

Appendix to NQF Submission:

**Hospital 30-Day All-Cause Risk-Standardized Readmission Rate
(RSRR) following Vascular Procedures**

Submitted By:

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Hospital 30-Day All-Cause Risk-Standardized Readmission Rate (RSRR) following Vascular Procedures

Measure Methodology Report

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1. INTRODUCTION

1.1 Background

The present work develops a hospital 30-day all-cause risk-standardized readmission measure for patients undergoing vascular procedures. Vascular procedures are prevalent, commonly performed on older patients with multiple comorbid conditions, and are costly. Readmissions to the hospital are increasingly recognized as adverse events from a patient perspective and important measures of the quality of care provided by a health system. Research on a variety of conditions and procedures has shown that readmission rates are influenced by the quality of care provided within the health system [1] and, specifically, that interventions, such as improved discharge planning, reconciling patient medications, and improving communications with outpatient providers can reduce readmission rates [2]. The Centers for Medicare and Medicaid Services (CMS) currently publicly reports outcomes and efficiency measures on the consumer website, Hospital Compare (<http://www.hospitalcompare.hhs.gov>), as mandated by the 2005 Deficit Reduction Act. Outcomes measures reported on the website include acute myocardial infarction (AMI), heart failure (HF), and pneumonia risk-standardized readmission measures.

Given the prevalence and cost of readmission following vascular procedures, CMS contracted with Yale New Haven Health Services Corporation/Center for Outcomes Research and Evaluation (YNHHSC/CORE) to develop several new administrative claims-based readmission measures, including a hospital readmission measure for patients undergoing vascular procedures.

The aim of the vascular readmission measure is to improve patient outcomes by providing patients, physicians, and hospitals with information about hospital risk-standardized readmission rates (RSRRs) following vascular procedures. The measure focuses attention not only on ensuring high quality procedural and other in-hospital processes of care but also on the need for broad improvement in the transitions of care.

1.2 Overview

The measure was developed with CMS Medicare claims and enrollment data. To comprehensively assess hospital performance on readmission following vascular procedures, the cohort for the measure includes hospital stays for vascular procedures performed on both patients who are admitted to the hospital (inpatients) and on patients who receive their procedure at a hospital but who are not admitted as an inpatient (outpatients). Both of these scenarios are hereafter referred to as “hospital stays.” The model estimates hospital 30-day all-cause RSRRs following discharge (or claim end date for hospital outpatients). To account for the clustering of observations within hospitals and differences in the number of patient admissions across hospitals, RSRRs were estimated with hierarchical logistic regression models. The overall methodological

approach for this measure is consistent with that used to develop three prior CMS readmission measures that are endorsed by the National Quality Forum (NQF) and which CMS now publicly reports on *Hospital Compare*.

This report conveys the goals of the measure, development methodology, and results. First, we describe the purpose of the measure and its function in public reporting. Second, we present the methodology used to develop the measure and results of key analyses, and the results of both the final risk adjustment model and the models derived to assess measure reliability. Finally, we summarize the main findings of this project.

1.3 Why Readmission following Vascular Procedures?

Hospital readmission within 30 days of a vascular procedure is often unplanned and due to an adverse event: the 2007 Medicare Payment Advisory Commission (MedPAC) Report to Congress identified “other vascular” as one of the seven conditions which account for nearly 30 percent of potentially preventable readmissions within 15 days of discharge. The rate of preventable readmissions within 15 days of discharge in 2005 following these procedures was 11.7% and cost \$182 million [3].

To further assess the need for a readmission measure for Medicare patients receiving a vascular procedure, we conducted analyses using 2009 Medicare Part A inpatient and hospital outpatient claims. These analyses confirmed that vascular procedures are high volume procedures and have a high readmission rate which varies significantly across hospitals. We identified 256,610 hospital stays from 2,659 hospitals containing at least one qualifying vascular procedure among eligible patients with an overall 30-day readmission rate of 13.9%. The two most common primary discharge diagnostic codes are International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes 433.10 (occlusion and stenosis of carotid artery disease) (21%) and 440.21 (atherosclerosis of the extremities with intermittent claudication) (14%), suggesting a population with significant illness and potentially multiple comorbid conditions.

1.4 Purpose of the Measure

Vascular procedures are used in the diagnosis and management of diseases affecting all parts of the vascular system and include a broad spectrum of procedures. Specifically, vascular procedures may include:

- Open surgical procedures (e.g., bypass, endarterectomy)
- Percutaneous procedures (e.g., angioplasty, stenting)
- Other procedures on arteries and/or veins

These procedures cross several physician specialties, including vascular surgery, interventional radiology, and interventional cardiology. Care for these patients involves

many areas of the hospital system, including the operating rooms, recovery rooms, intensive care units, and inpatient floors.

In appropriately selected patients, vascular procedures may improve overall quality of life, reduce the risk of long-term illness or need for more significant procedures, and improve survival. Although advances in technology have improved procedural success and safety, many patients undergoing vascular procedures have multiple comorbid conditions and the performance of vascular procedures still carries significant risks of short-term adverse outcomes including procedural complications, readmission, and death.

Focusing on hospital readmission rates will provide an incentive for hospitals to reduce readmission-related risks during hospital stays in which a vascular procedure is performed. Of note, the proposed measure does not attempt to assess the quality of individual vascular surgeons or interventional radiologists who perform vascular procedures, but rather reflects the outcomes achieved by the systems of care within which the procedures are performed. Publicly reporting readmission rates after a vascular procedure will provide patients, physicians, and hospitals with information that could be used to understand and improve quality of care and outcomes. Specifically, hospitals, in collaboration with their medical communities, can take actions to reduce readmissions, such as: ensure patients are clinically ready when they leave the hospital; reduce risk of infection; reconcile medications; improve communication among providers at transitions of care; review practice patterns; encourage strategies that promote disease management principles; and educate patients on what symptoms to monitor, whom to contact with questions, and how to seek follow-up care [4-8].

1.5 Core Principles for Hospital Outcomes Models Suitable for Public Reporting

We developed a model using an approach that is consistent with the rationale articulated in the American Heart Association (AHA) scientific statement, “Standards for Statistical Models Used for Public Reporting of Health Outcomes” [9].

We derived the model using a risk adjustment method that adjusts for pre-existing conditions but not complications potentially related to the procedure. To calculate RSRRs we used a hierarchical logistic regression model, a statistical approach that takes into account the clustering of patients within hospitals and differences in sample size across hospitals. We computed indices that describe model performance in terms of calibration (over-fitting indices), discriminant ability (R-Square, ROC, and predicted vs. observed readmission), and overall fit (residuals, lack of fit, and model chi-square).

2. METHODS

2.1 Overview

We developed a hospital, 30-day, all-cause risk-standardized measure of readmission for acute care hospitals in the US (including the territories – US Virgin Islands, Puerto Rico, Guam, Northern Mariana Islands, and American Samoa) following a hospital stay during which a qualifying vascular procedure was performed. We developed this model for all eligible procedures performed at a hospital, including those performed on patients who were admitted (inpatients) and those who were not admitted (outpatients). To account for the clustering of patients within hospitals, we fit a hierarchical logistic regression model which estimates hospital 30-day RSRRs. To account for differences in hospital case mix, the model adjusts for patient risk factors including age, gender, procedure type (i.e., open surgical or endovascular); procedure anatomic location (i.e., head/neck, thoracic/abdominal, limb, and unspecified); and patient diagnoses from inpatient and outpatient visits for the 12 months before the index hospital stay and those present during the hospital stay. The model does not risk adjust for diagnoses that may have been a complication of the index hospital stay. A detailed description of the risk-adjustment variables and the measure methodology appears in Sections 2.7 and 2.8.

We developed the model using 2009 Medicare inpatient and outpatient claims data. Index hospital stays are defined as inpatient or outpatient hospital stays during which a qualifying vascular procedure was performed. We identified these procedures using ICD-9 (inpatient) and Current Procedural Terminology (CPT) (outpatient) procedure codes. Using the inpatient claims, we then identified inpatient readmissions within 30 days of the discharge date. Model performance was evaluated in 2008 Medicare claims.

2.2 Expert and Stakeholder Input

Throughout measure development we obtained expert and stakeholder input via three mechanisms: regular discussions with our working group, a national Technical Expert Panel (TEP), and a 30-day public comment period. The working group provided regular input on all measure decisions. The TEP provided key input regarding select key measure decisions and overall measure validity during structured meetings and via email. The Working Group Member Roster and TEP Member Roster can be found in Appendix A and Appendix B, respectively.

The internal working group met regularly throughout measure development and consisted of clinicians, including a noninvasive cardiologist, vascular surgeon, family physician, and interventional cardiologist; and other professionals with expertise in biostatistics, measure methodology, and quality improvement. Working group meetings were held once or twice per week and addressed key issues related to measure development, (e.g., defining the measure cohort and outcome) to ensure the measure is meaningful, useful, and well-designed.

In addition to the working group, and in alignment with the CMS Measures Management System (MMS), we convened a TEP to provide input and feedback during measure development from a group of recognized experts in relevant fields. To create the TEP we released a public call for nominations and selected individuals to represent a range of perspectives including physicians, consumers, and purchasers, as well as individuals with experience in quality improvement, performance measurement, and health care disparities. We convened three TEP conference calls. The TEP calls followed a structured format consisting of presentation of key issues, our proposed approach, and relevant data. These presentations were followed by open discussion of these issues by the TEP members.

Following completion of the preliminary model, we solicited public comment on the measure through the CMS site link https://www.CMS.gov/MMS/17_CallforPublicComment.asp. The public comments were then posted publicly for 30 days. The resulting input was taken into consideration during the final stages of measure development and contributed to minor modifications to the measure.

2.3 Outcome

2.3.1 Definition

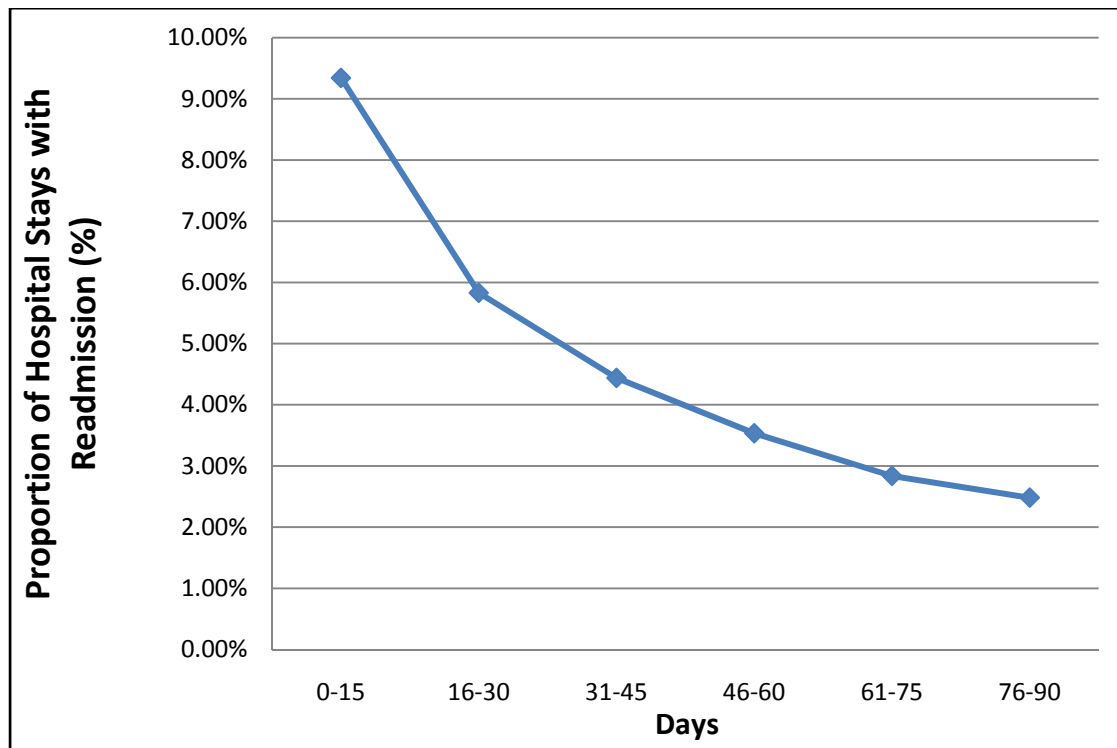
The outcome for this measure is 30-day all-cause readmission following a qualifying index hospital stay (any stay with an eligible vascular procedure, as defined in Section 2.4.1). We define a readmission as a subsequent hospital inpatient admission within 30 days of leaving the hospital following an index hospital stay with a vascular procedure. We do not count as readmissions returns to the hospital for outpatient stays or any subsequent admissions which are “staged” or planned (as defined in Section 2.3.4).

2.3.2 30-Day Timeframe

We considered a range of time periods for the outcome and ultimately selected a 30-day timeframe for several reasons. First, we examined the proportion of hospital stays within our cohort associated with a readmission over a 90-day period (Figure 1). The proportion was highest within the first 15 days and decreased with every time interval thereafter. We selected a 30-day timeframe as a way to not only capture the time period during which patients are at highest risk for readmission, but also capture a greater percentage of readmissions which are likely attributable to the care delivered both within an index hospital stay and during the transition from that setting. A shorter timeframe such as 15 days may have an even stronger association with the initial care of the patient but would miss the substantial number of readmissions occurring between 15 and 30 days and may limit the efforts to improve the quality of transitions into the outpatient setting. A number of studies have demonstrated that improvements in care at the time of patient discharge can reduce

30-day readmission rates [5, 10-13]. Both the working group and TEP agreed that a 30-day readmission measure had the greatest potential to stimulate better collaboration between hospitals and their surrounding medical communities aimed at reducing readmission rates. Finally, this timeframe is consistent with the other readmission measures endorsed by NQF.

Figure 1. Proportion of Hospital Stays with a Readmission following Vascular Procedures over Time (in Days)



2.3.3 All-Cause Readmission

We measured all-cause readmission rather than vascular procedure-specific readmissions for several reasons. First, from the patient perspective, unplanned readmission for any reason is an undesirable outcome of care, even though not all readmissions are preventable. Second, limiting the outcome to vascular procedure-related readmissions may limit the focus of efforts to improve care to a narrow set of approaches as opposed to encouraging broader initiatives aimed overall at improving the care within the hospital and transitions from the hospital setting. Moreover, there is no reliable way to exclude quality issues and accountability based on the documented cause of readmission. For example, a patient receiving a vascular procedure who develops a wound infection may ultimately be readmitted for sepsis. It would be inappropriate to treat this readmission as unrelated to the care the patient received during the initial vascular procedure. In addition, the range of potentially avoidable readmissions also includes those not directly related to vascular procedures, such as those resulting from poor communication at discharge or

inadequate follow-up post-discharge. As such, creating a comprehensive list of potential vascular procedure-related complications would be arbitrary and challenging to implement. The goal of an all-cause readmission measure is not to reduce readmissions to zero, but to assess hospital performance relative to what is expected given the performance of other hospitals with similar case mixes while minimizing the potential for systematic coding misclassifications (gaming).

2.3.4 Planned Readmissions

Physicians may opt to “stage” procedures across multiple hospital stays. As admissions for these planned procedures are not a signal of the quality of care provided, we attempted to identify follow-up admissions for procedures which are likely planned (planned readmissions) and not count them as readmissions.

In defining planned readmissions we considered only those readmissions that represent follow-on care to the index vascular procedure. Additionally, we consider as planned only those readmissions for which both the index vascular procedure(s) and the procedure(s) performed during readmission are performed on admitted patients, as it is unlikely that non-admitted patients (outpatients) with an index vascular procedure will be later admitted for a planned procedure. That is, if follow-on care were required, it would also likely happen in the outpatient setting. Finally we only considered a readmission as planned if it occurred at the same hospital as the index hospital stay, as it is unlikely that medical team would plan a follow-up procedure to occur at a different hospital.

Planned readmissions can be identified in claims data using a combination of procedure and diagnosis codes. For this measure we identified planned readmissions by identifying procedure pairs for which the second procedure is often planned. We did not consider as planned, however, any such readmissions if the primary discharge diagnosis codes for the readmission indicated one of a number of specified acute conditions, as these readmissions would not be planned.

Below we first describe the three ways by which we identify planned procedures: (1) specified same-procedure pairs; (2) specified different-procedure pairs; and (3) specified amputation procedures. We then list the discharge diagnosis codes which, when present at readmission, suggest the readmission is for an acute condition and thus not planned (regardless of the procedure(s) performed at readmission). Readmissions are considered planned and thus not counted as readmissions if they represent one of the procedure pairs below, are not associated with one of the acute diagnosis codes in Section 2.3.4.2, and if they occur at the same hospital as the index procedure.

2.3.4.1 Identifying Potentially Planned Procedures

We explored various options for identifying planned readmissions. For an index hospital stay with subsequent inpatient stays (readmissions) we considered the

following methods to identify planned readmissions: accompanying vascular and non-vascular procedures, primary and secondary discharge diagnoses, procedure/diagnosis combinations, associated diagnostic related groups (DRGs), and procedure order within a hospital stay. Ultimately, in consultation with the working group and TEP, we determined the most efficient approach to identifying planned readmissions was procedure code pairings in the index hospital stay and the readmission. Specifically, for a readmission to be designated as planned (and, thus, not counted as a readmission), the index hospital stay and subsequent readmission must meet one of the following three scenarios:

(1) Same-procedure pairs

Procedures that occur during the index hospital stay and are repeated in the readmission may represent a set of procedures planned, or staged, over two hospital stays. For example, a set of stents which cross distinct anatomic areas within the body, such as the left and right extremities, may be placed over two hospital stays.

Although some procedures that are repeated during a readmission may be the result of a complication of the first procedure, it is difficult to distinguish these scenarios from planned events using administrative claims data. We recognize that labeling all such procedure pairs as planned will inevitably capture some unplanned events. On balance, however, identifying the below same-procedure pairs as planned will avoid penalizing hospitals that opt to stage procedures over multiple hospital stays. This approach may be further refined with the 2013 implementation of ICD-10 codes which distinguish, for example, anatomic laterality.

Table 1 lists the same-procedure pairs for which the readmission likely represents follow-on care for planned or staged procedures. Unless the admitting diagnosis is for an acute illness as described in Section 2.3.4.2, a hospital stay for one of these procedures that is followed by an inpatient admission for the same procedure at the same hospital is not counted as a readmission.

Table 1. Planned Same-Procedure Pairs (Procedures Which Occur in Both the Index Hospital Stay and the Readmission)

ICD-9 Procedure Code	ICD-9 Procedure Description
39.50	Angioplasty or atherectomy of other non-coronary vessel(s)
38.12	Endarterectomy-other vessels of head and neck
39.90	Insertion of non-drug-eluting, non-coronary artery stent(s)
39.29	Other (peripheral) vascular shunt or bypass
38.18	Endarterectomy-lower limb arteries
39.79	Other endovascular repair (of aneurysm) of other vessels
00.61	Percutaneous angioplasty or atherectomy of precerebral (extracranial) vessel(s), basilar, carotid, vertebral
00.63	Percutaneous insertion of carotid artery stent(s), Includes: the use of any embolic protection device, distal protection device, filter device, or stent delivery system, Non-drug-eluting stent
38.08	Incision of vessels-lower limb arteries
39.52	Other repair of aneurysm
39.72	Endovascular repair or occlusion of head and neck vessels
38.03	Incision of vessels-upper limb vessels
39.59	Other repair of vessel
00.55	Insertion of drug-eluting stent(s) of other peripheral vessel(s), endograft(s), endovascular graft(s), stent grafts
39.57	Repair of blood vessel with synthetic patch graft
39.56	Repair of blood vessel with tissue patch graft
38.48	Resection of vessel with replacement-lower limb arteries
39.53	Repair of arteriovenous fistula
39.58	Repair of blood vessel with unspecified type of patch graft
38.68	Other excision of vessels-lower limb arteries
38.02	Incision of vessels-other vessels of head and neck
00.64	Percutaneous insertion of other precerebral (extracranial) artery stent(s)
38.42	Resection of vessel with replacement-other vessels of head and neck
38.38	Resection of vessel with anastomosis-lower limb arteries
38.32	Resection of vessel with anastomosis-other vessels of head and neck
38.13	Endarterectomy-upper limb vessels
38.43	Resection of vessel with replacement-upper limb vessels
38.10	Endarterectomy-unspecified site
38.33	Resection of vessel with anastomosis-upper limb vessels
38.00	Incision of vessels-unspecified site
38.40	Resection of vessel with replacement-unspecified site
00.60	Insertion of drug-eluting stent(s) of superficial femoral artery
38.30	Resection of vessel with anastomosis-unspecified site

(2) Different-procedure pairs

We identified additional clinically sensible index-readmission different-procedure pairs that may represent planned events. For example, a carotid endarterectomy is sometimes performed prior to a planned aortic aneurysm repair. Table 2 lists the different-procedure pairs which are likely planned across hospital stays and for which the second hospital stay will not be counted as a readmission (unless the readmission is to a different hospital than that at which the index hospital stay occurred or is accompanied by an acute primary discharge diagnosis code listed in Section 2.3.4.2).

Table 2. Planned Different-Procedure Pairs

Index Procedure	Procedure at Readmission
38.12 Endarterectomy-other vessels of head and neck	38.44 Resection of abdominal aorta with replacement
39.22 Aorta-subclavian-carotid bypass	39.73 Endovascular implantation of graft in thoracic aorta
39.73 Endovascular implantation of graft in thoracic aorta	39.22 Aorta-subclavian-carotid bypass
39.90 Insertion of non-drug-eluting, non-coronary artery stent(s)	39.29 Other (peripheral) vascular shunt or bypass
39.90 Insertion of non-drug-eluting, non-coronary artery stent(s)	39.50 Angioplasty or atherectomy of other non-coronary vessel(s)
39.25 Aorta-iliac-femoral bypass	86.60 Free skin graft, not otherwise specified
39.29 Other (peripheral) vascular shunt or bypass	86.60 Free skin graft, not otherwise specified
39.25 Aorta-iliac-femoral bypass	86.22 Excisional debridement of wound, infection, or burn
39.29 Other (peripheral) vascular shunt or bypass	86.22 Excisional debridement of wound, infection, or burn
39.23 Other intrathoracic vascular shunt or bypass	39.73 Endovascular implantation of graft in thoracic aorta
39.24 Aorta-renal bypass	39.71 Endovascular implantation of graft in abdominal aorta
39.26 Other intra-abdominal vascular shunt or bypass	39.71 Endovascular implantation of graft in abdominal aorta

(3) Amputation procedures

In some cases readmissions which include amputations are likely planned follow-on care. Specifically, readmissions with toe or foot amputations may represent planned events, which may indicate good clinical practice and a prior vascular procedure's success at maximizing tissue preservation. Table 3 indicates the procedure codes which, if occurring in the second hospital stay, will not be considered a readmission (unless the readmission is to a different hospital than that at which the index hospital stay occurred or is accompanied by an acute primary discharge diagnosis code listed in Section 2.3.4.2). Again, the index vascular procedure(s) must be performed on patients who were admitted for a subsequent amputation to be considered planned.

Table 3. Potentially Planned Amputation Procedures (at Readmission)

ICD-9 Procedure Code	ICD-9 Procedure Description
84.11	Amputation toe
84.12	Amputation through foot

2.3.4.2 Identifying Acute Readmissions That Are Not “Planned”

If a planned readmission is identified as described above it will *not* be counted as a readmission unless it is associated with a common acute diagnosis which would suggest that the readmission was not planned. Any readmissions associated with the following acute ICD-9 primary discharge diagnosis codes will not be considered planned, regardless of procedure(s) performed at readmission:

- 038.xx, 785.52, 785.59, 790.7, 995.91, 995.92, 998.0, 998.59 (Sepsis)
- 410.xx (excluding 410.x2) (AMI)
- 996.xx, 997.xx, 998.xx (Complication of prior procedure)

Readmissions that are associated with these primary discharge diagnoses are likely unplanned. These diagnoses were identified as the most common discharge diagnoses that follow hospital stays for vascular procedures and that represent specific and clearly acute conditions.

2.3.5 Handling of Deaths without a Readmission

The current measure focuses on 30-day readmission and not death. Patients who die within 30 days of discharge who were not readmitted are included in the cohort but are not counted in the measure outcome. Although this method has the effect of counting such a death as a “no event” outcome, the frequency of death without a readmission is relatively low and is distributed across hospitals, minimizing the impact on the measure. In 3,334 index hospital stays (1.30% of 2009 cohort), the patient died within 30 days of discharge without being readmitted.

2.4 Cohort Derivation

Hospital stays with one or more “qualifying” vascular procedures are included in the measure cohort. When selecting qualifying procedures for inclusion in the measure, we sought to include those which meet all of the following criteria:

- Major (have significant potential benefits and/or risks for the patient)
- Central to the hospital stay (likely related to the primary reason for the hospital stay)
- Clinically coherent group of procedures (performed on a classifiable group of patients who follow a similar care pathway). Procedures on veins, procedures on

cardiac and intracranial arteries, and procedures addressing vascular access for hemodialysis, do not qualify for inclusion in the cohort as they represent hospital stays for patient populations distinct from those intended for inclusion in the measure, with differing risks for readmission. Similarly, hospital stays associated with a primary discharge diagnosis of ICD-9 code 996.73 (other complications due to renal dialysis device implant and graft) are not included in the cohort.

Many vascular procedures can be performed on both patients admitted to the hospital (i.e., inpatients) as well as patients who are never admitted and are cared for under observation status (i.e., outpatients). Factors that influence the decision of whether to admit include not only patient comorbidities and risk of adverse outcomes, but also nonclinical factors such as reimbursement and local practice. As such, hospitals likely have very different thresholds for selecting which patients undergo vascular procedures as outpatients. In order to fairly characterize the outcomes of vascular procedures at the hospital level it is important to consider the full population of patients, including those performed both on the inpatient and outpatient basis. Working group and TEP members agreed that to create a valid and inclusive model, qualifying procedures performed on outpatients should be included in the cohort. Accordingly, all qualifying vascular procedures performed on both inpatients and outpatients are included in the measure cohort.

2.4.1 Identifying Qualifying Vascular Procedures

Inpatient hospital stays

Identifying procedures for inclusion in the cohort was a multi-step process (see Figure 2 below). Beginning with the 2007 MedPAC Report to Congress' definition of "other vascular," we both expanded the number and type of procedures included and excluded some procedures that did not meet the criteria noted above (major, central, and clinically coherent).

First we cross-walked the all patient refined diagnostic related groups (APR-DRGs) used in the MedPAC report to define "other vascular" (APR-DRG 173) to Medicare severity diagnostic related groups (MS-DRGs) (252, 253, and 254, which comprise other vascular procedures with and without complications or comorbidity). We then expanded our consideration of procedures to all the MS-DRGs found in the major diagnostic category (MDC) 05: diseases and disorders of the circulatory system. Refer to Appendix C for full description of DRGs.

With clinical experts on our working group, we reviewed all MS-DRGs within MDC 05 and added those that were deemed relevant based on DRG definition, including MS-DRGs 237, 238, 239, 240, 241, 255, 256, 257, and 264. We then identified all ICD-9 procedure codes found in each APR- and MS-DRG and added additional ICD-9 codes which are vascular in nature (38.xx, 39.xx, and 00.xx). These codes were systematically and independently reviewed and classified by the clinicians in the working group. These classifications were compared and any discrepancies were resolved within the working group meetings. Procedure codes were not included in the cohort if they did not meet

all of the necessary criteria (major, central, and clinically coherent) (the list of ICD-9 codes not selected for inclusion in the cohort appears in Appendix D.). A total of 54 ICD-9 procedure codes were selected for inclusion in the cohort.

Outpatient hospital stays

After all relevant ICD-9 codes were identified for inclusion in the cohort, these codes were mapped to Medicare Part A outpatient CPT codes in order to produce a list of all outpatient codes suitable for identifying index hospital stays. All CPT codes that mapped to ICD-9 codes were then reviewed by a cardiologist to ensure accuracy and codes which did not meet the three criteria for inclusion were removed. A total of 138 CPT codes were selected for inclusion. The mapping from ICD-9 codes to CPT codes for outpatient stays was performed by working group members using the 2010 Procedural Cross Coder produced by Ingenix® as a guide [14].

Table 4 provides examples of procedures included and not included in the cohort based on the defined criteria.

Table 4. Examples of Cohort Inclusions and Exclusions Using Procedural Criteria*

Criterion	Example of Exclusion	Example of Inclusion
<i>Major Procedure</i>	<ul style="list-style-type: none"> ▪ Ligation of a varicose vein ▪ Arterial catheterization 	<ul style="list-style-type: none"> ▪ AAA Repair ▪ Endovascular stenting ▪ Carotid Endarterectomy ▪ Carotid stenting ▪ Lower extremity bypass
<i>Clinically Coherent Cohort</i>	<ul style="list-style-type: none"> ▪ Cardiac (CABG, PCI) ▪ Intracranial procedures ▪ Hemodialysis access procedures ▪ Inferior vena cava filters ▪ Transjugular intrahepatic portosystemic shunts (TIPS) 	
<i>Central to Hospital Stay</i>	<ul style="list-style-type: none"> ▪ Suture of an artery 	

**Excludes all cardiac, intracranial, venous, and renal dialysis procedures*

The final list of procedure codes recommended for inclusion in the cohort was then reviewed by the TEP. Table 5 lists all ICD-9 and CPT procedure codes included in the cohort. Figure 2 depicts the steps taken to define the measure cohort.

Figure 2. Steps for Defining Vascular Measure Cohort

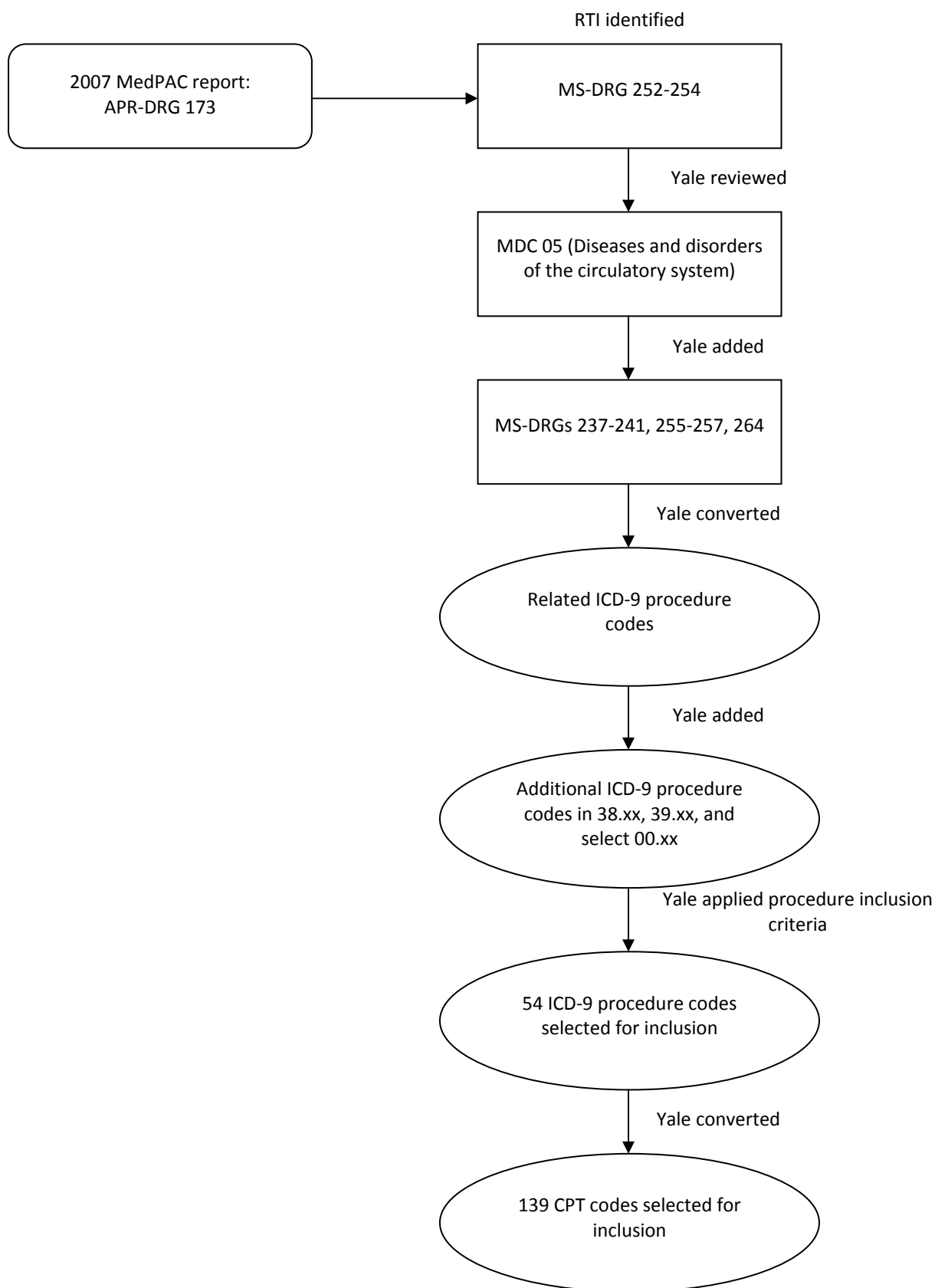


Table 5. Vascular Procedure Codes Included in Cohort

ICD-9/ CPT Code	ICD-9/CPT Code Description
ICD-9 Codes	
00.55	Insertion of drug-eluting stent(s) of other peripheral vessel(s), endograft(s), endovascular graft(s), stent grafts
00.60	Insertion of drug-eluting stent(s) of superficial femoral artery
00.61	Percutaneous angioplasty or atherectomy of precerebral (extracranial) vessel(s), basilar, carotid, vertebral
00.63	Percutaneous insertion of carotid artery stent(s), Includes: the use of any embolic protection device, distal protection device, filter device, or stent delivery system, Non-drug-eluting stent
00.64	Percutaneous insertion of other precerebral (extracranial) artery stent(s)
38.00	Incision of vessels-unspecified site
38.02	Incision of vessels-other vessels of head and neck
38.03	Incision of vessels-upper limb vessels
38.08	Incision of vessels-lower limb arteries
38.10	Endarterectomy-unspecified site
38.12	Endarterectomy-other vessels of head and neck
38.13	Endarterectomy-upper limb vessels
38.14	Endarterectomy-aorta
38.15	Endarterectomy-other thoracic vessels
38.16	Endarterectomy-abdominal arteries
38.18	Endarterectomy-lower limb arteries
38.30	Resection of vessel with anastomosis-unspecified site
38.32	Resection of vessel with anastomosis-other vessels of head and neck
38.33	Resection of vessel with anastomosis-upper limb vessels
38.34	Resection of Abdominal Aorta with anastomosis
38.35	Resection of vessel with anastomosis-other thoracic vessels
38.36	Resection of vessel with anastomosis-abdominal arteries
38.38	Resection of vessel with anastomosis-lower limb arteries
38.40	Resection of vessel with replacement-unspecified site
38.42	Resection of vessel with replacement-other vessels of head and neck
38.43	Resection of vessel with replacement-upper limb vessels
38.44	Resection of abdominal Aorta with replacement
38.45	Resection of vessel with replacement-thoracic vessel
38.46	Resection of vessel with replacement-abdominal artiers
38.48	Resection of vessel with replacement-lower limb arteries
38.66	Other excision of vessels-abdominal arteries
38.68	Other excision of vessels-lower limb arteries
39.22	Aorta-subclavian-carotid bypass
39.23	Other intrathoracic vascular shunt or bypass
39.24	Aorta-renal bypass
39.25	Aorta-iliac-femoral bypass

Table 5. Vascular Procedure Codes Included in Cohort

ICD-9/ CPT Code	ICD-9/CPT Code Description
39.26	Other intra-abdominal vascular shunt or bypass
39.29	Other (peripheral) vascular shunt or bypass
39.49	Other revision of vascular procedure
39.50	Angioplasty or atherectomy of other non-coronary vessel(s)
39.52	Other repair of aneurysm
39.53	Repair of arteriovenous fistula
39.54	Re-entry operation (aorta)
39.55	Reimplantation of aberrant renal vessel
39.56	Repair of blood vessel with tissue patch graft
39.57	Repair of blood vessel with synthetic patch graft
39.58	Repair of blood vessel with unspecified type of patch graft
39.59	Other repair of vessel
39.71	Endovascular repair of abdominal aortic aneurysm with graft
39.72	Endovascular repair or occlusion of head and neck vessels
39.73	Endovascular implantation of graft in thoracic aorta
39.74	Endovascular removal of obstruction from head and neck vessel(s)
39.79	Other endovascular repair (of aneurysm) of other vessels
39.90	Insertion of non-drug-eluting, non-coronary artery stent(s)
CPT Codes	
33320	Suture repair of aorta or great vessels; without shunt or cardiopulmonary bypass
33330	Insertion of graft, aorta or great vessels; without shunt, or cardiopulmonary bypass
33877	Repair of thoracoabdominal aortic aneurysm with graft, with or without cardiopulmonary bypass
33880	Endovascular repair of descending thoracic aorta (eg. aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption); involving coverage of left subclavian artery origin, initial endoprosthesis plus descending thoracic aortic extensions (s), if required, to level of celiac artery origin
33881	Endovascular repair of descending thoracic aorta (eg, aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption); not involving coverage of left subclavian artery origin, initial endoprosthesis plus descending thoracic aortic extensions(s), if required, to level of celiac artery origin
33886	Placement of distal extension prosthesis(s) delayed after endovascular repair of descending thoracic aorta
34001	Embolectomy of thrombectomy, with or without catheter; carotid, subclavian, or innominate artery, by neck incision
34101	Embolectomy or thrombectomy, with or without catheter; axillary, brachial, innominate, subclavian artery, by arm incision
34111	Embolectomy or thrombectomy, with or without catheter; radial or ulnar artery, by arm incision
34800	Endovascular repair of infrarenal abdominal aortic aneurysm or dissection; using nono-aortic tube prosthesis

Table 5. Vascular Procedure Codes Included in Cohort

ICD-9/ CPT Code	ICD-9/CPT Code Description
34802	Endovascular repair of infrarenal abdominal aortic aneurysm or dissection; using modular bifurcated prosthesis (1 docking limb)
34803	Endovascular repair of infrarenal abdominal aortic aneurysm or dissection; using modular bifurcated prosthesis (2 docking limb)
34804	Endovascular repair of infrarenal abdominal aortic aneurysm or dissection; using unibody bifurcated prosthesis
34805	Endovascular repair of infrarenal abdominal aortic aneurysm or dissection; using aorto-uniliac or aorto-unifemoral prosthesis
34808	Endovascular placement of iliac artery occlusion device (List separately in addition to code for primary procedure)
34812	Open femoral artery exposure for delivery of endovascular prosthesis, by groin incision, unilateral
34813	Placement of femoral-femoral prosthetic graft during endovascular aortic aneurysm repair (list separately in addition to code for primary procedure)
34820	Open iliac artery exposure for delivery of endovascular prosthesis or iliac occlusion during endovascular therapy, by abdominal or retroperitoneal incision, unilateral
34825	Placement of proximal or distal extension prosthesis for endovascular repair of infrarenal abdominal aortic or iliac aneurysm, false aneurysm, or dissection; initial vessel
34831	Open repair of infrarenal aortic aneurysm or dissection, plus repair of associated arterial trauma, following unsuccessful endovascular repair; aorto-bi-iliac prosthesis
34900	Endovascular graft placement for repair of iliac artery (eg, aneurysm, pseudoaneurysm, arteriovenous malformation, trauma)
35005	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, vertebral artery
35011	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm and associated occlusive disease, axillary-brachial artery, by arm incision
35013	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for ruptured aneurysm, axillary-brachial artery, by arm incision
35045	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, radial or ulnar artery
35081	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, abdominal aorta
35082	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for ruptured aneurysm, abdominal aorta

Table 5. Vascular Procedure Codes Included in Cohort

ICD-9/ CPT Code	ICD-9/CPT Code Description
35091	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, abdominal aorta involving visceral vessels (mesenteric, celiac, renal)
35092	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for ruptured aneurysm, abdominal aorta involving visceral vessels (mesenteric, celiac, renal)
35102	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, abdominal aorta involving iliac vessels (common, hypogastric, external)
35103	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for ruptured aneurysm, abdominal aorta involving iliac vessels (common, hypogastric, external)
35121	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, hepatic, celiac, renal, or mesenteric artery
35131	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, iliac artery (common, hypogastric, external)
35141	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, common femoral artery (profunda femoris, superficial femoral)
35142	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for ruptured aneurysm, common femoral artery (profunda femoris, superficial femoral)
35151	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, popliteal artery
35184	Repair, congenital arteriovenous fistula; extremities
35190	Repair, acquired or traumatic arteriovenous fistula; extremities
35201	Repair blood vessel, direct; neck
35206	Repair blood vessel, direct; upper extremity
35207	Repair blood vessel, direct; hand, finger
35216	Repair blood vessel, direct; intrathoracic without bypass
35221	Repair blood vessel, direct; intra-abdominal
35226	Repair blood vessel, direct; lower extremity
35231	Repair blood vessel with vein graft; neck
35236	Repair blood vessel with vein graft; upper extremity
35256	Repair blood vessel with vein graft; lower extremity
35266	Repair blood vessel with graft other than vein; upper extremity

Table 5. Vascular Procedure Codes Included in Cohort

ICD-9/ CPT Code	ICD-9/CPT Code Description
35276	Repair blood vessel with graft other than vein; intrathoracic, without bypass
35286	Repair blood vessel with graft other than vein; lower extremity
35301	Thromboendarterectomy, including patch graft, if performed; carotid, vertebral, subclavian, by neck incision
35302	Thromboendarterectomy, including patch graft, if performed; superficial femoral artery
35303	Thromboendarterectomy, including patch graft, if performed; popliteal artery
35304	Thromboendarterectomy, including patch graft, if performed; tibioperoneal trunk artery
35305	Thromboendarterectomy, including patch graft, if performed; tibial or peroneal artery, initial vessel
35306	Thromboendarterectomy, including patch graft, if performed; each additional tibial or peroneal artery (List separately in addition to code for primary procedure)
35321	Thromboendarterectomy, including patch graft, if performed; abdominal aorta
35355	Thromboendarterectomy, including patch graft, if performed, iliofemoral
35371	Thromboendarterectomy, including patch graft, if performed; common femoral
35372	Thromboendarterectomy, including patch graft, if performed; deep (profunda) femoral
35450	Transluminal balloon angioplasty, open; renal or other visceral artery
35452	Transluminal balloon angioplasty, open; aortic
35454	Transluminal balloon angioplasty, open; iliac
35456	Transluminal balloon angioplasty, open; femoral-popliteal
35458	Transluminal balloon angioplasty, open; brachiocephalic trunk or branches, each vessel
35459	Transluminal balloon angioplasty, open; tibioperoneal trunk and branches
35470	Transluminal balloon angioplasty, percutaneous; tibioperoneal trunk or branches, each vessel
35471	Transluminal balloon angioplasty, percutaneous; renal or visceral artery
35472	Transluminal balloon angioplasty, percutaneous; aortic
35473	Transluminal balloon angioplasty, percutaneous; iliac
35474	Transluminal balloon angioplasty, percutaneous; femoral-popliteal
35475	Transluminal balloon angioplasty, percutaneous; brachiocephalic trunk or branches, each vessel
35480	Transluminal peripheral atherectomy, open; renal or other visceral artery
35481	Transluminal peripheral atherectomy, open; aortic
35483	Transluminal peripheral atherectomy, open; femoral-popliteal
35484	Transluminal peripheral atherectomy, open; brachiocephalic trunk or branches, each vessel
35485	Transluminal peripheral atherectomy, open; tibioperoneal trunk and branches
35490	Transluminal peripheral atherectomy, percutaneous; renal or other visceral artery
35491	Transluminal peripheral atherectomy, percutaneous; aortic
35492	Transluminal peripheral atherectomy, percutaneous; iliac

Table 5. Vascular Procedure Codes Included in Cohort

ICD-9/ CPT Code	ICD-9/CPT Code Description
35493	Transluminal peripheral atherectomy, percutaneous; femoral-popliteal
35494	Transluminal peripheral atherectomy, percutaneous; brachiocephalic trunk or branches, each vessel
35495	Transluminal peripheral atherectomy, percutaneous; tibioperoneal trunk and branches
35506	Bypass graft, with vein; carotid-subclavian or subclavian-carotid
35518	Bypass graft, with vein; axillary-axillary
35521	Bypass graft, with vein; axillary-femoral
35523	Bypass graft, with vein; brachial-ulnar or radial
35525	Bypass graft, with vein; brachial-brachial
35531	Bypass graft, with vein; aortoceliac or aortomesenteric
35537	Bypass graft, with vein; aortoiliac
35539	Bypass graft, with vein; aortofemoral
35556	Bypass graft, with vein; femoral-popliteal
35558	Bypass graft, with vein; femoral-femoral
35565	Bypass graft, with vein; iliofemoral
35566	Bypass graft, with vein; femoral-anterior tibial, posterior tibial, peroneal artery or other distal vessels
35570	Bypass graft, with vein; tibial-tibial, peroneal-tibial, or tibial/peroneal trunk-tibial
35571	Bypass graft, with vein; popliteal-tibial, -peroneal artery or other distal vessels
35585	In-situ vein bypass; femoral-anterior tibial, posterior tibial, or peroneal artery
35606	Bypass graft, with other than vein; carotid-subclavian
35616	Bypass graft, with other than vein; subclavian-axillary
35637	Bypass graft, with other than vein; aortoiliac
35646	Bypass graft, with other than vein; aortobifemoral
35650	Bypass graft, with other than vein; axillary-axillary
35651	Bypass graft, with other than vein; aortofemoral-popliteal
35656	Bypass graft, with other than vein; femoral-popliteal
35661	Bypass graft, with other than vein; femoral-femoral
35663	Bypass graft, with other than vein; ilioiliac
35665	Bypass graft, with other than vein; iliofemoral
35681	Bypass graft; composite, prosthetic and vein (List separately in addition to code for primary procedure)
35685	Placement of vein patch or cuff at distal anastomosis of bypass graft, synthetic conduit (list separately in addition to code for primary procedure)
35697	Reimplantation, visceral artery to infrarenal aortic prosthesis, each artery (List separately in addition to code for primary procedure)
35701	Exploration (not followed by surgical repair), with or without lysis of artery; carotid artery
35761	Exploration (not followed by surgical repair), with or without lysis of artery; other vessels
35875	Thrombectomy of arterial or venous graft (other than hemodialysis graft or fistula)

Table 5. Vascular Procedure Codes Included in Cohort

ICD-9/ CPT Code	ICD-9/CPT Code Description
35876	Thrombectomy of arterial or venous graft (other than hemodialysis graft or fistula); with revision of arterial or venous graft
35879	Revision, lower extremity arterial bypass, without thrombectomy, open; With vein patch angioplasty
35881	Revision, lower extremity arterial bypass, without thrombectomy, open; with segmental vein interposition
35883	Revision, femoral anastomosis of synthetic arterial bypass graft in groin, open; with nonautogenous patch graft (eg, Dacron, ePTFE, bovine pericardium)
35884	Revision, femoral anastomosis of synthetic arterial bypass graft in groin, open; with autogenous vein patch graft
35903	Excision of infected graft; extremity
35905	Excision of infected graft; thorax
35907	Excision of infected graft; abdomen
37184	Primary percutaneous transluminal mechanical thrombectomy, noncoronary, arterial or arterial bypass graft, including fluoroscopic guidance and intraprocedural pharmacological thrombolytic injection(s); initial vessel
37185	Primary percutaneous transluminal mechanical thrombectomy, noncoronary, arterial or arterial bypass graft, including fluoroscopic guidance and intraprocedural pharmacological thrombolytic injection(s); second and all subsequent vessel(s) within the same vascular family (List separately in addition to code for primary mechanical thrombectomy procedure)
37186	Secondary percutaneous transluminal thrombectomy (eg, nonprimary mechanical, snare basket, suction technique), noncoronary, arterial or arterial bypass graft, including fluoroscopic guidance and intraprocedural pharmacological thrombolytic injections, provided in conjunction with another percutaneous intervention other than primary mechanical thrombectomy (List separately in addition to code for primary procedure)
37187	Percutaneous transluminal mechanical thrombectomy, vein(s), including intraprocedural pharmacological thrombolytic injections and fluoroscopic guidance
37204	Transcatheter occlusion or embolization (eg, for tumor destruction, to achieve hemostasis, to occlude a vascular malformation), percutaneous, any method, non-central nervous system, non-head or neck
37205	Transcatheter placement of an intravascular stent(s) (except coronary, carotid, and vertebral vessel), percutaneous; initial vessel
37206	Transcatheter placement of an intravascular stent(s) (except coronary, carotid, and vertebral vessel), percutaneous; each additional vessel (List separately in addition to code for primary procedure)
37207	Transcatheter placement of an intravascular stent(s) (non-coronary vessel), open; initial vessel
37208	Transcatheter placement of an intravascular stent(s) (non-coronary vessel), open; each additional vessel (List separately in addition to code for primary procedure)
37215	Transcatheter placement of intravascular stent(s), cervical carotid artery, percutaneous; with distal embolic protection

Table 5. Vascular Procedure Codes Included in Cohort

ICD-9/ CPT Code	ICD-9/CPT Code Description
37216	Transcatheter placement of intravascular stent(s), cervical carotid artery, percutaneous; without distal embolic protection
37799	Unlisted procedure, vascular surgery
0075T	Transcatheter placement of extracranial vertebral or intrathoracic carotid artery stent(s), including radiologic supervision and interpretation, percutaneous; initial vessel
0078T	Endovascular repair using prosthesis of abdominal aortic aneurysm, pseudoaneurysm or dissection, abdominal aorta involving visceral branches (superior mesenteric, celiac and/or renal arteries)
0080T	Endovascular repair of abdominal aortic aneurysm, pseudoaneurysm or abdominal aortic aneurysm involving visceral vessels (superior mesenteric, celiac or renal), using fenestrated modular bifurcated prosthesis (2 docking limbs), radiological supervision and interpretation
0081T	Placement of visceral extension prosthesis for endovascular repair of abdominal aortic aneurysm involving visceral vessels each visceral branch, radiological supervision and interpretation (Use separately in addition to code for primary procedure)

The process of procedure selection through expansion of MedPAC's definition of "other vascular" led to capturing a greater number of vascular procedures as index procedures, a greater number of readmissions, and a higher readmission rate (Table 6).

Table 6. Comparison of MedPAC and YNHHS/CORE Approach and Results

Characteristic	MedPAC (2005 Medicare claims)	YNHHS/CORE (2009 Medicare claims)
Setting	Inpatient	Inpatient and hospital outpatient
Definition of readmission	Potentially preventable*	All-cause
Readmission timeframe	15 days	30 days
Number of admissions/hospital stays	~154,000	256,610
Number of readmissions	18,029	35,579
Readmission rate	11.7%	13.9%

*using 3M's software that defines potentially preventable readmissions

2.4.2 Hospital Stay Exclusions

Hospital stays are excluded from the cohort if they meet any one of the following criteria:

- 1) Lack of continuous enrollment in Medicare Fee-for-Service (FFS) for 12 months prior to index hospital stay. Hospital stays for patients who lack continuous

enrollment in Medicare FFS for 12 months prior to index hospital stay are excluded.

Rationale: We exclude these hospital stays to ensure full data availability for risk adjustment.

- 2) In-hospital deaths. Hospital stays for patients with in-hospital deaths are excluded.

Rationale: Patients who die during the initial hospital stay are not at risk for readmission.

- 3) Transfers-out. Hospital stays in which patients receive qualifying vascular procedures and are then transferred to another acute care facility are excluded.

Rationale: In this instance, the hospital that performed the vascular procedure does not provide discharge care and cannot be fairly held responsible for outcomes following discharge. Of note, these stays are a part of a single acute episode of care and only the transfer-out admission is excluded from the index cohort (i.e., not the full episode of care; if a patient is transferred from one hospital to another and has a qualifying vascular procedure at the second hospital, which then discharges them to a non-acute setting, the second hospital stay is part of the index cohort and evaluated for readmission).

- 4) Lack of follow-up in Medicare FFS for at least 30 days post discharge. Hospital stays for patients without at least 30-days of enrollment in Medicare FFS after the index stay are excluded.

Rationale: We exclude these hospital stays because the 30-day readmission outcome cannot be assessed in this group.

- 5) Hospital stays for patients who leave hospital against medical advice (AMA). Hospital stays for patients who are discharged AMA are excluded.

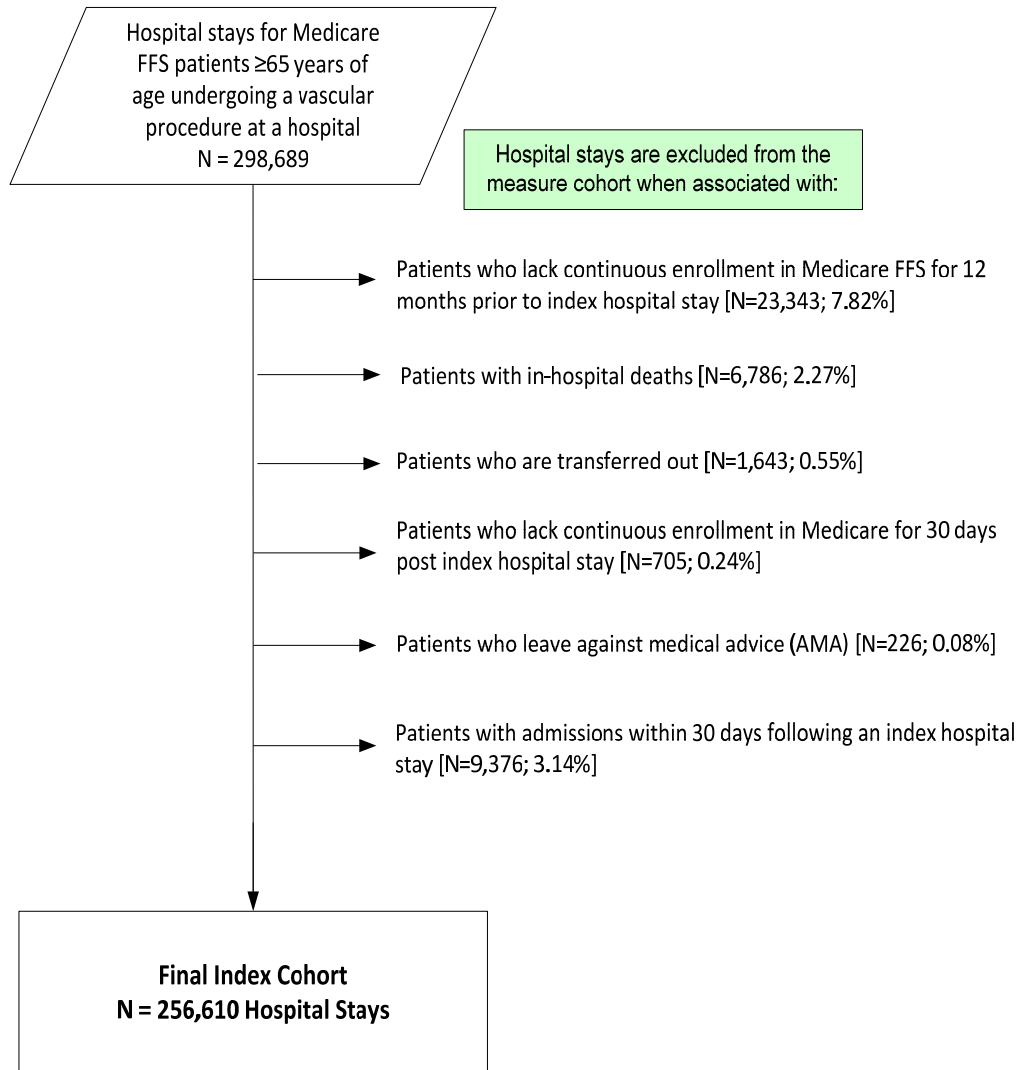
Rationale: We exclude hospital stays for patients who are discharged AMA because providers in these circumstances do not have the opportunity to deliver full care and prepare the patient for discharge.

- 6) Subsequent qualifying vascular procedures within 30 days of discharge of an index stay. Subsequent hospital stays with a qualifying vascular procedure within 30 days of discharge from an index hospital stay will not be counted as another index hospital stay.

Rationale: Qualifying vascular procedures occurring within 30 days of discharge of an index hospital stay fall within the 30-day readmission assessment period during which no new hospital stay can be counted as an index hospital stay. The next eligible hospital stay is the first hospital stay with a qualifying vascular procedure after the 30-day readmission assessment period.

Figure 3 presents the details of the derivation of the development cohort (2009 Dataset A – refer to Section 2.6), which includes the total number of hospital stays with a qualifying vascular procedure, the proportion excluded as a result of each exclusion criterion, and the number included in the final sample as index hospital stays. Dataset A consists of 256,610 admissions at 2,659 hospitals. These hospitals represent all hospitals which performed at least one qualifying vascular procedure; no other hospitals submitted qualifying Medicare claims in 2009.

Figure 3. Hospital Stay Exclusions



2.4.3 Procedure Group Assignment

Both procedure type (open vs. endovascular) and anatomic location of the procedure influence patient readmission risk. For example, a patient undergoing an open surgical procedure to repair a ruptured aortic aneurism will likely have a higher risk of readmission than a patient undergoing endovascular repair of a vessel in the neck. Accordingly, for the purposes of risk adjustment, hospital stays were assigned to one of six groups indicating procedure type and anatomic location or to one of two anatomically unspecified groups. First, procedures were classified as open or endovascular. Then, when possible, we mapped procedure codes to one of three anatomic locations: head/neck, thoracic/abdominal, or limb. If the procedure could not definitively be assigned to one of these three groups, it was assigned to the unspecified group (see Appendix E for procedure group assignment of individual codes):

Anatomically Specified Procedure Groups

- Head/neck-endovascular
- Head/neck-open
- Thoracic/abdominal-endovascular
- Thoracic/abdominal-open
- Limb-endovascular
- Limb-open

Anatomically Unspecified Procedure Groups

- Unspecified-endovascular
- Unspecified-open

We used the following algorithm to assign hospital stays to procedure groups based on the procedures associated with the hospital stays and the accompanying ICD-9 condition codes (see Figure 4):

Rule #1

For hospital stays with one qualifying procedure, the stay is assigned to the associated group. The same applies if a hospital stay had multiple procedures that all map to the same procedure group.

Example 1: A hospital stay with ICD-9 procedure code 38.18 (Endarterectomy-lower limb arteries) is assigned to "limb-open" group

Example 2: A hospital stay with ICD-9 procedure code 39.52 (Other repair of aneurysm) is assigned to "unspecified-open" group

Rule #2

For hospital stays with qualifying procedures which can be mapped to more than one procedure group, the stay is assigned to the highest-risk procedure group, as determined by clinical input and empiric evidence of mortality and readmission risk, as well as average length of stay. The stays are assigned in the following order:

1. Limb-open (highest)
2. Thoracic/abdominal-open
3. Limb-endovascular
4. Thoracic/abdominal-endovascular
5. Head/neck-endovascular
6. Head/neck-open

Example: A hospital stay with ICD-9 procedure code 38.18 (Endarterectomy-lower limb arteries) and procedure code 38.12 (Endarterectomy-other vessels of head and neck) is assigned to "limb-open" group as it has a higher risk than "head/neck-open" group

Rule #3

Hospital stays which a) only contain procedures in anatomically unspecified procedure groups and b) can be anatomically classified using accompanying ICD-9 primary discharge diagnosis code

For hospital stays containing only procedure codes which cannot be assigned to any procedure group, rules were created to assign hospital stays to anatomic groups based on accompanying ICD-9 primary discharge diagnosis. Where the discharge diagnosis *identified a vascular problem in a clear anatomic location*, hospital stays were assigned to the appropriate anatomically specified procedure group indicated by the discharge diagnosis; otherwise they were assigned to anatomically unspecified procedure groups (see Appendix F).

Example: A hospital stay with ICD-9 procedure code 39.90 (insertion of drug-eluting, non-coronary artery stent(s)) and accompanying primary ICD-9 discharge diagnosis of 440.21 (Atherosclerosis of an extremity in a native artery with claudication) assigned to the "limb-endovascular" group

Rule #4

Hospital stays which a) only contain procedures in anatomically unspecified procedure groups and b) cannot be anatomically classified using accompanying ICD-9 primary discharge diagnosis code

If a hospital stay cannot be assigned to a specified procedure group based on the rules above, the stay is assigned to an anatomically unspecified group. If the hospital

stay contains procedures in both anatomically unspecified procedure groups, the stay is assigned to the highest-risk procedure group as determined with clinical input and empiric evidence, in the following order:

1. Unspecified-open
2. Unspecified-endovascular

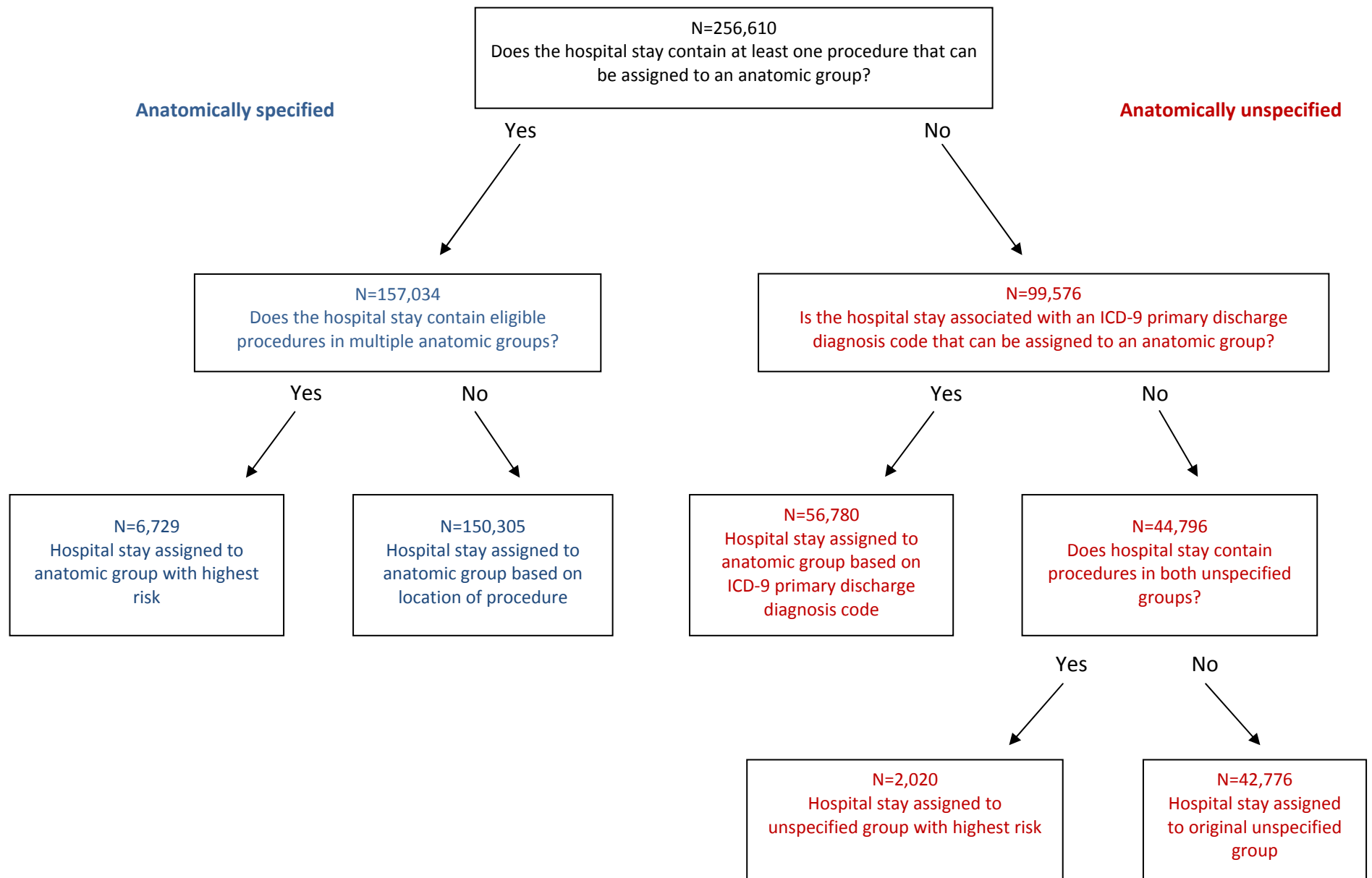
Example: A hospital stay with an ICD-9 procedure code of 39.52 (other repair of aneurysm) and 39.79 (other endovascular repair of aneurysm of other vessels) would be assigned to unspecified-open

Table 7 depicts the final procedure groupings and the number of hospital stays assigned to each.

Table 7. Number of hospital stays by procedure group

Procedure Group	Number of Hospital Stays
Head/Neck-Endovascular	11,169
Head/Neck-Open	52,219
Thoracic/Abdominal-Endovascular	40,115
Thoracic/Abdominal-Open	13,121
Limb-Endovascular	61,260
Limb-Open	33,930
Unspecified-Endovascular	29,421
Unspecified-Open	15,375
Total	256,610

Figure 4. Assignment of Hospital Stays to Procedure Groups



2.5 Data Sources

We obtained data on index hospital stays, readmissions, and comorbidity data from Medicare's Standard Analytic File (SAF). Index hospital stays were derived from Medicare Part A inpatient and outpatient data. Readmissions were assessed using Part A inpatient data. Comorbidities were derived using Part A inpatient, outpatient, and Part B office visit Medicare claims in the 12 months prior to and during the index hospital stay. Enrollment status was obtained from Medicare's enrollment database which contains beneficiary demographic and benefit/coverage information.

2.5.1 2008 and 2009 Part A Inpatient Data

Part A data includes claims for Medicare inpatient admission, skilled nursing facility care, some home health agency services, and hospice care. For purposes of this project, Part A inpatient data is used to refer to inpatient services only and includes data from two time periods:

- *Index hospital stay*: Index hospital stay data are based on the inclusion/exclusion criteria for vascular procedures, and comorbidities (if any) are identified from the secondary diagnoses associated with the index hospital stay.
- *Pre-index*: 12 months prior to the index hospital stay

2.5.2 2008 and 2009 Part A Outpatient Data – Index and 12 Months Pre-index

Part A outpatient data refers to Medicare claims paid for the facility component of surgical or diagnostic procedures, emergency room care, and other non-inpatient services performed in a hospital outpatient department or ambulatory surgical/diagnostic center during the following two time periods:

- *Index hospital stay*: index hospital stay data are based on the inclusion/exclusion criteria for vascular procedures, and comorbidities (if any) are identified from the secondary diagnoses associated with the index hospital stay.
- *Pre-index*: 12 months prior to the index hospital stay

2.5.3 Part B data – 12 Months Pre-index

Part B data refers to Medicare claims for the services of physicians (regardless of setting) and other outpatient care, services, and supplies. For purposes of this project, Part B services include only face-to-face encounters between a care provider and

patient. We thus do not include services such as laboratory tests, medical supplies, or other ambulatory services.

2.6 Model Development and Testing

For model development, we used two datasets. The first, the full 2009 calendar year, was used to derive the cohort and define the outcome (Dataset A). All final model results presented in Sections 3.1 and 3.3 are produced using this dataset. To determine variables for inclusion in the model (variable selection), we use a randomly selected 50% sample of the full 2009 dataset (Dataset A1).

We used Dataset A1 plus two additional datasets to assess model reliability. One additional dataset is the other half of the full 2009 dataset (Dataset A2). The other includes data from the full 2008 calendar year (Dataset B). Table 8 summarizes the different datasets and their purposes.

Table 8. Datasets for Model Development and Testing

Dataset	Year	Purpose
Dataset A	2009 (100%)	Development (cohort and outcome definition)
Dataset A1	2009 (50%)	Development (variable selection); Reliability testing
Dataset A2	2009 (50%)	Reliability testing
Dataset B	2008 (100%)	Reliability testing

2.7 Candidate and Final Risk-adjustment Variables

Our goal was to develop a parsimonious model that includes clinically relevant variables strongly associated with risk of readmission. The candidate variables for the model were derived from the index hospital stay, with comorbidities identified from the index hospital stay secondary diagnoses (excluding potential complications), 12 months pre-index hospital stay inpatient Part A data, outpatient hospital data, and Part B physician visit data.

For candidate variable selection using Dataset A1 (see Table 8), we started with the 189 diagnostic groups included in the Hierarchical Condition Category (HCC) clinical classification system [15]. The HCC clinical classification system was developed for CMS in preparation for all-encounter risk adjustment for Medicare Advantage (managed care) plans and represented a refinement of an earlier risk-adjustment method based solely on principal inpatient diagnosis. The HCC model makes use of all physician and hospital encounter diagnoses and was designed to predict a beneficiary's expenditures based on the total clinical profile represented by all of his/her assigned HCCs. Under the HCC algorithm, the 15,000+ ICD-9-CM diagnosis codes are first assigned to one of 804 mutually exclusive groupings ("DxGroups") and then subsequently

aggregated into 189 condition categories (CCs). We used the ICD-9-to-CC assignment map, which is maintained by CMS and posted at www.qualitynet.org. To select candidate variables a team of clinicians reviewed all 189 CCs and excluded those that were not relevant to the Medicare population or that were not clinically relevant to the readmission outcome (e.g., attention deficit disorder, female infertility). Clinically relevant CCs were selected as candidate variables; some of these CCs were combined into clinically coherent groups. For each CC, the team determined whether the particular condition might represent a complication of care that developed during the hospital stay and was not present at the time of arrival at the hospital. A list of CCs that were considered as potential complications, and were thus not included in the risk adjustment if coded *only* during the index hospital stay, is presented in Appendix G. Other candidate variables included age, gender, and procedure group (e.g., limb-open, head/neck-endovascular). All candidate variables are listed in Table 9.

Table 9. Candidate Variables for Risk Adjustment

Category	Variable	CC
Demographics	Age (>65)	
	Gender (Male)	
Procedure Group	Unspecified-Open	
	Unspecified-Endovascular	
	Limb-Open	
	Thoracic/Abdominal-Open	
	Limb-Endovascular	
	Thoracic/Abdominal-Endovascular	
	Head/Neck-Endovascular	
	Head/Neck-Open	
	Unspecified-Open	
Comorbidities	Diabetes and DM Complications	15, 17-20, 119-120
	Diabetes with Neurologic or Peripheral Circulatory Manifestation	16
	Precerebral Arterial Occlusion and Transient Cerebral Ischemia	97
	Cerebral Atherosclerosis and Aneurysm	98
	Cerebrovascular Disease, Unspecified	99
	Cerebrovascular Disease Late Effects, Unspecified	103
	Vascular Disease with Complications	104
	Vascular Disease	105
	Other Circulatory Disease	106
	History of Infection	1, 3-6
	Septicemia/Shock	2
	Metastatic Cancer and Acute Leukemia	7
	Cancer	8-12
	Other Neoplasms	13

Table 9. Candidate Variables for Risk Adjustment

Category	Variable	CC
	Benign Neoplasms of Skin, Breast, Eye	14
	Protein-Calorie Malnutrition	21
	Disorders of Fluid/Electrolyte/Acid-Base	22-23
	Other Endocrine/Metabolic/Nutritional Disorders	24
	Liver and Biliary Disease	25-30
	Intestinal Obstruction/Perforation	31
	Pancreatic Disease	32
	Inflammatory Bowel Disease	33
	Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders	34
	Other Gastrointestinal Disorders	36
	Bone/Joint/Muscle Infections/Necrosis	37
	Rheumatoid Arthritis and Inflammatory Connective Tissue Disease	38
	Disorders of the Vertebrae and Spinal Discs	39
	Osteoarthritis of Hip or Knee	40
	Osteoporosis and Other Bone/Cartilage Disorders	41
	Other Musculoskeletal and Connective Tissue Disorders	43
	Severe Hematological Disorders	44
	Disorders of Immunity	45
	Coagulation Defects and Other Specified Hematological Disorders	46
	Iron Deficiency and Other/Unspecified Anemias and Blood Disease	47
	Delirium and Encephalopathy	48
	Dementia or Senility	49-50
	Drug/alcohol dependence/psychosis	51-52
	Drug/Alcohol Abuse, Without Dependence	53
	Major Psychiatric Disorders	54-56
	Depression	58
	Anxiety Disorders	59
	Other Psychiatric Disorders	60
	Hemiplegia, Paraplegia, Paralysis, Functional Disability	67-69, 100-102
	Polyneuropathy	71
	Parkinsons and Huntingtons Diseases	73
	Seizure Disorders and Convulsions	74
	Coma, Brain Compression/Anoxic Damage	75
	Mononeuropathy, Other Neurological Conditions/Injuries	76
	Respirator Dependence/Tracheostomy Status	77
	Respiratory Arrest/Cardio-Respiratory Failure and Shock	78-79

Table 9. Candidate Variables for Risk Adjustment

Category	Variable	CC
	Congestive heart failure	80
	Acute coronary syndrome	81-82
	Coronary atherosclerosis or angina	83-84
	Heart Infection/Inflammation, Except Rheumatic	85
	Valvular and Rheumatic Heart Disease	86
	Congenital cardiac/circulatory defect	87-88
	Hypertensive Heart and Renal Disease or Encephalopathy	89
	Hypertensive heart disease	90
	Hypertension	91
	Specified heart arrhythmias	92-93
	Other and Unspecified Heart Disease	94
	Cerebral Hemorrhage	95
	Ischemic or Unspecified Stroke	96
	COPD	108
	Fibrosis of Lung and Other Chronic Lung Disorder	109
	Asthma	110
	Pneumonia	111-113
	Pleural Effusion/Pneumothorax	114
	Other Lung Disorders	115
	Retinal Disorders, except Detachment and Vascular Retinopathies	121
	Glaucoma	122
	Cataract	123
	Other Eye Disorders	124
	Kidney Transplant Status	128
	End-stage Renal Disease or Dialysis	129, 130
	Renal Failure	131
	Nephritis	132
	Urinary Obstruction and Retention	133
	Urinary Tract Infection/Other Urinary Tract Disorders	135-136
	Decubitus Ulcer of Skin	148
	Chronic Ulcer of Skin, Except Decubitus	149
	Cellulitis, Local Skin Infection	152
	Trauma	154-156, 158-161
	Vertebral Fractures	157
	Other Injuries	162
	Poisonings and Allergic Reactions	163
	Major Organ/Other Organ Transplant/Replacement	173-175
	Artificial Openings for Feeding or Elimination	176
	Amputation Status, Lower Limb/Upper Limb	177-178

To inform variable selection a modified approach to stepwise logistic regression was performed. Dataset A1 was used to create 500 bootstrap samples. For each sample, we ran a logistic regression that included all candidate variables. The results were summarized to show the percentage of times that each of the candidate variables was significantly associated with readmission (at the $p < 0.05$ level) in the 500 bootstrap samples (e.g., 70% would mean that the candidate variable was selected as significant at $p < 0.05$ in 70% of the estimations). We also assessed the direction and magnitude of the regression coefficients.

The working group reviewed these results and decided to retain all risk adjustment variables above a 70% cutoff. The 70% cutoff was chosen because variables above this cutoff demonstrate a relatively strong association with readmission and were clinically relevant. The one exception was cataract, which despite a high frequency of being associated with readmission (99.8%) was not considered clinically relevant. Variables which were significantly associated with readmission in less than 70% of the bootstrap samples were only included in the final model if they were markers for end of life/frailty or they were on the same clinical spectrum as a variable above the 70% cutoff and were clinically important for vascular procedure patients. This resulted in a final risk-adjusted readmission model that included 46 variables (Table 10).

Table 10. Final Model Variables

Category	Variable	CC
Intercept		
Demographics	Age (>65) (mean)	
	Gender (Male)	
Procedure Group	Unspecified-Open	
	Unspecified-Endovascular	
	Limb-Open	
	Thoracic/Abdominal-Open	
	Limb-Endovascular	
	Thoracic/Abdominal-Endovascular	
	Head/Neck-Endovascular	
	Head/Neck-Open	
Vascular Comorbidity	Diabetes or DM complications	15, 17-20, 119-120
	Diabetes with Neurologic or Peripheral Circulatory Manifestation	16
	Precerebral Arterial Occlusion and Transient Cerebral Ischemia	97
	Cerebral Atherosclerosis and Aneurysm	98
	Cerebrovascular Disease, Unspecified	99
	Cerebrovascular Disease Late Effects, Unspecified	103
	Vascular Disease with Complications	104
	Vascular Disease	105
Other Comorbidity	History of infection	1, 3-6
	Metastatic cancer or acute leukemia	7
	Cancer	8-12
	Benign neoplasms of skin, breast and eye	14
	Protein-calorie malnutrition	21
	Disorders of fluid, electrolyte, acid-base	22, 23
	Other Endocrine/Metabolic/Nutritional Disorders	24
	Pancreatic Disease	32
	Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders	34
	Severe hematological disorders	44
	Dementia or other specified brain disorders	49-50
	Hemiplegia, paraplegia, paralysis, functional disability	67-69, 100-102
	Congestive heart failure	80
	Acute coronary syndrome	81-82
	Coronary atherosclerosis or angina	83-84
	Hypertensive Heart and Renal Disease or Encephalopathy	89
	Hypertensive heart disease	90
	Hypertension	91

Table 10. Final Model Variables

Category	Variable	CC
	Specified arrhythmias	92-93
	Ischemic or Unspecified Stroke	96
	COPD	108
	Pneumonia	111-113
	Other Lung Disorders	115
	End stage renal disease or dialysis	129, 130
	Renal failure	131
	Chronic Ulcer of Skin, Except Decubitus	149
	Cellulitis, local skin infection	152
	Other injuries	162

2.8 Statistical Approach to Model Development

Due to the natural clustering of the observations within hospitals, we estimated hierarchical logistic regression models. We modeled the log-odds of readmission within 30 days of discharge from an index hospital stay in which a qualifying vascular procedure was performed as a function of patient demographic and clinical characteristics, and an intercept with the hospital specific random effect. This strategy accounts for within-hospital correlation of the observed outcomes and models the assumption that underlying differences in quality among the health care facilities being evaluated lead to systematic differences in outcomes.

We used the above strategy to calculate the hospital-specific RSRRs. These rates are calculated as the ratio of “predicted” number of readmissions to expected number of readmissions, multiplied by the national unadjusted readmission rate. The expected number of readmissions for each hospital is estimated using its patient mix and the average hospital-specific intercept. The predicted number of readmissions in each hospital was estimated given the same patient mix but an estimated hospital-specific intercept. Operationally, the expected number of readmissions for each hospital is obtained by summing the expected readmission probabilities for all patients in the hospital. The expected readmission probability for each patient is calculated via the hierarchical model by applying the subsequent estimated regression coefficients to the observed patient characteristics and adding the average of the hospital-specific intercepts.

The predicted number of readmissions for each hospital is calculated by summing the predicted readmission probabilities for all patients in the hospital. The predicted readmission probability for each patient is calculated through the hierarchical model by applying the estimated regression coefficients to the patient characteristics observed and adding the hospital-specific

intercept. In order to assess hospital performance in any specific year (e.g. Datasets A2 and B, see Section 2.6), we re-estimate the model coefficients using that year's data.

More specifically, we estimate two types of regression models. First, for variable selection, we fit a logistic regression model linking the outcome to the risk factors [16]. Let Y_{ij} denote the outcome (equal to 1 if patient readmitted within 30 days, zero otherwise) for the j^{th} patient discharged from the i^{th} hospital; \mathbf{Z}_{ij} denotes a set of risk factors, identified via administrative data. Let I denote the total number of hospitals and n_i the number of index patient stays in hospital i . We assume the outcome is related linearly to the covariates via a known linked function, h , where

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

and $\mathbf{Z}_{ij} = (Z_{1ij}, Z_{2ij}, \dots, Z_{pij})$ is a set of p patient-specific covariates. In our case, h = the logit link.

To account for the natural clustering of observations within hospitals and estimated risk-standardized readmission rate (RSRR) as detailed in next section, we estimate a hierarchical logistic regression model that links the risk factors to the same outcome and a hospital-specific random effect,

$$h(Y_{ij}) = \alpha_i + \beta \mathbf{Z}_{ij} \quad (2)$$

$$\alpha_i = \mu + \omega_i; \quad \omega_i \sim N(0, \tau^2) \quad (3)$$

where α_i represents the hospital-specific intercept, \mathbf{Z}_{ij} is defined as above, μ the mean intercept over all hospitals in the sample, and τ^2 the between-hospital variance component [17]. This model separates within-hospital variation from between-hospital variation. Both hierarchical logistic regression models and logistic regression models are estimated using the SAS software system (SAS 9.2 GLIMMIX and LOGISTIC procedures, respectively).

We first fit the logistic regression model described in Equation (1) using the logit link. Having identified the covariates that remained, we next fit the hierarchical logistic regression model described in Equations (2) and (3), again using the logit link function; e.g.,

$$\begin{aligned} \text{Logit } (P(Y_{ij} = 1)) &= \alpha_i + \beta \mathbf{Z}_{ij} \\ \alpha_i &= \mu + \omega_i; \quad \omega_i \sim N(0, \tau^2) \end{aligned}$$

where \mathbf{Z}_{ij} consisted of the covariates retained in the logistic regression model. As before, $Y_{ij} = 1$ if patient j treated at hospital i had the event; 0 otherwise.

2.9 Hospital Performance Reporting

Using the set of risk factors in the logistic regression model, we fit the hierarchical logistic regression model defined by Equations (2) - (3) and estimate the parameters, $\hat{\mu}$, $\{\hat{\alpha}_1, \hat{\alpha}_2, \dots, \hat{\alpha}_I\}$, $\hat{\beta}$, and $\hat{\sigma}^2$. We calculate a standardized outcome, s_i , for each hospital by computing the ratio of the number of predicted readmissions to the number of expected readmissions, multiplied by the unadjusted overall readmission rate, \bar{y} . Specifically, we calculate

$$\text{Predicted} \quad \hat{y}_{ij}(Z) = h^{-1}(\hat{\alpha}_i + \hat{\beta}Z_{ij}) \quad (4)$$

$$\text{Expected} \quad \hat{e}_{ij}(Z) = h^{-1}(\hat{\mu} + \hat{\beta}Z_{ij}) \quad (5)$$

$$\hat{s}_i(Z) = \frac{\sum_{j=1}^{n_i} \hat{y}_{ij}(Z)}{\sum_{j=1}^{n_i} \hat{e}_{ij}(Z)} \times \bar{y} \quad (6)$$

If more (fewer) “predicted” cases than “expected” cases have the outcome in a hospital, then \hat{s}_i will be higher (lower) than the unadjusted average. For each hospital, we can compute an interval estimate of s_i to characterize the level of uncertainty around the point estimate using bootstrapping simulations. The point estimate and interval estimate can be used to characterize and compare hospital performance (e.g., higher than expected, as expected, or lower than expected). See Figure 5 for analysis steps.

2.9.4 Creating Interval Estimates

Because the statistic described in Equation 6 (Section 2.10) is a complex function of parameter estimates, we use the re-sampling technique, bootstrapping, to derive an interval estimate. Bootstrapping has the advantage of avoiding unnecessary distributional assumptions.

2.9.5 Algorithm

Let I denote the total number of hospitals in the sample. We repeat steps 1-4 below for $b = 1, 2, \dots, B$ times:

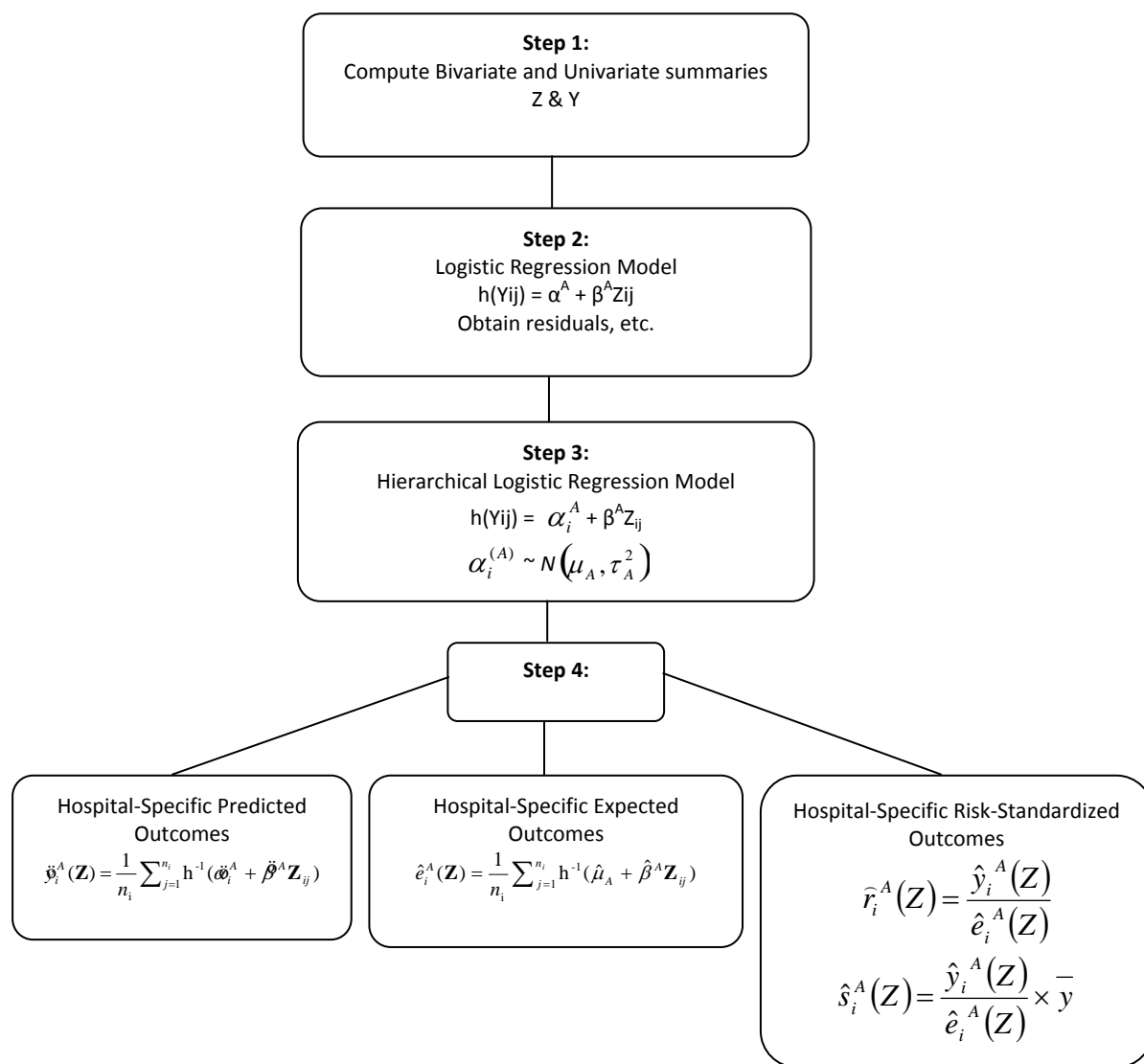
1. Sample I hospitals with replacement.
2. Fit the hierarchical logistic regression model using all patients within each sampled hospital. We use as starting values the parameter estimates obtained by fitting the model to all hospitals. If some hospitals are selected more than once in a bootstrapped sample, we treat them as distinct so that

we have I random effects to estimate the variance components. At the conclusion of Step 2, we have:

- a. $\hat{\beta}^{(b)}$ (the estimated regression coefficients of the risk factors).
 - b. The parameters governing the random effects, hospital adjusted outcomes, distribution, $\hat{\mu}^{(b)}$ and $\hat{\tau}^{2(b)}$.
 - c. The set of hospital-specific intercepts and corresponding variances, $\{\hat{\alpha}_i^{(b)}, \text{var}(\hat{\alpha}_i^{(b)}); i = 1, 2, \dots, I\}$.
3. We generate a hospital random effect by sampling from the distribution of the hospital-specific distribution obtained in Step 2c. We approximate the distribution for each random effect by a normal distribution. Thus, we draw $\alpha_i^{(b*)} \sim N(\hat{\alpha}_i^{(b)}, \text{var}(\hat{\alpha}_i^{(b)}))$ for the unique set of hospitals sampled in Step 1.
 4. Within each unique hospital i sampled in Step 1, and for each case j in that hospital, we calculate $\hat{y}_{ij}^{(b)}$, $\hat{e}_{ij}^{(b)}$, and $\hat{s}_i(Z)^{(b)}$ 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 hospital-standardized outcome can be computed by identifying the 2.5th and 97.5th percentiles of the B estimates (or the percentiles corresponding to the alternative desired intervals) [18].

Figure 5. Analysis Steps



3. RESULTS

3.1 Model Results

Table 11 shows the number of hospital stays and number of hospitals associated with each of the datasets used for development and testing as outlined in Section 2.6.

Table 11. Description of Development and Testing Datasets

Dataset	Year	Purpose	Number of Hospital Stays	Number of Hospitals
Dataset A	2009 (100%)	Development (cohort and outcome definition)	256,610	2,659
Dataset A1	2009 (50%)	Development (variable selection); Reliability testing	128,490	2,506
Dataset A2	2009 (50%)	Reliability testing	128,120	2,475
Dataset B	2008 (100%)	Reliability testing	259,597	2,711

The frequencies of model variables for all datasets, as shown in Table 12, are consistent over the two years of data.

Table 12. 30-Day Readmission Model Risk Factor Frequency by Dataset

Description	2009 Dataset A (%)	2009 Dataset A1 (%)	2009 Dataset A2 (%)	2008 Dataset B (%)
Demographics				
Age (>65) (mean)	11.51	11.51	11.51	11.53
Gender (Male)	55	55	55	55
Vascular Procedure				
Unspecified-Open	6	6	6	6
Unspecified-Endovascular	11	11	12	11
Limb-Open	13	13	13	13
Thoracic/Abdominal-Open	5	5	5	6
Limb-Endovascular	24	24	24	23
Thoracic/Abdominal-Endovascular	16	16	16	16
Head/Neck-Endovascular	4	4	4	4
Head/Neck-Open	20	20	20	21
Vascular Comorbidity				
Diabetes or DM complications (CCs 15,	44	45	44	44

Table 12. 30-Day Readmission Model Risk Factor Frequency by Dataset

Description	2009 Dataset A (%)	2009 Dataset A1 (%)	2009 Dataset A2 (%)	2008 Dataset B (%)
17-20, 119-120)				
Diabetes with Neurologic or Peripheral Circulatory Manifestation (CC16)	12	12	12	12
Precerebral Arterial Occlusion and Transient Cerebral Ischemia (CC97)	45	45	45	46
Cerebral Atherosclerosis and Aneurysm (CC98)	6	6	6	6
Cerebrovascular Disease, Unspecified (CC99)	2	2	2	2
Cerebrovascular Disease Late Effects, Unspecified (CC103)	3	3	3	3
Vascular Disease with Complications (CC104)	24	24	24	24
Vascular Disease (CC105)	73	73	72	72
Other Comorbidity				
History of infection (CCs 1, 3-6)	25	25	26	25
Metastatic cancer or acute leukemia (CC7)	2	2	2	2
Cancer (CC8-12)	22	22	22	22
Benign neoplasms of skin, breast and eye (CC14)	12	12	12	12
Protein-calorie malnutrition (CC21)	4	4	4	4
Disorders of fluid, electrolyte, acid-base (CCs 22, 23)	26	26	26	25
Other Endocrine/Metabolic/Nutritional Disorders (CC24)	80	80	79	78
Pancreatic Disease (CC32)	2	2	2	2
Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders (CC34)	11	11	11	11
Severe hematological disorders (CC44)	2	2	2	2
Dementia or other specified brain disorders (CCs 49-50)	11	11	11	10
Hemiplegia, paraplegia, paralysis, functional disability (CCs 67-69, 100-102)	5	5	5	5
Congestive heart failure (CC80)	27	27	27	27
Acute coronary syndrome (CCs 81-82)	10	10	10	11

Table 12. 30-Day Readmission Model Risk Factor Frequency by Dataset

Description	2009 Dataset A (%)	2009 Dataset A1 (%)	2009 Dataset A2 (%)	2008 Dataset B (%)
Coronary atherosclerosis or angina (CCs 83-84)	64	64	64	64
Hypertensive Heart and Renal Disease or Encephalopathy (CC89)	17	17	17	16
Hypertensive heart disease (CC90)	7	7	7	7
Hypertension (CC91)	87	87	86	86
Specified arrhythmias (CCs 92-93)	35	35	36	35
Ischemic or Unspecified Stroke (CC96)	12	12	11	12
COPD (CC108)	33	33	32	33
Pneumonia (CC s 111-113)	15	15	15	15
Other Lung Disorders (CCs 115)	28	28	28	28
End stage renal disease or dialysis (CCs 129, 130)	6	6	6	6
Renal failure (CC131)	25	25	25	24
Chronic Ulcer of Skin, Except Decubitus (CC149)	17	17	17	17
Cellulitis, local skin infection (CC152)	17	18	17	17
Other injuries (CC162)	27	27	27	26

The variable descriptions, estimates, and standard errors for the logistic regression model using the 2009 Dataset A used for development are shown in Table 13.

Table 13. 30-Day Readmission Model (2009 Dataset A – Logistic Regression Model Results)

Risk Factor	Estimate	Standard Error	Odds Ratio (95% Confidence Interval)
Intercept	-2.284	0.029	-
Demographics			
Age (>65) (mean)	0.012	0.001	1.012 (1.010,1.014)
Gender (Male)	-0.055	0.012	0.946 (0.924,0.969)
Vascular Procedure			
Unspecified-Open	0.595	0.028	1.813 (1.716,1.916)
Unspecified-Endovascular	0.459	0.025	1.582 (1.507,1.660)
Limb-Open	0.621	0.024	1.860 (1.775,1.949)
Thoracic/Abdominal-Open	0.785	0.030	2.193 (2.069,2.325)
Limb-Endovascular	0.022	0.024	1.022 (0.975,1.071)
Thoracic/Abdominal-Endovascular	0.264	0.025	1.302 (1.240,1.366)
Head/Neck-Endovascular	0.205	0.034	1.227 (1.148,1.311)
Head/Neck-Open	0.000	.	1.000
Vascular Comorbidity			
Diabetes or DM complications (cc 15, 17-20, 119-120)	0.076	0.014	1.079 (1.051,1.108)
Diabetes with Neurologic or Peripheral Circulatory Manifestation (CC16)	0.094	0.019	1.098 (1.058,1.140)
Precerebral Arterial Occlusion and Transient Cerebral Ischemia (CC97)	-0.094	0.014	0.911 (0.886,0.936)
Cerebral Atherosclerosis and Aneurysm (CC98)	-0.010	0.025	0.990 (0.943,1.039)
Cerebrovascular Disease, Unspecified (CC99)	0.007	0.041	1.007 (0.930,1.090)
Cerebrovascular Disease Late Effects, Unspecified (CC103)	0.090	0.035	1.094 (1.022,1.170)
Vascular Disease with Complications (CC104)	0.089	0.015	1.093 (1.061,1.126)
Vascular Disease (CC105)	-0.175	0.015	0.840 (0.815,0.865)
Other Comorbidity			
History of infection (CC1, 3-6)	0.074	0.014	1.077 (1.048,1.107)
Metastatic cancer or acute leukemia (CC7)	0.256	0.037	1.291 (1.201,1.389)
Cancer (CC8-12)	0.014	0.015	1.014 (0.985,1.044)
Benign neoplasms of skin, breast and eye (CC14)	-0.121	0.019	0.887 (0.854,0.920)
Protein-calorie malnutrition (CC21)	0.256	0.024	1.291 (1.231,1.354)
Disorders of fluid, electrolyte, acid-base (CC22, CC23)	0.149	0.015	1.161 (1.127,1.196)
Other Endocrine/Metabolic/Nutritional	-0.193	0.015	0.825 (0.801,0.849)

Table 13. 30-Day Readmission Model (2009 Dataset A – Logistic Regression Model Results)

Risk Factor	Estimate	Standard Error	Odds Ratio (95% Confidence Interval)
Disorders (CC24)			
Pancreatic Disease (CC32)	0.179	0.036	1.196 (1.116,1.283)
Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders (CC34)	0.118	0.018	1.125 (1.086,1.165)
Severe hematological disorders (CC44)	0.164	0.039	1.179 (1.092,1.272)
Dementia or other specified brain disorders (CC49-50)	0.094	0.018	1.098 (1.059,1.138)
Hemiplegia, paraplegia, paralysis, functional disability (CC67-69, 100-102)	0.084	0.026	1.088 (1.034,1.145)
Congestive heart failure (CC80)	0.211	0.015	1.235 (1.201,1.271)
Acute coronary syndrome (CC81-82)	0.086	0.019	1.089 (1.050,1.130)
Coronary atherosclerosis or angina (CC83-84)	0.020	0.014	1.020 (0.993,1.048)
Hypertensive Heart and Renal Disease or Encephalopathy (CC89)	0.071	0.018	1.073 (1.037,1.111)
Hypertensive heart disease (CC90)	0.005	0.023	1.005 (0.961,1.050)
Hypertension (CC91)	-0.236	0.017	0.790 (0.764,0.817)
Specified arrhythmias (CC92-93)	0.109	0.013	1.115 (1.087,1.144)
Ischemic or Unspecified Stroke (CC96)	0.104	0.020	1.110 (1.067,1.155)
COPD (CC108)	0.115	0.013	1.122 (1.094,1.151)
Pneumonia (CC 111-113)	0.208	0.016	1.231 (1.192,1.271)
Other Lung Disorders (CC115)	0.056	0.014	1.057 (1.030,1.086)
End stage renal disease or dialysis (CC129, 130)	0.214	0.024	1.239 (1.181,1.299)
Renal failure (CC131)	0.095	0.018	1.100 (1.062,1.140)
Chronic Ulcer of Skin, Except Decubitus (CC149)	0.235	0.018	1.264 (1.220,1.310)
Cellulitis, local skin infection (CC152)	0.081	0.017	1.084 (1.049,1.120)
Other injuries (CC162)	0.075	0.014	1.078 (1.050,1.107)

3.2 Model Validation

We computed five summary statistics for assessing model performance [19]: over-fitting indices,^{*} predictive ability, area under the receiver operating characteristic (ROC) curve,

^{*} Over-fitting refers to the phenomenon in which a model well describes the relationship between predictive variables and outcome in the development dataset, but fails to provide valid predictions in new patients.

distribution of residuals, and model chi-square.[†] Table 14 shows model performance results for Datasets A1, A2, and B. Model performance is similar in each dataset with strong model discrimination and fit. Predictive ability is also similar across datasets. The C statistic (area under the ROC curve) is not substantially different across datasets (0.667, 0.670, and 0.669 in Datasets A1, A2, and B, respectively).

Table 14. 30-Day Readmission Model Performance (Logistic Regression)

Indices	2009 Dataset A1	2009 Dataset A2	2008 Dataset B
Number of hospital stays	128,490	128,120	259,597
Number of hospitals	2,506	2,475	2,711
Unadjusted readmission rate	13.9	13.9	14.1
Calibration (γ_0, γ_1) [‡]	(0,1)	(-0.0074, 0.9958)	(0.0216, 1.0017)
Discrimination -Predictive Ability [§] (lowest decile %, highest decile %)	(6.9%, 23.9%)	(6.9%, 23.9%)	(6.9%, 24.4%)
Discrimination – Area under receiver operator curve (ROC)	0.667	0.668	0.669
Residuals Lack of Fit (Pearson Residual Fall %)			
<-2	0.00	0.00	0.00
[-2, 0)	86.14	86.12	85.91
[0, 2)	4.40	4.40	4.62
[2+	9.46	9.48	9.46
Model χ^2 [number of covariates] ^{**}	5215 [45]	5259 [45]	10832 [45]
Between hospital variance (standard error)	0.033 (0.005)	0.030 (0.005)	0.023 (0.003)

[†] Chi-Square – A test of statistical significance usually employed for categorical data to determine whether there is a good fit between the observed data and expected values; i.e., whether the differences between observed and expected values are attributable to true differences in characteristics or instead the result of chance variation. The formula for computing the chi-square is as follows:

$$\sum \frac{(O-E)^2}{E}$$

where O = observed value

E = expected value, and

degrees of freedom (df) = (rows-1)(columns-1)

[‡] Over-Fitting Indices (γ_0, γ_1) provide evidence of over-fitting and require several steps to calculate. Let b denote the *estimated vector* of regression coefficients. *Predicted Probabilities* (\hat{p}) = $1/(1+\exp\{-Xb\})$, and $Z = Xb$ (e.g., the linear predictor that is a scalar value for everyone). A new logistic regression model that includes only an intercept and a slope by regressing the logits on Z is fitted in the validation sample; e.g., $\text{Logit}(P(Y=1|Z)) = \gamma_0 + \gamma_1 Z$. Estimated values of γ_0 far from 0 and estimated values of γ_1 far from 1 provide evidence of over-fitting.

[§] Observed Rates

^{**} Wald Chi-Square

The model's discriminant ability (ability to predict patient-level risk) is consistent with that of models currently used to publicly report condition-specific rates of mortality and readmission. Readmissions are inherently more difficult to predict than mortality. For example, the C statistic for CMS' publicly reported AMI 30-day mortality measure (0.719) is higher than that for CMS' publicly reported 30-day AMI readmission measure (0.629) for the years 2007-2009. In addition, we did not include in our model covariates such as potential complications in the index hospital stay, certain patient demographics (e.g., race), patients' admission path (e.g., outpatient, emergency department), and discharge destination (e.g., discharged home versus other facilities, both non-acute and acute care). Although these variables may be associated with readmission and could increase the model's ability to predict patient readmission, they may be related to quality or supply factors which should not be included in an adjustment that seeks to control for patient clinical characteristics.

We also examined the temporal variation of the odds ratios (95% confidence intervals) of the model variables (Table 15). The regression coefficients are consistent over the two years of data.

Table 15. 30-Day Readmission Model (Logistic Regression) Odds Ratios by Dataset

Description	2009 Dataset A1 OR (LOR, UOR)	2009 Dataset A2 OR (LOR, UOR)	2008 Dataset B OR (LOR, UOR)
Demographics			
Age (>65) (mean)	1.013 (1.010,1.015)	1.011 (1.009,1.014)	1.011 (1.009,1.012)
Gender (Male)	0.948 (0.917,0.981)	0.944 (0.913,0.976)	0.944 (0.922,0.966)
Vascular Procedure			
Unspecified-Open	1.831 (1.695,1.979)	1.796 (1.660,1.943)	1.897 (1.799,2.001)
Unspecified-Endovascular	1.587 (1.482,1.699)	1.578 (1.474,1.691)	1.713 (1.633,1.796)
Limb-Open	1.852 (1.734,1.979)	1.871 (1.750,1.999)	1.895 (1.809,1.984)
Thoracic/Abdominal-Open	2.148 (1.978,2.332)	2.241 (2.064,2.434)	2.197 (2.077,2.325)
Limb-Endovascular	1.000 (0.936,1.068)	1.045 (0.977,1.116)	1.045 (0.998,1.095)
Thoracic/Abdominal-Endovascular	1.259 (1.175,1.348)	1.346 (1.257,1.442)	1.332 (1.270,1.398)
Head/Neck-Endovascular	1.201 (1.093,1.320)	1.254 (1.142,1.377)	1.222 (1.144,1.307)
Head/Neck-Open (reference group)	1.000	1.000	1.000
Vascular Comorbidity			
Diabetes or DM complications (CCs 15, 17-20, 119-120)	1.084 (1.044,1.125)	1.075 (1.035,1.116)	1.044 (1.017,1.072)
Diabetes with Neurologic or Peripheral Circulatory	1.074 (1.019,1.133)	1.121 (1.064,1.182)	1.159 (1.116,1.202)

Table 15. 30-Day Readmission Model (Logistic Regression) Odds Ratios by Dataset

Description	2009 Dataset A1 OR (LOR, UOR)	2009 Dataset A2 OR (LOR, UOR)	2008 Dataset B OR (LOR, UOR)
Manifestation (CC16)			
Precerebral Arterial Occlusion and Transient Cerebral Ischemia (CC97)	0.922 (0.887,0.959)	0.900 (0.865,0.935)	0.899 (0.875,0.924)
Cerebral Atherosclerosis and Aneurysm (CC98)	0.957 (0.894,1.026)	1.023 (0.956,1.096)	1.061 (1.012,1.112)
Cerebrovascular Disease, Unspecified (CC99)	1.024 (0.916,1.145)	0.991 (0.885,1.110)	1.045 (0.967,1.128)
Cerebrovascular Disease Late Effects, Unspecified (CC103)	1.107 (1.005,1.220)	1.081 (0.983,1.188)	1.098 (1.026,1.175)
Vascular Disease with Complications (CC104)	1.087 (1.042,1.133)	1.098 (1.053,1.146)	1.064 (1.033,1.096)
Vascular Disease (CC105)	0.844 (0.809,0.881)	0.834 (0.800,0.870)	0.827 (0.803,0.852)
Other Comorbidity			
History of infection (CCs 1, 3-6)	1.092 (1.050,1.135)	1.062 (1.022,1.104)	1.043 (1.016,1.072)
Metastatic cancer or acute leukemia (CC7)	1.273 (1.149,1.410)	1.314 (1.186,1.457)	1.332 (1.239,1.432)
Cancer (CCs 8-12)	1.015 (0.974,1.058)	1.012 (0.972,1.055)	1.056 (1.027,1.087)
Benign neoplasms of skin, breast and eye (CC14)	0.893 (0.848,0.941)	0.880 (0.835,0.928)	0.882 (0.849,0.915)
Protein-calorie malnutrition (CC21)	1.244 (1.162,1.331)	1.341 (1.254,1.434)	1.197 (1.139,1.259)
Disorders of fluid, electrolyte, acid-base (CCs 22, 23)	1.152 (1.104,1.201)	1.171 (1.123,1.221)	1.164 (1.130,1.199)
Other Endocrine/Metabolic/Nutritional Disorders (CC24)	0.824 (0.791,0.859)	0.825 (0.792,0.860)	0.804 (0.782,0.827)
Pancreatic Disease (CC32)	1.198 (1.086,1.322)	1.193 (1.080,1.317)	1.160 (1.081,1.244)
Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders (CC34)	1.110 (1.056,1.167)	1.141 (1.085,1.198)	1.144 (1.105,1.185)
Severe hematological disorders (CC44)	1.300 (1.171,1.445)	1.061 (0.949,1.185)	1.262 (1.172,1.359)
Dementia or other specified brain disorders (CCs 49-50)	1.062 (1.009,1.117)	1.135 (1.079,1.193)	1.172 (1.131,1.214)
Hemiplegia, paraplegia,	1.059 (0.985,1.139)	1.117 (1.039,1.200)	1.098 (1.044,1.155)

Table 15. 30-Day Readmission Model (Logistic Regression) Odds Ratios by Dataset

Description	2009 Dataset A1 OR (LOR, UOR)	2009 Dataset A2 OR (LOR, UOR)	2008 Dataset B OR (LOR, UOR)
paralysis, functional disability (CCs 67-69, 100-102)			
Congestive heart failure (CC80)	1.250 (1.200,1.302)	1.221 (1.173,1.272)	1.202 (1.169,1.237)
Acute coronary syndrome (CCs 81-82)	1.100 (1.045,1.159)	1.078 (1.023,1.135)	1.122 (1.083,1.163)
Coronary atherosclerosis or angina (CCs 83-84)	1.027 (0.989,1.067)	1.012 (0.974,1.052)	1.081 (1.053,1.111)
Hypertensive Heart and Renal Disease or Encephalopathy (CC89)	1.081 (1.029,1.135)	1.065 (1.015,1.119)	1.099 (1.061,1.138)
Hypertensive heart disease (CC90)	0.997 (0.937,1.062)	1.012 (0.951,1.077)	0.994 (0.952,1.038)
Hypertension (CC91)	0.794 (0.757,0.833)	0.786 (0.749,0.824)	0.833 (0.806,0.861)
Specified arrhythmias (CCs 92-93)	1.111 (1.071,1.152)	1.118 (1.079,1.160)	1.080 (1.052,1.107)
Ischemic or Unspecified Stroke (CC96)	1.091 (1.031,1.153)	1.129 (1.067,1.194)	1.074 (1.033,1.117)
COPD (CC108)	1.132 (1.092,1.173)	1.113 (1.073,1.154)	1.126 (1.098,1.154)
Pneumonia (CCs 111-113)	1.221 (1.167,1.277)	1.240 (1.185,1.297)	1.224 (1.186,1.263)
Other Lung Disorders (CC115)	1.072 (1.033,1.113)	1.043 (1.004,1.082)	1.054 (1.027,1.082)
End stage renal disease or dialysis (CCs 129, 130)	1.214 (1.135,1.299)	1.262 (1.180,1.350)	1.200 (1.144,1.259)
Renal failure (CC131)	1.110 (1.056,1.167)	1.090 (1.037,1.146)	1.113 (1.074,1.153)
Chronic Ulcer of Skin, Except Decubitus (CC149)	1.285 (1.221,1.351)	1.245 (1.184,1.310)	1.313 (1.267,1.360)
Cellulitis, local skin infection (CC152)	1.066 (1.019,1.116)	1.102 (1.053,1.154)	1.083 (1.048,1.118)
Other injuries (CC162)	1.089 (1.049,1.131)	1.066 (1.027,1.107)	1.056 (1.029,1.085)

3.3 Final Model Results

The final hierarchical logistic regression model was created using the 2009 Dataset A. Model variable descriptions, estimates, standard errors, and odds ratios are shown in Table 16.

Table 16. 30-Day Readmission Model (2009 Dataset A – Hierarchical Logistic Regression Model Results)^{*†‡}

Risk Factor	Estimate	Standard Error	Odds Ratio (95% Confidence Interval)
Intercept	-2.292	0.029	0.100 (0.096,0.107)
Demographics			
Age (>65) (mean)	0.012	0.001	1.010 (1.010,1.014)
Gender (Male)	-0.054	0.012	0.950 (0.926,0.970)
Vascular Procedure			
Unspecified-Open	0.591	0.028	1.810 (1.710,1.908)
Unspecified-Endovascular	0.455	0.025	1.580 (1.502,1.654)
Limb-Open	0.620	0.024	1.860 (1.774,1.948)
Thoracic/Abdominal-Open	0.770	0.030	2.160 (2.037,2.288)
Limb-Endovascular	0.027	0.024	1.030 (0.981,1.077)
Thoracic/Abdominal-Endovascular	0.264	0.025	1.300 (1.241,1.367)
Head/Neck-Endovascular	0.192	0.034	1.210 (1.133,1.295)
Head/Neck-Open	0.000	.	1.000
Vascular Comorbidity			
Diabetes or DM complications (cc 15, 17-20, 119-120)	0.077	0.013	1.080 (1.052,1.109)
Diabetes with Neurologic or Peripheral Circulatory Manifestation (CC16)	0.094	0.019	1.100 (1.058,1.140)
Precerebral Arterial Occlusion and Transient Cerebral Ischemia (CC97)	-0.090	0.014	0.910 (0.889,0.939)
Cerebral Atherosclerosis and Aneurysm (CC98)	-0.017	0.025	0.980 (0.937,1.032)
Cerebrovascular Disease, Unspecified (CC99)	0.004	0.040	1.000 (0.927,1.087)
Cerebrovascular Disease Late Effects, Unspecified (CC103)	0.091	0.034	1.100 (1.024,1.171)
Vascular Disease with Complications (CC104)	0.087	0.015	1.090 (1.059,1.123)
Vascular Disease (CC105)	-0.175	0.015	0.840 (0.815,0.865)
Other Comorbidity			
History of infection (CC1, 3-6)	0.068	0.014	1.070 (1.042,1.100)
Metastatic cancer or acute leukemia (CC7)	0.247	0.037	1.280 (1.191,1.376)
Cancer (CC8-12)	0.012	0.015	1.010 (0.983,1.042)

* N=256,610 in 2,659 hospitals

† ROC=0.677

‡ Between hospital variance=0.031; Standard Error=0.003

Table 16. 30-Day Readmission Model (2009 Dataset A – Hierarchical Logistic Regression Model Results)^{*†‡}

Risk Factor	Estimate	Standard Error	Odds Ratio (95% Confidence Interval)
Benign neoplasms of skin, breast and eye (CC14)	-0.118	0.019	0.890 (0.856,0.922)
Protein-calorie malnutrition (CC21)	0.257	0.024	1.290 (1.233,1.355)
Disorders of fluid, electrolyte, acid-base (CC22, CC23)	0.151	0.015	1.160 (1.129,1.197)
Other Endocrine/Metabolic/Nutritional Disorders (CC24)	-0.190	0.015	0.830 (0.803,0.851)
Pancreatic Disease (CC32)	0.174	0.035	1.190 (1.111,1.276)
Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders (CC34)	0.117	0.018	1.120 (1.086,1.164)
Severe hematological disorders (CC44)	0.157	0.039	1.170 (1.085,1.262)
Dementia or other specified brain disorders (CC49-50)	0.093	0.018	1.100 (1.060,1.138)
Hemiplegia, paraplegia, paralysis, functional disability (CC67-69, 100-102)	0.085	0.026	1.090 (1.035,1.145)
Congestive heart failure (CC80)	0.210	0.015	1.230 (1.199,1.269)
Acute coronary syndrome (CC81-82)	0.084	0.019	1.090 (1.049,1.128)
Coronary atherosclerosis or angina (CC83-84)	0.018	0.014	1.020 (0.991,1.046)
Hypertensive Heart and Renal Disease or Encephalopathy (CC89)	0.071	0.018	1.070 (1.037,1.111)
Hypertensive heart disease (CC90)	-0.001	0.023	1.000 (0.956,1.044)
Hypertension (CC91)	-0.234	0.017	0.790 (0.765,0.818)
Specified arrhythmias (CC92-93)	0.105	0.013	1.110 (1.083,1.140)
Ischemic or Unspecified Stroke (CC96)	0.100	0.020	1.110 (1.063,1.150)
COPD (CC108)	0.118	0.013	1.130 (1.098,1.154)
Pneumonia (CC 111-113)	0.206	0.016	1.230 (1.191,1.268)
Other Lung Disorders (CC115)	0.056	0.013	1.060 (1.030,1.086)
End stage renal disease or dialysis (CC129, 130)	0.217	0.024	1.240 (1.185,1.303)
Renal failure (CC131)	0.094	0.018	1.100 (1.061,1.138)
Chronic Ulcer of Skin, Except Decubitus (CC149)	0.235	0.018	1.270 (1.221,1.311)
Cellulitis, local skin infection (CC152)	0.081	0.016	1.080 (1.050,1.119)
Other injuries (CC162)	0.077	0.013	1.080 (1.052,1.109)

Figure 6 and Figure 7 display the frequency distributions of the unadjusted and risk-standardized hospital-specific 30-day readmission rates, respectively, in the 2009 Dataset A. Of

note, using our approach to defining planned readmissions, 8.6% of readmissions are considered planned and so are not included in the results presented here.

The hospital unadjusted readmission rate ranged from 0% to 100% across 2,659 hospitals with a median (quartile range) of 12.9% (7.9%, 17.6%). The mean hospital unadjusted readmission rate is 14.3% (see Figure 6). After adjusting for patient and clinical characteristics, the risk-standardized rates at the hospital-level were found to be more normally distributed with a mean of 13.9%, ranging from 10.7% to 18.5% across 2,659 hospitals. The median risk-adjusted hospital readmission rate is 13.8% (Figure 7).

Figure 6. Distribution of Unadjusted Hospital 30-Day Readmission Rates (2009 Dataset A; N=2,659 Hospitals)

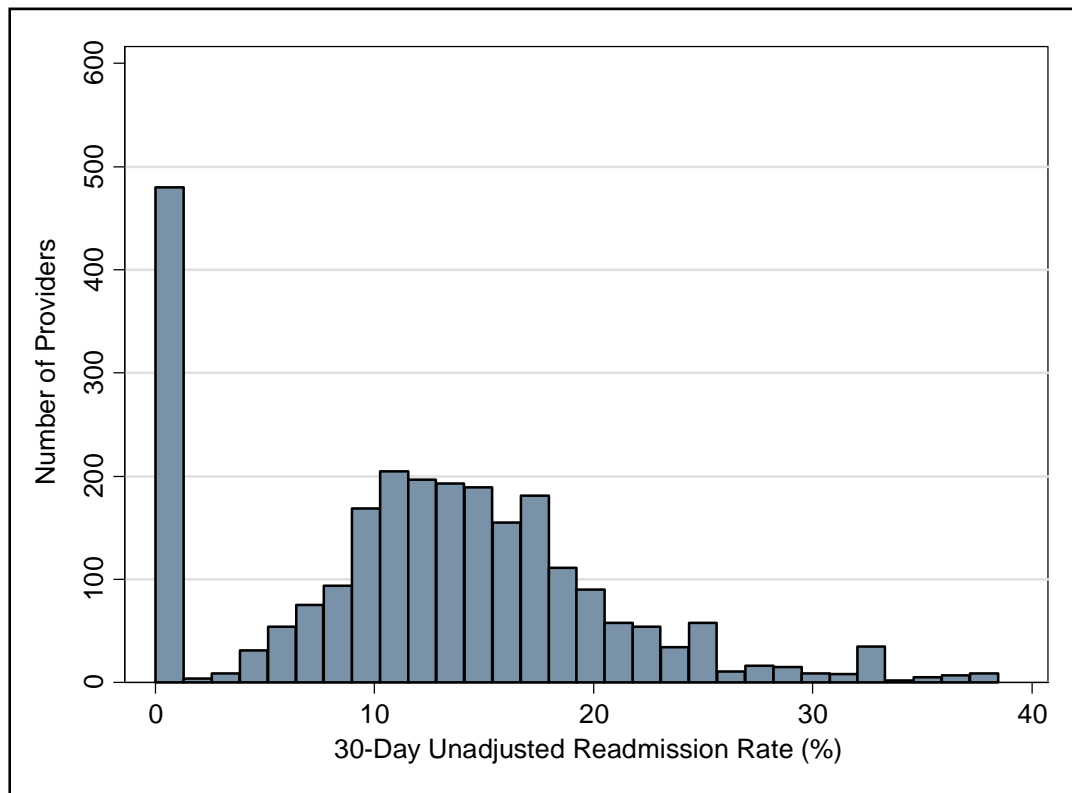
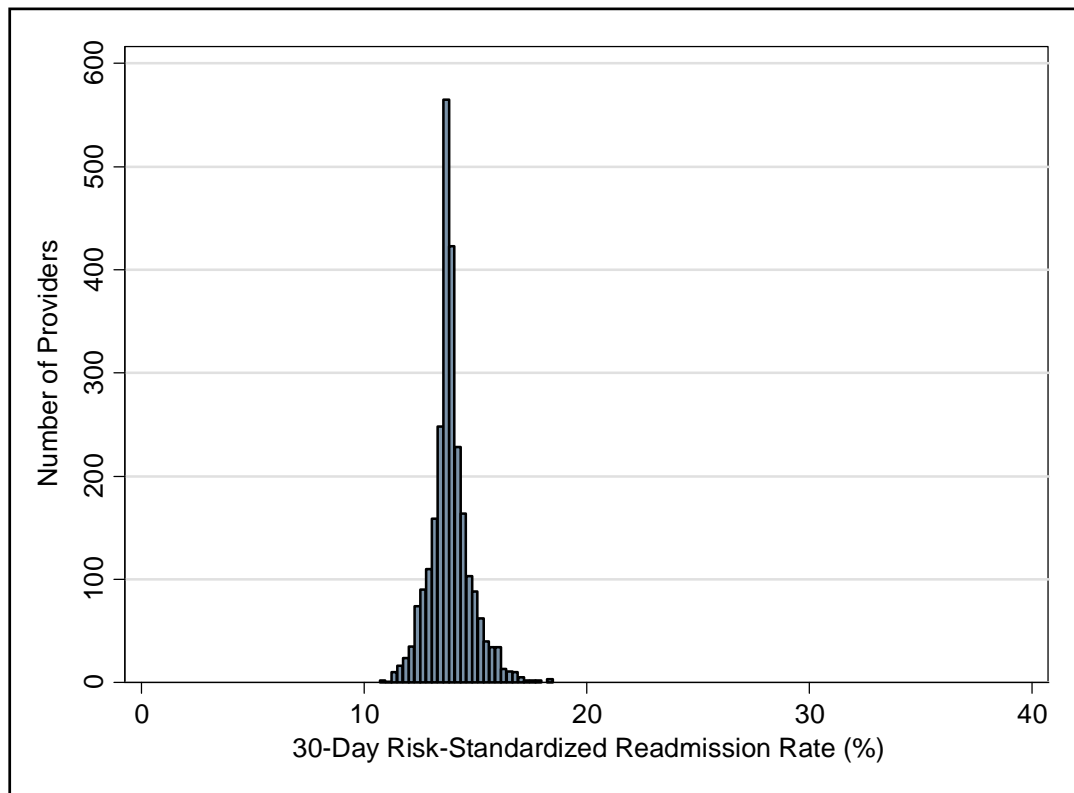


Figure 7. Distribution of Risk-Standardized Hospital 30-Day Readmission Rates (2009 Dataset A; N=2,659 Hospitals)



3.4 Measure Testing

Once the measures are developed, we examine both validity and reliability of both the data elements and overall results.

3.4.1 Reliability

3.4.1.1 Data element reliability

In constructing the measures we aim to utilize only those data elements from the claims that have both face validity and reliability. We avoid the use of fields that are thought to be coded inconsistently across hospitals or providers. Specifically, we use fields that are consequential for payment and which are audited. We identify such variables through empiric analyses and our understanding of CMS auditing and billing policies and seek to avoid variables which do not meet this standard. For example, “discharge disposition” is a variable in Medicare claims data that is not thought to be a reliable way of identifying

a transfer between two acute care facilities. Thus, we derive a variable using admission and discharge dates as a surrogate for “discharge disposition” to identify hospital stays involving transfers. This allows us to identify these stays using variables in the claims data which have greater reliability than the “discharge disposition” variable.

In addition, 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, including diagnosis and procedure codes and other elements that are consequential to payment.

Finally, we assess the reliability of the data elements by comparing risk factor frequencies and odds ratios in three data sets. No notable differences were observed in risk factor frequency or ORs across the three datasets. Additionally, the overall unadjusted 30-day readmission rate was consistent across datasets, 13.9% in Datasets A1 and A2, and 14.1% in Dataset B. The consistency in the prevalence of the risk factors and their relationship with readmission over two years, when it is unlikely that case mix changed dramatically, suggests that such elements are coded in a consistent manner.

3.4.1.2 Measure result reliability

We assess reliability of the measure results by model performance in the 2009 split-year Dataset A1 (see Section 3.1) with its performance in the 2009 split-year Dataset A2 and in the 2008 full-year Dataset B

Model performance was similar in each dataset with strong model discrimination and fit. Predictive ability was also similar across datasets. The C statistic (area under the ROC curve) was not substantially different across datasets (0.667, 0.670, and 0.669 in Datasets A1, A2, and B, respectively). This demonstrates the consistency in the models discriminant ability, supporting the reliability of the overall measure.

3.4.2 Validity

3.4.2.1 Validity of Claims-Based Measures

Our team has demonstrated for a number of prior measures the validity of claims-based measures for profiling hospitals by comparing either the measure results or individual data elements against medical records. CMS validated the six NQF-endorsed 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 two national, multi-site validation efforts for two procedure-based complications measures (for primary elective hip/knee arthroplasty and implantable cardioverter defibrillator [ICD]). Both projects demonstrated strong agreement between complications coded in claims and abstracted medical record data. These validation efforts suggest that such claims data variables are valid across a variety of conditions.

3.4.2.2 Validity Indicated by Established Measure Development Guidelines

We developed this measure in consultation with national guidelines for publicly reported outcomes measures, with outside experts, and with the public. The measure is consistent with the technical approach to outcomes measurement set forth in National Quality Forum (NQF) guidance for outcomes measures (National Quality Forum, 2010), CMS Measure Management System guidance, and the guidance articulated in the American Heart Association scientific statement, “Standards for Statistical Models Used for Public Reporting of Health Outcomes” (Krumholz et al., 2006).

3.4.2.3 Validity as Assessed by External Groups

Throughout measure development, we obtained expert and stakeholder input via three mechanisms: regular discussions with an advisory working group, a national Technical Expert Panel (TEP), and a 30-day public comment period in order to increase transparency and to gain broader input into the measure.

The working group was assembled, and regular meetings were held throughout the development phase. The working group was tailored for development of this measure and consisted of clinicians, including a noninvasive cardiologist, vascular surgeon, family physician, and interventional cardiologist; and other professionals with expertise in biostatistics, measure methodology, and quality improvement. Working group meetings addressed key issues related to measure development, including weighing the pros and cons of and finalizing key decisions (e.g., defining the measure cohort and outcome) to ensure the measure is meaningful, useful, and well-designed. The working group

provided a forum for focused expert review and discussion of technical issues during measure development prior to consideration by the broader TEP.

In addition to the working group, and in alignment with the CMS Measures Management System, we convened a TEP to provide input and feedback during measure development from a group of recognized experts in relevant fields. To convene the TEP, we released a public call for nominations and selected individuals to represent a range of perspectives including physicians, consumers, and purchasers, as well as individuals with experience in quality improvement, performance measurement, and health care disparities. We held three structured TEP conference calls consisting of presentation of key issues, our proposed approach, and relevant data, followed by open discussion among TEP members.

Finally, we held a 30-day public comment period through the CMS MMS website. Based on input received from stakeholders, we made additional minor changes to the measure, such as adding additional planned readmissions.

3.4.2.4 Face Validity as Determined by TEP

Additionally, we systematically assessed the face validity of the measure score as an indicator of quality by soliciting the Technical Expert Panel (TEP) members' (listed below) agreement with the following statement: "The risk-standardized readmission rates obtained from the vascular readmission measure as specified will provide an accurate reflection of quality." The 11 TEP members overwhelmingly agreed with the face validity of the measure with only one expressing any concern with a vote of 3 on a six-point scale: 1=Strongly disagree, 2=Moderately disagree, 3=Somewhat disagree, 4=Somewhat agree, 5=Moderately agree, 6=Strongly agree.

4. MAIN FINDINGS / SUMMARY

We present a hierarchical logistic regression model for predicting hospital 30-day all-cause readmission for patients undergoing vascular procedures. Our approach to model development and risk adjustment is consistent with quality measure methods recommendations for publicly-reported outcomes measures from NQF, CMS, and the American Heart Association scientific statement [9]. This proposed measure is based on administrative claims data for FFS Medicare beneficiaries 65 years and older and was developed with extensive input from clinical and methodological experts with knowledge and experience relevant to quality measurement of vascular procedures. The study dataset is appropriately defined, consisting of patients undergoing arterial procedures in the inpatient and hospital outpatient setting, excluding cardiac and intracranial procedures and procedures related to access for hemodialysis. The outcome consists of readmissions within 30 days of discharge, except those deemed likely to represent a planned readmission within the scope of the overall management strategy for the vascular condition. The risk adjustment process accounts for comorbid conditions identified in inpatient and outpatient claims in the year prior to the index hospital stay. The hierarchical modeling accounts for hospital case mix, hospital sample size, and the clustering of patients within hospitals, thereby making the measure suitable for public reporting. We found significant differences in readmission rates across hospitals, and these differences remained after risk adjustment. Thus, implementation of the measure has the potential to significantly improve the quality of care for patients undergoing vascular procedures.

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APPENDICES

Appendix A. Working Group Member Roster

Name	Title/Affiliation
Yale-CORE Members	
Susannah Bernheim, MD	Associate Director, Quality Measures
Lori Geary, MPH	Co-Lead, Project Manager for Quality Measures
Shu-Xia Li, PhD	Lead Analyst
Zhenqiu Lin, PhD	Consulting Project Analyst
Robert McNamara, MD, MHS	Co-Lead; Cardiologist; Associate Professor of Medicine (Cardiovascular Medicine) Yale School of Medicine
Julia Montague, MPH	Project Coordinator
Smitha Vellanky, MSc	Research Assistant
Haiyan Wang, MD, MS	Supporting Analyst
Invited Members	
Jeptha Curtis, MD	Assistant Professor of Medicine (Cardiovascular Medicine), Yale School of Medicine
Alan Dardik, MD, PhD	Associate Professor of Surgery (Vascular), Yale School of Medicine Chief, Peripheral Vascular Surgery, VA Connecticut

Appendix B. Technical Expert Panel Member Roster

Name	Title	Organization	Area of Expertise
Terry Golash, MD	Senior Medical Director	Aetna	Purchaser Perspective Quality Improvement
Bruce Hall, MD, PhD, MBA	Professor of Surgery and Healthcare Management	Washington University Saint Louis	Topic Knowledge Performance Measurement Quality Improvement
Jeffrey Indes, MD	Assistant Professor of Surgery and Radiology, Section of Vascular Surgery	Yale University School of Medicine	Topic Knowledge (Vascular Surgery) Performance Measurement
Sanjay Misra, MD	Associate Professor of Radiology	Mayo Clinic	Topic Knowledge (Interventional Radiology) Quality Improvement
Leila Mureebe, MD	Assistant Professor of Surgery; Attending Surgeon	Duke University Medical Center	Topic Knowledge (Vascular Surgery) Healthcare Disparities Performance Measurement
Ileana L. Piña, MD, MPH	Professor of Medicine; Professor of Epidemiology/Biostatistics	Case Western Reserve University	Topic Knowledge (Cardiology) Healthcare Disparities Quality Improvement Performance Measurement
Anne Roberts, MD	Professor of Radiology; Chief of Vascular and Interventional Radiology	University of California, San Diego	Topic Knowledge (Interventional Radiology) Quality Improvement
Sean P. Roddy, MD	Health Policy Committee Chair	Society for Vascular Surgery	Topic Knowledge (Vascular Surgery) Quality Improvement
John Santa, MD, MPH	Director	Consumer Reports Health Ratings Center	Consumer Perspective Quality Improvement
Laurel Trujillo, MD	Medical Director of Quality	Palo Alto Medical Foundation	Quality Improvement Performance Measurement
Todd R. Vogel, MD	Assistant Professor of Surgery; Director of Vascular Laboratory RWJUH; Director of Surgical Outcomes Research Group	UMDNJ-RWJ Medical School	Topic Knowledge (Vascular Surgery) Healthcare Disparities Performance Measurement Quality Improvement
Christopher J. White, MD	Chairman	Ochsner Clinic Foundation Department of Cardiology	Topic Knowledge (Interventional Cardiology) Quality Improvement

Appendix C. DRG Descriptions

DRG #	Description
APR-DRG 173	Other Vascular Procedures
MS-DRG 252	Other Vascular Procedures with Major Complication or Comorbidity
MS-DRG 253	Other Vascular Procedures With Complication or Comorbidity
MS-DRG 254	Other Vascular Procedures Without Major Complication or Comorbidity, or Without Complication or Comorbidity
MS-DRG 237	Major Cardiovascular Procedures With Major Complications and Comorbidities of Thoracic Aortic Aneurysm Repair
MS-DRG 238	Major Cardiovascular Procedures Without Major Complications and Comorbidities
MS-DRG 239	Amputation for Circulatory System Disorders Except Upper Limb and Toe With Major Complications and Comorbidities
MS-DRG 240	Amputation for Circulatory System Disorders Except Upper Limb and Toe With Complications and Comorbidities
MS-DRG 241	Amputation for Circulatory System Disorders Except Upper Limb and Toe Without Major Complications and Comorbidities
MS-DRG 255	Upper Limb and Toe Amputation for Circ System Disorders With Major Complications and Comorbidities
MS-DRG 256	Upper Limb and Toe Amputations for Circ System Disorders With Complications and Comorbidities
MS-DRG 257	Upper Limb and Toe Amputation for Circ System Disorders Without Major Complications and Comorbidities
MS-DRG 264	Other Circulatory System Operating Room Procedures

Appendix D. ICD-9 Procedure Codes Not Selected for Inclusion in Measure Cohort

ICD-9 Code	Description	Unmet Criterion
00.4	Adjunct vascular system procedures	Clinically coherent
00.40	procedure on single vessel	Clinically coherent
00.41	Procedure on two vessels	Clinically coherent
00.42	Procedure on three vessels	Clinically coherent
00.43	Procedure on four or more vessels	Clinically coherent
00.44	Procedure on vessel bifurcation	Clinically coherent
00.45	Insertion of one vascular stent	Clinically coherent
00.46	Insertion of two vascular stents	Clinically coherent
00.47	Insertion of three vascular stents	Clinically coherent
00.48	Insertion of four or more vascular stents	Clinically coherent
00.49	SuperSaturated oxygen therapy	Major
00.5	Other cardiovascular procedure	Clinically coherent
00.50	Implantation of cardiac resynchronization pacemaker without mention of defibrillation, total system	Clinically coherent
00.51	Implantation of cardiac resynchronization pacemaker, total system	Clinically coherent
00.52	Implantation or replacement of transvenous lead [electrode] into left ventricular coronary venous system	Clinically coherent
00.53	Implantation or replacement of cardiac resynchronization pacemaker pulse generator only	Clinically coherent
00.54	Implantation or replacement of cardiac resynchronization defibrillator pulse generator device only	Clinically coherent
00.56	Insertion or replacement of implantable pressure sensor (lead) for intracardiac hemodynamic monitoring AND Implantation or replacement of subcutaneous device for intracardiac hemodynamic monitoring	Clinically coherent
00.57	Implantation or replacement of subcutaneous device for intracardiac hemodynamic monitoring	Clinically coherent
00.58	Insertion of intra-aneurysm sac pressure monitoring device (intraoperative)	Clinically coherent
00.59	Intravascular pressure measurement of coronary arteries	Major
00.62	Percutaneous angioplasty or atherectomy of intracranial vessel(s)	Clinically coherent
00.65	Percutaneous insertion of intracranial vascular stent(s)	Clinically coherent
00.66	Percutaneous transluminal coronary angioplasty [PTCA] or coronary atherectomy, balloon angioplasty of coronary artery, coronary atherectomy, percutaneous coronary angioplasty NOS, PTCA NOS	Clinically coherent
00.67	Intravascular pressure measurement of intrathoracic arteries	Major
00.68	Intravascular pressure measurement of peripheral arteries	Major
00.69	Intravascular pressure measurement, other specified and unspecified vessels	Major
04.92	Implantation or replacement of peripheral neurostimulator lead(s)	Major
05.0	Division of sympathetic nerve or ganglion	Clinically coherent
05.21	Sphenopalatine ganglionectomy	Clinically coherent
05.22	Cervical sympathectomy	Clinically coherent
05.23	Lumber sympathectomy	Clinically coherent
05.24	Presacral sympathectomy	Clinically coherent

ICD-9 Code	Description	Unmet Criterion
05.25	Periarterial sympathectomy	Clinically coherent
05.29	Other sympathectomy and ganglionectomy	Clinically coherent
05.89	Other operations on sympathetic nerves or ganglion	Clinically coherent
17.32	Laparoscopic cecectomy	Clinically coherent
17.33	Laparoscopic right hemicolectomy	Clinically coherent
17.34	Laparoscopic resection of transverse colon	Clinically coherent
17.35	Laparoscopic left hemicolectomy	Clinically coherent
17.39	Other laparoscopic partial excision of large intestine	Clinically coherent
21.04	Control of epistaxis by ligation of ethmoidal arteries	Clinically coherent
21.05	Control of epistaxis by (transantral) ligation of the maxillary artery	Clinically coherent
21.06	Control of epistaxis by ligation of the external carotid artery	Clinically coherent
21.07	Control of epistaxis by excision of nasal mucosa and skin grafting on septum and lateral nasal wall	Clinically coherent
21.09	Control of epistaxis by other means	Clinically coherent
25.1	Excision or destruction of lesion or tissue of tongue	Clinically coherent
31.72	Closure of external fistula of trachea	Clinically coherent
31.74	Revision of tracheostomy	Clinically coherent
33.20	Thoracoscopic lung biopsy	Clinically coherent
33.27	Closed endoscopic biopsy of lung	Clinically coherent
33.28	Open biopsy of lung	Clinically coherent
34.02	Exploratory thoracotomy	Clinically coherent
34.03	Reopening of recent thoracotomy site	Clinically coherent
34.1	Incision of mediastinum	Clinically coherent
34.21	Transpleural thoracoscopy	Clinically coherent
34.22	Mediastinoscopy	Clinically coherent
34.26	Open biopsy of mediastinum	Clinically coherent
34.29	Other diagnostic procedures on mediastinum	Clinically coherent
35.01	Closed heart valvotomy, aortic valve	Clinically coherent
35.02	Closed heart valvotomy, mitral valve	Clinically coherent
35.03	Closed heart valvotomy, pulmonary valve	Clinically coherent
35.04	Closed heart valvotomy, tricuspid valve	Clinically coherent
37.12	Pericardiotomy	Clinically coherent
37.24	Biopsy of pericardium	Clinically coherent
37.31	Pericardiectomy	Clinically coherent
37.41	Implantation of prosthetic cardiac support device around the heart	Clinically coherent
37.49	Other repair of heart and pericardium	Clinically coherent
37.55	Removal of internal biventricular heart replacement system	Clinically coherent
37.61	Implant of pulsation balloon	Clinically coherent
37.64	Removal of external heart assist system(s) or device(s)	Clinically coherent
37.67	Implantation of cardiomyostimulation system	Clinically coherent
37.91	Open chest cardiac massage	Clinically coherent
37.99	Other operations on heart and pericardium	Clinically coherent
38.01	Incision of vessels, intracranial vessels	Clinically coherent

ICD-9 Code	Description	Unmet Criterion
38.04	Incision of vessels-aorta	Central
38.05	Incision of vessels-other thoracic vessels	Central
38.06	Incision of vessels-abdominal arteries	Central
38.07	Incision of vessels-abdominal veins	Clinically coherent
38.09	Incision of vessels, lower limb veins	Major
38.11	Endarterectomy, intracranial vessels	Clinically coherent
38.2	Diagnostic procedures on blood vessels	Major
38.21	Biopsy of blood vessel	Major
38.22	Percutaneous angiography	Major
38.23	Intravascular spectroscopy	Major
38.24	Intravascular imaging of coronary vessel(s) by optical coherence tomography [OCT]	Major
38.25	Intravascular imaging of non-coronary vessel(s) by optical coherence tomography [OCT]	Major
38.29	Other diagnostic procedures on blood vessels	Major
38.31	Resection of vessels with anastomosis, intracranial vessels	Clinically coherent
38.37	Resection of vessel with anastomosis-abdominal veins	Clinically coherent
38.39	Resection of vessels with anastomosis, lower limb veins	Central
38.41	Resection of vessel with replacement, intracranial vessels	Clinically coherent
38.47	Resection of vessel with replacement-abdominal veins	Clinically coherent
38.49	Resection of vessel with replacement, lower limb veins	Clinically coherent
38.5	Ligation and stripping of varicose veins	Major
38.50	Ligation and stripping of varicose veins, unspecified site	Major
38.51	Ligation and stripping of varicose veins, intracranial vessels	Major
38.52	Ligation and stripping of varicose veins-other vessels of head and neck	Major
38.53	Ligation and stripping of varicose veins, thoracic vessel	Major
38.55	Ligation and stripping of varicose veins-other thoracic vessels	Major
38.57	Ligation and stripping of varicose veins-abdominal veins	Major
38.59	Ligation and stripping of varicose veins, lower limb veins	Major
38.6	Other excision of vessels	Central
38.60	Other excision of vessels-unspecified site	Central
38.61	Other excision of vessels, intracranial vessels	Clinically coherent
38.62	Other excision of vessels-other vessels of head and neck	Central
38.63	Other excision of vessels-upper limb vessels	Central
38.64	Excision of Abdominal Aorta	Central
38.65	Other excision of vessels-other thoracic vessels	Central
38.67	Other excision of vessels-abdominal veins	Clinically coherent
38.69	Other excision of vessels, lower limb veins	Central
38.7	Interruption of vena cava	Clinically coherent
38.8	Other surgical occlusion of vessels	Central
38.80	Other surgical occlusion of vessels-unspecified vessels	Central
38.81	Other surgical occlusion of vessels, intracranial vessels	Clinically coherent
38.82	Other surgical occlusion of vessels-other vessels of the head and neck	Central
38.83	Other surgical occlusion of vessels-upper limb vessels	Major

ICD-9 Code	Description	Unmet Criterion
38.84	Other surgical occlusion of vessels-aorta	Central
38.85	Other surgical occlusion of vessels other thoracic vessels	Clinically coherent
38.86	Other surgical occlusion of vessels abdominal arteries	Central
38.87	Other surgical occlusion of vessels abdominal veins	Central
38.88	Other surgical occlusion of vessels-lower limb arteries	Central
38.89	Other surgical occlusion of vessels, lower limb veins	Major
38.9	Puncture of vessel	Major
38.91	Arterial catheterization	Major
38.92	Umbilical vein catheterization	Major
38.93	Venous catheterization, not elsewhere classified	Major
38.94	Venous cutdown	Major
38.95	Venous catheterization for renal dialysis	Major
38.98	Other puncture of artery	Major
38.99	Other puncture of vein	Major
39.0	Systemic to pulmonary artery shunt	Clinically coherent
39.1	Intra-abdominal venous shunt	Clinically coherent
39.21	Caval-pulmonary artery anastomosis	Clinically coherent
39.27	Arteriovenostomy for renal dialysis	Clinically coherent
39.28	Extracranial-intracranial (ec-ic) vascular bypass	Clinically coherent
39.3	Suture of vessel	Central
39.30	Suture of unspecified blood vessel	Central
39.31	Suture of artery	Central
39.32	Suture of vein	Major
39.41	Control of hemorrhage following vascular surgery	Major
39.42	Revision of arteriovenous shunt for renal dialysis	Clinically coherent
39.43	Removal of arteriovenous shunt for renal dialysis	Clinically coherent
39.51	Clipping of aneurysm	Clinically coherent
39.6	Extracorporeal circulation and procedures auxiliary to heart surgery	Clinically coherent
39.61	Extracorporeal circulation auxiliary to open heart surgery	Clinically coherent
39.62	Hypothermia (systemic) incidental to open heart surgery	Clinically coherent
39.63	Cardioplegia	Clinically coherent
39.64	Intraoperative cardiac pacemaker	Clinically coherent
39.65	Extracorporeal membrane oxygenation (ecmo)	Clinically coherent
39.66	Percutaneous cardiopulmonary bypass	Clinically coherent
39.75	Endovascular embolization or occlusion of vessel(s) of head or neck using bare coils	Clinically coherent
39.76	Endovascular embolization or occlusion of vessel(s) of head or neck using bioactive coils	Clinically coherent
39.8	Operations on carotid body, carotid sinus and other vascular bodies	Clinically coherent
39.81	Implantation or replacement of carotid sinus stimulation device, total system	Clinically coherent
39.82	Implantation or replacement of carotid sinus stimulation lead(s) only	Clinically coherent
39.83	Implantation or replacement of carotid sinus stimulation pulse generator only	Clinically coherent
39.84	Revision of carotid sinus stimulation lead(s) only	Clinically coherent

ICD-9 Code	Description	Unmet Criterion
39.85	Revision of carotid sinus stimulation pulse generator	Clinically coherent
39.86	Removal of carotid sinus stimulation device, total system	Clinically coherent
39.87	Removal of carotid sinus stimulation lead(s) only	Clinically coherent
39.88	Removal of carotid sinus stimulation pulse generator only	Clinically coherent
39.89	Other operations on carotid body, carotid sinus and other vascular bodies	Clinically coherent
39.91	Freeing of vessel	Major
39.92	Injection of sclerosing agent into vein	Major
39.93	Insertion of vessel-to-vessel cannula (listed with DRG 120)	Clinically coherent
39.94	Replacement of vessel-to-vessel cannula	Clinically coherent
39.95	Hemodialysis	Clinically coherent
39.96	Total body perfusion	Clinically coherent
39.97	Other perfusion	Clinically coherent
39.98	Control of hemorrhage, not otherwise specified	Central
39.99	Other operations on vessels	Clinically coherent
40.11	Biopsy of lymphatic structure	Major
40.19	Other diagnostic procedures on lymphatic structures	Major
40.21	Excision of deep cervical lymph node	Major
40.23	Excision of axillary lymph node	Major
40.24	Excision of inguinal lymph node	Major
40.29	Simple excision of other lymphatic structure	Major
40.3	Regional lymph node excision	Major
41.5	Total splenectomy	Clinically coherent
43.6	Partial gastrectomy with anastomosis to duodenum	Clinically coherent
43.7	Partial gastrectomy with anastomosis to jejunum	Clinically coherent
43.89	Other partial gastrectomy	Clinically coherent
43.99	Other total gastrectomy	Clinically coherent
44.38	Laparoscopic gastroenterostomy	Clinically coherent
44.39	Other gastroenterostomy	Clinically coherent
45.61	Multiple segmental resection of small intestine	Clinically coherent
45.62	Other partial resection of small intestine	Clinically coherent
45.72	Open and other cecectomy	Clinically coherent
45.73	Open and other right hemicolectomy	Clinically coherent
45.74	Open and other resection of transverse colon	Clinically coherent
45.75	Open and other left hemicolectomy	Clinically coherent
45.79	Other and unspecified partial excision of large intestine	Clinically coherent
45.81	Laparoscopic total intra-abdominal colectomy	Clinically coherent
45.82	Open total intra-abdominal colectomy	Clinically coherent
45.83	Other and unspecified total intra-abdominal colectomy	Clinically coherent
45.93	Other small-to-large intestinal anastomosis	Clinically coherent
46.03	Exteriorization of large intestine	Clinically coherent
46.13	Other permanent colostomy	Clinically coherent
47.09	Other appendectomy	Clinically coherent
48.25	Open biopsy of rectum	Clinically coherent
48.35	Local excision of rectal lesion or tissue	Clinically coherent

ICD-9 Code	Description	Unmet Criterion
48.62	Anterior resection of rectum with synchronous colostomy	Clinically coherent
48.63	Other anterior resection of rectum	Clinically coherent
48.69	Other resection of rectum	Clinically coherent
50.12	Open biopsy of liver	Clinically coherent
54.0	Incision of abdominal wall	Clinically coherent
54.11	Exploratory laparotomy	Clinically coherent
54.19	Other laparotomy	Clinically coherent
54.93	Creation of cutaneoperitoneal fistula	Clinically coherent
54.95	Incision of peritoneum	Clinically coherent
55.91	Decapsulation of kidney	Clinically coherent
84.00	Upper limb amputation, not otherwise specified	Clinically coherent
84.01	Amputation and disarticulation of finger	Clinically coherent
84.02	Amputation and disarticulation of thumb	Clinically coherent
84.03	Amputation through hand	Clinically coherent
84.04	Disarticulation of wrist	Clinically coherent
84.05	Amputation through forearm	Clinically coherent
84.06	Disarticulation of elbow	Clinically coherent
84.07	Amputation through humerus	Clinically coherent
84.08	Disarticulation of shoulder	Clinically coherent
84.09	Interthoracoscapular amputation	Clinically coherent
84.10	Lower limb amputation, not otherwise specified	Clinically coherent
84.11	Amputation of toe	Clinically coherent
84.12	Amputation through foot	Clinically coherent
84.13	Disarticulation of ankle	Clinically coherent
84.14	Amputation of ankle through malleoli of tibia and fibula	Clinically coherent
84.15	Other amputation below knee	Clinically coherent
84.16	Disarticulation of knee	Clinically coherent
84.17	Amputation above knee	Clinically coherent
84.18	Disarticulation of hip	Clinically coherent
84.19	Abdominopelvic amputation	Clinically coherent
84.3	Revision of amputation stump	Clinically coherent
84.91	Amputation, not otherwise specified	Clinically coherent
86.06	Insertion of totally implantable infusion pump	Clinically coherent
86.22	Excisional debridement of wound, infection, or burn	Clinically coherent
86.4	Radical excision of skin lesion	Clinically coherent
86.60	Free skin graft, not otherwise specified	Clinically coherent
86.61	Full-thickness skin graft to hand	Clinically coherent
86.62	Other skin graft to hand	Clinically coherent
86.63	Full-thickness skin graft to other sites	Clinically coherent
86.65	Heterograft to skin	Clinically coherent
86.66	Homograft to skin	Clinically coherent
86.67	Dermal regenerative graft	Clinically coherent
86.69	Other skin graft to other sites	Clinically coherent
86.70	Pedicle or flap graft, not otherwise specified	Clinically coherent

ICD-9 Code	Description	Unmet Criterion
86.71	Cutting and preparation of pedicle grafts or flaps	Clinically coherent
86.72	Advancement of pedicle graft	Clinically coherent
86.74	Attachment of pedicle or flap graft to other sites	Clinically coherent
86.75	Revision of pedicle or flap graft	Clinically coherent
86.91	Excision of skin for graft	Clinically coherent
86.93	Insertion of tissue expander	Clinically coherent
86.96	Insertion or replacement of other neurostimulator pulse generator	Clinically coherent
92.27	Implantation or insertion of radioactive elements	Clinically coherent

Appendix E. Anatomic Group Assignment of Procedure Codes

Anatomic Group	ICD-9/ CPT Code	ICD-9/CPT Code Description
Limb-Open	38.18	Endarterectomy-lower limb arteries
Limb-Open	38.08	Incision of vessels-lower limb arteries
Limb-Open	38.48	Resection of vessel with replacement-lower limb arteries
Limb-Open	38.68	Other excision of vessels-lower limb arteries
Limb-Open	38.38	Resection of vessel with anastomosis-lower limb arteries
Limb-Open	38.03	Incision of vessels-upper limb vessels
Limb-Open	38.13	Endarterectomy-upper limb vessels
Limb-Open	38.43	Resection of vessel with replacement-upper limb vessels
Limb-Open	38.33	Resection of vessel with anastomosis-upper limb vessels
Limb-Open	35226	Repair blood vessel, direct; lower extremity
Limb-Open	35903	Excision of infected graft; extremity
Limb-Open	35206	Repair blood vessel, direct; upper extremity
Limb-Open	35190	Repair, acquired or traumatic arteriovenous fistula; extremities
Limb-Open	35011	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm and associated occlusive disease, axillary-brachial artery, by arm incision
Limb-Open	35207	Repair blood vessel, direct; hand, finger
Limb-Open	35236	Repair blood vessel with vein graft; upper extremity
Limb-Open	35371	Thromboendarterectomy, including patch graft, if performed; common femoral
Limb-Open	35266	Repair blood vessel with graft other than vein; upper extremity
Limb-Open	35879	Revision, lower extremity arterial bypass, without thrombectomy, open; With vein patch angioplasty
Limb-Open	35045	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, radial or ulnar artery
Limb-Open	35883	Revision, femoral anastomosis of synthetic arterial bypass graft in groin, open; with nonautogenous patch graft (eg, Dacron, ePTFE, bovine pericardium)
Limb-Open	35302	Thromboendarterectomy, including patch graft, if performed; superficial femoral artery
Limb-Open	35372	Thromboendarterectomy, including patch graft, if performed; deep (profunda) femoral
Limb-Open	35556	Bypass graft, with vein; femoral-popliteal
Limb-Open	35656	Bypass graft, with other than vein; femoral-popliteal
Limb-Open	35881	Revision, lower extremity arterial bypass, without thrombectomy, open; with segmental vein interposition

Anatomic Group	ICD-9/ CPT Code	ICD-9/CPT Code Description
Limb-Open	35141	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, common femoral artery (profunda femoris, superficial femoral)
Limb-Open	35286	Repair blood vessel with graft other than vein; lower extremity
Limb-Open	35355	Thromboendarterectomy, including patch graft, if performed, iliofemoral
Limb-Open	35256	Repair blood vessel with vein graft; lower extremity
Limb-Open	35303	Thromboendarterectomy, including patch graft, if performed; popliteal artery
Limb-Open	35142	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for ruptured aneurysm, common femoral artery (profunda femoris, superficial femoral)
Limb-Open	35184	Repair, congenital arteriovenous fistula; extremities
Limb-Open	35151	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, popliteal artery
Limb-Open	35525	Bypass graft, with vein; brachial-brachial
Limb-Open	35566	Bypass graft, with vein; femoral-anterior tibial, posterior tibial, peroneal artery or other distal vessels
Limb-Open	35570	Bypass graft, with vein; tibial-tibial, peroneal-tibial, or tibial/peroneal trunk-tibial
Limb-Open	34813	Placement of femoral-femoral prosthetic graft during endovascular aortic aneurysm repair (list separately in addition to code for primary procedure)
Limb-Open	35013	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for ruptured aneurysm, axillary-brachial artery, by arm incision
Limb-Open	35304	Thromboendarterectomy, including patch graft, if performed; tibioperoneal trunk artery
Limb-Open	35305	Thromboendarterectomy, including patch graft, if performed; tibial or peroneal artery, initial vessel
Limb-Open	35306	Thromboendarterectomy, including patch graft, if performed; each additional tibial or peroneal artery (list separately in addition to code for primary procedure)
Limb-Open	35523	Bypass graft, with vein; brachial-ulnar or radial
Limb-Open	35585	In-situ vein bypass; femoral-anterior tibial, posterior tibial, or peroneal artery
Limb-Open	35661	Bypass graft, with other than vein; femoral-femoral
Limb-Open	35884	Revision, femoral anastomosis of synthetic arterial bypass graft in groin, open; with autogenous vein patch graft
Limb-Open	35518	Bypass graft, with vein; axillary-axillary
Limb-Open	35521	Bypass graft, with vein; axillary-femoral

Anatomic Group	ICD-9/ CPT Code	ICD-9/CPT Code Description
Limb-Open	35558	Bypass graft, with vein; femoral-femoral
Limb-Open	35571	Bypass graft, with vein; popliteal-tibial, -peroneal artery or other distal vessels
Limb-Open	35650	Bypass graft, with other than vein; axillary-axillary
Limb-Open	34101	Embolectomy or thrombectomy, with or without catheter; axillary, brachial, innominate, subclavian artery, by arm incision
Limb-Open	35459	Transluminal balloon angioplasty, open; tibioperoneal trunk and branches
Limb-Open	34111	Embolectomy or thrombectomy, with or without catheter; radial or ulnar artery, by arm incision
Limb-Open	35485	Transluminal peripheral atherectomy, open; tibioperoneal trunk and branches
Limb-Open	35483	Transluminal peripheral atherectomy, open; femoral-popliteal
Limb-Open	34812	Open femoral artery exposure for delivery of endovascular prosthesis, by groin incision, unilateral
Thoracic/Abdominal -Open	38.44	Resection of abdominal Aorta with replacement
Thoracic/Abdominal -Open	39.25	Aorta-iliac-femoral bypass
Thoracic/Abdominal -Open	38.45	Resection of vessel with replacement-thoracic vessel
Thoracic/Abdominal -Open	38.16	Endarterectomy-abdominal arteries
Thoracic/Abdominal -Open	39.22	Aorta-subclavian-carotid bypass
Thoracic/Abdominal -Open	38.14	Endarterectomy-aorta
Thoracic/Abdominal -Open	39.26	Other intra-abdominal vascular shunt or bypass
Thoracic/Abdominal -Open	38.46	Resection of vessel with replacement-abdominal arteries
Thoracic/Abdominal -Open	38.34	Resection of Abdominal Aorta with anastomosis
Thoracic/Abdominal -Open	39.24	Aorta-renal bypass
Thoracic/Abdominal -Open	38.66	Other excision of vessels-abdominal arteries
Thoracic/Abdominal -Open	39.55	Reimplantation of aberrant renal vessel
Thoracic/Abdominal -Open	38.36	Resection of vessel with anastomosis-abdominal arteries
Thoracic/Abdominal -Open	38.15	Endarterectomy-other thoracic vessels
Thoracic/Abdominal	38.35	Resection of vessel with anastomosis-other thoracic vessels

Anatomic Group	ICD-9/ CPT Code	ICD-9/CPT Code Description
-Open		
Thoracic/Abdominal -Open	39.23	Other intrathoracic vascular shunt or bypass
Thoracic/Abdominal -Open	39.54	Re-entry operation (aorta)
Thoracic/Abdominal -Open	35321	Thromboendarterectomy, including patch graft, if performed; abdominal aorta
Thoracic/Abdominal -Open	35221	Repair blood vessel, direct; intra-abdominal
Thoracic/Abdominal -Open	35907	Excision of infected graft; abdomen
Thoracic/Abdominal -Open	35082	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for ruptured aneurysm, abdominal aorta
Thoracic/Abdominal -Open	35102	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, abdominal aorta involving iliac vessels (common, hypogastric, exter
Thoracic/Abdominal -Open	35216	Repair blood vessel, direct; intrathoracic without bypass
Thoracic/Abdominal -Open	34820	Open iliac artery exposure for delivery of endovascular prosthesis or iliac occlusion during endovascular therapy, by abdominal or retroperitoneal incision, unilateral
Thoracic/Abdominal -Open	35091	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, abdominal aorta involving visceral vessels (mesenteric, celiac, ren
Thoracic/Abdominal -Open	35092	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for ruptured aneurysm, abdominal aorta involving visceral vessels (mesenteric, celiac, renal)
Thoracic/Abdominal -Open	35103	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for ruptured aneurysm, abdominal aorta involving iliac vessels (common, hypogastric, external)
Thoracic/Abdominal -Open	35121	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, hepatic, celiac, renal, or mesenteric artery
Thoracic/Abdominal -Open	35131	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, iliac artery (common, hypogastric, external)

Anatomic Group	ICD-9/ CPT Code	ICD-9/CPT Code Description
Thoracic/Abdominal -Open	35480	Transluminal peripheral atherectomy, open; renal or other visceral artery
Thoracic/Abdominal -Open	35905	Excision of infected graft; thorax
Thoracic/Abdominal -Open	33330	Insertion of graft, aorta or great vessels; without shunt, or cardiopulmonary bypass
Thoracic/Abdominal -Open	35081	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, abdominal aorta
Thoracic/Abdominal -Open	35276	Repair blood vessel with graft other than vein; intrathoracic, without bypass
Thoracic/Abdominal -Open	35697	Reimplantation, visceral artery to infrarenal aortic prosthesis, each artery (List separately in addition to code for primary procedure)
Thoracic/Abdominal -Open	35663	Bypass graft, with other than vein; ilioiliac
Thoracic/Abdominal -Open	34831	Open repair of infrarenal aortic aneurysm or dissection, plus repair of associated arterial trauma, following unsuccessful endovascular repair; aorto-bi-iliac prosthesis
Thoracic/Abdominal -Open	33877	Repair of thoracoabdominal aortic aneurysm with graft, with or without cardiopulmonary bypass
Thoracic/Abdominal -Open	35531	Bypass graft, with vein; aortoceliac or aortomesenteric
Thoracic/Abdominal -Open	35565	Bypass graft, with vein; iliofemoral
Thoracic/Abdominal -Open	35637	Bypass graft, with other than vein; aortoiliac
Thoracic/Abdominal -Open	35651	Bypass graft, with other than vein; aortofemoral-popliteal
Thoracic/Abdominal -Open	33320	Suture repair of aorta or great vessels; without shunt or cardiopulmonary bypass
Thoracic/Abdominal -Open	35537	Bypass graft, with vein; aortoiliac
Thoracic/Abdominal -Open	35539	Bypass graft, with vein; aortofemoral
Thoracic/Abdominal -Open	35646	Bypass graft, with other than vein; aortobifemoral
Thoracic/Abdominal -Open	35452	Transluminal balloon angioplasty, open; aortic
Thoracic/Abdominal -Open	35454	Transluminal balloon angioplasty, open; iliac
Thoracic/Abdominal -Open	35450	Transluminal balloon angioplasty, open; renal or other visceral artery
Thoracic/Abdominal -Open	35481	Transluminal peripheral atherectomy, open; aortic

Anatomic Group	ICD-9/ CPT Code	ICD-9/CPT Code Description
Thoracic/Abdominal -Open	35665	Bypass graft, with other than vein; iliofemoral
Thoracic/Abdominal -Open	35616	Bypass graft, with other than vein; subclavian-axillary
Thoracic/Abdominal -Open	35606	Bypass graft, with other than vein; carotid-subclavian
Thoracic/Abdominal -Open	35458	Transluminal balloon angioplasty, open; brachiocephalic trunk or branches, each vessel
Thoracic/Abdominal -Open	35484	Transluminal peripheral atherectomy, open; brachiocephalic trunk or branches, each vessel
Limb-Endovascular	00.60	Insertion of drug-eluting stent(s) of superficial femoral artery
Limb-Endovascular	35474	Transluminal balloon angioplasty, percutaneous; femoral-popliteal
Limb-Endovascular	35493	Transluminal peripheral atherectomy, percutaneous; femoral-popliteal
Limb-Endovascular	35470	Transluminal balloon angioplasty, percutaneous; tibioperoneal trunk or branches, each vessel
Limb-Endovascular	35495	Transluminal peripheral atherectomy, percutaneous; tibioperoneal trunk and branches
Limb-Endovascular	35456	Transluminal balloon angioplasty, open; femoral-popliteal
Thoracic/Abdominal -Endovascular	39.71	Endovascular repair of abdominal aortic aneurysm with graft
Thoracic/Abdominal -Endovascular	39.73	Endovascular implantation of graft in thoracic aorta
Thoracic/Abdominal -Endovascular	35473	Transluminal balloon angioplasty, percutaneous; iliac
Thoracic/Abdominal -Endovascular	35471	Transluminal balloon angioplasty, percutaneous; renal or visceral artery
Thoracic/Abdominal -Endovascular	35492	Transluminal peripheral atherectomy, percutaneous; iliac
Thoracic/Abdominal -Endovascular	35472	Transluminal balloon angioplasty, percutaneous; aortic
Thoracic/Abdominal -Endovascular	35490	Transluminal peripheral atherectomy, percutaneous; renal or other visceral artery
Thoracic/Abdominal -Endovascular	34808	Endovascular placement of iliac artery occlusion device (List separately in addition to code for primary procedure)
Thoracic/Abdominal -Endovascular	35491	Transluminal peripheral atherectomy, percutaneous; aortic
Thoracic/Abdominal -Endovascular	34825	Placement of proximal or distal extension prosthesis for endovascular repair of infrarenal abdominal aortic or iliac aneurysm false aneurysm, or dissection; initial vessel
Thoracic/Abdominal -Endovascular	34802	Endovascular repair of infrarenal abdominal aortic aneurysm or dissection; using modular bifurcated prosthesis (1 docking limb)
Thoracic/Abdominal -Endovascular	34800	Endovascular repair of infrarenal abdominal aortic aneurysm or dissection; using nono-aortic tube prosthesis

Anatomic Group	ICD-9/ CPT Code	ICD-9/CPT Code Description
Thoracic/Abdominal -Endovascular	34803	Endovascular repair of infrarenal abdominal aortic aneurysm or dissection; using modular bifurcated prosthesis (2 docking limb)
Thoracic/Abdominal -Endovascular	34805	Endovascular repair of infrarenal abdominal aortic aneurysm or dissection; using modular bifurcated prosthesis (1 docking limb), using aorto-iliac or aorto-unifemoral prosthesis
Thoracic/Abdominal -Endovascular	33880	Endovascular repair of descending thoracic aorta (eg. aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption); involving coverage of left subclavian artery origin, initial endoprosthesis plus descending thor
Thoracic/Abdominal -Endovascular	0078T	Endovascular repair using prosthesis of abdominal aortic aneurysm, pseudoaneurysm or dissection, abdominal aorta involving visceral branches (superior mesenteric, celiac and/or renal arteries)
Thoracic/Abdominal -Endovascular	33881	Endovascular repair of descending thoracic aorta (eg. aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption); not involving coverage of left subclavian artery origin, initial endoprosthesis plus descending
Thoracic/Abdominal -Endovascular	33886	Placement of distal extension prosthesis(s) delayed after endovascular repair of descending thoracic aorta
Thoracic/Abdominal -Endovascular	0080T	Endovascular repair of abdominal aortic aneurysm, pseudoaneurysm or abdominal aortic aneurysm involving visceral vessels (superior mesenteric, celiac or renal), using fenestrated modular bifurcated prosthesis (2 docking limbs), radiological supervision and
Thoracic/Abdominal -Endovascular	34804	Endovascular repair of infrarenal abdominal aortic aneurysm or dissection; using unibody bifurcated prosthesis
Thoracic/Abdominal -Endovascular	0081T	Placement of visceral extension prosthesis for endovascular repair of abdominal aortic aneurysm involving visceral vessels each visceral branch, radiological supervision and interpretation (Use separately in addition to code for primary procedure)
Thoracic/Abdominal -Endovascular	34900	Endovascular graft placement for repair of iliac artery (eg. aneurysm, pseudoaneurysm, arteriovenous malformation, trauma)
Thoracic/Abdominal -Endovascular	35475	Transluminal balloon angioplasty, percutaneous; brachiocephalic trunk or branches, each vessel
Thoracic/Abdominal -Endovascular	35494	Transluminal peripheral atherectomy, percutaneous; brachiocephalic trunk or branches, each vessel
Head/Neck- Endovascular	00.61	Percutaneous angioplasty or atherectomy of precerebral (extracranial) vessel(s), basilar, carotid, vertebral
Head/Neck- Endovascular	00.63	Percutaneous insertion of carotid artery stent(s), Includes: the use of any embolic protection device, distal protection device, filter device, or stent delivery system, Non-drug-eluting stent
Head/Neck- Endovascular	39.72	Endovascular repair or occlusion of head and neck vessels
Head/Neck- Endovascular	39.74	Endovascular removal of obstruction from head and neck vessel(s)

Anatomic Group	ICD-9/ CPT Code	ICD-9/CPT Code Description
Head/Neck-Endovascular	00.64	Percutaneous insertion of other precerebral (extracranial) artery stent(s)
Head/Neck-Endovascular	37215	Transcatheter placement of intravascular stent(s), cervical carotid artery, percutaneous; with distal embolic protection
Head/Neck-Endovascular	37216	Transcatheter placement of intravascular stent(s), cervical carotid artery, percutaneous; without distal embolic protection
Head/Neck-Endovascular	0075T	Transcatheter placement of extracranial vertebral or intrathoracic carotid artery stent(s), including radiologic supervision and interpretation, percutaneous; initial vessel
Head/Neck-Open	38.12	Endarterectomy-other vessels of head and neck
Head/Neck-Open	38.02	Incision of vessels-other vessels of head and neck
Head/Neck-Open	38.42	Resection of vessel with replacement-other vessels of head and neck
Head/Neck-Open	38.32	Resection of vessel with anastomosis-other vessels of head and neck
Head/Neck-Open	35201	Repair blood vessel, direct; neck
Head/Neck-Open	35005	Direct repair of aneurysm, pseudoaneurysm, or excision (partial or total) and graft insertion, with or without patch graft; for aneurysm, pseudoaneurysm, and associated occlusive disease, vertebral artery
Head/Neck-Open	35231	Repair blood vessel with vein graft; neck
Head/Neck-Open	35301	Thromboendarterectomy, including patch graft, if performed; carotid, vertebral, subclavian, by neck incision
Head/Neck-Open	35701	Exploration (not followed by surgical repair), with or without lysis of artery; carotid artery
Head/Neck-Open	34001	Embolectomy of thrombectomy, with or without catheter; carotid, subclavian, or innominate artery, by neck incision
Unspecified-Open	39.29	Other (peripheral) vascular shunt or bypass
Unspecified-Open	39.49	Other revision of vascular procedure
Unspecified-Open	39.52	Other repair of aneurysm
Unspecified-Open	39.59	Other repair of vessel
Unspecified-Open	39.57	Repair of blood vessel with synthetic patch graft
Unspecified-Open	39.56	Repair of blood vessel with tissue patch graft
Unspecified-Open	39.58	Repair of blood vessel with unspecified type of patch graft
Unspecified-Open	39.53	Repair of arteriovenous fistula
Unspecified-Open	38.10	Endarterectomy-unspecified site
Unspecified-Open	38.00	Incision of vessels-unspecified site
Unspecified-Open	38.40	Resection of vessel with replacement-unspecified site
Unspecified-Open	38.30	Resection of vessel with anastomosis-unspecified site
Unspecified-Open	35761	Exploration (not followed by surgical repair), with or without lysis of artery; other vessels
Unspecified-Open	35685	Placement of vein patch or cufl at distal anastomosis of bypass graft, synthetic conduit (list separately in addition to code for primary procedure)

Anatomic Group	ICD-9/ CPT Code	ICD-9/CPT Code Description
Unspecified-Open	35681	Bypass graft; composite, prosthetic and vein (List separately in addition to code for primary procedure)
Unspecified-Open	35506	Bypass graft, with vein; carotid-subclavian or subclavian-carotid
Unspecified-Open	37799	Unlisted procedure, vascular surgery
Unspecified-Open	37207	Transcatheter placement of an intravascular stent(s) (non-coronary vessel), open; initial vessel
Unspecified-Open	35875	Thrombectomy of arterial or venous graft (other than hemodialysis graft or fistula)
Unspecified-Open	35876	Thrombectomy of arterial or venous graft (other than hemodialysis graft or fistula); with revision of arterial or venous graft
Unspecified-Endovascular	39.50	Angioplasty or atherectomy of other non-coronary vessel(s)
Unspecified-Endovascular	39.90	Insertion of non-drug-eluting, non-coronary artery stent(s)
Unspecified-Endovascular	39.79	Other endovascular repair (of aneurysm) of other vessels
Unspecified-Endovascular	00.55	Insertion of drug-eluting stent(s) of other peripheral vessel(s), endograft(s), endovascular graft(s), stent grafts
Unspecified-Endovascular	37205	Transcatheter placement of an intravascular stent(s) (except coronary, carotid, and vertebral vessel), percutaneous; initial vessel
Unspecified-Endovascular	37206	Transcatheter placement of an intravascular stent(s) (except coronary, carotid, and vertebral vessel), percutaneous; each additional vessel (List separately in addition to code for primary procedure)
Unspecified-Endovascular	37204	Transcatheter occlusion or embolization (eg, for tumor destruction, to achieve hemostasis, to occlude a vascular malformation), percutaneous, any method, non-central nervous system, non-head or neck
Unspecified-Endovascular	37184	Primary percutaneous transluminal mechanical thrombectomy, noncoronary, arterial or arterial bypass graft, including fluoroscopic guidance and intraprocedural pharmacological thrombolytic injection(s); initial vessel
Unspecified-Endovascular	37186	Secondary percutaneous transluminal thrombectomy (eg, nonprimary mechanical, snare basket, suction technique), noncoronary, arterial or arterial bypass graft, including fluoroscopic guidance and intraprocedural pharmacological thrombolytic injections, pr
Unspecified-Endovascular	37187	Percutaneous transluminal mechanical thrombectomy, vein(s), including intraprocedural pharmacological thrombolytic injections and fluoroscopic guidance
Unspecified-Endovascular	37185	Primary percutaneous transluminal mechanical thrombectomy, noncoronary, arterial or arterial bypass graft, including fluoroscopic guidance and intraprocedural pharmacological thrombolytic injection(s); second and all subsequent vessel(s) within the same va

Anatomic Group	ICD-9/ CPT Code	ICD-9/CPT Code Description
Unspecified- Endovascular	37208	Transcatheter placement of an intravascular stent(s) (non-coronary vessel), open; each additional vessel (List separately in addition to code for primary procedure)

Appendix F. Assignment of Unspecified Procedures to Anatomic Groups Using Primary Discharge Diagnosis Code

Principal ICD-9 Discharge Diagnosis Code	ICD-9 Code Description	Anatomic Group
008.45	Intestinal infection due to clostridium difficile	Unspecified
38.12	Methicillin resistant staphylococcus aureus septicemia	Unspecified
38.9	Unspecified Septicemia	Unspecified
155.0	Malignant neoplasm of liver, primary	Unspecified
189.0	Malignant neoplasm of kidney except pelvis	Unspecified
197.7	Malignant neoplasm of liver secondary	Unspecified
250.60	Diabetes mellitus with neurological manifestations type ii or unspecified type not stated as uncontrolled	Unspecified
250.70	Diabetes mellitus with peripheral circulatory disorders type ii or unspecified type not stated as uncontrolled	Unspecified
250.72	Diabetes mellitus with peripheral circulatory disorders type ii or unspecified type uncontrolled	Unspecified
250.80	Diabetes mellitus with other specified manifestations type ii or unspecified type not stated as uncontrolled	Unspecified
250.82	Diabetes mellitus with other specified manifestations type ii or unspecified type uncontrolled	Unspecified
276.7	Hyperpotassemia	Unspecified
401.0	Malignant essential hypertension	Unspecified
401.9	Unspecified essential Hypertension	Unspecified
403.00	Malignant hypertensive renal disease without renal failure	Unspecified
403.90	Unspecified hypertensive renal disease without renal failure	Unspecified
403.91	Unspecified hypertensive renal disease with renal failure	Unspecified
404.91	Unspecified hypertensive heart and renal disease with heart failure	Unspecified
405.01	Malignant renovascular hypertension	Unspecified
405.91	Unspecified renovascular hypertension	Thoracic/abdominal
410.71	Subendocardial infarct episode of care unspecified	Unspecified
414.00	Coronary atherosclerosis of unspecified type of vessel native or graft	Unspecified
414.01	Coronary atherosclerosis of native coronary artery	Unspecified
414.02	Coronary atherosclerosis of autologous vein bypass graft	Unspecified

Principal ICD-9 Discharge Diagnosis Code	ICD-9 Code Description	Anatomic Group
415.19	Other pulmonary embolism and infarction	Unspecified
424.1	Aortic valve disorder	Unspecified
427.31	Atrial fibrillation	Unspecified
427.81	Sinoatrial node dysfunction	Unspecified
427.89	Other Specified Cardiac dysrhythmias	Unspecified
428.0	Congestive heart failure unspecified	Unspecified
428.23	Acute chronic systolic heart failure	Unspecified
428.33	Acute or chronic diastolic heart failure	Unspecified
433.10	Occlusion and stenosis of carotid artery without cerebral infarction	Head/neck
434.91	Cerebral artery occlusion unspecified with cerebral infarction	Head/neck
435.2	Subclavian steal syndrome	Thoracic/abdominal
440.0	Aortic atherosclerosis	Thoracic/abdominal
440.1	Atherosclerosis of renal artery	Thoracic/abdominal
440.20	Atherosclerosis of native arteries of the extremities unspecified	Limb
440.21	Atherosclerosis of native arteries of the extremities with intermittent claudication	Limb
440.22	Atherosclerosis of native arteries of the extremities with rest pain	Limb
440.23	Atherosclerosis of native arteries of the extremities with ulceration	Limb
440.24	Atherosclerosis of native arteries of the extremities with gangrene	Limb
440.29	Other atherosclerosis of native arteries of the extremities	Limb
440.30	Atherosclerosis of unspecified bypass graft of the extremities	Limb
440.31	Atherosclerosis of autologous vein bypass graft of the extremities	Unspecified
440.32	Atherosclerosis of nonautologous biological bypass graft of the extremities	Limb
440.8	Atherosclerosis of other specified arteries	Unspecified
441.2	Thoracic aneurysm without rupture	Thoracic/abdominal
441.3	Abdominal aneurysm ruptured	Thoracic/abdominal
441.4	Abdominal aneurysm without rupture	Thoracic abdominal
441.7	Thoracoabdominal aneurysm without rupture	Thoracic/abdominal

Principal ICD-9 Discharge Diagnosis Code	ICD-9 Code Description	Anatomic Group
442.2	Iliac artery aneurysm	Thoracic/abdominal
442.3	Lower extremity aneurysm	Limb
442.83	Aneurysm of splenic artery	Thoracic/abdominal
442.84	Aneurysm of other visceral artery	Thoracic/abdominal
443.89	Other peripheral vascular disease	Unspecified
443.9	Peripheral vascular disease unspecified	Unspecified
444.0	Embolism and thrombosis of abdominal aorta	Thoracic/abdominal
444.21	Arterial embolism and thrombosis of upper extremity	Limb
444.22	Arterial embolism and thrombosis of lower extremity	Limb
444.81	embolism and thrombosis of iliac artery	Thoracic/abdominal
444.89	Embolism and thrombosis of unspecified artery	Unspecified
445.02	Atheroembolism of lower extremity	Limb
447.1	Stricture of artery	Unspecified
447.4	Celiac artery compression syndrome	Thoracic/abdominal
453.40	Acute venous embolism and thrombosis of unspecified deep vessels of lower extremity	Unspecified
453.41	Acute venous embolism and thrombosis of deep vessels of proximal lower extremity	Unspecified
453.42	Acute venous embolism and thrombosis of deep vessels of distal lower extremity	Unspecified
453.8	Acute venous embolism and thrombosis of superficial veins of upper extremity	Unspecified
459.2	Compression of vein	Unspecified
459.81	Venous (peripheral) insufficiency unspecified	Unspecified
486	Pneumonia organism unspecified	Unspecified
491.21	Obstructive chronic bronchitis with (acute) exacerbation	Unspecified
518.81	Acute respiratory failure	Unspecified
557.0	Acute vascular insufficiency of intestine	Thoracic/abdominal
557.1	Chronic vascular insufficiency of intestine	Thoracic/abdominal
557.9	Unspecified vascular insufficiency of intestine	Thoracic/abdominal
562.12	Diverticulosis of colon with hemorrhage	Unspecified
578.9	Gastrointest hemorrhage	Unspecified
584.9	Acute kidney failure unspecified	Unspecified
585.6	End stage renal disease	Unspecified
599.0	Urinary tract infection not specified	Unspecified
682.6	Cellulitis and abscess of leg except foot	Unspecified
682.7	Cellulitis and abscess of foot except toes	Unspecified

Principal ICD-9 Discharge Diagnosis Code	ICD-9 Code Description	Anatomic Group
730.27	Unspecified osteomyelitis involving ankle and foot	Limb
786.50	Unspecified chest pain	Unspecified
786.59	Other chest pain	Unspecified
996.1	Mechanical complication of other vascular device implant and graft	Unspecified
996.62	Infection and inflammatory reaction due vascular device, implant and graft	Unspecified
996.72	Other complications due to other cardiac device implant and graft	Unspecified
996.74	Other complications due to other vascular device implant and graft	Unspecified
997.2	Peripheral vascular complications not elsewhere classified	Unspecified
997.62	Infection (chronic) of amputation stump	Limb
997.69	Other late amputation stump complication	Limb
998.11	Hemorrhage complicating a procedure	Unspecified
998.12	Hematoma complicating a procedure	Unspecified
998.59	Other postoperative infection	Unspecified
999.31	Infection due to central venous catheter	Unspecified
V58.11	Encounter for antineoplastic chemotherapy	Unspecified

Appendix G. CCs Not Risk Adjusted For If Coded in Index Hospital Stay Only

CC	Label
2	Septicemia/Shock
6	Other Infectious Diseases
17	Diabetes with Acute Complications
23	Disorders of Fluid/Electrolyte/Acid-Base
28	Acute Liver Failure/Disease
30	Gallbladder and Biliary Tract Disorders
31	Intestinal Obstruction/Perforation
34	Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders
46	Coagulation Defects and Other Specified Hematological Disorders
47	Iron Deficiency and Other/Unspecified Anemias and Blood Disease
48	Delirium and Encephalopathy
51	Drug/Alcohol Psychosis
68	Paraplegia
75	Coma, Brain Compression/Anoxic Damage
76	Mononeuropathy, Other Neurological Conditions/Injuries
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
85	Heart Infection/Inflammation, Except Rheumatic
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

CC	Label
133	Urinary Obstruction and Retention
134	Incontinence
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
157	Vertebral Fractures
158	Hip Fracture/Dislocation
159	Major Fracture, Except of Skull, Vertebrae, or Hip
160	Internal Injuries
161	Traumatic Amputation
162	Other Injuries
163	Poisonings and Allergic Reactions
164	Major Complications of Medical Care and Trauma
165	Other Complications of Medical Care
166	Major Symptoms, Abnormalities
176	Artificial Openings for Feeding or Elimination
177	Amputation Status, Lower Limb/Amputation
178	Amputation Status, Upper Limb

**2014 Measure Updates Memorandum:
Hospital 30-Day All-Cause Risk-Standardized Readmission Rate (RSRR)
following Vascular Procedures**

Submitted By:

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(YNHHSC/CORE)

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1. Purpose of Document

This document is intended to be used as a supplement to the attached 2011 Measure Methodology Report. Since the development of the Hospital 30-Day All-Cause Risk-Standardized Readmission Rate (RSRR) following Vascular Procedures measure in 2011, there have been changes to CMS's measure development methodology. This document describes the measure, updates made to the measure since its development, and the impact of the changes.

2. Overview of Measure

The Hospital 30-Day All-Cause Risk-Standardized Readmission Rate (RSRR) following Vascular Procedures measure (hereafter referred to as the vascular readmission measure) was developed to help hospitals understand the outcomes of patients undergoing vascular procedures. In brief, the cohort for the measure includes hospital stays with one or more qualifying vascular procedure in patients who are aged 65 years or older and either admitted to the hospital (inpatients) for their vascular procedure(s) or receive their procedure(s) at a hospital but are not admitted as an inpatient (i.e., outpatients). Both scenarios are hereafter referred to as "hospital stays." Medicare administrative claims data are used to identify hospital stays and subsequent readmissions. The measure estimates hospital 30-day all-cause unplanned RSRRs following discharge (or claim end date for hospital outpatients). RSRRs are estimated with hierarchical logistic regression models in order to account for clustering of observations within hospitals and differences in the number of patient hospital stays across hospitals. The overall methodological approach for this measure is consistent with that used to develop prior CMS readmission measures that are endorsed by the National Quality Forum (NQF) and which CMS now publicly reports.

3. Updates to Measure Since Its Development

The vascular readmission measure was developed in 2011, using data from 2008 and 2009. Since its development we have updated the measure specifications to 1) refine the way the inclusion and exclusion criteria are described and 2) refine the outcome definition to incorporate CMS's Planned Readmission Algorithm Version 3.0 – General Population. We have also performed updated testing of the measure using the revised specifications and newer years of data; these results can be found in the accompanying NQF application. We used 2009 and 2010 data for these revisions and updated testing.

3.1 Inclusion and Exclusion Criteria

This section describes updates to the way the inclusion and exclusion criteria are described. The original inclusion and exclusion criteria are described in Section 2.4 of the 2011 Measure Methodology Report.

3.1.1 Background and Definition

In order to maintain consistency with other similar measures developed by CMS, the inclusion and exclusion criteria have been revised. Specifically, three exclusion criteria from the 2011 methodology

have been modified and are now part of the inclusion criteria. For example, a hospital stay was previously excluded from the cohort if the patient died during the hospital stay. This criterion has been modified so that a hospital stay is included if the patient was discharged alive. The updated inclusion and exclusion criteria are as follows:

Hospital stays are eligible for inclusion in the cohort if:

- The patient is aged 65 years or older
- There is a qualifying vascular procedure (See Table 5 of the 2011 Measure Methodology Report)
- The patient has 12 months of continuous enrollment in Medicare fee-for-service prior to index hospital stay (updated from exclusion criteria)
- The patient was discharged alive from the hospital (updated from exclusion criteria)
- The patient was discharged from the hospital without a transfer to another acute hospital stay (updated from exclusion criteria)

Hospital stays are excluded from the cohort if they met any of the following criteria:

- Hospital stays for patients without at least 30 days post-discharge information
- Hospital stays for patients who leave hospital against medical advice (AMA)
- Hospital stays with a qualifying vascular procedure that occur within 30 days of a previous hospital stay with a qualifying vascular procedure

3.2 Planned Readmissions

During measure development we identified a set of "vascular-specific" planned readmissions, described further below and in section 2.3.4 of the 2011 Measure Methodology Report. We have since updated the measure to incorporate a broader planned readmission algorithm developed in a hospital-wide (not condition-specific) cohort that was adapted for this measure. Below we describe the original vascular-specific planned readmission definition, the adaptation of the broader hospital-wide algorithm as applied to this measure, and the final definition.

3.2.1 Original Approach to Identifying Planned Readmissions

During development of the vascular readmission measure, CMS, with input from a technical expert panel (TEP), identified a limited set of procedures that could be considered planned. Specifically, the original vascular-specific planned readmission definition considered the following three scenarios to be potentially planned readmissions, provided the index hospital stay and the subsequent hospitalization occurred at the same hospital: 1) same-procedure pairs (e.g., two subsequent admissions for endarterectomy), 2) different-procedure pairs (e.g., endovascular implantation of graft in abdominal aorta following an aorta-renal bypass), or 3) foot or toe amputations. With the exception of foot or toe amputations, the index hospital stay must be an inpatient stay for the readmission to be considered planned. If a planned readmission was identified, it was not counted in the measure outcome unless it was associated with a common acute diagnosis (e.g., sepsis), which would suggest that the readmission

was unplanned. The original lists of same- and different-procedure pairs and foot or toe amputation codes can be found in the accompanying 2011 Measure Methodology Report.

3.2.2 Process for Updating Definition of Planned Readmissions

Following the development of the vascular readmission measure, CMS contracted with YNHSC/CORE to develop CMS's Planned Readmission Algorithm based on a hospital-wide (not condition-specific) cohort of patients. The algorithm is a set of criteria for identifying readmissions that are typically planned and may occur within 30 days of discharge from the hospital. CMS has applied the algorithm to each of its NQF-endorsed readmission measures.

CMS based the Planned Readmission Algorithm Version 3.0 – General Population on three principles:

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

Unlike in the original vascular-specific planned readmission definition described above, information about the *index* hospital stay is not considered when determining whether a readmission is planned in the Planned Readmission Algorithm Version 3.0 – General Population. For more information on the development of the algorithm, please refer to the most recent publicly available version of the Planned Readmission Algorithm, the Centers for Medicare & Medicaid Services Planned Readmission Algorithm Version 2.1: General Population report (<http://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/HospitalQualityInits/Measure-Methodology.html>).

In order to ensure consistency with other CMS readmission measures and to take into account the recommendations of the TEP during measure development, we have modified the Planned Readmission Algorithm Version 3.0 – General Population to apply to the population undergoing vascular procedures. Specifically, we have integrated our original vascular-specific planned readmission definition into the Planned Readmission Algorithm Version 3.0 – General Population, and have also made modifications to the Planned Readmission Algorithm Version 3.0 – General Population to customize it for the population of patients included in the vascular readmission measure. This updated algorithm is called the Planned Readmission Algorithm Version 3.0 – Vascular Population.

3.2.3 Changes to the Planned Readmission Algorithm

In applying the Planned Readmission Algorithm Version 3.0 – General Population to the vascular readmission measure, a team of clinicians reviewed the algorithm in the context of the vascular readmission measure cohort and, where clinically indicated, adapted the algorithm to better accommodate the likely clinical experience of the cohort. Details of the Planned Readmission Algorithm Version 3.0 – Vascular Population, including procedures and diagnoses, can be found in the Appendix of this report.

Based on the input of clinical experts, the following procedure categories were removed from the Planned Readmission Algorithm Version 3.0 – General Population’s list of potentially planned procedures, as they are unlikely to be planned for the vascular population:

- Procedure CCS 51 (Endarterectomy; vessel of head and neck): Clinical experts agreed this was unlikely to represent a planned procedure for the vascular population unless it follows an index hospital stay with the same procedure (see Table PR4), at the same hospital.
- Procedure CCS 52 (Aortic resection; replacement of anastomosis): Clinical experts agreed this was unlikely to represent a planned procedure unless it follows an index hospital stay with one of a list of paired procedures (see Table PR4), at the same hospital.
- Procedure CCS 55 (Peripheral vascular bypass): Clinical experts agreed this was unlikely to represent a planned procedure unless it follows an index hospital stay with one of a list of paired procedures (see Table PR4), at the same hospital.
- Procedure CCS 59 (Other OR procedures of vessels of head and neck): Clinical experts agreed this was unlikely to represent a planned procedure unless it follows an index hospital stay with the same procedure (see Table PR4), at the same hospital.
- Procedure CCS 157 (Amputation of Lower Extremities): Amputation of a lower extremity, other than a toe or foot, after a vascular procedure may be due to a complication of the procedure and is unlikely to represent a planned procedure.
- Procedure CCS 169 (Debridement of wound; infection or burn): Clinical experts agreed this was unlikely to represent a planned procedure unless it follows an index hospital stay with one of a list of paired procedures (see Table PR4), at the same hospital.
- Procedure ICD-9 38.18 (Endarterectomy of lower limb arteries): Clinical experts agreed this was unlikely to represent a planned procedure unless it follows an index hospital stay with the same procedure (see Table PR4), at the same hospital.

The vascular readmission measure’s original planned readmission definition considered a small number of acute diagnoses which indicate an unplanned readmission, regardless of the procedure. In integrating the Planned Readmission Algorithm Version 3.0 – General Population with the vascular readmission measure’s original planned readmission definition, clinical experts recommended applying the broader list of acute diagnoses defined by the Planned Readmission Algorithm Version 3.0 – General Population to the Planned Readmission Algorithm Version 3.0 – Vascular Population. All of the original vascular readmission measure planned readmission definition’s original acute diagnoses, such as complications, AMI, and sepsis, are included in the Planned Readmission Algorithm Version 3.0 – General Population’s list of acute diagnoses.

3.2.4 Final Definition of Planned Readmissions

The Planned Readmission Algorithm Version 3.0 – Vascular Population uses a flowchart and five tables of specific procedure categories and discharge diagnosis categories¹ to classify readmissions as planned. As illustrated in the flowchart (Figure PR1), readmissions that include certain procedures (Table PR1) or are for certain diagnoses (Table PR2) are always considered planned. If the readmission does not include a procedure or diagnosis in Table PR1 or Table PR2, the algorithm checks whether the readmission contains at least one procedure that is considered potentially planned (Table PR3²). Two examples of potentially planned procedures are total hip replacement (Procedure CCS 153) and hernia repair (Procedure CCS 85).

If the readmission contains no procedures from Table PR3, the algorithm checks if the readmission could potentially be considered planned based on vascular-specific scenarios identified by clinical experts during development of the original vascular readmission measure. Specifically, the algorithm assesses whether the readmission is part of a same-procedure pair or a different-procedure pair, or a toe or foot amputation, at the same hospital as the index hospital stay, as listed in Table PR4.³ One example of a potentially planned different-pair procedure is a readmission for a peripheral vascular shunt or bypass (ICD-9 39.29) which follows an index hospital stay for an insertion of non-drug-eluting, non-coronary artery stent (ICD-9 39.90). The index hospital stay procedures in Table PR4 must be an inpatient hospital stay to be considered part of a planned same- or different-procedure pair; outpatient procedures are not eligible to be considered part of a same- or different-procedure pair. Toe or foot amputations are considered potentially planned regardless of whether they follow an inpatient or outpatient hospital stay.

If the readmission *does* have at least one potentially planned procedure from Table PR3 or Table PR4, the algorithm checks for a principal discharge diagnosis that is considered acute (Table PR5⁴). If the readmission has an acute principal discharge diagnosis from Table PR5, the readmission is considered unplanned. Otherwise, it is considered planned. Two examples of acute principal discharge diagnoses are pneumonia (Diagnosis CCS 122) and cardiac arrest (Diagnosis CCS 107). Any unplanned readmission within 30 days of an index hospital stay may be counted in the numerator of this measure, regardless of whether the patient had a planned readmission within 30 days of the index hospital stay.

¹ Agency for Healthcare Research and Quality (AHRQ) CCS codes group thousands of individual procedure and diagnosis ICD-9-CM codes into clinically coherent, mutually exclusive procedure CCS categories and mutually exclusive diagnosis CCS categories.

² Table PR3 includes 49 AHRQ procedure [Clinical Classification Software \(CCS\)](#) categories from among 231 AHRQ procedure CCS categories, plus 10 individual ICD-9-CM procedure codes.

³ Table PR4 includes the two amputation procedures, the 9 different-procedure pairs, and 33 same-procedure pairs that are considered potentially planned.

⁴ Table PR5 includes 101 diagnosis groups from among 285 AHRQ condition categories, plus 4 groupings of individual ICD-9-CM diagnosis codes that represent cardiac diagnoses that would not be associated with a planned readmission.

3.3 Updated Testing Results

Detailed measure results incorporating the updated outcome definition and more recent data can be found in the accompanying NQF application Measure Testing attachment.

4. Impact of Updates on Measure

The update to the inclusion and exclusion criteria has no impact on the cohort as it only changes whether a criterion is classified as an inclusion or exclusion criterion.

The impact of the updated Planned Readmission Algorithm Version 3.0 – Vascular Population on the vascular readmission measure is summarized in Table 1. In brief, of 39,334 readmissions in 2009, 3,357 (8.5%) were considered planned by the vascular readmission measure’s original planned readmission definition. With the updated Planned Readmission Algorithm Version 3.0 – Vascular Population, 5,200 (13.2%) were considered planned. The vast majority of readmissions considered planned in the original definition are still considered planned in the updated Planned Readmission Algorithm Version 3.0 – Vascular Population. The national unadjusted unplanned readmission rate with the vascular readmission measure’s original planned readmission definition is 14.2%, whereas the national unadjusted unplanned readmission rate with the Planned Readmission Algorithm Version 3.0 – Vascular Population is 13.5%.

Table 1. Impact of Planned Readmission Updates on Outcome (2009 Data)

	Original Planned Readmission Algorithm, 2011 Methodology Report	Planned Readmission Algorithm Version 3.0 – Vascular Population
Number of hospital stays	253,956	253,956
Number of readmissions (total)	39,334	39,334
Readmission rate (total, unadjusted)	15.5%	15.5%
Number of unplanned readmissions	35,977	34,314
Unplanned readmission rate (unadjusted)	14.2%	13.5%
Number of planned readmissions	3,357	5,200
Planned readmission rate (unadjusted)	1.3%	2.1%
% of readmissions that are planned	8.5%	13.2%

5. Appendix: Planned Readmission Algorithm Figure and Tables

Figure PR1: Planned Readmission Algorithm

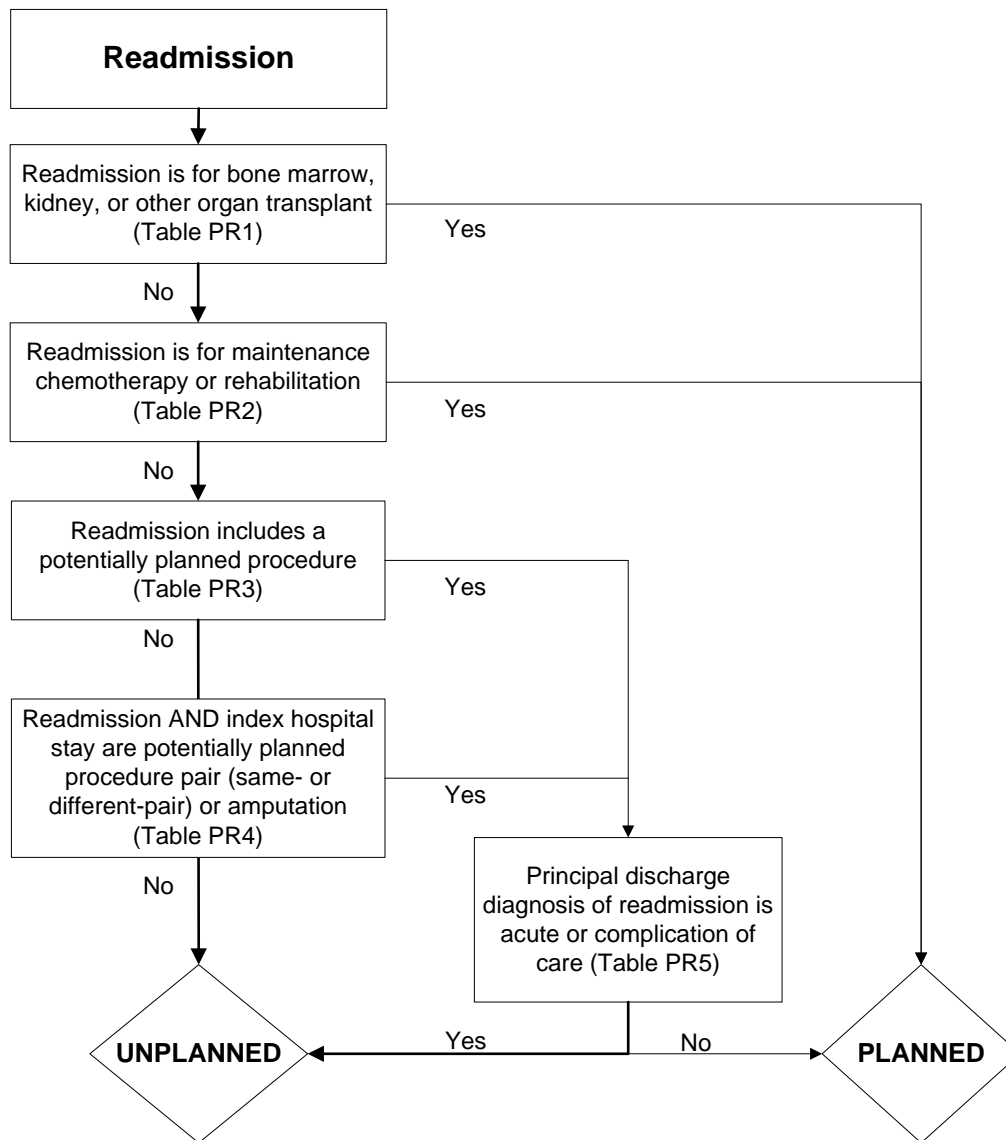


Table PR1: Procedure Categories That Are Always Planned (Version 3.0 — Vascular Population)

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

Table PR2: Diagnosis Categories That Are Always Planned (Version 3.0 — Vascular Population)

Diagnosis CCS	Description
45	Maintenance chemotherapy
254	Rehabilitation

Table PR3: Potentially Planned Procedure Categories (Version 3.0 — Vascular Population)

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

Procedure CCS	Description
153	Hip replacement; total and partial
154	Arthroplasty other than hip or knee
158	Spinal fusion
159	Other diagnostic procedures on musculoskeletal system
166	Lumpectomy; quadrantectomy of breast
167	Mastectomy
170	Excision of skin lesion
172	Skin graft
ICD-9 Codes	Description
30.1, 30.29, 30.3, 30.4, 31.74, 34.6	Laryngectomy, revision of tracheostomy, scarification of pleura (from Proc CCS 42- Other OR Rx procedures on respiratory system and mediastinum)
55.03, 55.04	Percutaneous nephrostomy with and without fragmentation (from Proc CCS 103- Nephrotomy and nephrostomy)
94.26, 94.27	Electroshock therapy (from Proc CCS 218- Psychological and psychiatric evaluation and therapy)

Table PR4: Vascular-Specific Procedure Pairs (Version 3.0 – Vascular Population)

ICD-9 Code	Description of Readmission Procedure	Only considered potentially planned following an index hospital stay procedure:
84.11	Amputation toe	Any vascular procedure
84.12	Amputation through foot	Any vascular procedure
38.44	Resection of abdominal aorta with replacement	38.12 Endarterectomy-other vessels of head and neck
39.73	Endovascular implantation of graft in thoracic aorta	39.22 Aorta-subclavian-carotid bypass
39.73	Endovascular implantation of graft in thoracic aorta	39.23 Other intrathoracic vascular shunt or bypass
39.71	Endovascular implantation of graft in abdominal aorta	39.24 Aorta-renal bypass
86.22	Excisional debridement of wound, infection, or burn	39.25 Aorta-iliac-femoral bypass
39.71	Endovascular implantation of graft in abdominal aorta	39.26 Other intra-abdominal vascular shunt or bypass
86.22	Excisional debridement of wound, infection, or burn	39.29 Other (peripheral) vascular shunt or bypass
39.29	Other (peripheral) vascular shunt or bypass	39.90 Insertion of non-drug-eluting, non-coronary artery stent(s)
39.50	Angioplasty or atherectomy of other non-coronary vessel(s)	39.90 Insertion of non-drug-eluting, non-coronary artery stent(s)
38.08	Incision of vessels-lower limb arteries	Same procedure during index hospital stay
38.12	Endarterectomy-other vessels of head and neck	Same procedure during index hospital stay
39.29	Other (peripheral) vascular shunt or bypass	Same procedure during index hospital stay
00.61	Percutaneous angioplasty or atherectomy of precerebral (extracranial) vessel(s), basilar, carotid, vertebral	Same procedure during index hospital stay
00.63	Percutaneous insertion of carotid artery stent(s), Includes: the use of any embolic protection device, distal protection device, filter device, or stent delivery system, Non-drug-eluting stent	Same procedure during index hospital stay
00.64	Percutaneous insertion of other precerebral (extracranial) artery stent(s)	Same procedure during index hospital stay
38.02	Incision of vessels-other vessels of head and neck	Same procedure during index hospital stay
38.32	Resection of vessel with anastomosis-other vessels of head and neck	Same procedure during index hospital stay
38.42	Resection of vessel with replacement-other vessels of head and neck	Same procedure during index hospital stay
39.72	Endovascular repair or occlusion of head and neck vessels	Same procedure during index hospital stay
38.18	Endarterectomy-lower limb arteries	Same procedure during index hospital stay
00.55	Insertion of drug-eluting stent(s) of other peripheral vessel(s), endograft(s), endovascular graft(s), stent grafts	Same procedure during index hospital stay

38.00	Incision of vessels-unspecified site	Same procedure during index hospital stay
38.03	Incision of vessels-upper limb vessels	Same procedure during index hospital stay
38.10	Endarterectomy-unspecified site	Same procedure during index hospital stay
38.13	Endarterectomy-upper limb vessels	Same procedure during index hospital stay
38.30	Resection of vessel with anastomosis-unspecified site	Same procedure during index hospital stay
38.33	Resection of vessel with anastomosis-upper limb vessels	Same procedure during index hospital stay
38.38	Resection of vessel with anastomosis-lower limb arteries	Same procedure during index hospital stay
38.40	Resection of vessel with replacement-unspecified site	Same procedure during index hospital stay
38.43	Resection of vessel with replacement-upper limb vessels	Same procedure during index hospital stay
38.48	Resection of vessel with replacement-lower limb arteries	Same procedure during index hospital stay
38.68	Other excision of vessels-lower limb arteries	Same procedure during index hospital stay
39.50	Angioplasty or atherectomy of other non-coronary vessel(s)	Same procedure during index hospital stay
39.52	Other repair of aneurysm	Same procedure during index hospital stay
39.53	Repair of arteriovenous fistula	Same procedure during index hospital stay
39.56	Repair of blood vessel with tissue patch graft	Same procedure during index hospital stay
39.57	Repair of blood vessel with synthetic patch graft	Same procedure during index hospital stay
39.58	Repair of blood vessel with unspecified type of patch graft	Same procedure during index hospital stay
39.59	Other repair of vessel	Same procedure during index hospital stay
39.79	Other endovascular repair (of aneurysm) of other vessels	Same procedure during index hospital stay
39.90	Insertion of non-drug-eluting, non-coronary artery stent(s)	Same procedure during index hospital stay
00.60	Insertion of drug-eluting stent(s) of superficial femoral artery	Same procedure during index hospital stay

Table PR5: Acute Diagnosis Categories (Version 3.0 — Vascular Population)

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

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

Diagnosis CCS	Description
247	Lymphadenitis
249	Shock
250	Nausea and vomiting
251	Abdominal pain
252	Malaise and fatigue
253	Allergic reactions
259	Residual codes; unclassified
650	Adjustment disorders
651	Anxiety disorders
652	Attention-deficit, conduct, and disruptive behavior disorders
653	Delirium, dementia, and amnestic and other cognitive disorders
656	Impulse control disorders, NEC
658	Personality disorders
660	Alcohol-related disorders
661	Substance-related disorders
662	Suicide and intentional self-inflicted injury
663	Screening and history of mental health and substance abuse codes
670	Miscellaneous disorders

ICD-9 codes	Description
Acute ICD-9 codes within Dx CCS 97: Peri-; endo-; and myocarditis; cardiomyopathy	
03282	Diphtheritic myocarditis
03640	Meningococcal carditis nos
03641	Meningococcal pericarditis
03642	Meningococcal endocarditis
03643	Meningococcal myocarditis
07420	Coxsackie carditis nos
07421	Coxsackie pericarditis
07422	Coxsackie endocarditis
07423	Coxsackie myocarditis
11281	Candidal endocarditis
11503	Histoplasma capsulatum pericarditis
11504	Histoplasma capsulatum endocarditis
11513	Histoplasma duboisii pericarditis
11514	Histoplasma duboisii endocarditis
11593	Histoplasmosis pericarditis
11594	Histoplasmosis endocarditis
1303	Toxoplasma myocarditis
3910	Acute rheumatic pericarditis
3911	Acute rheumatic endocarditis
3912	Acute rheumatic myocarditis
3918	Acute rheumatic heart disease nec
3919	Acute rheumatic heart disease nos
3920	Rheumatic chorea w heart involvement

Diagnosis CCS	Description
3980	Rheumatic myocarditis
39890	Rheumatic heart disease nos
39899	Rheumatic heart disease nec
4200	Acute pericarditis in other disease
42090	Acute pericarditis nos
42091	Acute idiopath pericarditis
42099	Acute pericarditis nec
4210	Acute/subacute bacterial endocarditis
4211	Acute endocarditis in other diseases
4219	Acute/subacute endocarditis nos
4220	Acute myocarditis in other diseases
42290	Acute myocarditis nos
42291	Idiopathic myocarditis
42292	Septic myocarditis
42293	Toxic myocarditis
42299	Acute myocarditis nec
4230	Hemopericardium
4231	Adhesive pericarditis
4232	Constrictive pericarditis
4233	Cardiac tamponade
4290	Myocarditis nos

Acute ICD-9 codes within Dx CCS 105: Conduction disorders

4260	Atrioventricular
42610	Atrioventricular block nos
42611	Atrioventricular block-1st degree
42612	Atrioventricular block-mobitz ii
42613	Atrioventricular block-2nd degree nec
4262	Left bundle branch hemiblock
4263	Left bundle branch block nec
4264	Right bundle branch block
42650	Bundle branch block nos
42651	Right bundle branch block/left posterior fascicular block
42652	Right bundle branch block/left ant fascicular block
42653	Bilateral bundle branch block nec
42654	Trifascicular block
4266	Other heart block
4267	Anomalous atrioventricular excitation
42681	Lown-ganong-levine syndrome
42682	Long qt syndrome
4269	Conduction disorder nos

Acute ICD-9 codes within Dx CCS 106: Dysrhythmia

4272	Paroxysmal tachycardia nos
7850	Tachycardia nos

Diagnosis CCS	Description
42789	Cardiac dysrhythmias nec
4279	Cardiac dysrhythmia nos
42769	Premature beats nec
Acute ICD-9 codes within Dx CCS 108: Congestive heart failure; nonhypertensive	
39891	Rheumatic heart failure
4280	Congestive heart failure
4281	Left heart failure
42820	Unspecified systolic heart failure
42821	Acute systolic heart failure
42823	Acute on chronic systolic heart failure
42830	Unspecified diastolic heart failure
42831	Acute diastolic heart failure
42833	Acute on chronic diastolic heart failure
42840	Unspec combined syst & dias heart failure
42841	Acute combined systolic & diastolic heart failure
42843	Acute on chronic combined systolic & diastolic heart failure
4289	Heart failure nos
Acute ICD-9 codes within Dx CCS 149: Biliary tract disease	
5740	Calculus of gallbladder with acute cholecystitis
57400	Calculus of gallbladder with acute cholecystitis without mention of obstruction
57401	Calculus of gallbladder with acute cholecystitis with obstruction
5743	Calculus of bile duct with acute cholecystitis
57430	Calculus of bile duct with acute cholecystitis without mention of obstruction
57431	Calculus of bile duct with acute cholecystitis with obstruction
5746	Calculus of gallbladder and bile duct with acute cholecystitis
57460	Calculus of gallbladder and bile duct with acute cholecystitis without mention of obstruction
57461	Calculus of gallbladder and bile duct with acute cholecystitis with obstruction
5748	Calculus of gallbladder and bile duct with acute and chronic cholecystitis
57480	Calculus of gallbladder and bile duct with acute and chronic cholecystitis without mention of obstruction
57481	Calculus of gallbladder and bile duct with acute and chronic cholecystitis with obstruction
5750	Acute cholecystitis
57512	Acute and chronic cholecystitis
5761	Cholangitis
Acute ICD-9 codes with Dx CCS 152: Pancreatic disorders	
5770	Acute pancreatitis