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Facility 7-Day Risk-Standardized Hospital Visit Rate after Outpatient Colonoscopy: Measure Technical Report

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YALE NEW HAVEN HEALTH

CORE

Facility 7-Day Risk-Standardized Hospital Visit Rate after Outpatient Colonoscopy: A Quality Measure for Profiling Facility Performance Using Claims Data

Measure Technical Report

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1. Executive Summary

This report presents the development, testing, and final specifications of a measure of unplanned hospital visits following outpatient colonoscopies. It is designed to assess the quality of colonoscopies at outpatient facilities. Yale New Haven Health Services Corporation – Center for Outcomes Research and Evaluation (CORE) developed the measure for the Center for Medicare & Medicaid Services (CMS) under a contract supporting the development of ambulatory care outcome measures. This facility-level measure will inform patient choice and help providers and facilities improve the quality of care.

1.1. Rationale for Assessing Hospital Visits Post Colonoscopy

Colonoscopy is a common and costly procedure performed at outpatient facilities and is frequently performed among relatively healthy patients to screen for colorectal cancer (CRC). Given the widespread use of colonoscopy, understanding and minimizing procedure-related adverse events is a high priority. These adverse events, such as abdominal pain, bleeding, and intestinal perforation, can result in unanticipated hospital visits post procedure. Physicians performing colonoscopies are often unaware that patients seek acute care at hospitals following the procedure and thus underestimate such events. This risk-standardized quality measure will address this information gap and promote quality improvement by providing feedback to facilities and physicians, as well as transparency for patients on the rates of and variation across facilities in unplanned hospital visits after colonoscopy.

1.2. Measure Development

CORE developed the measure consistent with CMS's measure development guidance. We assembled a multi-disciplinary team of clinicians, health services researchers, biostatisticians, and leading gastroenterologists. CORE also convened through a public process a national technical expert panel (TEP) consisting of patients, clinicians, methodologist, researchers, and providers. With input from our experts and CMS, we designed the measure cohort, specified the outcome, and developed and tested a risk adjustment model that estimates a facility-level score while accounting for differences in case mix across providers. We also held a public comment period soliciting stakeholder input on the measure methodology, and refined the measure in response to comments. The report presents the final measure specifications, methodology, and testing results.

1.3. Measure Specifications

In brief, the measure includes Medicare fee-for-service (FFS) patients aged ≥65 years undergoing a colonoscopy in the outpatient setting. It excludes patients undergoing concomitant high-risk endoscopy and patients with inflammatory bowel disease (IBD) or diverticulitis. The measure outcome is all unplanned hospital visits (admissions, observation stays, and emergency department [ED] visits) within 7 days of the procedure.

To calculate a facility-specific risk-standardized hospital visit rate, the measure uses hierarchical logistic regression to model the log-odds of the outcome from an index outpatient colonoscopy as a function of the patient demographic and clinical characteristics, and a random outpatient facility-specific intercept. This strategy accounts for within-facility correlation of the observed outcome, and it accommodates the assumption that underlying differences in quality across facilities lead to systematic difference in outcomes. For fairness, the model adjusts for clinical comorbidities and procedural variables that vary across patient populations, are unrelated to quality, and influence the outcome to help ensure differences in the measure score do not reflect differences in case mix across facilities.

1.4. Measure Testing and Results

We tested the measure against the National Quality Forum's (NQF's) criteria for scientific soundness and importance, including testing the risk adjustment model properties and evaluating the measure score variation in four states for which data were available. The model showed good fit and discrimination across risk groups. The median risk-standardized measure score was 12.3 hospital visits per 1,000 colonoscopies and the measure score ranged from 8.4 to 20 hospital visits per 1,000 colonoscopies among hospital outpatient departments (HOPDs) and ambulatory surgery centers (ASCs) in California, Florida, Nebraska and New York.

1.5. Summary

In summary we developed for CMS a risk-standardized measure of unplanned hospital visits within 7 days to assess colonoscopy quality at the facility level. Stakeholder and expert input informed measure development throughout. The measure is scientifically sound and reveals important variation across HOPDs and ASCs.

2. Introduction

Colonoscopy is a common and costly procedure. In 2002 alone, physicians performed an estimated 14 million colonoscopies in the United States.[1] The vast majority (90%) are done in the outpatient settings of HOPDs, ASCs, and physician offices.[2] While colonoscopy is used for the diagnosis and treatment of a wide range of conditions, most outpatient colonoscopies are for the screening of colorectal cancer (CRC) among relatively healthy patients. The United States Preventative Services Task Force (USPSTF) recommends CRC screening every 10 years for the general population aged 50-75 years and more frequently for individuals at higher risk.[3] While many modalities are available for CRC screening, colonoscopy is the most widely used[4] and is recommended by professional organizations as the optimal screening method due to the ability to visualize the bowel and the capacity to remove precancerous lesions (polyps) detected on examination.[5] Given the widespread use of colonoscopy in the outpatient setting, often among patients without a known illness, understanding and minimizing procedure-related adverse events is a high priority.

Colonoscopies are associated with a range of well described adverse events that lead to hospital visits, repeat procedures, or surgical intervention for treatment. The most severe adverse events reported after colonoscopy are colonic perforation; gastrointestinal (GI) bleeding; and cardiopulmonary events such as hypoxia, aspiration pneumonia, and cardiac arrhythmias.[6-8] Furthermore, 20-34% of patients report a range of less severe adverse events such as abdominal pain, abdominal distension, nausea, vomiting, and other non-specific symptoms post colonoscopy.[9,10] Yet clinicians performing colonoscopies underreport these clinical outcomes,[11] in part because they lack information about patients seeking follow-up care from other providers in settings such as a hospital ED. Hospital visits are generally unexpected after outpatient colonoscopy, yet reported hospital visit rates after outpatient colonoscopy range from 0.8-1% at 7-14 days and 2.4-3.8% at 30 days post procedure.[10-12]

Both patients and providers will benefit from outcome measures that capture the full range of adverse experiences associated with outpatient colonoscopy and illuminate quality differences. Currently, there are no publicly available quality reports of providers or facilities that conduct outpatient colonoscopies. Thus, there is an opportunity to enhance the information available to patients choosing among providers who offer this elective procedure. Further, providing outcome rates to providers will make visible to clinicians meaningful quality differences and incentivize improvement. Accordingly, we developed a facility-level quality measure of hospital-visits following colonoscopy.

3. Methods

3.1. Measure Development Process

CORE led the development of the measure under the guidance of CMS. The CORE team consisted of a multi-disciplinary team of clinicians, health services researchers, and statisticians with expertise in outcome measure development. CORE convened a small working group of staff clinicians and two national clinical leaders in the field of gastroenterology to provide clinical input. CORE also convened through a public process a national TEP consisting of patients, expert clinicians, methodologist, researchers, and providers, and held a public comment period soliciting stakeholder input on the measure methodology.

3.2. Data Sources

Consistent with scientific consensus standards for publicly reported outcomes measures,[13-15] we sought to define a clinically coherent group of patients for inclusion in the measure, adjust for case mix differences across providers, and accurately attribute outcomes to facilities. These challenges informed our definition of the measure cohort and of data sources used for development. Specifically, we required the ability to link patients' data across care settings to identify appropriate procedures for inclusion, comorbidities for risk adjustment, and the outcome of hospital visits. We therefore used claims data, as currently electronic health record (EHR) and clinical or registry-based data do not support these critical linkages across care settings.

We used two claims datasets for measure development. To develop and test the patient-level model, CORE used 2009-2011 claims data from Medicare inpatient, outpatient, and carrier (Part B Physician) Standard Analytical Files (SAF). Specifically, we identified outpatient colonoscopies using 20% of Medicare FFS beneficiaries' claims from the carrier SAF consisting of physician claims from ASCs, HOPDs and physician office settings. For ASCs, the facility claim (with a unique facility identifier) is included in the carrier SAF. Physician claims for colonoscopies performed at HOPDs were linked to the corresponding facility claim in the Medicare 100% outpatient SAF to obtain a facility identifier. We identified the outcomes of ED visits and observation stays after colonoscopy from the 100% hospital outpatient SAF and inpatient hospital admissions from the 100% Medicare Provider Analysis and Review (MedPAR) file. For measure development and testing, we randomly split the 2010 data into Development and Validation Samples (each sample containing approximately 50% of colonoscopies contained in the 2010 data). For patients in these samples, we used data from 2009 to derive comorbidities for risk adjustment. We derived a cohort of colonoscopies in 2011 for temporal validation of the model (2011 Validation Sample), using 2010 data for risk adjustment.

To test facility-level variation in the measure score we required a larger number of colonoscopies per facility than was available in the 20% sample. We therefore used Healthcare Cost and Utilization Project (HCUP) data from four states that provide HCUP with linked State Ambulatory Surgery Database (SASD), State Emergency Department Databases (SEDD), and the State Inpatient Database (SID) (New York, Nebraska, California, and Florida). These datasets provided 100% of the claims for colonoscopies at HOPDs and ASCs, linked to ED visits and hospital admissions after the colonoscopy. A limitation of this dataset is that HCUP data do not consistently collect observation stay visits and do not contain data from physician office settings.

3.3. Study Cohort

The target population for this measure is Medicare FFS patients aged ≥65 years undergoing outpatient colonoscopy. We chose this population because of the availability of a national dataset (Medicare) that could be used to develop, test, and publicly report the measure. While we considered all colonoscopy procedures and all colonoscopy patients during development of the study cohort, our goal was to develop a clinically coherent cohort that allowed for adequate risk adjustment of patient and procedural differences across facilities. Therefore, we did not include colonoscopy procedures in the measure that reflected fundamentally higher-risk procedures (such as colonoscopy with balloon dilation) that likely vary in frequency across facilities. Similarly, we excluded patient subgroups that had a substantially different unplanned hospital visit risk from the overall population of adults undergoing colonoscopy. Finally, to ensure the measure score reflects relative performance among all FFS providers conducting the procedure, the measure cohort includes colonoscopies conducted in all outpatient settings, including the office setting. However, we do not report the estimated scores for offices and do not recommend their reporting.

3.3.1. Inclusion Criteria

- The measure includes outpatient colonoscopy procedures identified using Healthcare Common Procedure Coding System (HCPCS) codes G0121 and G0105, and Common Procedural Terminology (CPT) codes 45378, 45380, 45385, 45384, 45383, and 45381 (see Table 1). Claims having the above codes and identified as Outpatient Hospital, Ambulatory Surgery Center or Office by the Line Place of Service Code were identified in the Part B Carrier SAF. Those procedures billed with a qualifying colonoscopy procedure code and a high-risk colonoscopy procedure code (see Appendix A, Table A1) were not included in the measure.

Rationale: These codes identify a clinically coherent group of patients undergoing outpatient colonoscopy for CRC screening, diagnostic evaluation for symptoms and signs of disease, and biopsies or removal of pre-cancerous lesions or polyps.

- The measure includes patients with continuous enrollment in Medicare FFS parts A and B in the 12 months prior to the procedure.

  Rationale: Patients with full enrollment have all claims available for identifying comorbidities for risk adjustment.

3.3.2. Exclusion Criteria

We determined the following exclusion criteria after extensive literature review, examination of existing measures, and discussion with the working group and TEP members. The goal was to be as inclusive as possible; we excluded only those high-risk procedures and patient groups for which risk adjustment would not be adequate. The exclusions, based on clinical rationale, prevent unfair distortion of performance results. After exclusions were applied, the measure captures the majority (93.3%) of all qualifying colonoscopies (Figure 1). All claims-based codes used to define exclusion criteria are listed in Appendix A, Table A2-Table A4.

- Procedures for patients who lack continuous enrollment in Medicare FFS Parts A and B in the 1 month after the procedure.

  Rationale: We exclude these patients to ensure all patients have full data available for outcome assessment.

- Colonoscopies that occur concurrently with high-risk upper GI endoscopies.

  Rationale: Patients undergoing concurrent high-risk upper GI endoscopies, such as upper GI endoscopies for control of bleeding or treatment of esophageal varices, are at higher risk for hospital visits than patients undergoing a typical colonoscopy. Patients undergoing these procedures are often unwell and have a higher risk profile than typical colonoscopy patients.

- Colonoscopies for patients with a history of IBD or diverticulitis in the year preceding the colonoscopy.

  Rationale: Patients with a diagnosis of IBD or diverticulitis at colonoscopy often include both stable and actively unwell patients, and we likely could not fully characterize and adjust for their pre-procedure risk of needing a post-procedure hospital visit. Furthermore, in our development data among patients with IBD or diverticulitis who are admitted to the hospital after colonoscopy, 47% and 30% of patients have a discharge

diagnosis of IBD and diverticulitis, respectively. We could not adequately identify whether these admissions are unplanned or planned (and therefore unrelated to quality of the colonoscopy) from claims data.

3.3.3. Capture of Colonoscopy Procedures Affected by the Medicare 3-Day Payment Window Policy

When developing the measure, we determined that colonoscopies performed at HOPDs can be affected by the Medicare 3-day payment window policy. The policy states that outpatient services (including all diagnostic services such as colonoscopy) provided by a hospital or any Part B entity wholly owned or wholly operated by a hospital (such as a HOPD) in the three calendar days preceding the date of a beneficiary's inpatient admission are deemed to be related to the admission.[16] For outpatient colonoscopies affected, the facility claim (for the technical portion of the colonoscopy) is bundled with the inpatient claim, although the Medicare Part B physician claim for professional services rendered is still submitted. This policy has implications for the measure because it may lead to: (1) failure to completely capture outpatient colonoscopies performed at HOPDs; (2) underreporting of outcomes for colonoscopies performed in the HOPD setting; and (3) an inability to compare the measure score across both types of facilities (HOPDs and ASCs).

To ensure the comprehensive capture of HOPD colonoscopies potentially affected by the policy, we identified physician claims for colonoscopy in the HOPD setting from the Medicare Part B SAF with an inpatient admission within 3 days and lacking a corresponding HOPD facility claim. We then attribute the colonoscopies identified as affected by this policy to the appropriate HOPD facility using the facility provider ID from the inpatient claim.

3.4. Outcome

We defined the outcome as any (i.e., one or more) unplanned hospital visit within 7 days of an outpatient colonoscopy. We define a hospital visit as any ED visit, observation stay visit, or unplanned inpatient admission. We focused on the outcome of unplanned hospital visits for several reasons. First, hospital visits are a broad outcome that captures the full range of potentially serious adverse events related to preparing for, undergoing, and recovering from the colonoscopy. Second, hospital visits are easily identifiable and measurable from claims data. Third, this broad outcome is consistent with a patient-centered view of care that prompts providers to fully account for and minimize to the fullest extent all acute complications, such as syncope or abdominal pain, not just those narrowly related to procedural technique. Finally, hospital visits are costly; reducing hospital visits following colonoscopy may lead to substantial healthcare savings.

We defined ED visits and observation stays using billing codes or revenue center codes identified in Medicare Part B outpatient hospital claims. Appendix B, Table B1 provides the specific codes used to identify ED visits and observation stays.

3.4.1. Outcome Timeframe

We limited the outcome of hospital visits to 7 days, as existing literature suggests the vast majority of adverse events after colonoscopy occur within the first 7 days following the procedure,[17] and we observed in our own data the highest rates of hospital visits within 7 days of colonoscopy. Given that some adverse events, such as bleeding, are known to occur over a longer time frame, we evaluated alternative outcomes, including all-cause, unplanned hospital visits within 7 days or unplanned hospital visits for bleeding within 8-14 days. However, based on input from our TEP, public comment, and empiric analysis, we concluded that unplanned hospital visits within 7 days is the optimal outcome to ensure capture of procedure-related adverse events and to minimize capture of hospital visits unrelated to the procedure.

3.4.2. Removal of Planned Admissions from the Outcome

We only include unplanned admissions in the measure outcome. "Planned" admissions are those planned by providers for anticipated medical treatment or procedures that must be provided in the inpatient setting. We do not count these in the outcome because variation in planned admissions does not reflect quality differences.

We cannot identify planned admissions directly so we adopted an algorithm we previously developed for CMS's hospital readmission measures, CMS's Planned Readmission Algorithm version 3.0. In brief, the algorithm uses the procedure codes and principal discharge diagnosis code on each hospital claim to identify admissions that are typically planned and may occur after a colonoscopy. A few specific, limited types of care are always considered planned (e.g., major organ transplant, rehabilitation, or maintenance chemotherapy). Otherwise, a planned admission is defined as a non-acute admission for a scheduled procedure (e.g., total hip replacement or cholecystectomy). Admissions for an acute illness or for complications of care are never considered planned. The CMS Planned Readmission Algorithm version 3.0, adapted to identify planned admissions following outpatient colonoscopy, is presented in Appendix C.

3.5. Model Development

3.5.1. Overview

The measure adjusts for case mix differences based on patient comorbidities and procedural considerations. Risk adjustment is necessary to ensure that variation in the measure score

among providers is due to quality of care rather than differences in patient characteristics or procedural techniques. To calculate a facility risk-standardized hospital visit rate, the measure uses a two-level hierarchical logistic regression model (Appendix D, Section D3). We model the log-odds of the outcome from an index outpatient colonoscopy as a function of the patient demographic and clinical characteristics, and a random outpatient facility-specific intercept. This strategy accounts for within-facility correlation of the observed outcome and sample size differences, and it accommodates the assumption that underlying differences in quality across facilities lead to systematic differences in outcomes. For fairness, the model adjusts for clinical comorbidities and procedural variables that vary across patient populations, are unrelated to quality, and influence the outcome to help ensure differences in the measure score do not reflect differences in case mix across facilities. This approach is tailored to, and appropriate for, a publicly reported outcome measure as articulated in published scientific guidelines.[13-15]

To develop the patient-level risk model, we used the developmental sample of the 2010 Medicare 20% FFS dataset. We identified candidate risk adjustment variables, systematically selected variables, tested the model's performance, and validated the model's performance across time and against other risk adjustment algorithms. To assess measure score variation, we applied the hierarchical model in the 4-state HCUP data.

3.5.2. Candidate Variables for Patient-Level Risk Adjustment

The relatively low number of outcome events constrained the number of variables we could consider for the risk adjustment model. In hierarchical logistic regression analyses, the number of outcomes, rather than the study cohort size, effectively determines the available sample size. Since the hospital visit rate following colonoscopy is generally low, a large number of candidate variables may preclude parameter estimation (model convergence). Accordingly, we limited the candidate variables included in our model to those with a strong clinical rationale.

To identify candidate variables, CORE categorized potential variables of interest into two tiers in consultation with the working group and the TEP: 1) variables of interest that were both clinically relevant and had a documented relationship with the outcome in the literature, and 2) those that were not supported directly in the literature but had a plausible clinical relevance and a statistically significant relationship with the outcome in bivariate analysis of our development sample. We defined two procedures which we included as candidate variables, polypectomy and high-risk upper GI endoscopy, using CPT procedure codes. To create comorbidity variables, we used CMS's Hierarchical Condition Category (HCC) clinical classification system to group more than 15,000 International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis codes into clinically coherent condition

categories (CCs).[18] The list of candidate variables considered for risk adjustment can be found in Appendix D, Table D1-Table D4.

In defining candidate variables, we identified those that could represent a complication of care if coded at the time the colonoscopy was performed. For those variables, we only coded the patient as having the comorbidity if it was documented prior to the colonoscopy (Appendix D, Table D5).

3.5.3. Final Variable Selection

Our goal was to minimize the number of variables in the model while preserving model performance (as measured by the c-statistic). To select the final variables to include in the risk adjustment model, we fitted an initial logistic regression model with all candidate variables to predict the outcome of hospital visits within 7 days. To develop a parsimonious model, we then iteratively removed non-significant variables from the initial model using a stepwise purposeful selection approach described by Hosmer and Lemeshow.[19,20] Upon completion of the iterative process we were left with the preliminary final model containing all variables significant at $p<0.05$.

We subsequently assessed the functional form of continuous variables (i.e. age) by entering polynomial terms into the model. Significant polynomial terms indicate non-linear relationships with the outcome. Continuous variables showing a non-linear relationship with the outcome were categorized to capture different risk profiles at varying levels of the variable.

In the final model-building step, interactions with age were assessed to improve model prediction across risk deciles. Every interaction with age was first evaluated individually in the model. Then all interactions having $p \leq 0.05$ were included in the model and iteratively removed by eliminating the least significant interaction first. Interaction terms were only retained in the model if a $p \leq .01$ is achieved. This was done to ensure that interactions have a higher likelihood of being a true interactions rather than spurious one.

3.5.4. Model Performance

To assess performance of the patient-level risk adjustment model in the development sample, we calculated the area under the Receiver Operating Characteristic curve as measured by the c-statistic. To test model discrimination, we calculated observed hospital visit rates in the lowest and highest deciles on the basis of predicted hospital visit probabilities.

3.5.5. Model Validation

We undertook several analyses to further validate the patient-level risk adjustment model. First, to validate the consistency of the patient-level risk adjustment model, we compared the model performance in the development sample with its performance in the 2010 Validation Split Sample. We evaluated model comparison by evaluation of the c-statistic, model information criteria (Akaike Information Criteria [AIC], Bayesian Information Criteria [BIC]), and model discrimination (predictive ability).[21] We recalibrated the model in the 2010 Validation Split Sample. We further assessed how our model performed across time by re-evaluating our model in our 2011 Medicare 20% Validation Sample. Second, we examined the stability of the risk factor frequencies and model estimates across the three datasets. Third, to further validate the adequacy of risk adjustment variables, we compared the performance of the model against the Charlson comorbidity index[22-24] and the Elixhauser Comorbidity Measure[24,25] which are claims-based non-condition specific or "generic" comorbidity indices that are widely used in the literature for comorbidity risk adjustment. We hypothesized that our colonoscopy-specific risk adjustment model was superior to these "generic" risk adjustment models.

3.5.6. Calculation of Facility-Level Measure Score

We estimated the measure score by fitting the hierarchical logistic regression model to the 2010 HCUP data from California, Florida, New York, and Nebraska. In contrast to our Medicare 20% dataset, this dataset contains 100% of colonoscopies at each facility and provides adequate sample size for a reliable measure score. We calculated the measure score for each outpatient facility by computing the ratio of the number of predicted unplanned hospital visits to the number of expected unplanned hospital visits. To transform this ratio into a rate for ease of interpretation, we multiplied each facility's ratio by the unplanned hospital visit rate for the entire HCUP data cohort.

To further explore how the measure categorizes relative performance, we classified facilities into three performance categories using the approach CMS employs for reporting similarly structured hospital outcome measures on the website Hospital Compare (http://www.medicare.gov/hospitalcompare/). Specifically, we used bootstrapping to empirically construct a 95% interval estimate for each risk-standardized visit rate (Appendix D, Sections D5-D6). If the facility's entire interval estimate was below the crude 7-day unplanned hospital visit rate in the 2010 HCUP cohort we classified the facility as having better than expected performance. If the entire interval estimate was above the crude rate, we classified the facility as having worse than expected performance. If the facility's interval estimate included the crude rate, we classified it as no different than expected.

3.5.7. Statistical Software

Statistical analyses were performed using SAS version 9.3 (SAS Institute Inc., Cary, NC). We estimated the hierarchical logistic regression model using the GLIMMIX procedure in SAS.

4. Results

4.1. Development and Validation Samples

After applying all inclusion and exclusion criteria, the 2010 Medicare 20% FFS dataset included 332,391 outpatient colonoscopies performed at 8,142 facilities (Figure 1). The development split sample consisted of 166,196 colonoscopies at 7,475 outpatient facilities. Patients undergoing colonoscopy were mostly female (54.4%) and had an average age of 74.2 years. Compared to the 2010 Development Split Sample, the mean age of patients and frequency of risk adjustment variables were similar in the 2010 Validation Split Sample and the 2011 Validation Dataset (Table 2).

The 7-day unplanned hospital visit rate in the development sample was 16.2 hospital visits per 1,000 colonoscopies. Among all hospital admissions, 34% were considered planned and were not included in the outcome. The most common planned admission following colonoscopy was for colorectal resection.

4.2. Patient-Level Risk Adjustment Model

4.2.1. Candidate and Final Variables

We identified 24 candidate risk adjustment variables (Appendix D, Table D1 and Table D2). These candidate variables consisted of age, sex, two procedural factors known to increase risk of hospital visits after colonoscopy (concomitant upper GI endoscopy and polypectomy during procedure), and 20 comorbidities. The final risk adjustment model included 15 variables (age, concomitant upper GI endoscopy, polypectomy during procedure, and 12 comorbidity variables). The risk of unplanned hospital visits increased with increasing age >65 in a non-linear manner and therefore was modeled as a categorical variable. The risk of hospital visits with age was modified by the presence or absence of a cardiac arrhythmia (p-value for interaction ≤0.001). Therefore, an interaction term (age category x arrhythmia) was included in the final model. Table 3 shows the variables included in the final model and the corresponding parameter estimates and odds ratios for risk of the outcome.

4.2.2. Model Performance

The final model c-statistic in the 2010 development sample was 0.67, which indicated good model discrimination. Additionally, the risk decile plots showed good discrimination; the model performed well in each of the risk deciles (Figure 2). The mean observed unplanned hospital visit rate in the development sample ranged from 0.71% in the lowest decile of predicted

colonoscopy hospital visit rate to 4.28% in the highest predicted risk decile, a range of 3.57% (Table 4).

4.2.3. Model Validation

Model performance was similar for the two validation datasets (Table 4, Figure 3 and Figure 4).The regression coefficients of the model variables were also stable in the 2010 Development Split Sample and the 2010 and 2011 Validation Samples (Table 3). Although the point estimates for two age variables, age 75-79 and 80-84 among arrhythmia patients, were protective in the development sample and associated with a risk of admission in the two validation samples, the confidence intervals across years overlapped. The patient-level model performed better than the same model substituting either the Charlson or Elixhauser comorbidity indices for risk adjustment (Table 5). Our model had a higher c-statistic (0.67) than the models developed using the Charlson (0.62) or Elixhauser (0.64) indices.

4.3. Facility-Level Measure Score

The 2010 HCUP data included 325,811 outpatient colonoscopies from 992 facilities meeting the inclusion and exclusion criteria. The mean rate of risk-standardized, all-cause, unplanned hospital visits was 12.3 per 1,000 colonoscopies; the 5th and 95th percentile for unplanned hospitals visits were 10.5 per 1,000 and 14.6 per 1,000 colonoscopies, respectively (Figure 5). The range of measure scores was similar for HOPDs and ASCs (Figure 6).

We identified a limited number of facilities as outliers out of the 992 outpatient facilities (ASCs and HOPDs). Using the 95 percent interval estimate, we classified four facilities as worse than expected (above the 95^{th} percentile), one facility as better than expected (below the 5^{th} percentile) and 987 facilities as no different than expected.

5. Summary

This proposed outcome measure of unplanned hospital visits following outpatient colonoscopy will inform healthcare providers about opportunities to improve care and strengthen incentives for quality improvement. Reducing unplanned hospitals visits for this common and costly procedure is likely to improve outcomes for patients and reduce healthcare costs. We found significant differences in risk-standardized unplanned hospital visit rates across outpatient facilities (ASCs, HOPDs, and physician office settings), suggesting there are differences in quality of care. The proposed risk adjustment model is consistent with the consensus standards for publicly reported outcomes measures, and can be implemented using available data. This measure was developed with input from experts with clinical and methodological expertise relevant to colonoscopy quality measurement. The study sample includes the majority of Medicare FFS patients undergoing outpatient colonoscopy and allows for valid comparisons of colonoscopy quality across outpatient facilities. The hierarchical modeling accounts for facility case mix, the clustering of patients within outpatient facilities, and differences in sample size across facilities, thereby making the measure suitable for public reporting.

6. References

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7. Tables and Figures

Table 1: Diagnostic Codes Used to Define Colonoscopies Included in the Measure

CPT or HCPCS Code	CODE Description
G0121*	Colonoscopy on individual not meeting criteria for high risk
G0105*	Colonoscopy on individual at high risk of colorectal cancer
45378	Diagnostic colonoscopy
45380	Colonoscopy with biopsy
45385	Colonoscopy with ablation of lesion(s)/polypectomy by snare
45384	Colonoscopy with ablation of lesion(s)/polypectomy by hot biopsy forceps or bipolar cautery
45383	Colonoscopy with ablation of lesion(s)/polypectomy by other techniques (i.e., techniques other than 45384/5)
45381	Colonoscopy, with directed submucosal injection, any substance

*Denotes HCPCS Codes, all other codes are CPT codes. Abbreviations as described in the text

Table 2: Risk Model Variables and Frequency in the Medicare Development and Validation Datasets

	2010 Development Split Sample		2010 Validation Split Sample		2011 Validation Sample	
	#	%	#	%	#	%
N	166,196		166,195		311,056	
Age: Mean (SD)	74.18	5.87	74.17	5.87	74.01	5.77
Age: 65-69 yrs	49,089	29.54	49,312	29.67	94,456	30.37
Age: 70-74 yrs	50,924	30.64	50,779	30.55	96,101	30.90
Age: 75-79 yrs	36,486	21.95	36,618	22.03	68,310	21.96
Age: 80-84	21,160	12.73	20,916	12.59	37,442	12.04
Age: 85+	8,537	5.14	8,570	5.16	14,747	4.74
Concomitant Endoscopy	26,064	15.68	25,924	15.60	50,115	16.11
Polypectomy during procedure	54,887	33.03	55,292	33.27	105,245	33.83
Chronic Heart Failure (CC 80)	18,684	11.24	18,567	11.17	34,322	11.03
Ischemic Heart Disease (CC 81-84)	46,455	27.95	46,359	27.89	84,527	27.17
Arrhythmias (CC 92-93)	34,239	20.60	33,927	20.41	63,926	20.55
Stroke/Transient Ischemic Attack (TIA) (CC 95-97)	21,265	12.80	20,895	12.57	38,940	12.52
Chronic Lung Disease (CC 108-110)	33,710	20.28	33,641	20.24	62,127	19.97
Metastatic Cancer (CC 7-9)	8,874	5.34	8,847	5.32	16,471	5.30
Liver Disease (CC 25-30)	13,184	7.93	13,240	7.97	24,923	8.01
Iron Deficiency Anemia (CC 47)	49,057	29.52	49,175	29.59	90,757	29.18
Disorders of Fluid, Electrolyte, Acid Base (CC 23)	18,026	10.85	17,980	10.82	34,211	11.00
Pneumonia (CC 111-113)	9,196	5.53	9,418	5.67	16,999	5.46
Psychiatric Disorders (CC 54-56, 58-60)	28,774	17.31	28,666	17.25	55,937	17.98
Drug and Alcohol Abuse/Dependence (CC 51-53)	7,149	4.30	7,354	4.42	14,456	4.65

Table 3: Model Parameter Estimates and Odds Ratios in the Medicare Derivation and Validation Samples

	2010 Development Split Sample		2010 Validation Split Sample		2011 Validation Sample	
	Estimate	**Odds Ratio (95% CI)**	**Estimate**	**Odds Ratio (95% CI)**	**Estimate**	**Odds Ratio (95% CI)**
Intercept	-4.989		4.968		4.881	
Concomitant Endoscopy	0.326	1.39 (1.26-1.52)	0.231	1.26 (1.14-1.39)	0.282	1.33 (1.24-1.42)
Polypectomy during Procedure	0.255	1.29 (1.19-1.40)	0.307	1.36 (1.26-1.47)	0.291	1.34 (1.26-1.41)
Chronic Heart Failure (CC 80)	0.326	1.39 (1.25-1.54)	0.328	1.39 (1.25-1.55)	0.334	1.40 (1.29-1.51)
Ischemic Heart Disease (CC 81-84)	0.185	1.20 (1.10-1.31)	0.178	1.19 (1.09-1.30)	0.205	1.23 (1.15-1.31)
Stroke/TIA (CC 95-97)	0.166	1.18 (1.07-1.31)	0.235	1.27 (1.14-1.40)	0.105	1.11 (1.03-1.20)
Chronic Lung Disease (CC 108-110)	0.197	1.22 (1.11-1.33)	0.217	1.24 (1.13-1.36)	0.153	1.17 (1.09-1.25)
Metastatic Cancer (CC 7-9)	0.175	1.19 (1.03-1.38)	0.259	1.30 (1.13-1.49)	0.096	1.10 (0.99-1.23)
Liver Disease (CC 25-30)	0.169	1.18 (1.05-1.34)	0.222	1.25 (1.11-1.41)	0.225	1.25 (1.15-1.36)
Iron Deficiency Anemia (CC 47)	0.194	1.21 (1.12-1.32)	0.165	1.18 (1.08-1.29)	0.215	1.24 (1.17-1.32)
Disorders of Fluid, Electrolyte, Acid Base (CC 23)	0.393	1.48 (1.34-1.64)	0.305	1.36 (1.22-1.51)	0.325	1.38 (1.28-1.49)
Pneumonia (CC 111-113)	0.257	1.29 (1.13-1.47)	0.319	1.38 (1.21-1.56)	0.214	1.24 (1.13-1.36)
Psychiatric Disorders (CC 54-56, 58-60)	0.264	1.30 (1.19-1.43)	0.337	1.40 (1.28-1.53)	0.344	1.41 (1.32-1.50)
Drug and Alcohol Abuse/Dependence (CC 51-53)	0.285	1.33 (1.14-1.55)	0.201	1.22 (1.05-1.43)	0.153	1.17 (1.04-1.30)
Age by Arrhythmia Interaction						
Among those with No Arrhythmia						
Age 70-74 v. Age 65-69	0.120	1.13 (0.99-1.28)	0.034	1.03 (0.91-1.17)	0.009	1.01 (0.92-1.10)
Age 75-79 v. Age 65-69	0.261	1.30 (1.13-1.49)	0.238	1.27 (1.11-1.45)	0.167	1.18 (1.07-1.30)
Age 80-84 v. Age 65-69	0.576	1.78 (1.54-2.06)	0.369	1.45 (1.24-1.69)	0.435	1.55 (1.39-1.72)
Age 85+ v. Age 65-69	0.805	2.24 (1.85-2.70)	0.674	1.96 (1.62-2.38)	0.664	1.94 (1.68-2.24)
Among those with Arrhythmia (CC 92-93)						
Age 70-74 v. Age 65-69	0.014	1.01 (0.82-1.25)	0.022	1.02 (0.82-1.27)	0.003	1.00 (0.86-1.16)
Age 75-79 v. Age 65-69	-0.082	0.92 (0.75-1.14)	0.193	1.21 (0.98-1.50)	0.011	1.01 (0.87-1.17)
Age 80-84 v. Age 65-69	-0.043	0.96 (0.76-1.20)	0.285	1.33 (1.06-1.66)	0.196	1.22 (1.04-1.42)
Age 85+ v. Age 65-69	0.390	1.48 (1.16-1.88)	0.600	1.82 (1.42-2.33)	0.382	1.47 (1.22-1.75)

Table 4: Risk Adjustment Model Performance in the Medicare Development and Validation Samples

	2010 Development Split Sample	2010 Validation Split Sample	2011 Validation Sample
Year	2010 (50%)	2010 (50%)	2011(100%)
N	166,196	166,195	311,056
Number of Hospital Visits in 7 days	2,686 (1.62%)	2,645 (1.59%)	5,185 (1.67)
Calibration (γ0,γ1)	(0,1)	(-0.03, 0.99)	(-0.13, 0.96)
c-statistic (95% CL)	0.67 (0.66-0.68)	0.66 (0.65-0.67)	0.66 (0.65-0.67)
Predictive Ability (Lowest-Highest Risk Decile)	0.71%-4.28%	0.70%-4.30%	0.75%-4.33%

Table 5: Validation of the Colonoscopy Risk Adjustment Model against Generic Claims-Based Comorbidity Indices

	2010 Development Split Sample Model	Charlson Model	Elixhauser Model
Akaike Information Criteria (AIC)	26550.70	26972.43	26759.78
Bayesian Information Criteria (BIC)	26781.18	26992.48	27060.41
c-statistic (95% CI)*	0.67 (0.66-0.68)	0.62 (0.61-0.63)	0.64 (0.63-0.65)
Predictive Ability (Lowest-Highest Risk Decile)	0.71%-4.28%	0.99%-3.59%	.93%-4.06%

*The observed c-statistic for the colonoscopy specific model was superior to Charlson model (P<0.001) and Elixhauser model (P<0.001) based on statistical testing.

Figure 1: Flow Chart Indicating Outpatient Colonoscopies Included in the Measure

(Exclusion criteria included in figure are not mutually exclusive)

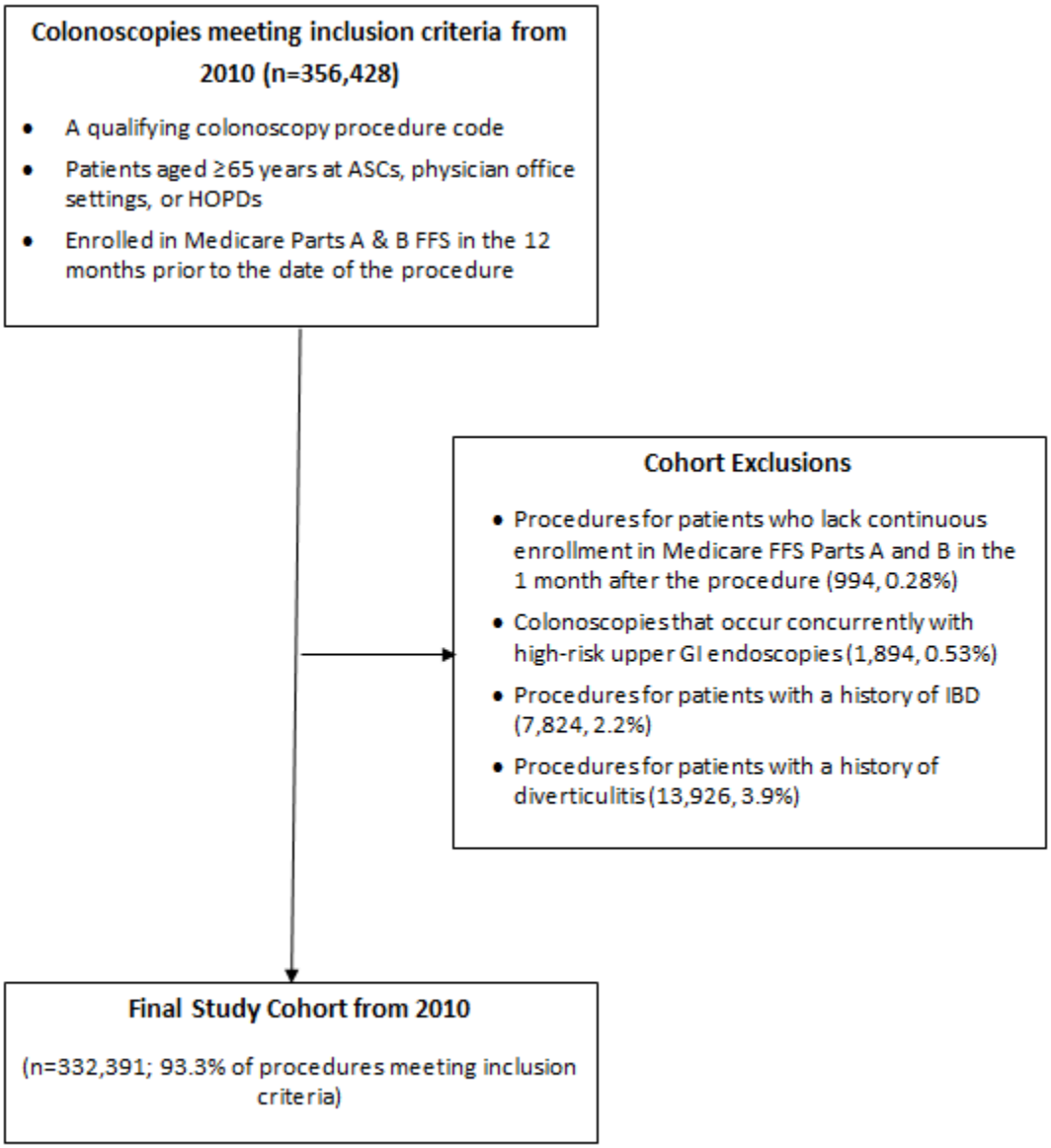


Figure 2: Calibration Plot of Expected versus Observed Outcomes across Deciles of Patient Risk in the 2010 Development Split Sample

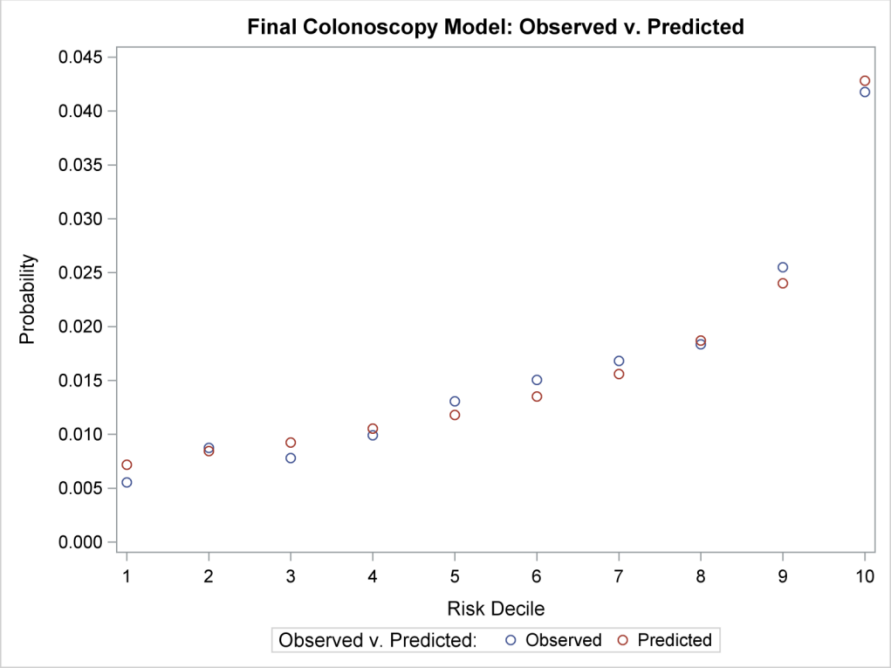


Figure 3: Calibration Plot of Expected versus Observed Outcomes across Deciles of Patient Risk in the 2010 Validation Split Sample

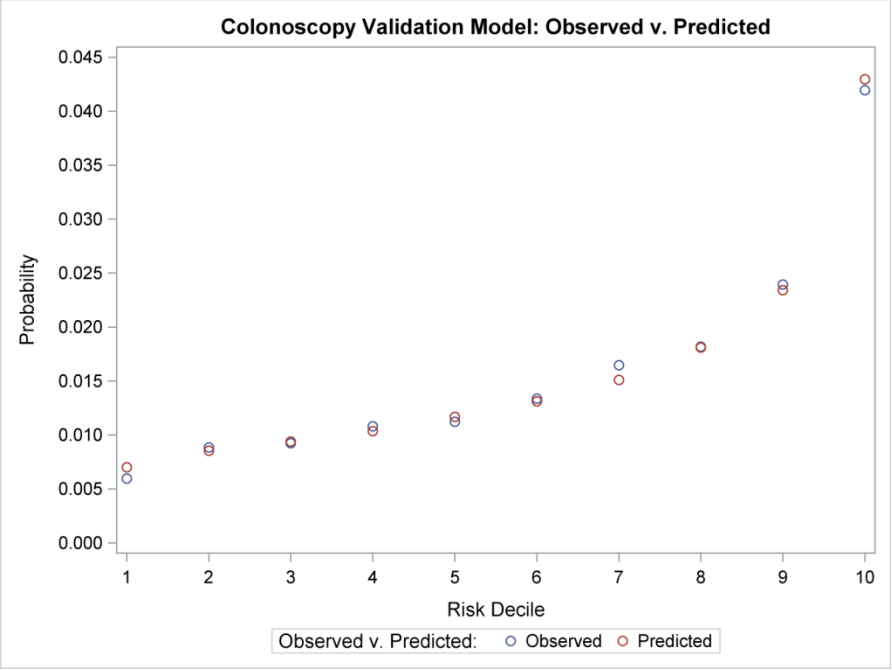


Figure 4: Calibration Plot of Expected versus Observed Outcomes across Deciles of Patient Risk in the 2011 Validation Sample

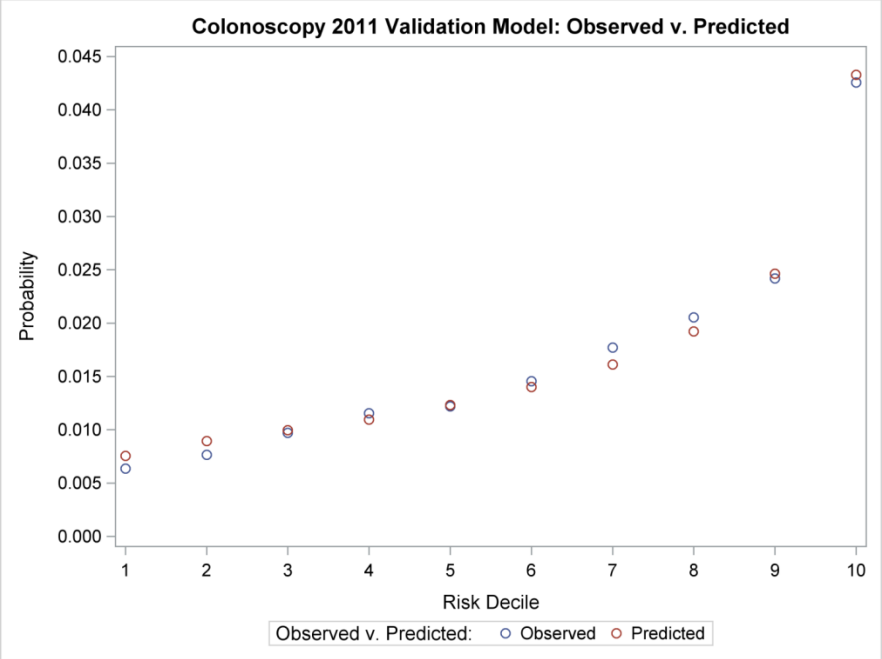


Figure 5: Distribution of Risk-Standardized Unplanned Hospital Visit Rates from all HOPDS and ASCs in Four States (New York, Nebraska, California, and Florida)

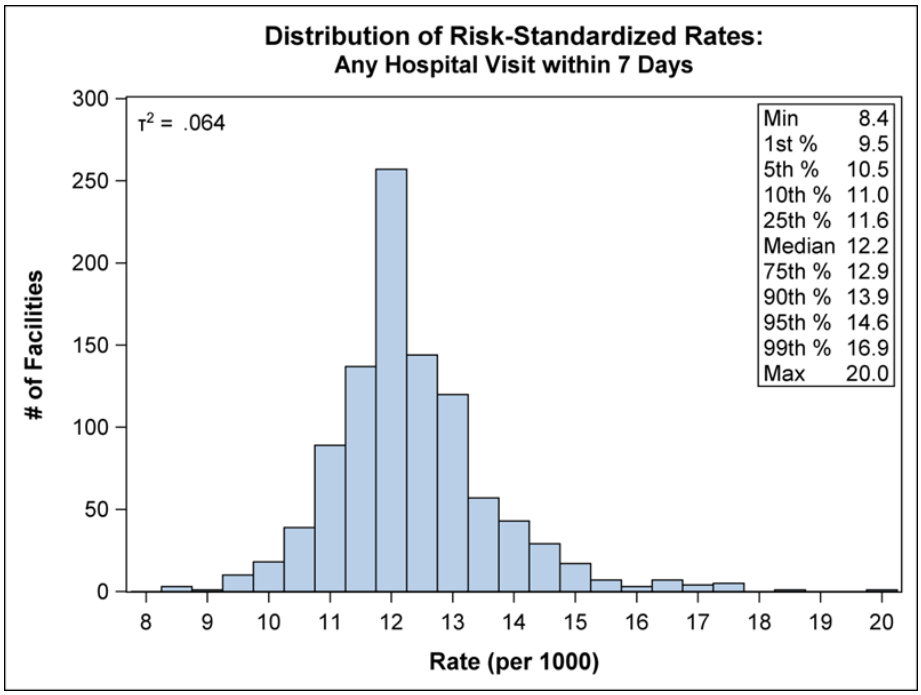
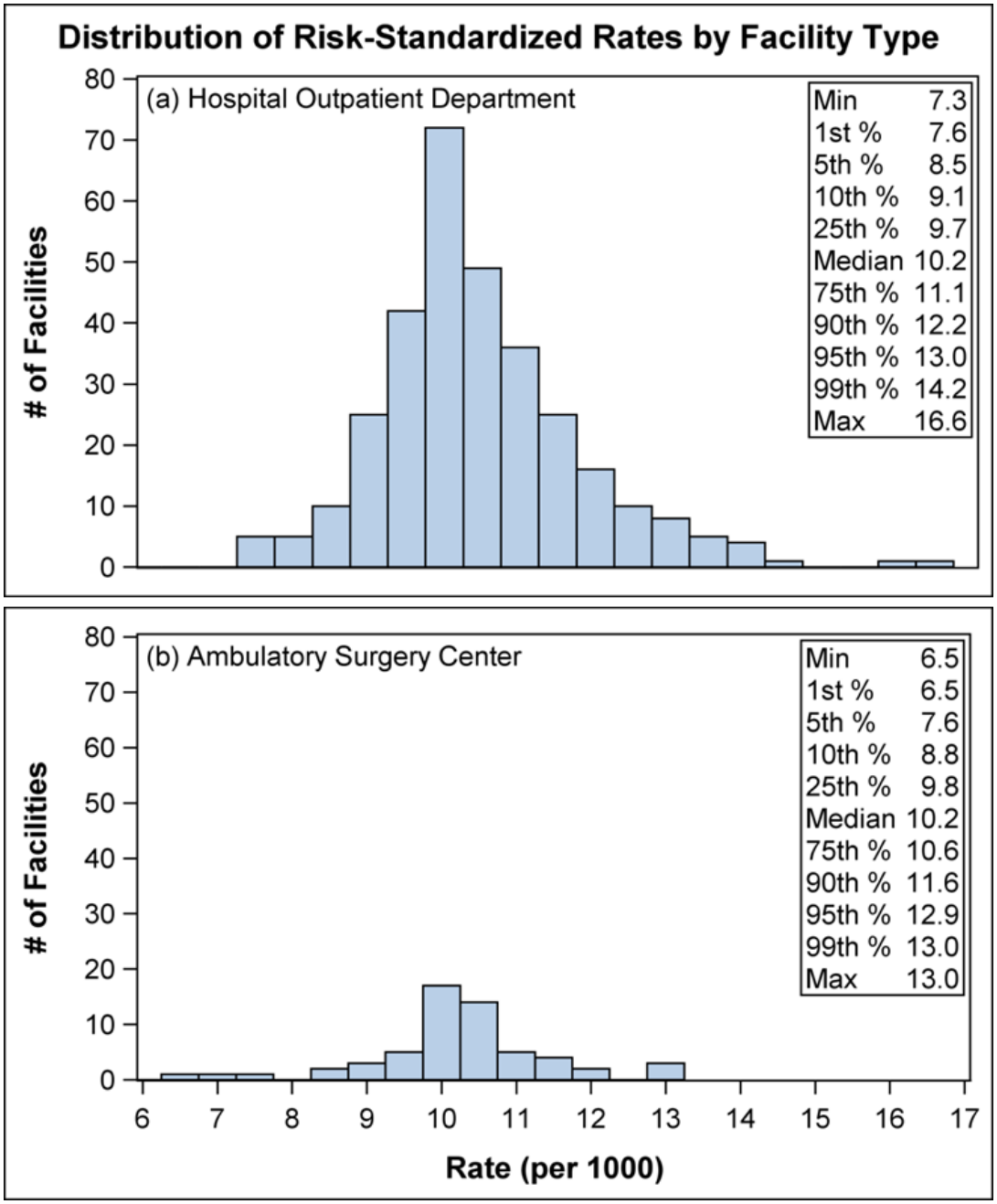


Figure 6: Distribution of Risk-Standardized Unplanned Hospital Visit Rates by Facility type (HOPDs vs. ASC) using 2010 HCUP data from California



Note: Analysis includes 58 ASCs and 315 HOPDs.

8. Appendices

Appendix A: Diagnostic Codes Used to Define Inclusion and Exclusion Criteria

Table A1: CPT Codes That Define "High-Risk" Colonoscopy Procedures

Code	Description
45382	Colonoscopy for control of bleeding (i.e., endoscopic homeostasis)
45379	Colonoscopy with removal of foreign body
45386	Colonoscopy with balloon dilation
45387	Colonoscopy with stent placement
45391	Colonoscopy with endoscopic ultrasound
44388	Colonoscopy through stoma; diagnostic colonoscopy
44389	Colonoscopy through stoma; with biopsy
44394	Colonoscopy through stoma; with ablation of lesion(s)/polypectomy by snare
44392	Colonoscopy through stoma; with ablation of lesion(s)/polypectomy by hot biopsy forceps or bipolar cautery
44393	Colonoscopy through stoma; with ablation of lesion(s)/polypectomy by other techniques (i.e., techniques other than 45384/45385)
45355	Colonoscopy performed via transabdominal surgical incision (not stoma)

Table A2: CPT Codes That Define "High-Risk" Upper GI Endoscopy Procedures

Code	Description
43231	Esophagoscopy with endoscopic ultrasound examination
43232	Esophagoscopy with transendoscopic ultrasound-guided fine needle aspiration/biopsy(s)
43237	Upper gastrointestinal endoscopy with endoscopic ultrasound examination limited to the esophagus
43259	Upper gastrointestinal endoscopy with endoscopic ultrasound, including the esophagus, stomach, and either the duodenum and/or jejunum as appropriate
43238	Upper gastrointestinal endoscopy with ultrasound-guided biopsy(s), (endoscopic ultrasound limited to the esophagus)
43242	Upper gastrointestinal endoscopy with ultrasound-guided biopsy (endoscopic ultrasound of the esophagus, stomach, and either the duodenum and/or jejunum)
43204	Esophagoscopy with injection sclerosis of esophageal varices
43205	Esophagoscopy with band ligation of esophageal varices
43215	Esophagoscopy with removal of foreign body
43216	Esophagoscopy with removal of tumor(s), polyp(s), or other lesion(s) by hot biopsy forceps or bipolar cautery

Code	Description
43217	Esophagoscopy with removal of tumor(s), polyp(s), or other lesion(s) by snare technique
43219	Esophagoscopy with insertion of plastic tube or stent
43227	Esophagoscopy with control of bleeding, any method
43228	Esophagoscopy with ablation of tumor(s), polyp(s), or other lesion(s), not amenable to removal by hot biopsy forceps, bipolar cautery or snare technique
43240	Upper gastrointestinal endoscopy with transmural drainage of pseudocyst
43241	Upper gastrointestinal endoscopy with transendoscopic tube or catheter placement
43243	Upper gastrointestinal endoscopy with injection sclerosis of esophageal and/or gastric varices
43244	Upper gastrointestinal endoscopy with band ligation of esophageal and/or gastric varices
43245	Upper gastrointestinal endoscopy with dilation of gastric outlet for obstruction, any method
43246	Upper gastrointestinal endoscopy with directed placement of percutaneous gastrostomy tube
43247	Upper gastrointestinal endoscopy with removal of foreign body
43250	Upper gastrointestinal endoscopy with removal of tumor(s), polyp(s), or other lesion(s) by hot biopsy forceps or bipolar cautery
43251	Upper gastrointestinal endoscopy with removal of tumor(s), polyp(s), or other lesion(s) by snare technique
43255	Upper gastrointestinal endoscopy with control of bleeding, any method
43256	Upper gastrointestinal endoscopy with transendoscopic stent placement (includes predilation)
43258	Upper gastrointestinal endoscopy with ablation of tumor(s), polyp(s), or other lesion(s) not amenable to removal by hot biopsy forceps, bipolar cautery or snare technique
43458	Dilation of esophagus with balloon (30 mm diameter or larger) for achalasia
43257	Upper gastrointestinal endoscopy with delivery of thermal energy to the muscle of lower esophageal sphincter and/or gastric cardia, for treatment of gastroesophageal reflux disease

Table A3: ICD-9-CM Codes that Define Patients with IBD

Code	Description
555.0	Regional enteritis of small intestine
555.1	Regional enteritis of large intestine
555.2	Regional enteritis of small intestine with large intestine
555.9	Regional enteritis of unspecified site
556.0	Ulcerative (chronic) enterocolitis
556.1	Ulcerative (chronic) ileocolitis
556.2	Ulcerative (chronic) proctitis
556.3	Ulcerative (chronic) proctosigmoiditis
556.4	Pseudopolyposis of colon
556.5	Left-sided ulcerative (chronic) colitis
556.6	Universal ulcerative (chronic) colitis
556.8	Other ulcerative colitis

Table A4: ICD-9-CM Codes that Define Patients with Diverticulitis

Code	Description
562.11	Diverticulitis of colon (without mention of hemorrhage)
562.13	Diverticulitis of colon with hemorrhage

Appendix B: Codes Used to Define the Measure Outcome

Table B1: HCPCS Codes or Revenue Center Codes that Define ED Visits and Observation Stays

Billing (HCPCS) or Revenue Code*	Description
0450	Emergency Room
0451	Emergency Room: EM/EMTALA
0452	Emergency Room: ER/Beyond EMTALA
0456	Emergency Room: Urgent care
0459	Emergency Room: Other emergency room
0981	Professional fees (096x) Emergency room
G0378†	Hospital observation service, per hour

*Identified in Medicare Part B Outpatient hospital claims.

†Denotes HCPCS Codes, all other codes are revenue center codes.

Appendix C: CMS Planned Readmission Algorithm Version 3.0, Adapted to Identify Planned Admissions after Outpatient Colonoscopy

C1. Planned Admission Algorithm Overview

The planned admission algorithm is adapted from the CMS Planned Readmission Algorithm Version 3.0. The algorithm is a set of criteria for classifying admissions within 7 days of a colonoscopy as planned or unplanned using Medicare claims. CMS seeks to count only unplanned admissions in the measure outcome, because variation in planned admissions does not reflect quality differences.

CORE developed the planned readmission algorithm under contract to CMS based on a hospital-wide (not condition-specific) cohort of patients. The current algorithm, Version 3.0, was modified slightly from Version 2.1, which has been reviewed and endorsed by the NQF. Version 3.0 incorporates improvements made following a validation study of the algorithm using data from a review of 634 medical records at seven hospitals.

As detailed in the next section, we have adapted the planned admission algorithm for the measure of hospital visit rates after outpatient colonoscopy. The algorithm classifies admissions as planned or unplanned using a flow chart (Figure PA1) and four tables of procedures and conditions (Table PA1-Table PA4). Table PA1 identifies procedures that, if present in an admission, classify the admission as planned. Table PA2 identifies principal discharge diagnoses that classify admissions as planned. Table PA3 identifies procedures that, if present, classify an admission as planned as long as that admission does not have an acute (unplanned) principal discharge diagnosis. Table PA4 lists the acute (unplanned) principal discharge diagnoses that disqualify admissions with a potentially planned procedure in Table PA3 as planned.

The algorithm uses the Agency for Healthcare Research and Quality's (AHRQ's) Clinical Classification Software (CCS) (http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp) codes to group thousands of individual procedure and diagnosis ICD-9-CM codes into clinically coherent, mutually exclusive procedure CCS categories and mutually exclusive diagnosis CCS categories, respectively.

In applying the algorithm to the colonoscopy population, a team of clinical experts reviewed the General Population version of the planned readmission algorithm in the context of the colonoscopy population. Where clinically indicated, we adapted the content of the tables to better reflect the likely clinical experience of the colonoscopy measure cohort. Specifically, for the colonoscopy population we added CCS 76 (Colonoscopy and biopsy) to the list of potentially planned procedures.

C2. Detailed Description of Planned Admission Algorithm Version 3.0 - Colonoscopy Population

The Colonoscopy Population algorithm uses the flow chart (Figure PA1) and Table PA1-Table PA4, adapted for the colonoscopy population, to identify specific procedure categories and discharge diagnosis categories to classify admissions as planned or unplanned. As illustrated in the flow chart (Figure PA1), admissions that include certain procedures (Table PA1) or are for certain diagnoses (Table PA2) are always considered planned. If the admission does not include a procedure or diagnosis in Table PA1 or Table PA2 that is always considered planned, the algorithm checks whether the admission has at least one procedure that is considered potentially planned (Table PA3). If the admission has no procedures from Table PA3, the admission is considered unplanned. Table PA3 includes 56 AHRQ procedure CCS categories from among 231 AHRQ procedure CCS categories and 11 individual ICD-9-CM procedure codes. Examples of potentially planned procedures are total hip replacement (Procedure CCS 153) and hernia repair (Procedure CCS 85).

If the admission has at least one potentially planned procedure from Table PA3, the algorithm checks for a principal discharge diagnosis that is considered acute (Table PA4). If the admission has an acute principal discharge diagnosis from Table PA4, the admission is considered unplanned. Otherwise, it is considered planned. The list of acute principal discharge diagnoses includes 101 diagnosis groups from among 285 AHRQ condition categories and six groupings of individual ICD-9-CM diagnosis codes that represent cardiac diagnoses that would not be associated with a planned admission. Examples of acute principal discharge diagnoses that identify admissions with potentially planned procedures as unplanned are pneumonia (Diagnosis CCS 122) and cardiac arrest (Diagnosis CCS 107).

C3. Figures and Tables for Planned Admission Algorithm Version 3.0 - Colonoscopy Population

Figure PA1: Planned Admission Algorithm Version 3.0 – Colonoscopy Population – Flow Chart

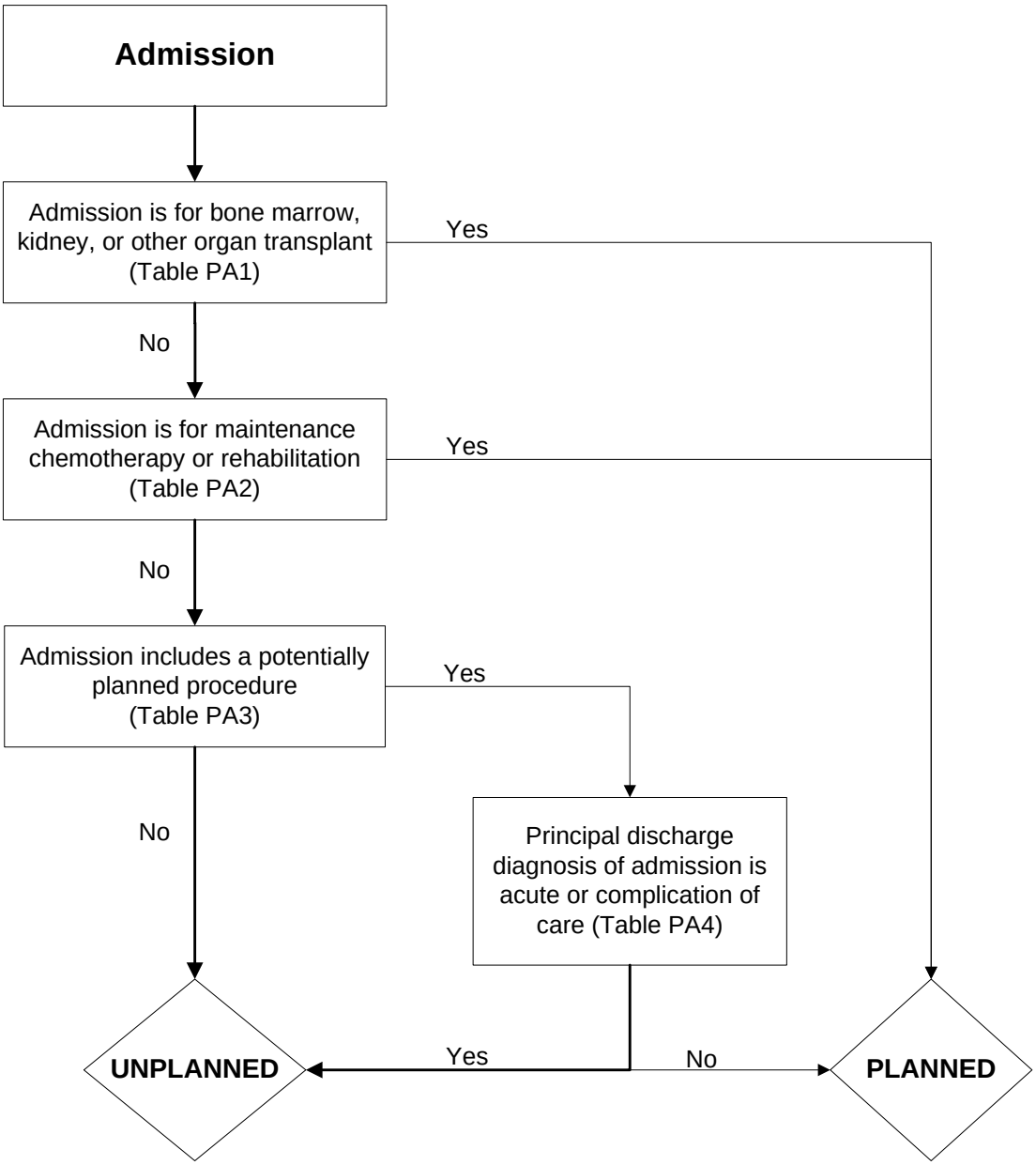


Table PA1: Procedure Categories that are Always Planned (Version 3.0 - Colonoscopy Population)

Procedure CCS	Description
64	Bone marrow transplant
105	Kidney transplant
176	Other organ transplantation

Table PA2: Diagnosis Categories that are Always Planned (Version 3.0 - Colonoscopy Population)

Diagnosis CCS	Description
45	Maintenance chemotherapy
254	Rehabilitation

Table PA3: Potentially Planned Procedure Categories (Version 3.0 - Colonoscopy Population)

Code type	Code	Description
Procedure CCS	3	Laminectomy; excision intervertebral disc
Procedure CCS	5	Insertion of catheter or spinal stimulator and injection into spinal
Procedure CCS	9	Other OR therapeutic nervous system procedures
Procedure CCS	10	Thyroidectomy; partial or complete
Procedure CCS	12	Other therapeutic endocrine procedures
Procedure CCS	33	Other OR therapeutic procedures on nose; mouth and pharynx
Procedure CCS	36	Lobectomy or pneumonectomy
Procedure CCS	38	Other diagnostic procedures on lung and bronchus
Procedure CCS	40	Other diagnostic procedures of respiratory tract and mediastinum
Procedure CCS	43	Heart valve procedures
Procedure CCS	44	Coronary artery bypass graft (CABG)
Procedure CCS	45	Percutaneous transluminal coronary angioplasty (PTCA)
Procedure CCS	47	Diagnostic cardiac catheterization; coronary arteriography
Procedure CCS	48	Insertion; revision; replacement; removal of cardiac pacemaker or cardioverter/defibrillator
Procedure CCS	49	Other OR heart procedures
Procedure CCS	51	Endarterectomy; vessel of head and neck
Procedure CCS	52	Aortic resection; replacement or anastomosis
Procedure CCS	53	Varicose vein stripping; lower limb
Procedure CCS	55	Peripheral vascular bypass
Procedure CCS	56	Other vascular bypass and shunt; not heart
Procedure CCS	59	Other OR procedures on vessels of head and neck
Procedure CCS	62	Other diagnostic cardiovascular procedures
Procedure CCS	66	Procedures on spleen
Procedure CCS	67	Other therapeutic procedures; hemic and lymphatic system
Procedure CCS	74	Gastrectomy; partial and total
Procedure CCS	76	Colonoscopy and biopsy
Procedure CCS	78	Colorectal resection
Procedure CCS	79	Local excision of large intestine lesion (not endoscopic)
Procedure CCS	84	Cholecystectomy and common duct exploration
Procedure CCS	85	Inguinal and femoral hernia repair
Procedure CCS	86	Other hernia repair
Procedure CCS	99	Other OR gastrointestinal therapeutic procedures
Procedure CCS	104	Nephrectomy; partial or complete
Procedure CCS	106	Genitourinary incontinence procedures
Procedure CCS	107	Extracorporeal lithotripsy; urinary
Procedure CCS	109	Procedures on the urethra
Procedure CCS	112	Other OR therapeutic procedures of urinary tract
Procedure CCS	113	Transurethral resection of prostate (TURP)
Procedure CCS	114	Open prostatectomy
Procedure CCS	119	Oophorectomy; unilateral and bilateral
Procedure CCS	120	Other operations on ovary
Procedure CCS	124	Hysterectomy; abdominal and vaginal
Procedure CCS	129	Repair of cystocele and rectocele; obliteration of vaginal vault

Code type	Code	Description
Procedure CCS	132	Other OR therapeutic procedures; female organs
Procedure CCS	142	Partial excision bone
Procedure CCS	152	Arthroplasty knee
Procedure CCS	153	Hip replacement; total and partial
Procedure CCS	154	Arthroplasty other than hip or knee
Procedure CCS	157	Amputation of lower extremity
Procedure CCS	158	Spinal fusion
Procedure CCS	159	Other diagnostic procedures on musculoskeletal system
Procedure CCS	166	Lumpectomy; quadrantectomy of breast
Procedure CCS	167	Mastectomy
Procedure CCS	169	Debridement of wound; infection or burn
Procedure CCS	170	Excision of skin lesion
Procedure CCS	172	Skin graft
ICD-9	30.1, 30.29, 30.3, 30.4, 31.74, 34.6	Laryngectomy, revision of tracheostomy, scarification of pleura (from Proc CCS 42- Other OR Rx procedures on respiratory system and mediastinum)
ICD-9	38.18	Endarterectomy leg vessel (from Proc CCS 60- Embolectomy and endarterectomy of lower limbs)
ICD-9	55.03, 55.04	Percutaneous nephrostomy with and without fragmentation (from Proc CCS 103- Nephrotomy and nephrostomy)
ICD-9	94.26, 94.27	Electroshock therapy (from Proc CCS 218- Psychological and psychiatric evaluation and therapy)

Table PA4: Acute Diagnosis Categories (Version 3.0 - Colonoscopy Population)

Code Type	Code	Description
Diagnosis CCS	1	Tuberculosis
Diagnosis CCS	2	Septicemia (except in labor)
Diagnosis CCS	3	Bacterial infection; unspecified site
Diagnosis CCS	4	Mycoses
Diagnosis CCS	5	HIV infection
Diagnosis CCS	7	Viral infection
Diagnosis CCS	8	Other infections; including parasitic
Diagnosis CCS	9	Sexually transmitted infections (not HIV or hepatitis)
Diagnosis CCS	54	Gout and other crystal arthropathies
Diagnosis CCS	55	Fluid and electrolyte disorders
Diagnosis CCS	60	Acute posthemorrhagic anemia
Diagnosis CCS	61	Sickle cell anemia
Diagnosis CCS	63	Diseases of white blood cells
Diagnosis CCS	76	Meningitis (except that caused by tuberculosis or sexually transmitted disease)
Diagnosis CCS	77	Encephalitis (except that caused by tuberculosis or sexually transmitted disease)
Diagnosis CCS	78	Other CNS infection and poliomyelitis
Diagnosis CCS	82	Paralysis
Diagnosis CCS	83	Epilepsy; convulsions
Diagnosis CCS	84	Headache; including migraine
Diagnosis CCS	85	Coma; stupor; and brain damage
Diagnosis CCS	87	Retinal detachments; defects; vascular occlusion; and retinopathy
Diagnosis CCS	89	Blindness and vision defects
Diagnosis CCS	90	Inflammation; infection of eye (except that caused by tuberculosis or sexually transmitted disease)
Diagnosis CCS	91	Other eye disorders
Diagnosis CCS	92	Otitis media and related conditions
Diagnosis CCS	93	Conditions associated with dizziness or vertigo
Diagnosis CCS	99	Hypertension with complications
Diagnosis CCS	100	Acute myocardial infarction (with the exception of ICD-9 codes 410.x2)
Diagnosis CCS	102	Nonspecific chest pain
Diagnosis CCS	104	Other and ill-defined heart disease
Diagnosis CCS	107	Cardiac arrest and ventricular fibrillation
Diagnosis CCS	109	Acute cerebrovascular disease
Diagnosis CCS	112	Transient cerebral ischemia
Diagnosis CCS	116	Aortic and peripheral arterial embolism or thrombosis
Diagnosis CCS	118	Phlebitis; thrombophlebitis and thromboembolism
Diagnosis CCS	120	Hemorrhoids
Diagnosis CCS	122	Pneumonia (except that caused by TB or sexually transmitted disease)
Diagnosis CCS	123	Influenza
Diagnosis CCS	124	Acute and chronic tonsillitis
Diagnosis CCS	125	Acute bronchitis
Diagnosis CCS	126	Other upper respiratory infections
Diagnosis CCS	127	Chronic obstructive pulmonary disease and bronchiectasis

Code Type	Code	Description
Diagnosis CCS	128	Asthma
Diagnosis CCS	129	Aspiration pneumonitis; food/vomitus
Diagnosis CCS	130	Pleurisy; pneumothorax; pulmonary collapse
Diagnosis CCS	131	Respiratory failure; insufficiency; arrest (adult)
Diagnosis CCS	135	Intestinal infection
Diagnosis CCS	137	Diseases of mouth; excluding dental
Diagnosis CCS	139	Gastroduodenal ulcer (except hemorrhage)
Diagnosis CCS	140	Gastritis and duodenitis
Diagnosis CCS	142	Appendicitis and other appendiceal conditions
Diagnosis CCS	145	Intestinal obstruction without hernia
Diagnosis CCS	146	Diverticulosis and diverticulitis
Diagnosis CCS	148	Peritonitis and intestinal abscess
Diagnosis CCS	153	Gastrointestinal hemorrhage
Diagnosis CCS	154	Noninfectious gastroenteritis
Diagnosis CCS	157	Acute and unspecified renal failure
Diagnosis CCS	159	Urinary tract infections
Diagnosis CCS	165	Inflammatory conditions of male genital organs
Diagnosis CCS	168	Inflammatory diseases of female pelvic organs
Diagnosis CCS	172	Ovarian cyst
Diagnosis CCS	197	Skin and subcutaneous tissue infections
Diagnosis CCS	198	Other inflammatory condition of skin
Diagnosis CCS	225	Joint disorders and dislocations; trauma-related
Diagnosis CCS	226	Fracture of neck of femur (hip)
Diagnosis CCS	227	Spinal cord injury
Diagnosis CCS	228	Skull and face fractures
Diagnosis CCS	229	Fracture of upper limb
Diagnosis CCS	230	Fracture of lower limb
Diagnosis CCS	232	Sprains and strains
Diagnosis CCS	233	Intracranial injury
Diagnosis CCS	234	Crushing injury or internal injury
Diagnosis CCS	235	Open wounds of head; neck; and trunk
Diagnosis CCS	237	Complication of device; implant or graft
Diagnosis CCS	238	Complications of surgical procedures or medical care
Diagnosis CCS	239	Superficial injury; contusion
Diagnosis CCS	240	Burns
Diagnosis CCS	241	Poisoning by psychotropic agents
Diagnosis CCS	242	Poisoning by other medications and drugs
Diagnosis CCS	243	Poisoning by nonmedicinal substances
Diagnosis CCS	244	Other injuries and conditions due to external causes
Diagnosis CCS	245	Syncope
Diagnosis CCS	246	Fever of unknown origin
Diagnosis CCS	247	Lymphadenitis
Diagnosis CCS	249	Shock
Diagnosis CCS	250	Nausea and vomiting
Diagnosis CCS	251	Abdominal pain
Diagnosis CCS	252	Malaise and fatigue
Diagnosis CCS	253	Allergic reactions

Code Type	Code	Description
Diagnosis CCS	259	Residual codes; unclassified
Diagnosis CCS	650	Adjustment disorders
Diagnosis CCS	651	Anxiety disorders
Diagnosis CCS	652	Attention-deficit, conduct, and disruptive behavior disorders
Diagnosis CCS	653	Delirium, dementia, and amnestic and other cognitive disorders
Diagnosis CCS	656	Impulse control disorders, NEC
Diagnosis CCS	658	Personality disorders
Diagnosis CCS	660	Alcohol-related disorders
Diagnosis CCS	661	Substance-related disorders
Diagnosis CCS	662	Suicide and intentional self-inflicted injury
Diagnosis CCS	663	Screening and history of mental health and substance abuse codes
Diagnosis CCS	670	Miscellaneous disorders
ICD-9*	03282	Diphtheritic myocarditis
ICD-9*	03640	Meningococcal carditis nos
ICD-9*	03641	Meningococcal pericarditis
ICD-9*	03642	Meningococcal endocarditis
ICD-9*	03643	Meningococcal myocarditis
ICD-9*	07420	Coxsackie carditis nos
ICD-9*	07421	Coxsackie pericarditis
ICD-9*	07422	Coxsackie endocarditis
ICD-9*	07423	Coxsackie myocarditis
ICD-9*	11281	Candidal endocarditis
ICD-9*	11503	Histoplasma capsulatum pericarditis
ICD-9*	11504	Histoplasma capsulatum endocarditis
ICD-9*	11513	Histoplasma duboisii pericarditis
ICD-9*	11514	Histoplasma duboisii endocarditis
ICD-9*	11593	Histoplasmosis pericarditis
ICD-9*	11594	Histoplasmosis endocarditis
ICD-9*	1303	Toxoplasma myocarditis
ICD-9*	3910	Acute rheumatic pericarditis
ICD-9*	3911	Acute rheumatic endocarditis
ICD-9*	3912	Acute rheumatic myocarditis
ICD-9*	3918	Acute rheumatic heart disease nec
ICD-9*	3919	Acute rheumatic heart disease nos
ICD-9*	3920	Rheumatic chorea w heart involvement
ICD-9*	3980	Rheumatic myocarditis
ICD-9*	39890	Rheumatic heart disease nos
ICD-9*	39899	Rheumatic heart disease nec
ICD-9*	4200	Acute pericarditis in other disease
ICD-9*	42090	Acute pericarditis nos
ICD-9*	42091	Acute idiopath pericarditis
ICD-9*	42099	Acute pericarditis nec
ICD-9*	4210	Acute/subacute bacterial endocarditis
ICD-9*	4211	Acute endocarditis in other diseases
ICD-9*	4219	Acute/subacute endocarditis nos
ICD-9*	4220	Acute myocarditis in other diseases
ICD-9*	42290	Acute myocarditis nos

Code Type	Code	Description
ICD-9*	42291	Idiopathic myocarditis
ICD-9*	42292	Septic myocarditis
ICD-9*	42293	Toxic myocarditis
ICD-9*	42299	Acute myocarditis nec
ICD-9*	4230	Hemopericardium
ICD-9*	4231	Adhesive pericarditis
ICD-9*	4232	Constrictive pericarditis
ICD-9*	4233	Cardiac tamponade
ICD-9*	4290	Myocarditis nos
ICD-9†	4260	Atrioventricular
ICD-9†	42610	Atrioventricular block nos
ICD-9†	42611	Atrioventricular block-1st degree
ICD-9†	42612	Atrioventricular block-mobitz ii
ICD-9†	42613	Atrioventricular block-2nd degree nec
ICD-9†	4262	Left bundle branch hemiblock
ICD-9†	4263	Left bundle branch block nec
ICD-9†	4264	Right bundle branch block
ICD-9†	42650	Bundle branch block nos
ICD-9†	42651	Right bundle branch block/left posterior fascicular block
ICD-9†	42652	Right bundle branch block/left ant fascicular block
ICD-9†	42653	Bilateral bundle branch block nec
ICD-9†	42654	Trifascicular block
ICD-9†	4266	Other heart block
ICD-9†	4267	Anomalous atrioventricular excitation
ICD-9†	42681	Lown-ganong-levine syndrome
ICD-9†	42682	Long qt syndrome
ICD-9†	4269	Conduction disorder nos
ICD-9‡	4272	Paroxysmal tachycardia nos
ICD-9‡	7850	Tachycardia nos
ICD-9‡	42789	Cardiac dysrhythmias nec
ICD-9‡	4279	Cardiac dysrhythmia nos
ICD-9‡	42769	Premature beats nec
ICD-9§	39891	Rheumatic heart failure
ICD-9§	4280	Congestive heart failure
ICD-9§	4281	Left heart failure
ICD-9§	42820	Unspecified systolic heart failure
ICD-9§	42821	Acute systolic heart failure
ICD-9§	42823	Acute on chronic systolic heart failure
ICD-9§	42830	Unspecified diastolic heart failure
ICD-9§	42831	Acute diastolic heart failure
ICD-9§	42833	Acute on chronic diastolic heart failure
ICD-9§	42840	Unspec combined syst & dias heart failure
ICD-9§	42841	Acute combined systolic & diastolic heart failure
ICD-9§	42843	Acute on chronic combined systolic & diastolic heart failure
ICD-9§	4289	Heart failure nos
ICD-9**	5740	Calculus of gallbladder with acute cholecystitis

Code Type	Code	Description
ICD-9**	57400	Calculus of gallbladder with acute cholecystitis without mention of obstruction
ICD-9**	57401	Calculus of gallbladder with acute cholecystitis with obstruction
ICD-9**	5743	Calculus of bile duct with acute cholecystitis
ICD-9**	57430	Calculus of bile duct with acute cholecystitis without mention of obstruction
ICD-9**	57431	Calculus of bile duct with acute cholecystitis with obstruction
ICD-9**	5746	Calculus of gallbladder and bile duct with acute cholecystitis
ICD-9**	57460	Calculus of gallbladder and bile duct with acute cholecystitis without mention of obstruction
ICD-9**	57461	Calculus of gallbladder and bile duct with acute cholecystitis with obstruction
ICD-9**	5748	Calculus of gallbladder and bile duct with acute and chronic cholecystitis
ICD-9**	57480	Calculus of gallbladder and bile duct with acute and chronic cholecystitis without mention of obstruction
ICD-9**	57481	Calculus of gallbladder and bile duct with acute and chronic cholecystitis with obstruction
ICD-9**	5750	Acute cholecystitis
ICD-9**	57512	Acute and chronic cholecystitis
ICD-9**	5761	Cholangitis
ICD-9††	5770	Acute pancreatitis

*These ICD-9 codes represent acute ICD-9 codes within Dx CCS 97: Peri-; endo-; and myocarditis; cardiomyopathy
†These ICD-9 codes represent acute ICD-9 codes within Dx CCS 105: Conduction disorders
‡These ICD-9 codes represent acute ICD-9 codes within DX CCS 106: Dysrhythmia
§These ICD-9 codes represent acute ICD-9 codes within Dx CCS 108: Congestive heart failure; nonhypertensive
** These ICD-9 codes represent acute ICD-9 codes within Dx CCS 149: Biliary tract disease
†† This ICD-9 code represents acute ICD-9 codes within Dx CCS 152: Pancreatic disorders

Appendix D: Risk Adjustment Model Development

D1. Candidate Variables Considered For the Risk Adjustment Model

Table D1: Variables with a Strong Clinical Rationale for Inclusion in the Risk Adjustment Model Based on the Existing Literature

Variables	Rationale
Age	Increasing risk of adverse events with increasing age
Sex	Male patients have been shown to have higher risk of adverse events
Concomitant Upper GI Endoscopy	Increases the risk of adverse events
Polypectomy during Procedure	Increases the risk of adverse events (especially bleeding)
Chronic Heart Failure	Increased risk of cardio-pulmonary events
Ischemic Heart Disease	
Valvular and Rheumatic Heart Disease	
Arrhythmias	
Stroke/ TIA	Associated with increased risk of stroke/TIA (may be mediated by stopping anti-platelet agents for procedure and arrhythmias such as atrial fibrillation)
Respiratory Failure/Dependence	Increased risk of respiratory complications with sedation
Chronic Lung Disease	
Pneumonia	
Morbid Obesity	
Chronic Renal Disease	At risk of complications from the bowel prep such as dehydration, electrolyte disturbances
Disorders of Fluid, Electrolyte, Acid-Base	
Diabetes	At risk of hyper/hypoglycemia with fasting Prone to fluid shifts and electrolyte abnormalities May increase cardiovascular risk
Protein-Calorie Malnutrition	May increase the risk of adverse events
Functional Disability/Frailty	Age-related factors hypothesized as an explanation for increased risk of procedural complications with increasing age

Table D2: Clinically Important Variables Identified through Empirical Analysis

Variables	Rationale
Metastatic or Major Cancer	May increase the risk of adverse events/and or unplanned hospital visits
Liver Disease	May increase the risk of adverse events
Iron deficiency anemia	May increase the risk of adverse events especially bleeding requiring transfusion
Hematological/Coagulation Disorders	May increase the risk of adverse events especially bleeding
Drug and Alcohol Abuse/Dependence	May increase the risk of adverse events/unplanned hospital visits
Psychiatric Disorders	May increase the risk of adverse events/unplanned hospital visits

Table D3: Variable: Polypectomy during Procedure

CPT Code	Description
45385	Colonoscopy with ablation of lesion(s)/polypectomy by snare
45384	Colonoscopy with ablation of lesion(s)/polypectomy by hot biopsy forceps or bipolar cautery
45383	Colonoscopy with ablation of lesion(s)/polypectomy by other techniques (i.e., techniques other than 45384/5)
45381	Colonoscopy, with directed submucosal injection, any substance

Table D4: Variable: Concomitant Upper-GI Endoscopy

CPT Code	Description
43200	Diagnostic esophagoscopy
43202	Diagnostic esophagoscopy with biopsy (single or multiple)
43234	Upper gastrointestinal endoscopy, simple primary examination (e.g., with small diameter flexible endoscope)
43235	Diagnostic upper gastrointestinal endoscopy including esophagus stomach, and either the duodenum and/or jejunum as appropriate
43239	Diagnostic upper gastrointestinal endoscopy including esophagus stomach, and either the duodenum and/or jejunum as appropriate with biopsy
43201	Esophagoscopy with directed submucosal injection(s), any substance
43220	Esophagoscopy with balloon dilation (less than 30mm diameter)
43226	Esophagoscopy with insertion of guide wire followed by dilation over guide wire
43236	Upper GI endoscopy with directed submucosal injection(s), any substance
43248	Upper GI endoscopy with insertion of guide wire followed by dilation of esophagus over guide wire
43249	Upper GI endoscopy with balloon dilation of esophagus (less than 30mm diameter)

D2. CCs That Are Not Risk-Adjusted For If They Only Occur at the Procedure

Table D5: CCs That Are Not Risk-Adjusted For If They Only Occur at the Procedure

Condition Category	Description
2	Septicemia/Shock
6	Other Infectious Diseases
17	Diabetes with Acute Complications
23	Disorders of Fluid/Electrolyte/Acid-Base
28	Acute Liver Failure/Disease
31	Intestinal Obstruction/Perforation
34	Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders
46	Coagulation Defects and Other Specified Hematological Disorders
48	Delirium and Encephalopathy
75	Coma, Brain Compression/Anoxic Damage
77	Respirator Dependence/Tracheostomy Status
78	Respiratory Arrest
79	Cardio-Respiratory Failure and Shock
80	Congestive Heart Failure
81	Acute Myocardial Infarction
82	Unstable Angina and Other Acute Ischemic Heart Disease
92	Specified Heart Arrhythmias
93	Other Heart Rhythm and Conduction Disorders
95	Cerebral Hemorrhage
96	Ischemic or Unspecified Stroke
97	Precerebral Arterial Occlusion and Transient Cerebral Ischemia
100	Hemiplegia/Hemiparesis
101	Diplegia (Upper), Monoplegia, and Other Paralytic Syndromes
102	Speech, Language, Cognitive, Perceptual
104	Vascular Disease with Complications
105	Vascular Disease
106	Other Circulatory Disease
111	Aspiration and Specified Bacterial Pneumonias
112	Pneumococcal Pneumonia, Emphysema, Lung Abscess
114	Pleural Effusion/Pneumothorax
129	End Stage Renal Disease
130	Dialysis Status
131	Renal Failure
132	Nephritis
133	Urinary Obstruction and Retention
135	Urinary Tract Infection
148	Decubitus Ulcer of Skin
152	Cellulitis, Local Skin Infection
154	Severe Head Injury
155	Major Head Injury
156	Concussion or Unspecified Head Injury
158	Hip Fracture/Dislocation

Condition Category	Description
159	Major Fracture, Except of Skull, Vertebrae, or Hip
163	Poisonings and Allergic Reactions
164	Major Complications of Medical Care and Trauma
165	Other Complications of Medical Care
174	Major Organ Transplant Status
175	Other Organ Transplant/Replacement
176	Artificial Openings for Feeding or Elimination
177	Amputation Status, Lower Limb/Amputation
178	Amputation Status, Upper Limb
179	Post-Surgical States/Aftercare/Elective

D3. Risk-Standardized Measure Score Calculation Algorithm

We fitted a hierarchical generalized linear model (HGLM), which accounts for the clustering of observations within facilities (ASCs, physician office settings, and HOPDs). We assume the outcome is a known exponential family distribution and is related linearly to the covariates via a known linked function, *h*. For our model, we assumed a binomial distribution and a logit link function. Further, we accounted for the clustering within facility by estimating a facility-specific effect, α_i, which is assumed to follow a normal distribution with mean μ and variance τ^2, the between-facility variance component. The HGLM is defined by the following equations:

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

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

$$i = 1 \ldots I; j = 1 \ldots n_i$$

Where Y_{ij} denotes the outcome (equal to 1 if patient has an eligible hospital visit within 7 days of a colonoscopy, 0 otherwise) for the *j-th* patient who had a colonoscopy at the *i-th* facility; $\mathbf{Z}_{ij} = (Z_{1ij}, Z_{2ij}, \ldots, Z_{pij})$ is a set of *p* patient-specific covariates derived from the data; and *I* denotes the total number of facilities and n_i the number of colonoscopies performed at facility *i*. The facility-specific intercept of the *i-th* facility, α_i, defined above, is comprised of μ, the adjusted average intercept over all facilities in the sample and ω_i the facility-specific intercept deviation from μ. A point estimate of ω_i, greater or less than 0, determines if facility performance is worse or better compared to the adjusted average outcome.

The HGLM is estimated using the SAS software system (GLIMMIX procedure).

D4. Provider Performance Reporting

Using the HGLM defined by Equations (1) - (2), we estimate the parameters $\hat{\mu}$, $\{\hat{a}_1, \hat{a}_2, \ldots, \hat{a}_I\}$, $\hat{\beta}$, and $\hat{\tau}^2$. We calculate a standardized outcome, s_i, for each facility by computing the ratio of the number of predicted hospital visits to the number of expected hospital visits, multiplied by the unadjusted overall hospital visit rate, $\bar{y}$. Specifically, we calculate:

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

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

$$\hat{s}_i(Z) = \frac{\sum_{j=1}^{n_i} \hat{y}_{ij}(Z)}{\sum_{j=1}^{n_i} \hat{e}_{ij}(Z)} \times \bar{y} \quad (5)$$

If the "predicted" number of hospital visits is higher (lower) than the "expected" number of hospital visits, then that facility's $\hat{s}_i$ will be higher (lower) than the unadjusted average.

D5. Outlier Evaluation

Because the statistic described in Equation (5) is a complex function of parameter estimates, we use re-sampling and simulation techniques to derive an interval estimate to determine if a facility is performing better than, worse than, or no different from its expected rate. A facility is considered as better than expected if its entire confidence interval falls below the expected rate, and considered worse if the entire confidence interval falls above the expected rate. It is considered no different if the confidence interval overlaps the expected rate.

More specifically, we use a bootstrapping procedure to compute confidence intervals. Because the theoretical-based standard errors are not easily derived, and to avoid making unnecessary assumptions, we use the bootstrap to empirically construct the sampling distribution for each facility-level risk-standardized rate. The bootstrapping algorithm is described below.

D6. Bootstrapping Algorithm

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

1. Sample *I* facilities with replacement.

2. Fit the hierarchical logistic regression model using all patients within each sampled facility. We use as starting values the parameter estimates obtained by fitting the model to all facilities. If some facilities are selected more than once in a bootstrapped sample, we treat them as distinct so that we have *I* random effects to estimate the variance components. At the conclusion of Step 2, we have:

   a. $\hat{\beta}^{(b)}$ (the estimated regression coefficients of the risk factors).

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

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

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

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

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