumatic	No
92	Specified Heart Arrhythmias	Yes
93	Other Heart Rhythm and Conduction Disorders	Yes
95	Cerebral Hemorrhage	Yes
96	Ischemic or Unspecified Stroke	Yes
97	Precerebral Arterial Occlusion and Transient Cerebral Ischemia	Yes
100	Hemiplegia/Hemiparesis	Yes
101	Diplegia (Upper), Monoplegia, and Other Paralytic Syndromes	Yes
102	Speech, Language, Cognitive, Perceptual	Yes
104	Vascular Disease with Complications	Yes
105	Vascular Disease	Yes

<b>CMS-CC<sup>59</sup></b>	<b>Label</b>	<b>Potential complication</b>
106	Other Circulatory Disease	Yes
111	Aspiration and Specified Bacterial Pneumonias	Yes
112	Pneumococcal Pneumonia, Emphysema, Lung Abscess	Yes
114	Pleural Effusion/Pneumothorax	Yes
124	Other Eye Disorders	No
129	End Stage Renal Disease	Yes
130	Dialysis Status	Yes
131	Renal Failure	Yes
132	Nephritis	Yes
133	Urinary Obstruction and Retention	Yes
135	Urinary Tract Infection	Yes
148	Decubitus Ulcer of Skin	Yes
152	Cellulitis, Local Skin Infection	Yes
154	Severe Head Injury	Yes
155	Major Head Injury	Yes
156	Concussion or Unspecified Head Injury	Yes
157	Vertebral Fractures	No
158	Hip Fracture/Dislocation	Yes
159	Major Fracture, Except of Skull, Vertebrae, or Hip	Yes
160	Internal Injuries	No

<b>CMS-CC<sup>59</sup></b>	<b>Label</b>	<b>Potential complication</b>
161	Traumatic Amputation	No
162	Other Injuries	No
163	Poisonings and Allergic Reactions	Yes
164	Major Complications of Medical Care and Trauma	Yes
165	Other Complications of Medical Care	Yes
166	Major Symptoms, Abnormalities	No
174	Major Organ Transplant Status	Yes
175	Other Organ Transplant/Replacement	Yes
176	Artificial Openings for Feeding or Elimination	Yes
177	Amputation Status, Lower Limb/Amputation	Yes
178	Amputation Status, Upper Limb	Yes
179	Post-Surgical States/Aftercare/Elective	Yes

**Table E2. Discharge condition categories considered acute and/or complications of care**

AHRQ CCS	Description of AHRQ CCS	30-day readmissions with this condition and one of the planned procedures (Total=64,181)
237	Complication of device; implant or graft	11,689
106	Cardiac dysrhythmias	10,267
207, 225, 226, 227, 229, 230, 231, 232	Fracture	6,307
100	Acute myocardial infarction	5,643
238	Complications of surgical procedures or medical care	5,438
108	Congestive heart failure; nonhypertensive	5,119
2	Septicemia (except in labor)	3,372
146	Diverticulosis and diverticulitis	2,434
105	Conduction disorders	2,130
109	Acute cerebrovascular disease	1,886
145	Intestinal obstruction without hernia	1,341
233	Intracranial injury	1,271
116	Aortic and peripheral arterial embolism or thrombosis	1,115
122	Pneumonia (except that caused by TB or sexually transmitted disease)	710
131	Respiratory failure; insufficiency; arrest (adult)	678
157	Acute and unspecified renal failure	645
201	Infective arthritis and osteomyelitis (except that caused by TB or sexually transmitted disease)	608
153	Gastrointestinal hemorrhage	566
130	Pleurisy; pneumothorax; pulmonary collapse	510
97	Peri-; endo-; and myocarditis; cardiomyopathy	484

<b>AHRQ CCS</b>	<b>Description of AHRQ CCS</b>	<b>30-day readmissions with this condition and one of the planned procedures (Total=64,181)</b>
127	Chronic obstructive pulmonary disease and bronchiectasis	462
55	Fluid and electrolyte disorders	424
159	Urinary tract infections	410
245	Syncope	353
139	Gastroduodenal ulcer (except hemorrhage)	133
160	Calculus of urinary tract	98
112	Transient cerebral ischemia	88

## Appendix F. Model Results

**Table F1. Cardiorespiratory cohort prevalence and model coefficient, development and validation cohorts**

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Age (years over 65)	14.0%	0.00 (0.00, 0.00)	13.7%	0.00 (0.00, 0.00)
Alcohol	3.5%	0.16 (0.13, 0.18)	3.7%	0.18 (0.15, 0.21)
Arrhythmias	33.3%	0.09 (0.08, 0.10)	29.0%	0.10 (0.09, 0.12)
Arthritis	5.8%	0.07 (0.05, 0.09)	6.1%	0.05 (0.03, 0.07)
CAD/CVD	58.9%	0.12 (0.11, 0.13)	54.5%	0.11 (0.10, 0.13)
Congestive Heart Failure	37.7%	0.18 (0.17, 0.20)	32.8%	0.19 (0.17, 0.20)
Low frequency Conditions	0.0%	-0.03 (-0.61, 0.56)	0.0%	0.04 (-0.64, 0.71)
Pulmonary heart disease (CCS 103)	4.8%	-0.09 (-0.18, -0.01)	6.0%	-0.10 (-0.20, 0.00)
Congestive heart failure; nonhypertensive (CCS 108)	34.8%	0.15 (0.07, 0.24)	19.9%	0.17 (0.07, 0.27)
Pneumonia (except that caused by tuberculosis or sexually transmitted disease) (CCS 122)	26.3%	-0.02 (-0.11, 0.06)	25.6%	-0.01 (-0.11, 0.08)
Acute bronchitis (CCS 125)	1.6%	-0.22 (-0.31, -0.13)	2.0%	-0.18 (-0.29, -0.08)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Chronic obstructive pulmonary disease and bronchiectasis (CCS 127)	19.8%	0.15 (0.06, 0.23)	30.0%	0.12 (0.02, 0.22)
Asthma (CCS 128)	1.7%	-0.04 (-0.14, 0.05)	1.4%	-0.14 (-0.25, -0.03)
Respiratory failure; insufficiency; arrest (adult) (CCS 131)	10.9%	ref	15.0%	ref
COPD	51.6%	0.20 (0.18, 0.21)	53.4%	0.19 (0.18, 0.20)
Cardiorespiratory	28.4%	0.16 (0.14, 0.17)	29.6%	0.19 (0.17, 0.20)
Coagulopathy	7.0%	0.03 (0.02, 0.05)	6.7%	0.04 (0.02, 0.06)
Diabetes	40.7%	0.09 (0.08, 0.10)	36.0%	0.09 (0.08, 0.10)
Hematological	1.1%	0.25 (0.20, 0.29)	1.1%	0.22 (0.17, 0.27)
Hip fracture	2.3%	-0.10 (-0.14, -0.07)	2.3%	-0.10 (-0.14, -0.07)
Hx infection	1.6%	0.14 (0.10, 0.18)	1.7%	0.09 (0.05, 0.13)
Iron deficiency	47.2%	0.18 (0.17, 0.19)	44.5%	0.18 (0.17, 0.19)
Liver disease	1.9%	0.15 (0.12, 0.18)	1.8%	0.14 (0.11, 0.18)
Lung disorder	7.6%	0.09 (0.07, 0.11)	7.6%	0.08 (0.06, 0.10)
Malnutrition	11.1%	0.08 (0.06, 0.09)	12.1%	0.10 (0.09, 0.12)
Metastatic cancer	2.8%	0.20 (0.17, 0.23)	3.2%	0.23 (0.20, 0.26)
Metabolic disorder	35.0%	0.13 (0.12, 0.14)	33.2%	0.13 (0.12, 0.15)
Motor dysfunction	4.3%	0.08 (0.05, 0.10)	4.8%	0.08 (0.05, 0.10)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
On dialysis	2.4%	0.22 (0.19, 0.25)	2.35%	0.22 (0.19, 0.25)
Other cancer	6.0%	0.07 (0.05, 0.09)	5.8%	0.06 (0.04, 0.08)
Other infectious	38.0%	0.09 (0.08, 0.10)	40.9%	0.06 (0.05, 0.07)
Pancreatic disease	8.7%	0.07 (0.05, 0.08)	8.0%	0.09 (0.07, 0.11)
Psychological	33.9%	0.08 (0.07, 0.09)	34.9%	0.09 (0.08, 0.11)
Renal failure	43.2%	0.18 (0.17, 0.20)	38.8%	0.17 (0.15, 0.18)
Respirator dependence	0.6%	0.18 (0.13, 0.23)	0.6%	0.09 (0.03, 0.15)
Seizure	3.8%	0.08 (0.05, 0.10)	3.9%	0.06 (0.04, 0.09)
Septicemia	9.9%	0.02 (0.00, 0.03)	10.3%	0.02 (0.00, 0.03)
Severe cancer	6.3%	0.20 (0.18, 0.22)	6.9%	0.21 (0.19, 0.24)
Transplants	0.7%	0.07 (0.02, 0.13)	0.7%	0.14 (0.07, 0.20)
Ulcers	5.4%	0.12 (0.10, 0.14)	4.8%	0.10 (0.08, 0.13)

**Table F2. Cardiovascular cohort: prevalence and model coefficients, development and validation cohorts.**

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	OR (95% CI)	%	OR (95% CI)
Age (years over 65)	13.4%	0.01 (0.01, 0.01)	13.3	0.01 (0.01, 0.01)
Alcohol	2.5%	0.20 (0.16, 0.24)	2.5%	0.22 (0.18, 0.27)
Arrhythmias	27.3%	0.08 (0.06, 0.10)	27.2%	0.06 (0.04, 0.08)
Arthritis	5.0%	0.13 (0.10, 0.16)	5.1%	0.11 (0.08, 0.15)
CAD/CVD	63.4%	0.10 (0.08, 0.12)	63.3%	0.09 (0.07, 0.11)
Congestive Heart Failure	21.9%	0.23 (0.21, 0.25)	21.9%	0.21 (0.19, 0.24)
Acute myocardial infarction (CCS 100)	23.1%	0.13 (0.11, 0.16)	24.9%	0.13 (0.11, 0.15)
Coronary atherosclerosis and other heart disease (CCS 101)	11.2%	-0.11 (-0.13, -0.08)	10.6%	-0.14 (-0.17, -0.11)
Nonspecific chest pain (CCS 102)	7.9%	-0.24 (-0.28, -0.21)	6.4%	-0.21 (-0.25, -0.18)
Other and ill-defined heart disease (CCS 104)	0.5%	-0.05 (-0.16, 0.05)	0.5%	0.00 (-0.11, 0.10)
Conduction disorders (CCS 105)	3.8%	-0.26 (-0.30, -0.22)	4.1%	-0.30 (-0.35, -0.26)
Cardiac dysrhythmias (CCS 106)	37.4%	0.11 (0.09, 0.13)	37.2%	0.11 (0.09, 0.13)
Cardiac arrest and ventricular fibrillation (CCS 107)	0.4%	0.01 (-0.09, 0.11)	0.4%	-0.03 (-0.13, 0.07)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	OR (95% CI)	%	OR (95% CI)
Peripheral and visceral atherosclerosis (CCS 114)	3.8%	0.00 (-0.04, 0.04)	3.3%	0.01 (-0.03, 0.06)
Aortic; peripheral; and visceral artery aneurysms (CCS 115)	2.9%	-0.02 (-0.07, 0.02)	3.6%	-0.07 (-0.11, -0.02)
Aortic and peripheral arterial embolism or thrombosis (CCS 116)	0.5%	0.17 (0.08, 0.25)	0.5%	0.12 (0.02, 0.22)
Other circulatory disease (CCS 117)	5.3%	-0.04 (-0.07, 0.00)	5.2%	-0.01 (-0.04, 0.03)
Cardiac and circulatory congenital anomalies (CCS 213)	0.3%	0.08 (-0.03, 0.20)	0.3%	0.14 (0.03, 0.24)
Heart valve disorders (CCS 96)	1.5%	-0.06 (-0.11, 0.00)	1.4%	-0.04 (-0.09, 0.02)
Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transm (CCS 97)	1.5%	ref	1.5%	ref
COPD	25.2%	0.27 (0.25, 0.29)	25.5%	0.28 (0.27, 0.30)
Cardiorespiratory	10.2%	0.07 (0.05, 0.10)	10.9%	0.06 (0.04, 0.08)
Coagulopathy	4.5%	0.02 (-0.01, 0.05)	4.8%	0.02 (-0.01, 0.05)
Diabetes	37.1%	0.14 (0.13, 0.16)	34.3%	0.13 (0.12, 0.15)
Hematological	0.8%	0.29 (0.22, 0.36)	0.7%	0.23 (0.16, 0.30)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	OR (95% CI)	%	OR (95% CI)
Hip fracture	1.4%	-0.08 (-0.14, -0.03)	1.4%	-0.10 (-0.16, -0.05)
Hx infection	0.8%	0.15 (0.08, 0.22)	0.8%	0.15 (0.08, 0.22)
Iron deficiency	34.2%	0.25 (0.24, 0.27)	34.3%	0.27 (0.25, 0.29)
Liver disease	1.3%	0.29 (0.24, 0.34)	1.4%	0.23 (0.18, 0.28)
Lung disorder	2.8%	0.09 (0.05, 0.13)	2.6%	0.13 (0.09, 0.17)
Malnutrition	5.7%	0.15 (0.13, 0.18)	6.4%	0.14 (0.12, 0.17)
Metastatic cancer	1.7%	0.37 (0.32, 0.43)	1.8%	0.31 (0.26, 0.36)
Metabolic disorder	22.0%	0.12 (0.10, 0.14)	22.1%	0.13 (0.11, 0.15)
Motor dysfunction	3.2%	0.09 (0.05, 0.12)	3.9%	0.13 (0.10, 0.17)
On dialysis	2.4%	0.32 (0.28, 0.36)	2.5%	0.37 (0.33, 0.40)
Other cancer	5.1%	0.04 (0.01, 0.08)	5.1%	0.05 (0.02, 0.08)
Other infectious	17.1%	0.14 (0.12, 0.16)	17.1%	0.14 (0.12, 0.17)
Pancreatic disease	6.1%	0.06 (0.04, 0.09)	6.2%	0.08 (0.05, 0.11)
Psychological	24.7%	0.14 (0.12, 0.15)	25.1%	0.12 (0.11, 0.14)
Renal failure	34.0%	0.25 (0.24, 0.27)	34.8%	0.27 (0.25, 0.28)
Respirator dependence	0.2%	0.08 (-0.06, 0.21)	0.2%	0.00 (-0.14, 0.14)
Seizure	3.0%	0.12 (0.08, 0.16)	3.1%	0.13 (0.09, 0.16)
Septicemia	4.9%	-0.01 (-0.04, 0.02)	5.2%	-0.02 (-0.05, 0.01)
Severe cancer	3.6%	0.22 (0.18, 0.25)	3.7%	0.25 (0.22, 0.29)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	OR (95% CI)	%	OR (95% CI)
Transplants	0.6%	0.17 (0.09, 0.25)	0.6%	0.11 (0.03, 0.19)
Ulcers	3.4%	0.21 (0.17, 0.24)	3.2%	0.18 (0.14, 0.21)

**Table F3. Medicine cohort: prevalence and model coefficients, development and validation cohorts.**

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Age (years over 65)	14.1%	0.00 (0.00, 0.00)	14.3%	0.00 (0.00, 0.00)
Alcohol	4.3%	0.07 (0.06, 0.09)	4.0%	0.10 (0.08, 0.11)
Arrhythmias	24.9%	0.08 (0.07, 0.09)	26.2%	0.08 (0.07, 0.09)
Arthritis	6.2%	0.10 (0.08, 0.11)	6.3%	0.10 (0.09, 0.11)
CAD/CVD	50.6%	0.11 (0.10, 0.11)	52.0%	0.11 (0.11, 0.12)
Congestive Heart Failure	22.4%	0.16 (0.15, 0.17)	25.0%	0.16 (0.15, 0.17)
Low Frequency Conditions	0.5%	-0.04 (-0.09, 0.01)	0.5%	0.01 (-0.04, 0.05)
Phlebitis; thrombophlebitis and thromboembolism (CCS 118)	1.2%	-0.02 (-0.05, 0.02)	1.0%	-0.04 (-0.07, -0.01)
Hemorrhoids (CCS 120)	0.3%	-0.05 (-0.11, 0.02)	0.2%	0.01 (-0.05, 0.08)
Other diseases of veins and lymphatics (CCS 121)	0.1%	0.01 (-0.07, 0.10)	0.1%	0.08 (-0.01, 0.16)
Influenza (CCS 123)	0.5%	-0.27 (-0.32, -0.21)	1.3%	-0.28 (-0.31, -0.24)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Other upper respiratory infections (CCS 126)	0.2%	-0.17 (-0.25, -0.09)	0.2%	-0.21 (-0.29, -0.13)
Aspiration pneumonitis; food/vomitus (CCS 129)	2.3%	0.05 (0.03, 0.07)	2.0%	0.06 (0.03, 0.08)
Pleurisy; pneumothorax; pulmonary collapse (CCS 130)	0.9%	0.32 (0.29, 0.36)	0.8%	0.36 (0.32, 0.39)
Lung disease due to external agents (CCS 132)	0.1%	0.17 (0.06, 0.29)	0.1%	0.19 (0.08, 0.30)
Other lower respiratory disease (CCS 133)	0.8%	0.05 (0.02, 0.09)	0.8%	0.08 (0.04, 0.11)
Other upper respiratory disease (CCS 134)	0.2%	0.01 (-0.07, 0.08)	0.2%	-0.01 (-0.09, 0.07)
Intestinal infection (CCS 135)	2.0%	0.17 (0.15, 0.20)	1.9%	0.15 (0.12, 0.17)
Disorders of teeth and jaw (CCS 136)	0.0%	-0.34 (-0.52, -0.16)	0.0%	-0.19 (-0.36, -0.01)
Diseases of mouth; excluding dental (CCS 137)	0.1%	-0.19 (-0.29, -0.08)	0.1%	-0.29 (-0.40, -0.17)
Esophageal disorders (CCS 138)	0.8%	-0.02 (-0.06, 0.02)	0.7%	0.00 (-0.04, 0.04)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Gastroduodenal ulcer (except hemorrhage) (CCS 139)	0.2%	-0.07 (-0.15, 0.01)	0.2%	-0.01 (-0.09, 0.06)
Gastritis and duodenitis (CCS 140)	0.6%	0.04 (0.00, 0.09)	0.5%	0.07 (0.03, 0.12)
Other disorders of stomach and duodenum (CCS 141)	0.4%	0.20 (0.16, 0.25)	0.4%	0.23 (0.18, 0.27)
Appendicitis and other appendiceal conditions (CCS 142)	0.1%	-0.06 (-0.22, 0.10)	0.1%	0.04 (-0.10, 0.18)
Abdominal hernia (CCS 143)	0.6%	-0.18 (-0.23, -0.13)	0.3%	-0.12 (-0.19, -0.06)
Regional enteritis and ulcerative colitis (CCS 144)	0.3%	0.28 (0.22, 0.34)	0.2%	0.32 (0.26, 0.38)
Intestinal obstruction without hernia (CCS 145)	2.8%	0.03 (0.01, 0.05)	2.5%	0.00 (-0.02, 0.03)
Diverticulosis and diverticulitis (CCS 146)	2.6%	-0.03 (-0.05, -0.01)	2.3%	0.00 (-0.03, 0.02)
Anal and rectal conditions (CCS 147)	0.2%	0.09 (0.01, 0.17)	0.2%	0.09 (0.01, 0.17)
Peritonitis and intestinal abscess (CCS 148)	0.1%	0.21 (0.13, 0.29)	0.1%	0.26 (0.17, 0.34)
Biliary tract disease (CCS 149)	0.9%	0.13 (0.09, 0.16)	1.0%	0.17 (0.13, 0.20)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Other liver diseases (CCS 151)	0.8%	0.39 (0.35, 0.42)	0.8%	0.40 (0.37, 0.44)
Pancreatic disorders (not diabetes) (CCS 152)	1.1%	0.02 (-0.01, 0.06)	1.0%	0.02 (-0.01, 0.06)
Gastrointestinal hemorrhage (CCS 153)	4.3%	-0.05 (-0.07, -0.04)	3.9%	-0.02 (-0.04, 0.00)
Noninfectious gastroenteritis (CCS 154)	1.0%	-0.03 (-0.06, 0.01)	0.9%	-0.03 (-0.06, 0.01)
Other gastrointestinal disorders (CCS 155)	1.3%	0.16 (0.14, 0.19)	1.2%	0.14 (0.12, 0.17)
Nephritis; nephrosis; renal sclerosis (CCS 156)	0.0%	0.51 (0.38, 0.64)	0.0%	0.39 (0.25, 0.53)
Acute and unspecified renal failure (CCS 157)	6.6%	0.13 (0.12, 0.15)	6.1%	0.12 (0.10, 0.13)
Chronic kidney disease (CCS 158)	0.1%	0.10 (0.01, 0.20)	0.0%	0.06 (-0.07, 0.19)
Urinary tract infections (CCS 159)	7.2%	0.03 (0.02, 0.05)	6.6%	0.02 (0.00, 0.03)
Calculus of urinary tract (CCS 160)	0.2%	-0.17 (-0.25, -0.08)	0.1%	-0.15 (-0.26, -0.03)
Other diseases of kidney and ureters (CCS 161)	0.3%	-0.07 (-0.13, -0.01)	0.4%	-0.01 (-0.06, 0.05)
Other diseases of bladder and urethra (CCS 162)	0.1%	0.14 (0.03, 0.25)	0.1%	0.13 (0.01, 0.24)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Genitourinary symptoms and ill-defined conditions (CCS 163)	0.3%	0.10 (0.04, 0.16)	0.3%	0.09 (0.03, 0.15)
Hyperplasia of prostate (CCS 164)	0.1%	0.16 (0.06, 0.26)	0.1%	0.21 (0.11, 0.31)
Inflammatory conditions of male genital organs (CCS 165)	0.1%	-0.21 (-0.31, -0.11)	0.1%	-0.35 (-0.46, -0.25)
Skin and subcutaneous tissue infections (CCS 197)	3.8%	-0.07 (-0.09, -0.06)	3.3%	-0.10 (-0.12, -0.08)
Other inflammatory condition of skin (CCS 198)	0.1%	0.35 (0.23, 0.47)	0.1%	0.30 (0.18, 0.42)
Chronic ulcer of skin (CCS 199)	0.3%	-0.04 (-0.10, 0.02)	0.2%	-0.05 (-0.12, 0.01)
Septicemia (except in labor) (CCS 2)	16.6%	0.00 (-0.01, 0.02)	16.6%	0.00 (-0.01, 0.01)
Other skin disorders (CCS 200)	0.0%	0.02 (-0.15, 0.19)	0.0%	
Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted di (CCS 201)	0.3%	-0.05 (-0.12, 0.01)	0.2%	0.04 (-0.03, 0.10)
Rheumatoid arthritis and related disease (CCS 202)	0.1%	0.01 (-0.12, 0.15)	0.1%	-0.04 (-0.18, 0.10)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Osteoarthritis (CCS 203)	0.2%	-0.24 (-0.33, -0.15)	0.2%	-0.20 (-0.29, -0.11)
Other non-traumatic joint disorders (CCS 204)	0.3%	-0.10 (-0.17, -0.03)	0.2%	-0.11 (-0.18, -0.04)
Spondylosis; intervertebral disc disorders; other back problems (CCS 205)	1.3%	-0.08 (-0.11, -0.05)	1.2%	-0.10 (-0.14, -0.07)
Pathological fracture (CCS 207)	0.4%	-0.02 (-0.07, 0.04)	0.3%	-0.07 (-0.13, -0.01)
Systemic lupus erythematosus and connective tissue disorders (CCS 210)	0.15%	0.19 (0.08, 0.30)	0.1%	0.27 (0.17, 0.37)
Other connective tissue disease (CCS 211)	0.8%	-0.12 (-0.16, -0.08)	0.7%	-0.15 (-0.19, -0.11)
Other bone disease and musculoskeletal deformities (CCS 212)	0.1%	-0.16 (-0.28, -0.04)	0.1%	-0.09 (-0.21, 0.02)
Fracture of neck of femur (hip) (CCS 226)	0.3%	-0.28 (-0.34, -0.21)	0.3%	-0.25 (-0.32, -0.18)
Skull and face fractures (CCS 228)	0.2%	-0.19 (-0.28, -0.09)	0.1%	-0.09 (-0.19, 0.00)
Fracture of upper limb (CCS 229)	0.5%	0.01 (-0.04, 0.06)	0.4%	-0.02 (-0.07, 0.04)
Fracture of lower limb (CCS 230)	0.4%	-0.05 (-0.11, 0.00)	0.4%	-0.12 (-0.18, -0.06)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Other fractures (CCS 231)	2.6%	-0.16 (-0.18, -0.13)	2.4%	-0.17 (-0.20, -0.15)
Sprains and strains (CCS 232)	0.1%	-0.12 (-0.23, -0.02)	0.1%	-0.19 (-0.30, -0.07)
Crushing injury or internal injury (CCS 234)	0.3%	0.02 (-0.05, 0.08)	0.3%	-0.12 (-0.19, -0.06)
Open wounds of head; neck; and trunk (CCS 235)	0.1%	-0.17 (-0.28, -0.07)	0.1%	-0.15 (-0.26, -0.04)
Open wounds of extremities (CCS 236)	0.1%	-0.04 (-0.17, 0.08)	0.1%	-0.03 (-0.16, 0.10)
Complication of device; implant or graft (CCS 237)	3.3%	0.13 (0.12, 0.15)	3.1%	0.13 (0.11, 0.15)
Complications of surgical procedures or medical care (CCS 238)	2.5%	0.03 (0.01, 0.05)	2.3%	0.04 (0.01, 0.06)
Superficial injury; contusion (CCS 239)	0.4%	-0.06 (-0.11, 0.00)	0.4%	-0.13 (-0.19, -0.08)
Burns (CCS 240)	0.0%	0.14 (-0.03, 0.31)	0.0%	0.09 (-0.08, 0.27)
Poisoning by psychotropic agents (CCS 241)	0.1%	-0.06 (-0.17, 0.05)	0.1%	-0.12 (-0.23, 0.00)
Poisoning by other medications and drugs (CCS 242)	0.5%	-0.04 (-0.09, 0.01)	0.4%	-0.06 (-0.10, -0.01)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Poisoning by nonmedicinal substances (CCS 243)	0.1%	-0.56 (-0.74, -0.37)	0.1%	-0.54 (-0.72, -0.36)
Other injuries and conditions due to external causes (CCS 244)	0.5%	-0.10 (-0.15, -0.05)	0.6%	-0.12 (-0.17, -0.08)
Syncope (CCS 245)	1.5%	-0.30 (-0.33, -0.27)	1.2%	-0.28 (-0.31, -0.25)
Fever of unknown origin (CCS 246)	0.3%	0.08 (0.02, 0.14)	0.2%	0.03 (-0.04, 0.09)
Gangrene (CCS 248)	0.1%	0.44 (0.35, 0.53)	0.1%	0.47 (0.37, 0.57)
Shock (CCS 249)	0.1%	0.03 (-0.07, 0.14)	0.1%	-0.02 (-0.14, 0.09)
Nausea and vomiting (CCS 250)	0.3%	0.19 (0.13, 0.25)	0.2%	0.26 (0.20, 0.32)
Abdominal pain (CCS 251)	0.5%	0.08 (0.03, 0.13)	0.4%	0.03 (-0.02, 0.09)
Malaise and fatigue (CCS 252)	0.4%	-0.01 (-0.06, 0.04)	0.4%	-0.04 (-0.09, 0.01)
Allergic reactions (CCS 253)	0.1%	-0.05 (-0.16, 0.06)	0.1%	-0.03 (-0.15, 0.08)
Other aftercare (CCS 257)	0.1%	-0.38 (-0.53, -0.23)	0.0%	-0.13 (-0.31, 0.04)
Other screening for suspected conditions (not mental disorders or infectious disease) (CCS 258)	0.1%	0.06 (-0.03, 0.16)	0.1%	0.02 (-0.08, 0.13)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Residual codes; unclassified (CCS 259)	0.7%	0.00 (-0.04, 0.04)	0.6%	-0.02 (-0.07, 0.02)
Adverse effects of medical drugs (CCS 2617)	0.1%	-0.03 (-0.12, 0.06)	0.0%	.
Poisoning by psychotropic agents (CCS 241)	0.0%	.	0.1%	0.05 (-0.05, 0.16)
Bacterial infection; unspecified site (CCS 3)	0.2%	0.03 (-0.05, 0.11)	0.2%	-0.04 (-0.11, 0.04)
Mycoses (CCS 4)	0.2%	0.36 (0.29, 0.43)	0.1%	0.35 (0.28, 0.42)
Other and unspecified benign neoplasm (CCS 47)	0.2%	-0.05 (-0.13, 0.03)	0.2%	0.01 (-0.07, 0.09)
Thyroid disorders (CCS 48)	0.1%	0.14 (0.03, 0.24)	0.1%	0.19 (0.09, 0.29)
Diabetes mellitus with complications (CCS 50)	2.0%	0.06 (0.04, 0.09)	2.0%	0.05 (0.03, 0.08)
Other endocrine disorders (CCS 51)	0.6%	0.17 (0.13, 0.21)	0.6%	0.15 (0.11, 0.19)
Nutritional deficiencies (CCS 52)	0.1%	0.17 (0.07, 0.27)	0.1%	0.13 (0.03, 0.23)
Gout and other crystal arthropathies (CCS 54)	0.2%	-0.21 (-0.28, -0.13)	0.2%	-0.15 (-0.23, -0.08)
Fluid and electrolyte disorders (CCS 55)	3.8%	0.10 (0.08, 0.11)	3.4%	0.08 (0.06, 0.10)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Other nutritional; endocrine; and metabolic disorders (CCS 58)	0.5%	0.08 (0.03, 0.12)	0.5%	0.12 (0.07, 0.16)
Deficiency and other anemia (CCS 59)	1.7%	0.17 (0.14, 0.19)	1.4%	0.17 (0.14, 0.19)
Hepatitis (CCS 6)	0.1%	0.34 (0.25, 0.43)	0.1%	0.37 (0.27, 0.47)
Acute posthemorrhagic anemia (CCS 60)	0.6%	0.07 (0.03, 0.11)	0.5%	0.09 (0.05, 0.13)
Coagulation and hemorrhagic disorders (CCS 62)	0.2%	0.37 (0.31, 0.44)	0.4%	0.19 (0.15, 0.24)
Diseases of white blood cells (CCS 63)	0.4%	0.20 (0.15, 0.25)	0.3%	0.25 (0.20, 0.30)
Delirium, dementia, and amnestic and other cognitive disorders (CCS 653)	1.1%	-0.05 (-0.09, -0.02)	1.0%	-0.06 (-0.10, -0.03)
Alcohol-related disorders (CCS 660)	0.6%	0.18 (0.14, 0.23)	0.6%	0.19 (0.15, 0.24)
Substance-related disorders (CCS 661)	0.2%	0.02 (-0.06, 0.10)	0.1%	-0.06 (-0.16, 0.03)
Viral infection (CCS 7)	0.3%	-0.01 (-0.07, 0.05)	0.3%	-0.04 (-0.10, 0.03)
Meningitis (except that caused by tuberculosis or sexually transmitted disease) (CCS 76)	0.1%	-0.03 (-0.17, 0.11)	0.1%	-0.05 (-0.19, 0.09)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Encephalitis (except that caused by tuberculosis or sexually transmitted disease) (CCS 77)	0.1%	0.16 (0.03, 0.29)	0.1%	0.20 (0.08, 0.33)
Other infections; including parasitic (CCS 8)	0.1%	-0.27 (-0.43, -0.11)	0.0%	-0.62 (-0.81, -0.42)
Headache; including migraine (CCS 84)	0.2%	-0.25 (-0.34, -0.16)	0.2%	-0.31 (-0.41, -0.21)
Blindness and vision defects (CCS 89)	0.0%	-0.30 (-0.47, -0.12)	0.0%	-0.25 (-0.43, -0.06)
Inflammation; infection of eye (except that caused by tuberculosis or sexually transmitted disease) (CCS 90)	0.1%	-0.08 (-0.24, 0.07)	0.0%	-0.05 (-0.21, 0.11)
Other eye disorders (CCS 91)	0.0%	-0.32 (-0.51, -0.13)	0.0%	-0.40 (-0.62, -0.19)
Conditions associated with dizziness or vertigo (CCS 93)	0.6%	-0.74 (-0.80, -0.67)	0.5%	-0.63 (-0.69, -0.56)
Essential hypertension (CCS 98)	0.6%	-0.31 (-0.37, -0.26)	0.2%	-0.23 (-0.31, -0.16)
Hypertension with complications and secondary hypertension (CCS 99)	2.7%	ref	9.9%	Ref
COPD	26.9%	0.16 (0.15, 0.17)	28.2%	0.16 (0.16, 0.17)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Cardiorespiratory	14.3%	0.07 (0.06, 0.08)	16.2%	0.08 (0.07, 0.09)
Coagulopathy	7.4%	0.07 (0.06, 0.08)	8.1%	0.07 (0.06, 0.08)
Diabetes	39.3%	0.10 (0.09, 0.10)	37.7%	0.10 (0.09, 0.10)
Hematological	1.4%	0.30 (0.28, 0.32)	1.4%	0.31 (0.29, 0.33)
Hip fracture	2.8%	-0.08 (-0.10, -0.06)	2.8%	-0.08 (-0.10, -0.06)
Hx infection	1.8%	0.13 (0.11, 0.15)	1.7%	0.12 (0.09, 0.14)
Iron deficiency	50.8%	0.18 (0.18, 0.19)	50.8%	0.17 (0.17, 0.18)
Liver disease	3.6%	0.27 (0.25, 0.29)	3.7%	0.24 (0.23, 0.26)
Lung disorder	3.4%	0.09 (0.08, 0.11)	3.3%	0.09 (0.07, 0.10)
Malnutrition	14.2%	0.13 (0.12, 0.14)	15.0%	0.13 (0.12, 0.14)
Metastatic cancer	4.3%	0.25 (0.23, 0.26)	4.2%	0.24 (0.23, 0.26)
Metabolic disorder	34.5%	0.15 (0.14, 0.16)	35.2%	0.15 (0.15, 0.16)
Motor dysfunction	6.4%	0.09 (0.08, 0.10)	7.2%	0.07 (0.06, 0.08)
On dialysis	3.1%	0.25 (0.24, 0.27)	3.3%	0.25 (0.23, 0.26)
Other cancer	9.7%	0.07 (0.06, 0.09)	9.4%	0.08 (0.07, 0.09)
Other infectious	30.2%	0.10 (0.09, 0.11)	31.2%	0.10 (0.09, 0.11)
Pancreatic disease	11.9%	0.14 (0.13, 0.15)	11.9%	0.11 (0.10, 0.12)
Psychological	31.7%	0.06 (0.06, 0.07)	31.9%	0.06 (0.05, 0.07)
Renal failure	41.2%	0.19 (0.18, 0.20)	44.0%	0.20 (0.19, 0.21)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Respirator dependence	0.6%	0.17 (0.13, 0.20)	0.5%	0.13 (0.10, 0.17)
Seizure	5.3%	0.10 (0.09, 0.11)	5.2%	0.08 (0.06, 0.09)
Septicemia	12.1%	0.02 (0.01, 0.03)	12.3%	0.03 (0.02, 0.04)
Severe cancer	6.6%	0.23 (0.22, 0.25)	6.6%	0.22 (0.21, 0.23)
Transplants	1.1%	0.19 (0.16, 0.22)	1.2%	0.19 (0.16, 0.21)
Ulcers	7.8%	0.12 (0.11, 0.13)	7.6%	0.11 (0.10, 0.13)

**Table F4. Neurology: prevalence and model coefficients, development and validation cohorts**

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Age (years over 65)	14.4%	0.00 (0.00, 0.00)	14.3%	0.00 (0.00, 0.00)
Alcohol	3.9%	0.08 (0.03, 0.12)	3.8%	0.06 (0.01, 0.10)
Arrhythmias	19.6%	0.10 (0.08, 0.13)	19.2%	0.09 (0.07, 0.12)
Arthritis	4.7%	0.07 (0.03, 0.11)	4.7%	0.10 (0.05, 0.14)
CAD/CVD	56.3%	0.12 (0.10, 0.14)	55.9%	0.13 (0.11, 0.15)
Congestive Heart Failure	14.6%	0.14 (0.11, 0.17)	14.6%	0.12 (0.09, 0.15)
Low Frequency Conditions	0.4%	0.11 (-0.03, 0.25)	0.5%	0.23 (0.12, 0.35)
Acute cerebrovascular disease (CCS 109)	46.1%	-0.03 (-0.06, 0.00)	46.9%	-0.06 (-0.09, -0.03)
Occlusion or stenosis of precerebral arteries (CCS 110)	0.9%	-0.21 (-0.31, -0.11)	0.8%	-0.16 (-0.27, -0.06)
Other and ill-defined cerebrovascular disease (CCS 111)	0.6%	-0.16 (-0.29, -0.04)	0.5%	-0.10 (-0.23, 0.03)
Transient cerebral ischemia (CCS 112)	11.7%	-0.28 (-0.32, -0.24)	10.6%	-0.28 (-0.32, -0.24)
Late effects of cerebrovascular disease (CCS 113)	1.4%	-0.12 (-0.19, -0.04)	1.3%	-0.13 (-0.21, -0.05)
Intracranial injury (CCS 233)	10.6%	0.24 (0.20, 0.27)	10.9%	0.22 (0.18, 0.26)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Parkinson`s disease (CCS 79)	1.4%	0.03 (-0.05, 0.11)	1.6%	-0.01 (-0.09, 0.06)
Multiple sclerosis (CCS 80)	0.3%	0.13 (-0.03, 0.29)	0.3%	0.27 (0.12, 0.42)
Other hereditary and degenerative nervous system conditions (CCS 81)	1.4%	0.09 (0.02, 0.17)	1.2%	0.00 (-0.09, 0.08)
Paralysis (CCS 82)	0.3%	-0.10 (-0.27, 0.06)	0.3%	-0.06 (-0.22, 0.10)
Epilepsy; convulsions (CCS 83)	8.2%	-0.04 (-0.08, 0.00)	8.4%	-0.04 (-0.08, 0.00)
Coma; stupor; and brain damage (CCS 85)	0.35	0.24 (0.10, 0.38)	0.0%	0.00 (0.00, 0.00)
Other nervous system disorders (CCS 95)	16.5%	Ref	16.7%	ref
COPD	18.2%	0.16 (0.14, 0.18)	18.1%	0.16 (0.13, 0.18)
Cardiorespiratory	8.4%	0.04 (0.01, 0.07)	8.8%	0.08 (0.04, 0.11)
Coagulopathy	4.5%	0.01 (-0.03, 0.05)	4.8%	0.06 (0.02, 0.10)
Diabetes	36.4%	0.14 (0.12, 0.16)	34.6%	0.16 (0.14, 0.18)
Hematological	0.7%	0.23 (0.13, 0.32)	0.6%	0.26 (0.16, 0.36)
Hip fracture	2.2%	-0.14 (-0.20, -0.08)	2.2%	-0.20 (-0.26, -0.14)
Hx infection	1.2%	0.19 (0.12, 0.26)	1.2%	0.11 (0.03, 0.18)
Iron deficiency	31.5%	0.21 (0.19, 0.23)	31.4%	0.19 (0.17, 0.22)
Liver disease	1.4%	0.22 (0.15, 0.29)	1.4%	0.31 (0.25, 0.38)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Lung disorder	1.8%	0.09 (0.03, 0.15)	1.7%	0.07 (0.00, 0.13)
Malnutrition	8.2%	0.12 (0.09, 0.15)	9.1%	0.11 (0.08, 0.14)
Metastatic cancer	3.1%	0.23 (0.18, 0.28)	3.3%	0.29 (0.24, 0.34)
Metabolic disorder	24.0%	0.12 (0.09, 0.14)	24.1%	0.11 (0.08, 0.13)
Motor dysfunction	7.7%	0.08 (0.05, 0.11)	9.2%	0.08 (0.05, 0.11)
On dialysis	1.9%	0.33 (0.27, 0.38)	2.0%	0.36 (0.30, 0.41)
Other cancer	6.3%	0.10 (0.06, 0.13)	6.4%	0.08 (0.05, 0.12)
Other infectious	16.8%	0.12 (0.09, 0.14)	16.8%	0.11 (0.09, 0.14)
Pancreatic disease	5.9%	0.06 (0.02, 0.09)	5.8%	0.04 (0.00, 0.07)
Psychological	29.4%	0.04 (0.02, 0.06)	29.7%	0.01 (-0.02, 0.03)
Renal failure	28.1%	0.19 (0.17, 0.22)	29.2%	0.21 (0.19, 0.23)
Respirator dependence	0.2%	0.05 (-0.11, 0.21)	0.2%	-0.04 (-0.21, 0.12)
Seizure	10.5%	0.15 (0.12, 0.18)	10.8%	0.14 (0.11, 0.17)
Septicemia	5.7%	-0.02 (-0.06, 0.02)	5.9%	0.00 (-0.04, 0.04)
Severe cancer	4.3%	0.28 (0.23, 0.32)	4.4%	0.23 (0.19, 0.28)
Transplants	0.5%	0.25 (0.14, 0.35)	0.6%	0.16 (0.06, 0.26)
Ulcers	3.2%	0.13 (0.08, 0.17)	3.2%	0.14 (0.09, 0.19)

**Table F5. Surgery/gynecology cohort: prevalence and model coefficients, development and validation cohorts**

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Age (years over 65)	10.9%	0.01 (0.01, 0.01)	10.8%	0.01 (0.01, 0.01)
Alcohol	2.6%	0.11 (0.08, 0.14)	2.5%	0.11 (0.08, 0.13)
Arrhythmias	13.7%	0.08 (0.07, 0.09)	13.5%	0.07 (0.06, 0.09)
Arthritis	5.3%	0.12 (0.10, 0.14)	5.5%	0.13 (0.11, 0.15)
CAD/CVD	37.8%	0.17 (0.16, 0.18)	37.5%	0.19 (0.18, 0.20)
Congestive Heart Failure	10.7%	0.12 (0.11, 0.14)	10.9%	0.13 (0.12, 0.15)
Low Frequency Conditions	1.9%	0.13 (0.10, 0.16)	2.0%	0.12 (0.08, 0.15)
Acute myocardial infarction (CCS 100)	1.4%	0.19 (0.15, 0.22)	1.1%	0.16 (0.12, 0.20)
Coronary atherosclerosis and other heart disease (CCS 101)	2.3%	-0.01 (-0.04, 0.02)	2.2%	-0.03 (-0.06, 0.01)
Cardiac dysrhythmias (CCS 106)	1.0%	0.10 (0.06, 0.15)	1.0%	0.05 (0.00, 0.09)
Congestive heart failure; nonhypertensive (CCS 108)	0.4%	0.35 (0.29, 0.40)	0.2%	0.30 (0.22, 0.38)
Acute cerebrovascular disease (CCS 109)	1.0%	0.25 (0.21, 0.29)	1.1%	0.19 (0.15, 0.23)
Cancer of head and neck (CCS 11)	0.3%	-0.08 (-0.17, 0.01)	0.3%	-0.07 (-0.16, 0.02)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Occlusion or stenosis of precerebral arteries (CCS 110)	2.2%	-0.61 (-0.66, -0.57)	2.2%	-0.61 (-0.65, -0.56)
Other and ill-defined cerebrovascular disease (CCS 111)	0.1%	-0.19 (-0.32, -0.05)	0.2%	-0.34 (-0.48, -0.20)
Peripheral and visceral atherosclerosis (CCS 114)	1.2%	0.28 (0.24, 0.31)	1.1%	0.20 (0.16, 0.24)
Aortic; peripheral; and visceral artery aneurysms (CCS 115)	0.6%	0.10 (0.04, 0.16)	0.4%	0.29 (0.22, 0.35)
Aortic and peripheral arterial embolism or thrombosis (CCS 116)	0.3%	0.40 (0.32, 0.48)	0.2%	0.44 (0.36, 0.52)
Other circulatory disease (CCS 117)	0.1%	0.22 (0.09, 0.34)	0.1%	0.33 (0.21, 0.44)
Phlebitis; thrombophlebitis and thromboembolism (CCS 118)	0.1%	0.23 (0.10, 0.36)	0.1%	0.08 (-0.04, 0.21)
Cancer of esophagus (CCS 12)	0.1%	0.51 (0.36, 0.65)	0.1%	0.57 (0.43, 0.70)
Pneumonia (except that caused by tuberculosis or sexually transmitted disease) (CCS 122)	0.2%	0.23 (0.15, 0.31)	0.2%	0.22 (0.14, 0.31)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Chronic obstructive pulmonary disease and bronchiectasis (CCS 127)	0.1%	0.44 (0.34, 0.54)	0.2%	0.33 (0.24, 0.41)
Aspiration pneumonitis; food/vomitus (CCS 129)	0.1%	0.25 (0.14, 0.36)	0.1%	0.30 (0.19, 0.41)
Cancer of stomach (CCS 13)	0.2%	0.27 (0.17, 0.37)	0.2%	0.17 (0.07, 0.28)
Pleurisy; pneumothorax; pulmonary collapse (CCS 130)	0.2%	0.05 (-0.04, 0.13)	0.2%	0.10 (0.01, 0.18)
Respiratory failure; insufficiency; arrest (adult) (CCS 131)	0.2%	0.26 (0.18, 0.34)	0.2%	0.17 (0.10, 0.25)
Other lower respiratory disease (CCS 133)	0.2%	-0.02 (-0.14, 0.10)	0.2%	-0.03 (-0.14, 0.08)
Other upper respiratory disease (CCS 134)	0.1%	-0.04 (-0.16, 0.09)	0.1%	0.12 (0.00, 0.23)
Esophageal disorders (CCS 138)	0.2%	-0.04 (-0.14, 0.06)	0.2%	-0.02 (-0.13, 0.08)
Gastroduodenal ulcer (except hemorrhage) (CCS 139)	0.2%	0.26 (0.16, 0.37)	0.2%	0.24 (0.13, 0.35)
Cancer of colon (CCS 14)	1.4%	-0.07 (-0.11, -0.04)	1.4%	-0.10 (-0.14, -0.06)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Other disorders of stomach and duodenum (CCS 141)	0.2%	0.27 (0.18, 0.35)	0.2%	0.23 (0.13, 0.32)
Appendicitis and other appendiceal conditions (CCS 142)	0.6%	-0.28 (-0.36, -0.21)	0.5%	-0.22 (-0.29, -0.14)
Abdominal hernia (CCS 143)	1.8%	-0.04 (-0.07, 0.00)	2.2%	-0.13 (-0.17, -0.10)
Regional enteritis and ulcerative colitis (CCS 144)	0.1%	0.59 (0.45, 0.73)	0.1%	0.53 (0.39, 0.67)
Intestinal obstruction without hernia (CCS 145)	1.3%	0.15 (0.12, 0.19)	1.3%	0.10 (0.06, 0.14)
Diverticulosis and diverticulitis (CCS 146)	0.9%	0.12 (0.07, 0.17)	0.9%	0.05 (0.00, 0.10)
Anal and rectal conditions (CCS 147)	0.3%	-0.08 (-0.16, 0.01)	0.3%	-0.13 (-0.22, -0.04)
Biliary tract disease (CCS 149)	2.8%	-0.11 (-0.14, -0.07)	2.4%	-0.17 (-0.20, -0.13)
Cancer of rectum and anus (CCS 15)	0.4%	0.40 (0.33, 0.46)	0.4%	0.42 (0.36, 0.49)
Other liver diseases (CCS 151)	0.1%	0.44 (0.31, 0.57)	0.1%	0.54 (0.43, 0.66)
Pancreatic disorders (not diabetes) (CCS 152)	0.4%	0.06 (-0.01, 0.13)	0.4%	0.03 (-0.05, 0.11)
Gastrointestinal hemorrhage (CCS 153)	0.5%	0.17 (0.12, 0.23)	0.4%	0.13 (0.07, 0.19)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Other gastrointestinal disorders (CCS 155)	0.8%	0.11 (0.06, 0.15)	0.8%	0.02 (-0.03, 0.07)
Acute and unspecified renal failure (CCS 157)	0.4%	0.35 (0.29, 0.41)	0.4%	0.32 (0.27, 0.38)
Urinary tract infections (CCS 159)	0.4%	0.29 (0.23, 0.35)	0.4%	0.30 (0.24, 0.37)
Cancer of liver and intrahepatic bile duct (CCS 16)	0.1%	0.34 (0.21, 0.47)	0.1%	0.41 (0.28, 0.54)
Calculus of urinary tract (CCS 160)	0.4%	-0.09 (-0.18, -0.01)	0.2%	-0.16 (-0.26, -0.05)
Other diseases of kidney and ureters (CCS 161)	0.4%	-0.08 (-0.15, -0.01)	0.5%	-0.11 (-0.18, -0.04)
Other diseases of bladder and urethra (CCS 162)	0.2%	0.08 (-0.02, 0.18)	0.2%	0.15 (0.04, 0.25)
Genitourinary symptoms and ill-defined conditions (CCS 163)	0.2%	0.11 (0.01, 0.21)	0.1%	0.08 (-0.03, 0.20)
Hyperplasia of prostate (CCS 164)	0.5%	-0.26 (-0.33, -0.19)	0.4%	-0.23 (-0.31, -0.16)
Cancer of pancreas (CCS 17)	0.2%	0.50 (0.42, 0.58)	0.2%	0.49 (0.41, 0.57)
Prolapse of female genital organs (CCS 170)	0.3%	-0.74 (-0.87, -0.62)	0.2%	-0.80 (-0.95, -0.64)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Other female genital disorders (CCS 175)	0.1%	-0.02 (-0.16, 0.11)	0.1%	0.01 (-0.14, 0.15)
Cancer of other GI organs; peritoneum (CCS 18)	0.2%	0.29 (0.20, 0.38)	0.2%	0.24 (0.14, 0.34)
Cancer of bronchus; lung (CCS 19)	1.0%	-0.09 (-0.14, -0.05)	1.0%	-0.10 (-0.15, -0.06)
Skin and subcutaneous tissue infections (CCS 197)	0.4%	-0.11 (-0.18, -0.04)	0.5%	-0.09 (-0.15, -0.02)
Chronic ulcer of skin (CCS 199)	0.3%	-0.01 (-0.08, 0.06)	0.3%	0.01 (-0.06, 0.08)
Septicemia (except in labor) (CCS 2)	3.0%	0.26 (0.23, 0.28)	3.1%	0.23 (0.20, 0.25)
Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted di (CCS 201)	0.6%	-0.08 (-0.14, -0.03)	0.6%	-0.11 (-0.17, -0.05)
Rheumatoid arthritis and related disease (CCS 202)	0.1%	-0.73 (-0.98, -0.48)	0.1%	-0.74 (-1.00, -0.48)
Osteoarthritis (CCS 203)	22.5%	-0.95 (-0.97, -0.93)	23.8%	-0.98 (-1.00, -0.96)
Other non-traumatic joint disorders (CCS 204)	0.3%	-0.87 (-1.00, -0.74)	0.2%	-0.85 (-1.00, -0.71)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Spondylosis; intervertebral disc disorders; other back problems (CCS 205)	5.6%	-0.38 (-0.40, -0.35)	5.1%	-0.40 (-0.43, -0.37)
Pathological fracture (CCS 207)	0.9%	-0.04 (-0.09, 0.00)	1.0%	-0.05 (-0.09, 0.00)
Other acquired deformities (CCS 209)	1.2%	-0.45 (-0.51, -0.40)	1.3%	-0.44 (-0.50, -0.39)
Cancer of bone and connective tissue (CCS 21)	0.1%	0.11 (-0.03, 0.25)	0.1%	0.18 (0.03, 0.32)
Other connective tissue disease (CCS 211)	0.5%	-0.53 (-0.61, -0.45)	0.6%	-0.61 (-0.70, -0.53)
Other bone disease and musculoskeletal deformities (CCS 212)	0.3%	-0.38 (-0.48, -0.29)	0.2%	-0.51 (-0.62, -0.39)
Cardiac and circulatory congenital anomalies (CCS 213)	0.1%	-0.05 (-0.20, 0.09)	0.1%	-0.07 (-0.21, 0.07)
Other congenital anomalies (CCS 217)	0.1%	-0.41 (-0.64, -0.18)	0.0%	
Joint disorders and dislocations; trauma-related (CCS 225)	0.2%	-0.15 (-0.27, -0.03)	0.1%	-0.16 (-0.29, -0.03)
Fracture of neck of femur (hip) (CCS 226)	9.0%	-0.17 (-0.19, -0.15)	8.9%	-0.20 (-0.22, -0.18)
Skull and face fractures (CCS 228)	0.1%	-0.23 (-0.41, -0.05)	0.1%	-0.27 (-0.45, -0.09)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Fracture of upper limb (CCS 229)	1.3%	-0.35 (-0.40, -0.30)	1.2%	-0.41 (-0.46, -0.36)
Other non-epithelial cancer of skin (CCS 23)	0.1%	-0.31 (-0.48, -0.14)	0.1%	-0.29 (-0.47, -0.11)
Fracture of lower limb (CCS 230)	2.0%	-0.11 (-0.15, -0.08)	2.1%	-0.15 (-0.19, -0.12)
Other fractures (CCS 231)	0.9%	0.04 (-0.01, 0.08)	1.0%	0.07 (0.02, 0.11)
Sprains and strains (CCS 232)	0.1%	-0.43 (-0.59, -0.27)	0.1%	-0.58 (-0.77, -0.39)
Intracranial injury (CCS 233)	0.5%	0.35 (0.29, 0.41)	0.5%	0.25 (0.20, 0.31)
Crushing injury or internal injury (CCS 234)	0.1%	0.06 (-0.08, 0.20)	0.1%	0.23 (0.10, 0.36)
Open wounds of head; neck; and trunk (CCS 235)	0.0%		0.1%	-0.34 (-0.55, -0.13)
Open wounds of extremities (CCS 236)	0.1%	-0.19 (-0.33, -0.05)	0.1%	-0.06 (-0.19, 0.07)
Complication of device; implant or graft (CCS 237)	4.9%	-0.01 (-0.03, 0.01)	4.7%	0.00 (-0.02, 0.02)
Complications of surgical procedures or medical care (CCS 238)	2.0%	0.14 (0.11, 0.17)	2.4%	0.08 (0.05, 0.11)
Cancer of breast (CCS 24)	0.3%	-0.50 (-0.60, -0.40)	0.3%	-0.44 (-0.55, -0.32)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Burns (CCS 240)	0.1%	0.24 (0.07, 0.41)	0.1%	0.22 (0.05, 0.39)
Other injuries and conditions due to external causes (CCS 244)	0.1%	0.01 (-0.16, 0.18)	0.1%	0.06 (-0.10, 0.23)
Gangrene (CCS 248)	0.5%	0.44 (0.39, 0.49)	0.4%	0.43 (0.37, 0.49)
Cancer of uterus (CCS 25)	0.3%	-0.07 (-0.16, 0.03)	0.3%	-0.16 (-0.26, -0.06)
Other aftercare (CCS 257)	0.1%	-0.42 (-0.57, -0.28)	0.1%	-0.35 (-0.48, -0.23)
Cancer of ovary (CCS 27)	0.2%	0.03 (-0.08, 0.13)	0.2%	-0.11 (-0.22, 0.00)
Cancer of other female genital organs (CCS 28)	0.1%	-0.11 (-0.28, 0.06)	0.1%	0.24 (0.08, 0.39)
Cancer of prostate (CCS 29)	0.8%	-0.58 (-0.65, -0.50)	0.9%	-0.59 (-0.66, -0.52)
Cancer of bladder (CCS 32)	0.5%	0.51 (0.46, 0.56)	0.5%	0.52 (0.46, 0.57)
Cancer of kidney and renal pelvis (CCS 33)	0.6%	-0.21 (-0.28, -0.15)	0.6%	-0.28 (-0.35, -0.21)
Cancer of other urinary organs (CCS 34)	0.1%	0.00 (-0.15, 0.16)	0.1%	0.01 (-0.15, 0.16)
Cancer of brain and nervous system (CCS 35)	0.2%	0.54 (0.44, 0.64)	0.2%	0.39 (0.29, 0.50)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Cancer of thyroid (CCS 36)	0.1%	-0.35 (-0.56, -0.13)	0.2%	0.87 (0.78,0.95)
Non-Hodgkin`s lymphoma (CCS 38)	0.2%	0.75 (0.66, 0.84)	0.8%	0.23 (0.18,0.28)
Secondary malignancies (CCS 42)	0.8%	0.19 (0.14, 0.24)	0.1%	0.30 (0.13,0.47)
Neoplasms of unspecified nature or uncertain behavior (CCS 44)	0.2%	-0.04 (-0.14, 0.07)	0.2%	-0.01 (-0.12,0.10)
Other and unspecified benign neoplasm (CCS 47)	1.0%	-0.11 (-0.16, -0.06)	1.0%	-0.10 (-0.15,-0.05)
Thyroid disorders (CCS 48)	0.1%	-0.64 (-0.88, -0.41)	0.0%	
Diabetes mellitus with complications (CCS 50)	1.1%	0.15 (0.11, 0.19)	1.6%	0.15 (0.11,0.18)
Other endocrine disorders (CCS 51)	0.1%	0.14 (-0.03, 0.32)	0.0%	0.00 (0.00,0.00)
Fluid and electrolyte disorders (CCS 55)	0.1%	0.34 (0.22, 0.45)	0.1%	0.24 (0.13,0.36)
Other nutritional; endocrine; and metabolic disorders (CCS 58)	0.3%	-0.39 (-0.49, -0.29)	0.3%	-0.49 (-0.60,-0.39)
Parkinson`s disease (CCS 79)	0.1%	-0.44 (-0.66, -0.22)	0.1%	-0.62 (-0.86, -0.38)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Other hereditary and degenerative nervous system conditions (CCS 81)	0.1%	-0.02 (-0.17, 0.12)	0.0%	
Other nervous system disorders (CCS 95)	0.4%	0.05 (-0.02, 0.13)	0.5%	0.11 (0.04, 0.17)
Heart valve disorders (CCS 96)	2.9%	0.00 (-0.03, 0.02)	3.2%	-0.05 (-0.08, -0.02)
Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transmitted (CCS 97)	0.2%	0.28 (0.19, 0.37)	0.2%	0.27 (0.18, 0.36)
Hypertension with complications and secondary hypertension (CCS 99)	0.3%	ref	0.6%	ref
COPD	18.1%	0.23 (0.22, 0.24)	17.9%	0.23 (0.22, 0.24)
Cardiorespiratory	6.6%	0.02 (0.00, 0.04)	7.0%	0.02 (0.00, 0.04)
Coagulopathy	3.5%	0.03 (0.01, 0.06)	3.7%	0.00 (-0.02, 0.03)
Diabetes	30.3%	0.15 (0.14, 0.16)	28.9%	0.16 (0.15, 0.17)
Hematological	0.6%	0.28 (0.23, 0.33)	0.5%	0.32 (0.27, 0.37)
Hip fracture	2.1%	-0.04 (-0.07, -0.01)	2.1%	-0.06 (-0.09, -0.03)
Hx infection	1.0%	0.11 (0.07, 0.15)	1.0%	0.18 (0.14, 0.21)
Iron deficiency	44.6%	0.23 (0.22, 0.24)	43.9%	0.24 (0.23, 0.25)

Variable	Dataset: HWR 2015-2016		Dataset: HWR 2016-2017	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)
Liver disease	1.4%	0.29 (0.26, 0.33)	1.4%	0.29 (0.25, 0.32)
Lung disorder	1.8%	0.12 (0.09, 0.16)	1.6%	0.12 (0.09, 0.15)
Malnutrition	7.7%	0.19 (0.17, 0.20)	8.2%	0.19 (0.18, 0.21)
Metastatic cancer	3.4%	0.27 (0.25, 0.30)	3.2%	0.26 (0.24, 0.29)
Metabolic disorder	17.3%	0.08 (0.06, 0.09)	17.5%	0.09 (0.08, 0.11)
Motor dysfunction	3.9%	0.08 (0.06, 0.10)	4.5%	0.08 (0.05, 0.10)
On dialysis	1.4%	0.31 (0.28, 0.34)	1.7%	0.30 (0.27, 0.33)
Other cancer	6.4%	0.06 (0.04, 0.07)	6.2%	0.06 (0.04, 0.08)
Other infectious	13.0%	0.12 (0.11, 0.14)	13.0%	0.10 (0.09, 0.12)
Pancreatic disease	5.8%	0.05 (0.03, 0.07)	6.0%	0.04 (0.02, 0.05)
Psychological	23.6%	0.10 (0.09, 0.11)	24.4%	0.10 (0.09, 0.11)
Renal failure	22.9%	0.24 (0.22, 0.25)	23.9%	0.24 (0.23, 0.25)
Respirator dependence	0.2%	0.05 (-0.03, 0.12)	0.2%	0.00 (-0.07, 0.08)
Seizure	2.7%	0.13 (0.10, 0.15)	2.7%	0.13 (0.10, 0.15)
Septicemia	5.2%	-0.05 (-0.07, -0.03)	5.3%	-0.06 (-0.08, -0.04)
Severe cancer	3.9%	0.19 (0.17, 0.22)	3.8%	0.18 (0.16, 0.21)
Transplants	0.6%	0.33 (0.28, 0.38)	0.6%	0.30 (0.25, 0.35)
Ulcers	4.9%	0.05 (0.02, 0.07)	5.2%	0.06 (0.04, 0.08)