Technical Notes

for

Cardiac Surgery in Pennsylvania
2007 Report

Calendar Years 2006-2007 Data

The Pennsylvania Health Care Cost Containment Council
July 2009

Preface

The *Technical Notes for Cardiac Surgery in Pennsylvania* serves as a technical supplement to the Pennsylvania Health Care Cost Containment Council's (PHC4) report on coronary artery bypass graft (CABG) and valve surgery for combined calendar years 2006 and 2007 (January 1, 2006 to December 31, 2007) and calendar year 2007 only (January 1, 2007 to December 31, 2007). This document describes the methodology and development of the report and includes information on statewide results, cases excluded from analysis, and risk-adjustment models.

- The cardiac surgery report presents data on the outcomes associated with CABG surgery and heart valve surgery. The report includes two sets of outcomes for hospitals: 1) outcomes for combined 2006-2007 data, and 2) outcomes for 2007 only. The report includes one set of outcomes for surgeons based on the combined 2006-2007 data.
- The analysis included adult patients at least 30 years of age who underwent a CABG procedure, a valve procedure, or combined valve and CABG procedures in a Pennsylvania general acute care (GAC) hospital. Information is reported for each of the following four reporting groups:
    - CABG without valve
    - Valve without CABG
    - Valve with CABG
    - Total valve
- Risk-adjusted measures for hospitals and surgeons with at least 30 cases are reported for:
    - In-hospital mortality
    - Operative mortality (includes in-hospital and 30-day)
    - 7-day readmissions
    - 30-day readmissions
    - Post-surgical length of stay
- Average hospital charge (case-mix adjusted) is reported for hospitals with at least 13 cases.

The rigorous methodology described in this document was developed to account for the differences among individual patients that had the potential to influence the outcome of CABG and/or valve surgery.

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DATA COLLECTION AND VERIFICATION

The data for the Pennsylvania Health Care Cost Containment Council's (PHC4) *Cardiac Surgery in Pennsylvania* report was submitted electronically on a quarterly basis to PHC4 by Pennsylvania GAC hospitals. The data submitted included demographic information, hospital charges, and diagnosis and procedure codes. The standard data verification process included extensive quality assurance and data quality checks. Error reports were generated and returned to each facility with an opportunity to correct any problems.

In addition, hospitals used the MediQual *Atlas Outcomes*™ System to abstract information from the medical record that described each patient's state of health on admission.

Death certificate data was obtained to identify deaths that occurred subsequent to the hospitalization in which the CABG/valve surgery was performed. These data were supplied by the Bureau of Health Statistics and Research, Pennsylvania Department of Health, Harrisburg, Pennsylvania. The Pennsylvania Department of Health specifically disclaims responsibility for any analyses, interpretations, or conclusions.

Hospital and Cardiothoracic Surgeon Verification of Data

Discharge records for patients who underwent an open heart procedure in 2006 and/or 2007 were subjected to extensive data verification and quality assurance checks. Hospitals were requested to confirm the accuracy of discharge records, provide additional diagnoses and procedure codes as appropriate, and confirm that cases had the correct surgeon assignment. Surgeons were requested to perform a patient level review of the submitted records and then attest to the accuracy of the data and the surgeon assignment. Hospitals and/or surgeons had the opportunity to request special exclusions for cases in which the patient's outcome was most directly associated with conditions unrelated to the CABG/valve surgical episode or the care received during that hospitalization that were not accounted for through risk adjustment. The medical records were reviewed to determine whether special requests for exclusion (SRE) would be granted. In addition, because of their importance as risk factors, hospitals and surgeons had the opportunity to submit medical records for cases in which cardiogenic shock and/or acute renal failure were present at the time of or immediately prior to the surgery. These records were reviewed to verify that the criteria for pre-operative cardiogenic shock and/or pre-operative acute renal failure were met.

STUDY POPULATION

The CABG and valve study population included those patients discharged from Pennsylvania GAC hospitals in calendar year 2006 or 2007 after undergoing CABG and/or valve surgery as identified by the presence of an appropriate ICD-9-CM procedure code(s) in either the principal or secondary procedure code positions of the discharge record. The population included three subgroups of patients as defined below.

1. ***CABG without Valve:*** patients who underwent at least one CABG procedure as defined below and ***no*** valve procedures.

ICD-9-CM CABG Procedure Codes

Code	Description
36.10	Aortocoronary bypass for heart revascularization, not otherwise specified
36.11	Aortocoronary bypass of one coronary artery
36.12	Aortocoronary bypass of two coronary arteries
36.13	Aortocoronary bypass of three coronary arteries
36.14	Aortocoronary bypass of four or more coronary arteries
36.15	Single internal mammary-coronary artery bypass
36.16	Double internal mammary-coronary artery bypass
36.17	Abdominal-coronary artery bypass
36.19	Other bypass anastomosis for heart revascularization

2. ***Valve without CABG:*** patients who underwent at least one valve procedure as defined below and ***no*** CABG procedures.

ICD-9-CM Valve Procedure Codes

Code	Description
35.10	Open heart valvuloplasty without replacement, unspecified valve
35.11	Open heart valvuloplasty of aortic valve without replacement
35.12	Open heart valvuloplasty of mitral valve without replacement
35.13	Open heart valvuloplasty of pulmonary valve without replacement
35.14	Open heart valvuloplasty of tricuspid valve without replacement
35.20	Replacement of unspecified heart valve
35.21	Replacement of aortic valve with tissue graft
35.22	Other replacement of aortic valve
35.23	Replacement of mitral valve with tissue graft
35.24	Other replacement of mitral valve
35.25	Replacement of pulmonary valve with tissue graft
35.26	Other replacement of pulmonary valve
35.27	Replacement of tricuspid valve with tissue graft
35.28	Other replacement of tricuspid valve
35.33	Annuloplasty
35.99	Other operations on valves of heart

3. ***Valve with CABG:*** patients who underwent at least one of the above valve procedures ***and*** at least one of the above CABG procedures during the same admission.

EXCLUSIONS FOR OUTCOME ANALYSES

Cases meeting certain criteria were excluded from the outcome analyses. Standard exclusions consisted of the following: 1) patients less than 30 years of age, 2) patients who left against medical advice, and 3) clinically complex cases (see Appendix A for definitions). Standard exclusion criteria were applied to the in-hospital mortality analysis. Standard exclusion *and* exclusion criteria particular to the measure of interest were applied to the analyses of operative mortality, 7-day and 30-day readmissions, post-surgical length of stay, and average hospital charge. Appendix B displays exclusion data for each of these outcome measures.

MEASURES REPORTED

Note that two sets of outcomes are reported for hospitals: 1) outcomes for combined 2006-2007 data, and 2) outcomes for 2007 only. The report includes one set of outcomes for surgeons based on the combined 2006-2007 data.

Number of Cases

The number of cases (after standard exclusions were removed) is reported for hospitals and surgeons for each of the following reporting groups:

- ***CABG without Valve*** is the number of patients who underwent at least one CABG procedure without any valve procedures during the same admission.
- ***Valve without CABG*** is the number of patients who underwent at least one valve procedure without any CABG procedures during the same admission.
- ***Valve with CABG*** is the number of patients who underwent at least one valve procedure and at least one CABG procedure during the same admission.
- ***Total Valve*** is the number of patients who underwent at least one valve procedure with or without a CABG procedure during the same admission.

Note that the actual number of CABG/valve surgeries performed by a particular surgeon may be underreported. For example, procedures done in Veterans' hospitals and in other states were not included in this report.

In-Hospital Mortality

The in-hospital mortality rating was based on the number of deaths that occurred during the hospital admission in which the CABG/valve surgery was performed compared to the expected number of deaths. Information on whether the patient died during the hospital stay was provided by hospitals.

Operative Mortality

The operative mortality rating was based on the total number of operative deaths compared to the expected number of deaths. Operative deaths were defined as:

- The number of deaths that occurred during the hospitalization in which the CABG/valve surgery was performed, even if after 30 days, *and*
- The number of deaths that occurred after the patient was discharged from the hospital, but within 30 days of the procedure unless the death was clearly caused by unusual circumstances, such as those related to motor vehicle accidents or suicides. To determine whether a patient died within 30 days, death certificate information was obtained from the Pennsylvania Department of Health. Out-of-state residents were excluded from the analysis, because death certificate information was not available for these patients.

7-Day Readmissions

The 7-day readmissions rating was based on the number of patients who were readmitted to a GAC hospital (in Pennsylvania) within 1 to 7 days of being discharged from the hospitalization in which the CABG/valve surgery was performed compared to the expected number of readmissions. A readmission was counted only if the patient was readmitted with a principal diagnosis that indicated a heart-related condition, or an infection or a complication that was likely related to the CABG/valve surgery hospitalization. See Appendix C for a list of diagnosis categories that were counted as readmissions. Appendix D displays the number of readmissions for each category.

30-Day Readmissions

Similar to 7-day readmissions, the 30-day readmission rating was based on the number of patients who were readmitted to a GAC hospital within 1 to 30 days of being discharged from the hospitalization in which the CABG/valve surgery was performed compared to the expected number of readmissions. Readmissions were counted using the same principal diagnosis criteria used for 7-day readmissions. See Appendix C for a list of diagnosis categories that were counted as readmissions. Appendix D displays the number of readmissions for each category.

Post-Surgical Length of Stay

Post-surgical length of stay is the risk-adjusted number of days, on average, that patients stayed in the hospital following CABG/valve surgery.

Average Hospital Charge

Average hospital charge is reported for hospitals only. The average charges that appear in the report were trimmed for outliers and case-mix adjusted. The charges reported are those associated with the entire hospitalization during which the CABG/valve surgery was performed (not just the treatment associated with surgery). The charges do not include professional fees (e.g., physician fees). While charges are a standard way of reporting data, they do not reflect the actual cost of treatment, nor do they reflect the payment that the hospital may have actually received.

RISK ADJUSTMENT

In-hospital mortality, operative mortality, 7-day readmissions, 30-day readmissions, and post-surgical length of stay were risk adjusted, which means that the measure took into account the patient's health condition before surgery. Some patients who underwent CABG/valve surgery were more seriously ill than others. In order to report fair comparisons among hospitals and surgeons, PHC4 developed a complex mathematical formula to "risk adjust" the data, meaning that hospitals and surgeons receive "extra credit" for operating on patients who were more seriously ill or at a greater risk than others. Risk adjusting the data was important because sicker patients might be more likely to die, stay in the hospital longer, or be readmitted. Through logistic or linear regression modeling, risk factors (e.g., the age and sex of the patient and factors that indicate the illness level of the patient) were "tested" to determine which factors predicted patient outcomes (i.e., in-hospital mortality, operative mortality, 7-day and 30-day readmissions, and post-surgical length of stay). Note that a separate risk-adjustment model was built for each of these outcome measures and for each time period analyzed. The risk-adjustment models were then used to calculate the risk-adjusted ratings displayed in the report.

Each hospital and surgeon with at least 30 cases in a particular procedure group (after exclusions) received ratings for in-hospital mortality, operative mortality, 7-day readmissions, and 30-day readmissions. The ratings indicate whether the hospital or the surgeon's mortality or readmission rates were within the expected range or higher or lower than expected, taking into account the risk factors that were included in the risk-adjustment models. Rather than reporting a statistical rating for post-surgical length of stay, the risk-adjusted length of stay is reported in days. Additional detail on the methodology used to build the models and compute statistical ratings can be found in the sections titled "Risk Adjustment Methodology."

MORTALITY AND READMISSIONS ANALYSES

Risk Adjustment Methodology

Data Preparation

After cases meeting exclusion criteria were removed from the analysis, the remaining cases for each procedure group (i.e., CABG without Valve, Valve without CABG, and Valve with CABG) were randomly split into two equal-size samples for each procedure group: a development sample and a cross-validation sample. The number of relevant cases for each sample, combining the three procedure groups, is shown in Table 1a and Table 1b.

Table 1a. 2006-2007 Frequencies for Development Sample, Cross-Validation Sample, and Full Data Set

	Development Sample	Cross-Validation Sample	Full Data Set
In-Hospital Mortality			
Number of cases	16,145	16,143	32,288
Number of in-hospital deaths	440	410	850
Mortality rate (%)	2.7	2.5	2.6
Operative Mortality			
Number of cases	14,565	14,563	29,128
Number of operative deaths	465	493	958
Mortality rate (%)	3.2	3.4	3.3
7-Day Readmissions			
Number of cases	14,184	14,182	28,366
Number of readmissions within 7 days	856	941	1,797
Readmissions rate (%)	6.0	6.6	6.3
30-Day Readmissions			
Number of cases	14,184	14,182	28,366
Number of readmissions within 30 days	2,148	2,172	4,320
Readmissions rate (%)	15.1	15.3	15.2

Table 1b. 2007 Frequencies for Development Sample, Cross-Validation Sample, and Full Data Set

	Development Sample	Cross-Validation Sample	Full Data Set
In-Hospital Mortality			
Number of cases	7,828	7,827	15,655
Number of in-hospital deaths	200	193	393
Mortality rate (%)	2.6	2.5	2.5
Operative Mortality			
Number of cases	7,053	7,052	14,105
Number of operative deaths	234	214	448
Mortality rate (%)	3.3	3.0	3.2
7-Day Readmissions			
Number of cases	6,877	6,876	13,753
Number of readmissions within 7 days	472	442	914
Readmissions rate (%)	6.9	6.4	6.6
30-Day Readmissions			
Number of cases	6,877	6,876	13,753
Number of readmissions within 30 days	1,107	1,105	2,212
Readmissions rate (%)	16.1	16.1	16.1

Building the Risk-Adjustment Models

Identifying possible risk factors. The first step in building the risk-adjustment models for in-hospital mortality, operative mortality, 7-day readmissions, and 30-day readmissions was to identify possible risk factors, that is, those factors that potentially contributed to these events. In doing so, both clinical and demographic factors identified in the literature were considered, taking into account the availability and usability of the variables in the database. Also considered were factors tested in previous cardiac-related reports released by PHC4, as well as, MediQual's Key Clinical Findings (KCFs; see Appendix G). These possible risk-adjustment factors, referred to as candidate variables, were built using PHC4 data alone, MediQual data alone, or by combining the PHC4 and MediQual data (see Appendix E for definitions). In some instances variable definitions overlapped. In these instances only one of the variables was considered for a particular model(s). For example, if "AMI Other Inferior Wall Initial Episode[C]" was considered for a model, "Acute Myocardial Infaction[P]" was not. Also, some variables were not considered for a particular model(s) because they were not applicable. For example, the calendar year in which the surgery was performed was not applicable to the one-year (2007) model. Once the candidate variables were identified, models for each outcome measure were developed using the following processes: model selection, cross-validation, and calculation of model adequacy measures.

Model selection. Binary logistic regression was used to select risk factors for the mortality and readmission models. For the mortality models, the variables in Tables 2a and 3a, which were developed primarily by MediQual for their CABG/valve in-hospital mortality model using the MediQual *Atlas Outcomes*™ System data, were entered into the models and retained, unless the analysis did not suggest that the variable would be predictive of the outcome. Note that for the readmission models, the variables developed primarily by MediQual competed equally with other potential predictors during the selection process. Appendix F provides frequency data for candidate variables that were tested in the models.

The variables in Tables 2b, 3b, 4a, and 4b were entered into the models and tested for their impact in each model. Using a backward stepwise technique, candidate variables that had the least impact in the model were eliminated one at a time, until all variables remaining in the model were statistically significant. All tests of significance ($p < 0.10$) were based on the likelihood ratio. Results of the variable testing for the development model are displayed in Tables 2b, 3b, 4a, and 4b.

Cross-validation. After the development models were built for in-hospital mortality, operative mortality, 7-day readmissions, and 30-day readmissions, the models were cross-validated. That is, the models built in the model selection process (i.e., the development models) were re-estimated using the cases in the cross-validation samples. Regression analyses were performed to determine whether the selected candidate variables would remain predictive of the relevant outcomes for the cross-validation sample. As long as the coefficient of a variable did not change from positive to negative, the variable was retained in the final model that applied to the full data set. Note that during the cross-validation process of the mortality models, the variables developed primarily by MediQual were entered in the models but not considered for cross-validation. See Tables 2b, 3b, 4a, and 4b for the cross-validation and full data set results.

[C] This variable was based on both MediQual and PHC4 data.
[P] This variable was based on PHC4 data.

Table 2a. Candidate Variables Entered Into the Mortality Models, 2006-2007 Data

Variables retained in the model(s) are in bold text

Demographic Variables	*Clinical Variables Other Than Lab*	
Age in Years [P]	**AMI Other Inferior Wall Initial Episode** [C]	**History of Peripheral Vascular Disease** [C]
Age # of Years > 65 [P]	**ASA Class 5** [MQ]	**MI/AMI Other Anterior Wall** [C]
Female [P]	**ASA Emergency** [MQ]	**Mild, Moderate or Severe Altered Mental Status** [MQ]
Lab Variables	**CAD >70, 5-7 Vessels Group** [MQ]	**Other CV Procedure Group** [C]
Albumin < 2.5 g/dL [MQ]	**Current Med Immunosuppressive** [MQ, 1]	Percent of Left Main Stenosis [MQ, 2]
Albumin 2.5 - 3 g/dL [MQ]	**Current Med Insulin** [MQ]	**Procedure Group** [P]
BUN > 40 mg/dL [MQ]	**Ejection Fraction** [MQ]	**PTCA/Stent/Tear Same Day CABG/Valve Surgery** [C]
Creatinine > 1.4 mg/dL [MQ]	**Heart Failure** [C]	Septal Other Anomalous Repair Heart [MQ, 3]
Glucose > 165 mg/dL [MQ]	**History of CABG or Valve Surgery** [C]	**SIRS Group** [MQ]

Table 2b. Candidate Variables Tested as Potential Predictors of Mortality, 2006-2007 Data

The results of variable testing for the 2006-2007 mortality models are displayed in the table below. Variables found to be significant predictors and their associated *p*-values are in bold text.

Candidate Variables	In-Hospital Mortality			Operative Mortality		
	Develop-ment	Cross-Validation	Full Data Set	Develop-ment	Cross-Validation	Full Data Set
Demographic Variables						
Race (category) [P]	ns	nt[1]	nt[1]	**0.049**	**0.432**	**0.040**
Clinical Variables Other Than Lab						
AMI Except Other Anterior or Other Inferior Wall [P]	**< 0.001**	**0.003**	**< 0.001**	**< 0.001**	**0.002**	**< 0.001**
Cachexia [P]	**0.009**	**< 0.001**	**< 0.001**	**< 0.001**	**0.002**	**< 0.001**
Cardiac Adhesions [P]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]
Cardiogenic Shock, Pre-Operative [P]	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**
Cardiomyopathy [P]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]
Chronic Lung Disease [P]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]
Chronic Pulmonary Hypertension [P]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]
Fibrosis in Mediastinum and Heart [P]	ns	nt[1]	nt[1]	nt[2]	nt[2]	nt[2]
Hypertension with Complications [P]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery [P]	**0.098**	**0.201**	**0.033**	ns	nt[1]	nt[1]
Liver Disease [P]	**< 0.001**	**0.001**	**< 0.001**	**0.001**	**< 0.001**	**< 0.001**
Lupus Erythematosus, Systemic [P]	**0.059**	**0.019**	**0.004**	nt[2]	nt[2]	nt[2]
Multiple Valve Procedures [P]	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**0.010**	**< 0.001**
Renal Failure/Dialysis (category) [P]	**0.039**	**0.523**	**0.051**	**0.005**	**0.642**	**0.041**

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.
[1] This variable was not retained in the in-hospital mortality model because the analysis did not suggest that the variable would be predictive of the relevant outcome (i.e., the variable's coefficient was negative).
[2] This variable was not entered or retained in the in-hospital or operative mortality model because the value was missing for 70 percent of cases.
[3] This variable was not retained in the in-hospital or operative mortality model because the analysis did not suggest that the variable would be predictive of the relevant outcome (i.e., the variable's coefficient was negative).
ns Not significant. This variable was not included in the final model because it was not a significant ($p < 0.10$) predictor of the relevant outcome.
nt[1] Not tested. This variable was not tested in the cross-validation or full data set model because it was not significant in the development model.
nt[2] Not tested. The univariate analysis did not suggest that the variable would be predictive of the relevant outcome.

Table 3a. Candidate Variables Entered Into the Mortality Models, 2007 Data

Variables retained in the model(s) are in bold text

Demographic Variables	*Clinical Variables Other Than Lab*	
Age in Years [P]	**AMI Other Inferior Wall Initial Episode** [C]	**History of Peripheral Vascular Disease** [C]
Age # of Years > 65 [P]	**ASA Class 5** [MQ]	**MI/AMI Other Anterior Wall** [C]
Female [P]	**ASA Emergency** [MQ]	**Mild, Moderate or Severe Altered Mental Status** [MQ, 2]
Lab Variables	**CAD >70, 5-7 Vessels Group** [MQ]	**Other CV Procedure Group** [C]
Albumin < 2.5 g/dL [MQ]	**Current Med Immunosuppressive** [MQ]	Percent of Left Main Stenosis [MQ, 3]
Albumin 2.5 - 3 g/dL [MQ]	**Current Med Insulin** [MQ]	**Procedure Group** [P]
BUN > 40 mg/dL [MQ]	**Ejection Fraction** [MQ]	**PTCA/Stent/Tear Same Day CABG/Valve Surgery** [C]
Creatinine > 1.4 mg/dL [MQ]	**Heart Failure** [C]	Septal Other Anomalous Repair Heart [MQ, 1]
Glucose > 165 mg/dL [MQ, 1]	**History of CABG or Valve Surgery** [C]	**SIRS Group** [MQ]

Table 3b. Candidate Variables Tested as Potential Predictors of Mortality, 2007 Data

The results of variable testing for the 2007 mortality models are displayed in the table below.
Variables found to be significant predictors and their associated *p*-values are in bold text.

Candidate Variables	In-Hospital Mortality			Operative Mortality		
	Develop-ment	Cross-Validation	Full Data Set	Develop-ment	Cross-Validation	Full Data Set
Clinical Variables Other Than Lab						
AMI Except Other Anterior or Other Inferior Wall [P]	**0.001**	**0.056**	**< 0.001**	**0.009**	**0.005**	**< 0.001**
Cachexia [P]	**0.019**	**0.230**	**0.023**	ns	nt[1]	nt[1]
Cardiac Adhesions [P]	ns	nt[1]	nt[1]	nt[2]	nt[2]	nt[2]
Cardiogenic Shock, Pre-Operative [P]	**< 0.001**	**0.038**	**< 0.001**	**0.001**	**0.015**	**< 0.001**
Cardiomyopathy [P]	ns	nt[1]	nt[1]	nt[2]	nt[2]	nt[2]
Chronic Lung Disease [P]	ns	nt[1]	nt[1]	nt[2]	nt[2]	nt[2]
Chronic Pulmonary Hypertension [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]
Hypertension with Complications [P]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]
Liver Disease [P]	**0.079**	**0.021**	**0.006**	**0.013**	**0.006**	**< 0.001**
Lupus Erythematosus, Systemic [P]	ns	nt[1]	nt[1]	**0.057**	**0.088**	**0.013**
Multiple Valve Procedures [P]	**0.004**	**< 0.001**	**< 0.001**	**0.003**	**0.001**	**< 0.001**
Renal Failure/Dialysis (category) [P]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.
[1] This variable was not retained in the in-hospital or operative mortality model because the analysis did not suggest that the variable would be predictive of the relevant outcome (i.e., the variable's coefficient was negative).
[2] This variable was not retained in the operative mortality model because the analysis did not suggest that the variable would be predictive of the relevant outcome (i.e., the variable's coefficient was negative).
[3] This variable was not entered or retained in the in-hospital or operative mortality model because the value was missing for 70 percent of cases.
ns Not significant. This variable was not included in the final model because it was not a significant ($p < 0.10$) predictor of the relevant outcome.
nt[1] Not tested. This variable was not tested in the cross-validation or full data set model because it was not significant in the development model.
nt[2] Not tested. The univariate analysis did not suggest that the variable would be predictive of the relevant outcome.

Table 4a. Candidate Variables Tested as Potential Predictors of Readmission, 2006-2007 Data

The results of variable testing for the 2006-2007 readmission models are displayed in the table below. Variables found to be significant predictors and their associated *p*-values are in bold text.

Candidate Variables	7-Day Readmissions			30-Day Readmissions		
	Develop-ment	Cross-Validation	Full Data Set	Develop-ment	Cross-Validation	Full Data Set
Year	**0.091**	**0.228**	**0.041**	**0.004**	**0.048**	**0.001**
Demographic Variables						
Age in Years [P]	**< 0.001**	**0.001**	**< 0.001**	ns	nt[1]	nt[1]
Age # of Years > 65 [P]	ns	nt[1]	nt[1]	**< 0.001**	**< 0.001**	**< 0.001**
Female [P]	**0.017**	**0.563**	**0.040**	**0.001**	**0.001**	**< 0.001**
Race (category) [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]
Clinical Variables Other Than Lab						
Anemia [P]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]
Cachexia [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]
Cancer [P]	**0.069**	**0.228**	**0.034**	nt[2]	nt[2]	nt[2]
Cardiac Adhesions [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]
Cardiogenic Shock, Pre-Operative [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]
Cardiomyopathy [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]
Cerebrovascular Disease [P]	nt[2]	nt[2]	nt[2]	**0.060**	**0.283**	**0.037**
Chronic Lung Disease [P]	ns	nt[1]	nt[1]	**0.055**	**0.001**	**< 0.001**
Chronic Pulmonary Hypertension [P]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]
Depression [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]
Diabetes (category) [P]	**0.005**	**0.018**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**
Excision or Other Lesion/Heart Tissue, Open Approach – Same Date as Valve Surgery [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]
Fibrosis in Mediastinum and Heart [P]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]
Heart Failure [P]	**0.098**	**0.001**	**0.001**	**< 0.001**	**< 0.001**	**< 0.001**
History of CABG or Valve Surgery [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]
History of PTCA/Stent [P]	nt[2]	nt[2]	nt[2]	**0.001**	**0.030**	**< 0.001**
History of Chronic Steroid Use [P]	nt[2]	nt[2]	nt[2]	**0.011**	**0.693**	**0.139**
History of Peripheral Vascular Disease [P]	ns	nt[1]	nt[1]	**0.030**	**0.074**	**0.005**
Hypertension with Complications [P]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]
Liver Disease [P]	nt[2]	nt[2]	nt[2]	**0.013**	**0.270**	**0.011**
Lupus Erythematosus, Systemic [P]	nt[2]	nt[2]	nt[2]	**0.076**	**0.164**	**0.022**
MediQual Predicted Length of Stay [MQ]	**0.002**	**0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**
Multiple Valve Procedures [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]
Obesity, Morbid [P]	ns	nt[1]	nt[1]	**0.003**	**0.009**	**< 0.001**
Other CV Procedure Group [C]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]
Procedure Group [P]	**Entered and retained in model**			**Entered and retained in model**		
Renal Failure/Dialysis (category) [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.
ns Not significant. This variable was not included in the final model because it was *not* a significant ($p < 0.10$) predictor of the relevant outcome.
nt[1] Not tested. This variable was not tested in the cross-validation or full data set model because it was not significant in the development model.
nt[2] Not tested. The univariate analysis did not suggest that the variable would be predictive of the relevant outcome.

Table 4b. Candidate Variables Tested as Potential Predictors of Readmission, 2007 Data

The results of variable testing for the 2007 readmission models are displayed in the table below. Variables found to be significant predictors and their associated *p*-values are in bold text.

Candidate Variables	7-Day Readmissions			30-Day Readmissions		
	Develop-ment	Cross-Validation	Full Data Set	Develop-ment	Cross-Validation	Full Data Set
Demographic Variables						
Age in Years [P]	**< 0.001**	**< 0.001**	**< 0.001**	ns	nt[1]	nt[1]
Age # of Years > 65[P]	ns	nt[1]	nt[1]	**< 0.001**	**0.001**	**< 0.001**
Female [P]	**0.078**	**0.098**	**0.015**	**0.014**	**< 0.001**	**< 0.001**
Race (category) [P]	**0.016**	**0.252**	**0.011**	**< 0.001**	**0.356**	**0.002**
Clinical Variables Other Than Lab						
Anemia [P]	ns	nt[1]	nt[1]	**0.070**	**0.376**	**0.494**
Cachexia [P]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]
Cancer [P]	**0.018**	**0.425**	**0.021**	ns	nt[1]	nt[1]
Cardiomyopathy [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]
Cerebrovascular Disease [P]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]
Chronic Lung Disease [P]	ns	nt[1]	nt[1]	**< 0.001**	**0.100**	**< 0.001**
Chronic Pulmonary Hypertension [P]	ns	nt[1]	nt[1]	**0.097**	**0.930**	**0.222**
Diabetes (category) [P]	**0.014**	**0.151**	**0.005**	**0.008**	**0.044**	**0.001**
Heart Failure [P]	**0.009**	**0.071**	**0.002**	**0.009**	**0.027**	**0.001**
History of CABG or Valve Surgery [P]	ns	nt[1]	nt[1]	nt[2]	nt[2]	nt[2]
History of Peripheral Vascular Disease [P]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]
Hypertension with Complications [P]	**0.072**	**0.629**	**0.106**	**0.005**	**0.412**	**0.011**
Liver Disease [P]	nt[2]	nt[2]	nt[2]	**0.032**	**0.511**	**0.042**
Lupus Erythematosus, Systemic [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]
MediQual Predicted Length of Stay [MQ]	**0.060**	**0.164**	**0.019**	**0.001**	**< 0.001**	**< 0.001**
Multiple Valve Procedures [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]
Obesity, Morbid [P]	**0.009**	**0.360**	**0.009**	**0.016**	**0.002**	**< 0.001**
Other CV Procedure Group [C]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]
Procedure Group [P]	**Entered and retained in model**			**Entered and retained in model**		
PTCA/Stent Same Day as CABG/Valve Surgery [P]	ns	nt[1]	nt[1]	nt[2]	nt[2]	nt[2]
Renal Failure/Dialysis (category) [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.
ns Not significant. This variable was not included in the final model because it was *not* a significant ($p < 0.10$) predictor of the relevant outcome.
nt[1] Not tested. This variable was not tested in the cross-validation or full data set model because it was not significant in the development model.
nt[2] Not tested. The univariate analysis did not suggest that the variable would be predictive of the relevant outcome.

Measure of model adequacy. To evaluate the model performance for both the development and cross-validation samples, the estimated coefficients from the development model were applied to both samples. The coefficients from the final model were applied to the full data set. The *c* statistic was used to measure model adequacy. The *c* statistic, the measure of "goodness of fit" used to describe a logistic regression model, is a common measure for models with binary dependent variables. For binary outcomes, the *c* statistic is defined as the area under the receiver operating characteristic (ROC) curve[1]. The *c* statistic ranges between 0.5 and 1.0, with higher values associated with better discrimination, and can be expressed as a percentage ranging from 50 to 100 percent. In some respects, the *c* statistic is similar to the R^2 commonly used in linear regression. Both the *c* statistic and R^2 approach 1.0 for models that perfectly discriminate. However, unlike R^2, the *c* statistic is not dependent on the frequency of the outcome. The *c* statistics for the models are listed in Table 5.

Table 5. C Statistics for Development, Cross-Validation, and Full Data Set Models

Measure	Development Model %	Cross-Validation Model %	Full Data Set Model %
2006-2007 Models			
In-Hospital Mortality	80.7	80.6	81.1
Operative Mortality	82.0	77.1	79.9
7-Day Readmissions	60.5	60.7	60.8
30-Day Readmissions	62.6	62.5	62.6
2007 Models			
In-Hospital Mortality	79.5	80.1	80.3
Operative Mortality	79.1	78.9	79.5
7-Day Readmissions	64.8	61.8	63.7
30-Day Readmissions	65.0	62.1	63.8

Coefficients and Odds Ratios

The coefficients and odds ratios for each risk factor included in the final models are listed in Tables 6a, 6b, 7a, and 7b. The entire data set was used in creating the final coefficients (i.e., the development sample and the cross-validation sample were "recombined", and the coefficients were re-estimated). For a binary variable, the odds ratio is the change in the odds for a patient with the risk factor compared to a patient without it. For example, the odds ratio for Cardiogenic Shock – Preoperative is 3.506 for the 2006-2007 in-hospital mortality model, meaning that a patient with cardiogenic shock prior to surgery was more than three times as likely to die during the hospital admission as patients who did not have this risk factor. Odds ratios are not applicable for continuous variables such as age in years and MediQual Predicted Length of Stay.

[1] Hanley, J. A., & McNeil, B. J. (1982). The meaning and use of the area under a receiver operating characteristic (ROC) curve. *Radiology, 143*(1), 29-36.

Table 6a. Coefficients and Odds Ratios of Final Mortality Models, 2006-2007 Data

Predictor Variables	In-Hospital Mortality		Operative Mortality	
	Coefficient	Odds Ratio	Coefficient	Odds Ratio
Constant	-6.7850		-6.3470	
Demographic Variables				
Age in Years [P]	0.0191	NA	0.0170	NA
Age # Years > 65 [P]	0.0347	NA	0.0389	NA
Female [P]	0.3413	1.407	0.3590	1.432
Race (category)				
Black	ns	–	0.3488	1.417
Other	ns	–	0.1967	1.217
White	ns	–	*	*
Laboratory Variables				
Albumin < 2.5 [MQ]	0.5378	1.712	0.4282	1.534
Albumin 2.5-3 [MQ]	0.0842	1.088	0.2316	1.261
BUN > 40 [MQ]	0.4484	1.566	0.4225	1.526
Creatinine > 1.4 [MQ]	0.2450	1.278	0.2460	1.279
Glucose > 165 [MQ]	0.0843	1.088	0.0344	1.035
Clinical Variables Other Than Laboratory Variables				
AMI Except Other Anterior or Other Inferior Wall [P]	0.5384	1.713	0.5480	1.730
AMI Other Inferior Wall Initial Episode [C]	0.9214	2.513	0.7650	2.149
ASA Class 5 [MQ]	1.0035	2.728	1.1908	3.290
ASA Emergency Flag [MQ]	0.5364	1.710	0.5767	1.780
Cachexia [P]	0.6771	1.968	0.8499	2.339
CAD > 70, 5-7 Vessels Grp [MQ]	0.1807	1.198	0.1978	1.219
Cardiogenic Shock, Preoperative [P]	1.2545	3.506	1.3233	3.756
Current Med Immunosuppresive [MQ]	nr	–	0.0840	1.088
Current Med Insulin [MQ]	0.2089	1.232	0.2118	1.236
Ejection Fraction [MQ]				
<25%	0.5072	1.661	0.6354	1.888
25-45%	0.2106	1.234	0.2564	1.292
>45%	*	*	*	*
Heart Failure [C]	0.6313	1.880	0.5702	1.769
History of CABG or Valve Surgery [C]	0.7949	2.214	0.6862	1.986
History of Peripheral Vascular Disease [C]	0.2908	1.338	0.3366	1.400
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery [P]	0.3068	1.359	ns	–
Liver Disease [P]	1.4681	4.341	1.4292	4.175
Lupus Erythematosus, Systemic [P]	1.3693	3.933	nt	–
MI/AMI Other Anterior Wall [C]	0.4353	1.545	0.3475	1.415
Mild, Moderate or Severe Altered Mental Status [MQ]	0.3482	1.417	0.2887	1.335
Multiple Valve Procedures [P]	0.7516	2.120	0.6410	1.898
Other CV Procedure Group [C]	0.2946	1.343	0.1977	1.219
Procedure Group [P]				
CABG without Valve	*	*	*	*
Valve without CABG	0.2830	1.327	0.2264	1.254
Valve with CABG	0.5967	1.816	0.5322	1.703
PTCA/Stent/Tear Same Day as CABG/Valve Surgery [C]	0.6904	1.995	0.5666	1.762
Renal Failure Dialysis (category) [P]				
All cases not assigned to chronic and acute/dialysis categories	*	*	*	*
Chronic	0.1967	1.217	0.2586	1.295
Acute/dialysis	0.4815	1.619	0.4385	1.550
SIRS Group [MQ]	0.0347	1.035	0.0326	1.033

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.
* This is the reference level for the variable.
NA Not applicable. This variable was tested as a continuous variable.
nr Not retained: This variable's coefficient was negative. It was not retained because the risk factors included in the models are those that are more likely to contribute to the relevant outcome.
ns Not significant. This variable was not included in the final model because it was *not* a significant ($p < 0.10$) predictor of the relevant outcome.
nt Not tested. The univariate analysis did not suggest that the variable would be predictive of the relevant outcome.

Table 6b. Coefficients and Odds Ratios of Final Mortality Models, 2007 Data

Predictor Variables	In-Hospital Mortality		Operative Mortality	
	Coefficient	Odds Ratio	Coefficient	Odds Ratio
Constant	-7.0965		-6.7882	
Demographic Variables				
Age in Years [P]	0.0244	NA	0.0226	NA
Age # Years > 65 [P]	0.0320	NA	0.0413	NA
Female [P]	0.3788	1.461	0.4016	1.494
Laboratory Variables				
Albumin < 2.5 [MQ]	0.6586	1.932	0.7017	2.017
Albumin 2.5-3 [MQ]	0.2925	1.340	0.3161	1.372
BUN > 40 [MQ]	0.3516	1.421	0.3198	1.377
Creatinine > 1.4 [MQ]	0.3910	1.479	0.3633	1.438
Clinical Variables Other Than Laboratory Variables				
AMI Except Other Anterior or Other Inferior Wall [P]	0.5705	1.769	0.5502	1.734
AMI Other Inferior Wall Initial Episode [C]	0.9507	2.588	0.5701	1.768
ASA Class 5 [MQ]	0.8478	2.335	1.3156	3.727
ASA Emergency Flag [MQ]	0.3949	1.484	0.5872	1.799
Cachexia [P]	0.4742	1.607	ns	–
CAD > 70, 5-7 Vessels Grp [MQ]	0.0867	1.091	0.2034	1.226
Cardiogenic Shock, Preoperative [P]	1.2681	3.554	1.2210	3.391
Current Med Immunosuppresive [MQ]	0.0921	1.096	0.1716	1.187
Current Med Insulin [MQ]	0.1377	1.148	0.1836	1.202
Ejection Fraction [MQ]				
<25%	0.2850	1.330	0.3986	1.490
25-45%	0.1121	1.119	0.1861	1.204
>45%	*	*	*	*
Heart Failure [C]	0.6646	1.944	0.7032	2.020
History of CABG or Valve Surgery [C]	0.8433	2.324	0.7421	2.100
History of Peripheral Vascular Disease [C]	0.4474	1.564	0.4621	1.587
Liver Disease [P]	1.0938	2.986	1.3658	3.919
Lupus Erythematosus, Systemic [P]	ns	–	1.4697	4.348
MI/AMI Other Anterior Wall [C]	0.3308	1.392	0.1605	1.174
Mild Moderate or Severe AMS [MQ]	0.0273	1.028	nr	–
Multiple Valve Procedures [P]	0.8562	2.354	0.7763	2.173
Other CV Procedure Group [C]	0.3541	1.425	0.3394	1.404
Procedure Group [P]				
CABG without Valve	*	*	*	*
Valve without CABG	0.1144	1.121	0.0117	1.012
Valve with CABG	0.4523	1.572	0.3926	1.481
PTCA/Stent/Tear Same Day as CABG/Valve Surgery [C]	0.7590	2.136	0.5608	1.752
SIRS Group [MQ]	0.1416	1.152	0.1276	1.136

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.
* This is the reference level for the variable.
NA Not applicable. This variable was tested as a continuous variable.
nr Not retained: This variable's coefficient was negative. It was not retained because the risk factors included in the models are those that are more likely to contribute to the relevant outcome.
ns Not significant. This variable was not included in the final model because it was *not* a significant ($p < 0.10$) predictor of the relevant outcome.

Table 7a. Coefficients and Odds Ratios of Final Readmissions Models, 2006-2007 Data

Predictor Variables	7-Day Readmissions		30-Day Readmissions	
	Coefficient	**Odds Ratio**	**Coefficient**	**Odds Ratio**
Constant	-4.1730		-2.7698	
Year [P]				
2006	*	*	*	*
2007	0.0999	1.105	0.1166	1.124
Demographic Variables				
Age in Years [P]	0.0117	NA	ns	–
Age # of Years > 65 [P]	ns	–	0.0167	NA
Female [P]	0.1084	1.114	0.1721	1.188
Clinical Variables Other Than Lab				
Cancer [P]	0.3056	1.357	nt	–
Cerebrovascular Disease [P]	nt	nt	0.1451	1.156
Chronic Lung Disease [P]	ns	ns	0.1517	1.164
Diabetes [P]				
No Diabetes	*	*	*	*
Diabetes without Complication	0.1644	1.179	0.1585	1.172
Diabetes with Complication	0.3341	1.397	0.3429	1.409
Heart Failure [P]	0.2119	1.236	0.2467	1.280
History of PTCA/Stent [P]	nt	–	0.2044	1.227
History of Chronic Steroid Use [P]	nt	–	0.3439	1.410
History of Peripheral Vascular Disease [P]	ns	–	0.1299	1.139
Liver Disease [P]	nt	–	0.4691	1.599
Lupus Erythematosus, Systemic [P]	nt	–	0.6273	1.873
MediQual Predicted Length of Stay [MQ]	0.0354	NA	0.0478	NA
Obesity, Morbid [P]	ns	–	0.2967	1.345
Procedure Group [P]				
CABG without Valve	*	*	*	*
Valve without CABG	0.1804	1.198	0.1978	1.219
Valve with CABG	0.1667	1.181	0.1151	1.122

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
* This is the reference level for the variable.
NA Not applicable. This variable was tested as a continuous variable.
ns Not significant. This variable was not included in the final model because it was *not* a significant ($p < 0.10$) predictor of the relevant outcome.
nt Not tested. The univariate analysis did not suggest that the variable would be predictive of the relevant outcome.

Table 7b. Coefficients and Odds Ratios of Final Readmissions Models, 2007 Data

Predictor Variables	7-Day Readmissions		30-Day Readmissions	
	Coefficient	**Odds Ratio**	**Coefficient**	**Odds Ratio**
Constant	-4.6692		-2.6842	
Demographic Variables				
Age in Years [P]	0.0199	NA	ns	–
Age # of Years > 65 [P]	ns	–	0.0198	NA
Female [P]	0.1816	1.199	0.2317	1.261
Race (category) [P]				
Black	0.4135	1.512	0.3702	1.448
Other	-0.1735	0.841	0.0201	1.020
White	*	*	*	*
Clinical Variables Other Than Lab				
Anemia [P]	nt	–	0.0379	1.039
Cancer [P]	0.4428	1.557	ns	–
Chronic Lung Disease [P]	ns	–	0.2085	1.232
Chronic Pulmonary Hypertension	ns	–	0.0962	1.101
Diabetes [P]				
No Diabetes	*	*	*	*
Diabetes without Complication	0.1407	1.151	0.1244	1.133
Diabetes with Complication	0.3958	1.485	0.3119	1.366
Heart Failure [P]	0.2691	1.309	0.2015	1.223
Hypertension with Complications [P]	0.1655	1.180	0.1839	1.202
Liver Disease [P]	nt	–	0.4923	1.636
MediQual Predicted Length of Stay [MQ]	0.0278	NA	0.0464	NA
Obesity, Morbid [P]	0.3710	1.449	0.3964	1.486
Procedure Group [P]				
CABG without Valve	*	*	*	*
Valve without CABG	0.1441	1.155	0.1855	1.204
Valve with CABG	0.1923	1.212	0.1472	1.159

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
* This is the reference level for the variable.
NA Not applicable. This variable was tested as a continuous variable.
ns Not significant. This variable was not included in the final model because it was *not* a significant ($p < 0.10$) predictor of the relevant outcome.
nt Not tested. The univariate analysis did not suggest that the variable would be predictive of the relevant outcome.

Calculation of Statistical Ratings

Once the risk-adjustment models were built for each outcome measure (in-hospital mortality, operative mortality, 7-day readmissions, and 30-day readmissions), the statistical ratings were calculated. In doing so, actual rates were compared to expected rates to determine whether the difference was statistically significant.

Determining Actual (Observed) Rates

In-hospital mortality rates were determined by dividing the total number of deaths that occurred during the hospital stay by the total number of cases included in the analysis.

Operative mortality rates were determined by dividing the total number of deaths that occurred during the hospital stay *and* within 30 days of the CABG/valve surgery date by the total number of cases included in the analysis.

Seven-day and 30-day readmissions were determined by dividing the total number of cases readmitted to a general acute care hospital (for a particular principal diagnoses) within 7 or 30 days of discharge from the original hospital by the total number of cases included in the analysis.

Determining Expected Rates

The first step in calculating the expected rates was to estimate the probability of each of the relevant events occurring for each patient, that is: 1) the probability of in-hospital death, 2) the probability of death in the hospital or within 30 days, 3) the probability of being readmitted within 7 days, and 4) the probability of being readmitted within 30 days. The probability of each of these events occurring was estimated by using the statistical technique of logistic regression. In logistic regression each category for each clinical or demographic risk factor was assigned a coefficient or "weight." A factor category's weight was higher (or lower) if patients with that factor category tended to have a higher (or lower) chance of the event occurring. These weights, determined using the statewide CABG/valve data set, were used to estimate each individual patient's probability of in-hospital death, operative death (in-hospital or within 30 days), or 7-day or 30-day readmissions given the risk factors of the patient. (Note that coefficients are displayed in Tables 6a, 6b, 7a, and 7b in the "Coefficients and Odds Ratios" section.)

The results for all patients were then summed to determine the expected number of in-hospital deaths, deaths in the hospital or within 30 days, and readmissions within 7 days or 30 days for a given hospital/surgeon. The expected rate was calculated by dividing the total number of expected events by the total number of cases in the analysis.

The following example of the in-hospital mortality analysis illustrates the calculations used in determining the statistical ratings. Similar calculations apply to operative mortality and 7-day and 30-day readmissions.

Example 1. *2007 Calculations of Statistical Ratings for In-Hospital Mortality Analysis*

Total Cases: Number of hospitalizations after exclusions.

Actual Deaths: Total number of deaths (death is a discharge status equal to 20)

Percentage: Total number of deaths / Total number of cases

Expected Deaths: Sum of each patient's probability of death (PD)

Percentage: Total number of expected deaths / Total number of cases

To calculate a patient's probability of death:

Step 1: Calculate βX:

βX = -7.0965 *(constant)* + 0.0244 (Age) + 0.0320 (Age # Years > 65) + 0.3788 (Female) + 0.6586 (Albumin < 2.5) + coefficient (other variables in in-hospital mortality model) . . .

Step 2: Calculate the estimated probability of death (PD) using βX:

$PD = e^{\beta X} / (1 + e^{\beta X})$ where $e \approx 2.7182818285$

Test Statistic: (Actual Deaths – Expected Deaths) / Standard Deviation of Mortality

To compute Standard Deviation of Mortality:

Step 1: Compute the estimated variance of each patient's probability of death (VARPAT):

VARPAT = (PD) (1-PD)

Step 2: Calculate the Standard Deviation of Mortality

SUMVAR = sum of VARPAT across all cases

Standard Deviation of Mortality = square root of SUMVAR

***p*-value (two sided):** Calculated using test statistic as a normal z-score

Statistical Rating: If *p*-value <0.05 and test statistic > 0, then more deaths than expected (denoted as "●")
If *p*-value <0.05 and test statistic < 0, then fewer deaths than expected (denoted as "○")
Otherwise, the number of deaths were within the expected range (denoted as "⊙")

Expected Range: Lower limit = Expected Deaths – 1.960 (Standard Deviation of Mortality)
Upper limit = Expected Deaths + 1.960 (Standard Deviation of Mortality)

POST-SURGICAL LENGTH OF STAY ANALYSIS

Risk Adjustment Methodology

Data Preparation

After cases meeting the exclusion criteria were removed from the post-surgical length of stay analysis, the remaining cases for each procedure group were split into two equal-size samples by each procedure group: a development sample and a cross-validation sample. The relevant number of cases for each sample is shown in Table 8.

Table 8. Case Counts and Average Post-Surgical Length of Stay in Days

	Development Sample	Cross-Validation Sample	Full Data Set
2006-2007 Model			
Number of cases	15,570	15,569	31,139
Average post-surgical length of stay *(arithmetic)*	7.4	7.4	7.4
Average post-surgical length of stay *(geometric)*	6.4	6.4	6.4
2007 Model			
Number of cases	7,565	7,562	15,127
Average post-surgical length of stay *(arithmetic)*	7.4	7.5	7.4
Average post-surgical length of stay *(geometric)*	6.5	6.5	6.5

Building the Risk-Adjustment Model

While logistic regression was used to construct the models for in-hospital mortality, operative mortality, 7-day readmissions, and 30-day readmissions, a general linear modeling approach was used for post-surgical length of stay because it is a continuous variable. The model building steps were similar to those in the logistic regression models.

Model selection. The model was constructed using the development sample, after a natural log transformation was done to adjust for skewness in the distribution. All tests of significance ($p < 0.10$) were based on general linear model *F*-tests. The results for the development model are shown in Table 9.

Cross-validation. After the development model was built for post-surgical length of stay, the model was cross-validated. That is, the model built in the model selection process (i.e., the development model) was re-estimated using the cases in the cross-validation sample. Regression analysis was performed to determine whether the selected candidate variables would remain predictive of the relevant outcome for the cross-validation sample. As long as the coefficient of a variable did not change from positive to negative, the variable was retained in the final model that applied to the full data set. See Table 9 for cross-validation and full data set results.

***Table 9.* Case Counts and Average Post-Surgical Length of Stay in Days**

The results of variable testing for the readmission models are displayed in the table below. Variables found to be significant predictors and their associated *p*-values are in bold text.

Candidate Variables	2006-2007 Data			2007 Data		
	Develop-ment	Cross-Validation	Full Data Set	Develop-ment	Cross-Validation	Full Data Set
Demographic Variables						
Age in Years [P]	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Age # of Years > 65[P]	**0.0004**	**0.0001**	**<0.0001**	**0.0035**	**0.0244**	**0.0003**
Female [P]	**<0.0001**	**<0.0001**	**<0.0001**	**0.0004**	**0.0013**	**<0.0001**
Race (category) [P]	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Clinical Variables Other Than Lab						
Acute Myocardial Infarction [P]	**0.0299**	**0.0023**	**0.0002**	ns	nt[1]	nt[1]
Anemia [P]	**<0.0001**	**0.0014**	**<0.0001**	**0.0003**	**0.0367**	**<0.0001**
Cachexia [P]	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Cancer [P]	**0.0583**	**0.3148**	**0.0391**	**0.0667**	**0.1243**	**0.0181**
Cardiac Adhesions [P]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]
Cardiogenic Shock, Pre-Operative [P]	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Cardiomyopathy [P]	nr	nr	nr	ns	nt[1]	nt[1]
Chronic Lung Disease [P]	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Chronic Pulmonary Hypertension [P]	nr	nr	nr	nr	nr	nr
Diabetes with Long Term/Unspecified Complications [P]	**<0.0001**	**0.0007**	**<0.0001**	**0.0175**	**0.1015**	**0.0055**
Excision or Other Lesion/Heart Tissue, Open Approach – Same Date as Valve Surgery [P]	ns	nt[1]	nt[1]	nr	nr	nr
Fibrosis in Mediastinum and Heart [P]	ns	nt[1]	nt[1]	nr	nr	nr
Heart Failure [P]	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
History of CABG or Valve Surgery [P]	ns	nt[1]	nt[1]	ns	nt[1]	nt[1]
History of Peripheral Vascular Disease [P]	nt[2]	nt[2]	nt[2]	ns	nt[1]	nt[1]
Hypertension with Complications [P]	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery [P]	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Liver Disease [P]	**0.0990**	**<0.0001**	**<0.0001**	**0.0416**	**0.0003**	**<0.0001**
MediQual Predicted Length of Stay [MQ]	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Multiple Valve Procedures [P]	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Obesity, Morbid [P]	nt[2]	nt[2]	nt[2]	**0.0001**	**<0.0001**	**<0.0001**
Other Open Heart Procedure [P]	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**0.0005**	**<0.0001**
Procedure Group [P]	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
PTCA/Stent Same Day as CABG/Valve Surgery[P]	**0.0001**	**<0.0001**	**<0.0001**	**0.0003**	**0.0002**	**<0.0001**
Renal Failure/Dialysis (binary) [P]	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
nr Not retained: This variable's coefficient was negative. It was not retained because the risk factors included in the models are those that are more likely to contribute to the relevant outcome.
ns Not significant. This variable was not included in the final model because it was *not* a significant ($p < 0.10$) predictor of the relevant outcome.
nt[1] Not tested. This variable was not tested in the cross-validation or full data set model because it was not significant in the development model.
nt[2] Not tested. The univariate analysis did not suggest that the variable would be predictive of the relevant outcome.

Measure of model adequacy. To evaluate the model performance for both the development and cross-validation samples, the estimated coefficients from the development model were applied to both samples. The coefficients from the final model were applied to the full data set. The Coefficient of Determination (R^2) was the measure considered in evaluating the models' performance. R^2 refers to the percentage of the total variability in post-surgical length of stay among the patients in the sample that can be explained by the estimated model involving the specified risk factors. R^2 values for each of the models are listed in Table 10.

Table 10. R-Squared Statistics for Development, Cross-Validation, and Full Data Set Models

Post-Surgical Length of Stay Model	Development Model %	Cross-Validation Model %	Full Data Set Model %
2006-2007 Model	29.1	29.1	29.1
2007 Model	31.0	30.3	30.7

Coefficients

Each category for each statistically significant clinical or demographic factor was assigned a coefficient or weight. These coefficients were used to compute each individual patient's expected post-surgical length of stay given the risk factors of the patient. Table 11 displays the coefficients for the variables included in the final models.

Table 11. Coefficients of Predictors in the Final Post-Surgical Length of Stay Models

Predictor Variables	2006-2007 Data	2007 Data
Intercept	1.163479460	1.163200617
Demographic Variables		
Age in Years [P]	0.004324769	0.004060821
Age # of Years > 65 [P]	0.003937873	0.003885066
Female [P]	0.041825004	0.036305086
Race (category) [P]		
Black	0.136507034	0.139237221
Other	0.077082988	0.084187394
White	*	*
Clinical Variables Other Than Lab		
Acute Myocardial Infarction [P]	0.025840561	ns
Anemia [P]	0.032178952	0.032536529
Cachexia [P]	0.458412946	0.447016212
Cancer [P]	0.030947218	0.048876934
Cardiogenic Shock, Pre-Operative [P]	0.358974700	0.318720056
Chronic Lung Disease [P]	0.068385495	0.076203938
Diabetes with Long Term/Unspecified Complications [P]	0.052081937	0.038178585
Heart Failure [P]	0.172064736	0.165478856
Hypertension with Complications [P]	0.077378796	0.086745380
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery [P]	0.115990523	0.130603027
Liver Disease [P]	0.117207421	0.147774493
MediQual Predicted Length of Stay [MQ]	0.019585781	0.021218252
Multiple Valve Procedures [P]	0.148469087	0.156774757
Obesity, Morbid [P]	nt	0.085644917
Other Open Heart Procedure [P]	0.091118248	0.087875774
Procedure Group [P]		
CABG without Valve	*	*
Valve without CABG	0.080709499	0.082927806
Valve with CABG	0.163221374	0.161689685
PTCA/Stent Same Day as CABG/Valve Surgery [P]	0.150549881	0.197675495
Renal Failure/Dialysis (binary) [P]	0.146904346	0.185895240

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
* This is the reference level of the variable.
ns Not significant. This variable was not included in the final model because it was *not* a significant ($p < 0.10$) predictor of the relevant outcome.
nt Not tested. The univariate analysis did not suggest that the variable would be predictive of the relevant outcome.

Calculation of Risk-Adjusted Post-Surgical Length of Stay

Once the significant risk factors were determined, the actual post-surgical length of stay and the expected post-surgical length of stay were used to calculate the risk-adjusted post-surgical length of stay.

Actual Length of Stay

The actual post-surgical length of stay was derived by subtracting the CABG/valve procedure date from the discharge date. The average post-surgical length of stay is reported as a geometric mean[1], rather than an arithmetic mean.

Expected Length of Stay

Coefficients in the final model were summed to compute each individual patient's expected length of stay, given the risk factors of the patient. The coefficient for a category represented the estimated difference in mean (log) length of stay for the category compared to the base category of that factor. Thus, the coefficient for the base category of a factor was always zero. When dealing with categorical variables in the length of stay model there was no particular importance to the order of these categories. The constant term in the model represents the predicted value for all categorical factors at the base level. The coefficients for the other levels within a factor represent adjustments to that "baseline." No adjustment was required at the base level for any factor, because it was already accounted for in the constant. For example, a patient without heart failure had a zero or baseline coefficient; while a patient with heart failure would be adjusted upward by 0.172064736 (see Table 11). The order was not important because each ordering scheme would result in different coefficients, but the estimated difference between any pairs of levels would be the same (i.e., the difference between heart failure and no heart failure would always be 0.172064736 independent of what the specific coefficients were for each). For the quantitative factor age, there is always an adjustment because the baseline is zero.

Risk-Adjusted Post-Surgical Length of Stay

Post-surgical length of stay is reported in average days instead of a statistical rating. Unlike other measures (such as mortality where a lower number of deaths is obviously better than a higher number), it is not known whether shorter lengths of stay are "better" than longer lengths of stay or vice versa. Reporting the average length of stay in days, therefore, presents information that can be used to examine differences in lengths of stay without taking a position on what is "best."

The following example illustrates the complete calculation.

[1] Because a natural log transformation of each length of stay value was done to adjust for skewness in the distribution, it was necessary to convert the logarithm values back to days when reporting or displaying post-surgical length of stay. This process results in geometric means, rather than arithmetic means. Unlike an arithmetic mean that is derived by summing individual values and dividing by the number of observations, a geometric mean is calculated by multiplying the individual values and taking the n^{th} root of the product. Geometric means are averages and are the natural result when using the log transformation.

Example 2. *Calculations Used for Post-Surgical Length of Stay Analysis*

Total Cases is the number of hospitalizations after exclusions (equal to n).

Actual LOS is the number of days the patient was in the hospital post-surgery

Step 1. Calculate the actual length of stay (LOS) for each case:

LOS = Discharge date – procedure date

Natural Log (ln) is the function used in a natural log transformation (**ln** = logarithm base e).

Step 2. Perform natural log transformation across all cases to adjust for skewness in the distribution of actual length of stay values:

ln(LOS) = natural log transformation of LOS

Mean Actual LOS is the geometric mean of the actual lengths of stay (GMLOS) across all cases.

Step 3. Calculate the arithmetic mean of the natural log lengths of stay (Am**ln**(LOS)):

$$\text{Am}\mathbf{ln}(\text{LOS}) = (1/n)(\mathbf{ln}\text{LOS}_{\text{case 1}} + \mathbf{ln}\text{LOS}_{\text{case 2}} + \ldots + \mathbf{ln}\text{LOS}_{\text{case n}})$$

Step 4. Convert the arithmetic mean of the natural log lengths of stay into a value that can be expressed in days, which yields a geometric mean:

$$\text{GMLOS} = e^{\text{Am}\mathbf{ln}(\text{LOS})} \quad \text{where } e \approx 2.7182818285$$

Mean Expected LOS is the geometric mean of the *expected* lengths of stay (GM*E*LOS) across all cases

Step 5. Calculate the expected natural log lengths of stay (ElnLOS) for each case using the appropriate coefficients:

*E***ln**LOS = (constant) + (risk factor category coefficients relevant for a particular case)

Step 6. Calculate the arithmetic mean of the expected natural log lengths of stay (AM*E***ln**(LOS)):

$$\text{AM}E\mathbf{ln}(\text{LOS}) = (1/n)(E\mathbf{ln}\text{LOS}_{\text{case 1}} + E\mathbf{ln}\text{LOS}_{\text{case 2}} + \ldots + E\mathbf{ln}\text{LOS}_{\text{case n}})$$

Step 7. Convert the arithmetic mean of the expected natural log lengths of stay into a value that can be expressed in days, which yields a geometric mean:

$$\text{GM}E\text{LOS} = e^{\text{AM}E\mathbf{ln}(\text{LOS})} \quad \text{where } e \approx 2.7182818285$$

Risk-Adjusted Average Post-Surgical Length of Stay for a particular hospital/surgeon

Step 8. Calculate the risk-adjusted average post-surgical length of stay (RALOS):

$$\text{RALOS} = \frac{\text{GMLOS for hospital/surgeon}}{\text{GM}E\text{LOS for hospital/surgeon}} \times \text{GMLOS for the reporting group}$$

AVERAGE HOSPITAL CHARGE ANALYSIS

Average charges were trimmed for outliers and case-mix adjusted separately for the three procedure groups (CABG without valve, valve without CABG, and valve with CABG) and for the two years (2006 and 2007). Average charge is reported for hospitals only.

Construction of Reference Database

After exclusions were applied, the charge data for each procedure group was analyzed by region and by groups based on the Diagnostic Related Group (CMS-DRG/MS-DRG) assignment.

Patients who underwent CABG without valve procedures were comprised of the following DRG groups:

DRG Group 1	CMS-DRG 106[1]	Coronary Bypass with PTCA
	MS-DRG 231[2]	Coronary Bypass with PTCA with MCC
	MS-DRG 232[2]	Coronary Bypass with PTCA without MCC
DRG Group 2	CMS-DRG 547[1]	Coronary Bypass with Cardiac Catheterization with Major Cardiovascular Diagnosis
	CMS-DRG 548[1]	Coronary Bypass with Cardiac Catheterization without Major Cardiovascular Diagnosis
	MS-DRG 233[2]	Coronary Bypass with Cardiac Catheterization with MCC
	MS-DRG 234[2]	Coronary Bypass with Cardiac Catheterization without MCC
DRG Group 3	CMS-DRG 108[1]	Other Cardiothoracic Procedures
	MS-DRG 228[2]	Other Cardiothoracic Procedures with MCC
	MS-DRG 229[2]	Other Cardiothoracic Procedures with CC
	MS-DRG 230[2]	Other Cardiothoracic Procedures without CC/MCC
DRG Group 4	CMS-DRG 549[1]	Coronary Bypass without Cardiac Catheterization with Major Cardiovascular Diagnosis
	CMS-DRG 550[1]	Coronary Bypass without Cardiac Catheterization without Major Cardiovascular Diagnosis
	MS-DRG 235[2]	Coronary Bypass without Cardiac Catheterization with MCC
	MS-DRG 236[2]	Coronary Bypass without Cardiac Catheterization without MCC

Patients who underwent valve procedures with or without CABG procedures were comprised of the following DRG groups:

DRG Group 5	CMS-DRG 104[1]	Cardiac Valve and Other Major Cardiothoracic Procedures with Cardiac Catheterization
	MS-DRG 216[2]	Cardiac Valve and Other Major Cardiothoracic Procedures with Cardiac Catheterization with MCC
	MS-DRG 217[2]	Cardiac Valve and Other Major Cardiothoracic Procedures with Cardiac Catheterization with CC
	MS-DRG 218[2]	Cardiac Valve and Other Major Cardiothoracic Procedures with Cardiac Catheterization without CC/MCC
DRG Group 6	CMS-DRG 105[1]	Cardiac Valve and Other Major Cardiothoracic Procedures without Cardiac Catheterization
	MS-DRG 219[2]	Cardiac Valve and Other Major Cardiothoracic Procedures without Cardiac Catheterization with MCC
	MS-DRG 220[2]	Cardiac Valve and Other Major Cardiothoracic Procedures without Cardiac Catheterization with CC
	MS-DRG 221[2]	Cardiac Valve and Other Major Cardiothoracic Procedures without Cardiac Catheterization without CC/MCC

[1] Quarter 1, 2006 through Q3, 2007
[2] Q4, 2007

Trim Methodology

Trimming was used to remove outlier charges from the study population. Identification of outliers eliminates extreme values that may have a significant and unrepresentative impact on the mean.

For each of the procedure groups, trim points were calculated for each DRG group within each region and for each year. Cases with a charge that was below the lower trim point or above the upper trim point were excluded from further analysis.

For this analysis, upper and lower trim points were calculated using the "+/- 3.0 interquartile range" method. This non-parametric methodology was used because, historically, the distribution for charges does not follow a normal "bell-shaped" pattern.

Since charges varied dramatically among regions, upper and lower trim points were calculated at the regional level for each DRG group within each procedure group for each year.

Trim points were determined as follows:

Q1 = *the first quartile (25th percentile total charge) of all patient records from the comparative database in a particular category*

Q3 = *the third quartile (75th percentile total charge) of all patient records from the comparative database in a particular category*

IQR = *Q3 – Q1*

Lower Trim Point = *Q1 – (3.0 x IQR)*

Upper Trim Point = *Q3 + (3.0 x IQR)*

See Tables 12a through 13c for upper trim points, percent of outliers, and average charge after trimming for each DRG group within each region for each of the procedure groups.

Table 12a. CABG without Valve: Trim Points for Average Charge, 2006

DRG Group	Upper Trim Point*	Outlier %	Median Charge After Trimming	Average Charge After Trimming
Group 1 (CMS-DRG 106; MS-DRG 231, 232)				
Region 1	$573,699	0.8	$118,911	$140,657
Region 2	$471,255	0.0	$192,255	$183,773
Region 3	$169,089	0.0	$87,380	$87,090
Region 4	**	**	**	**
Region 5	$212,657	0.0	$97,923	$101,650
Region 6	$280,687	7.4	$87,061	$90,688
Region 7	$433,246	3.7	$139,780	$158,589
Region 8	$764,180	0.0	$189,889	$225,903
Region 9	$812,409	0.0	$253,532	$276,612
Group 2 (CMS-DRG 547, 548; MS-DRG 233, 234)				
Region 1	$380,888	0.8	$75,281	$98,254
Region 2	$280,097	2.4	$121,732	$123,627
Region 3	$142,460	1.0	$60,554	$66,463
Region 4	$211,901	2.9	$73,160	$80,957
Region 5	$168,707	2.1	$69,796	$73,304
Region 6	$173,061	1.0	$66,123	$71,015
Region 7	$299,472	2.7	$103,896	$116,422
Region 8	$540,590	1.6	$137,218	$158,643
Region 9	$752,441	1.2	$180,451	$213,549
Group 3 (CMS-DRG 108; MS-DRG 228, 229, 230)				
Region 1	$537,705	0.0	$189,969	$193,948
Region 2	$249,070	0.0	$108,277	$111,597
Region 3	$104,901	4.3	$65,208	$63,733
Region 4	**	**	**	**
Region 5	**	**	**	**
Region 6	$186,360	4.2	$69,927	$76,729
Region 7	$255,014	5.4	$100,001	$107,730
Region 8	$402,256	0.0	$120,489	$136,990
Region 9	**	**	**	**
Group 4 (CMS-DRG 549, 550; MS-DRG 235, 236)				
Region 1	$361,859	0.8	$64,474	$86,598
Region 2	$180,276	2.0	$81,975	$84,274
Region 3	$96,721	4.2	$44,497	$46,766
Region 4	$129,777	3.5	$54,176	$58,716
Region 5	$127,008	2.2	$51,817	$55,039
Region 6	$122,339	1.6	$46,139	$49,593
Region 7	$241,547	4.1	$73,357	$88,607
Region 8	$429,738	1.3	$93,104	$117,034
Region 9	$664,140	1.6	$141,269	$178,241

* Charges of less than $10,000 were considered invalid. Therefore, with the exception of DRG Group 3 in Region 3, there were no lower trim points. The lower trim point for DRG Group 3 in Region 3 was $22,078.

** These regions under the DRG group were excluded from analysis due to low volume.

Table 12b. Valve without CABG: Trim Points for Average Charge, 2006

DRG Group	Upper Trim Point*	Outlier %	Median Charge After Trimming	Average Charge After Trimming
Group 5 (CMS-DRG 104; MS-DRG 216, 217, 218)				
Region 1	$681,979	0.7	$142,353	$170,054
Region 2	$630,248	0.0	$158,809	$185,027
Region 3	$275,339	0.0	$84,678	$103,944
Region 4	$561,278	0.0	$134,381	$151,708
Region 5	$303,749	1.1	$91,720	$106,483
Region 6	$260,672	2.3	$86,236	$93,567
Region 7	$389,783	1.1	$129,037	$149,181
Region 8	$667,785	1.1	$194,198	$226,562
Region 9	$850,934	0.5	$216,285	$260,699
Group 6 (CMS-DRG 105; MS-DRG 219, 220, 221)				
Region 1	$443,370	0.7	$80,977	$111,175
Region 2	$288,459	1.0	$110,565	$115,938
Region 3	$150,333	3.3	$68,986	$72,230
Region 4	$382,761	3.7	$123,116	$134,020
Region 5	$173,656	1.0	$66,667	$70,523
Region 6	$179,101	3.6	$66,222	$69,762
Region 7	$411,157	0.7	$107,633	$128,655
Region 8	$448,707	3.5	$141,868	$156,732
Region 9	$518,634	2.8	$160,591	$187,759

* Charges of less than $10,000 were considered invalid; therefore, there were no lower trim points.

Table 12c. Valve with CABG: Trim Points for Average Charge, 2006

DRG Group	Upper Trim Point*	Outlier %	Median Charge After Trimming	Average Charge After Trimming
Group 5 (CMS-DRG 104; MS-DRG 216, 217, 218)				
Region 1	$709,278	1.4	$130,839	$171,490
Region 2	$578,777	3.6	$186,261	$209,784
Region 3	$202,646	3.0	$104,617	$108,125
Region 4	$618,795	2.6	$156,694	$169,934
Region 5	$307,986	2.1	$117,226	$122,925
Region 6	$266,767	3.3	$100,348	$111,473
Region 7	$558,473	1.8	$164,409	$195,129
Region 8	$681,227	1.3	$199,420	$237,629
Region 9	$1,079,584	2.2	$278,991	$330,924
Group 6 (CMS-DRG 105; MS-DRG 219, 220, 221)				
Region 1	$620,743	0.6	$104,319	$141,040
Region 2	$394,799	0.0	$133,411	$154,501
Region 3	$192,382	0.0	$80,965	$93,208
Region 4	$410,041	1.8	$108,995	$129,858
Region 5	$206,713	1.5	$77,545	$84,323
Region 6	$215,070	0.0	$71,142	$78,764
Region 7	$443,791	5.3	$124,182	$145,122
Region 8	$655,470	1.0	$144,398	$180,922
Region 9	$969,732	1.0	$212,095	$275,205

* Charges of less than $10,000 were considered invalid. Therefore, with the exception of DRG Group 5 in Region 3, there were no lower trim points. The lower trim point for DRG Group 5 in Region 3 was $13,138.

Table 13a. CABG without Valve: Trim Points for Average Charge, 2007

DRG Group	Upper Trim Point*	Outlier %	Median Charge After Trimming	Average Charge After Trimming
Group 1 (CMS-DRG 106; MS-DRG 231, 232)				
Region 1	$359,956	6.7	$100,201	$114,312
Region 2	$465,221	0.0	$165,233	$185,606
Region 3	$199,833	7.7	$100,723	$94,719
Region 4	**	**	**	**
Region 5	$212,048	3.9	$98,869	$100,117
Region 6	$242,418	0.0	$93,795	$104,066
Region 7	$288,379	5.4	$138,695	$138,341
Region 8	$710,096	0.0	$221,280	$240,955
Region 9	$874,626	4.2	$236,957	$257,231
Group 2 (CMS-DRG 547, 548; MS-DRG 233, 234)				
Region 1	$392,866	1.6	$75,961	$101,008
Region 2	$336,477	1.5	$133,952	$140,024
Region 3	$127,882	2.6	$62,255	$64,341
Region 4	$273,481	5.1	$100,305	$104,430
Region 5	$184,145	1.2	$73,301	$79,410
Region 6	$186,128	0.8	$68,652	$74,207
Region 7	$329,426	2.0	$113,204	$132,182
Region 8	$578,790	1.4	$162,941	$177,181
Region 9	$684,856	2.2	$193,170	$219,021
Group 3 (CMS-DRG 108; MS-DRG 228, 229, 230)				
Region 1	$518,577	4.3	$202,143	$195,594
Region 2	$247,808	0.0	$114,535	$131,784
Region 3	**	**	**	**
Region 4	**	**	**	**
Region 5	**	**	**	**
Region 6	$179,780	0.0	$80,138	$85,171
Region 7	$460,083	0.0	$124,365	$143,372
Region 8	$523,820	7.7	$122,925	$142,391
Region 9	**	**	**	**
Group 4 (CMS-DRG 549, 550; MS-DRG 235, 236)				
Region 1	$335,216	1.0	$65,488	$87,016
Region 2	$188,924	3.1	$92,710	$93,892
Region 3	$103,875	1.0	$48,633	$49,830
Region 4	$196,536	3.4	$65,780	$74,400
Region 5	$125,787	1.6	$53,828	$56,821
Region 6	$131,278	1.2	$48,830	$54,086
Region 7	$236,034	7.6	$81,451	$93,047
Region 8	$395,850	1.2	$97,149	$118,867
Region 9	$681,297	1.1	$157,203	$202,784

* Charges of less than $10,000 were considered invalid. Therefore, there were no lower trim points.
** These regions under the DRG group were excluded from analysis due to low volume.

Table 13b. Valve without CABG: Trim Points for Average Charge, 2007

DRG Group	Upper Trim Point*	Outlier %	Median Charge After Trimming	Average Charge After Trimming
Group 5 (CMS-DRG 104; MS-DRG 216, 217, 218)				
Region 1	$668,778	2.0	$131,114	$169,419
Region 2	$737,963	0.0	$160,788	$209,649
Region 3	$252,240	0.0	$100,468	$107,590
Region 4	$696,614	0.0	$171,095	$199,739
Region 5	$290,388	2.4	$102,117	$111,824
Region 6	$238,830	1.3	$85,566	$93,780
Region 7	$339,079	3.7	$154,905	$154,098
Region 8	$714,381	1.9	$208,666	$227,239
Region 9	$739,621	4.8	$223,546	$266,567
Group 6 (CMS-DRG 105; MS-DRG 219, 220, 221)				
Region 1	$438,554	1.9	$89,245	$116,406
Region 2	$325,396	2.5	$112,714	$125,044
Region 3	$195,302	0.0	$76,938	$85,262
Region 4	$414,794	2.8	$139,694	$142,187
Region 5	$177,819	2.0	$70,624	$76,813
Region 6	$209,750	3.3	$70,569	$76,833
Region 7	$381,407	1.3	$115,377	$136,257
Region 8	$484,332	2.3	$149,541	$164,188
Region 9	$563,443	3.7	$180,632	$208,027

* Charges of less than $10,000 were considered invalid; therefore, there were no lower trim points.

Table 13c. Valve with CABG: Trim Points for Average Charge, 2007

DRG Group	Upper Trim Point*	Outlier %	Median Charge After Trimming	Average Charge After Trimming
Group 5 (CMS-DRG 104; MS-DRG 216, 217, 218)				
Region 1	$824,490	0.8	$148,351	$197,624
Region 2	$568,645	1.7	$197,161	$228,036
Region 3	$230,341	0.0	$105,541	$107,384
Region 4	$585,220	3.2	$191,862	$198,357
Region 5	$315,560	2.1	$114,158	$127,740
Region 6	$342,137	1.9	$112,334	$125,558
Region 7	$888,670	0.0	$189,944	$233,362
Region 8	$740,409	0.0	$211,488	$241,042
Region 9	$782,139	4.8	$257,019	$277,863
Group 6 (CMS-DRG 105; MS-DRG 219, 220, 221)				
Region 1	$568,848	0.3	$101,456	$140,920
Region 2	$401,512	3.4	$142,953	$155,632
Region 3	$188,380	0.0	$83,883	$94,492
Region 4	$606,303	0.0	$149,712	$177,093
Region 5	$215,395	4.7	$78,153	$86,050
Region 6	$193,560	4.7	$74,732	$77,890
Region 7	$495,428	1.8	$131,942	$164,580
Region 8	$416,128	5.7	$139,845	$157,677
Region 9	$676,920	1.5	$209,417	$248,167

* Charges of less than $10,000 were considered invalid. Therefore, there were no lower trim points.

Case-Mix Adjustment of Average Hospital Charge

Case-mix adjustment was used to adjust the average charge reported for hospitals after all exclusions were satisfied and outlier trimming was performed. A case-mix adjusted charge is reported separately for each reporting group for which the hospital had at least 13 cases. Charges were adjusted to account for differences in regional charges and the number of patients that a hospital had for each DRG group of patients within each procedure group.

To determine the case-mix adjusted charges at a particular hospital, first the actual charges were calculated for each reporting group. Next, expected charges were calculated for each reporting group. Expected charges were based on the average charges for each DRG group, region, procedure group, and year of discharge. The case-mix adjusted charge was calculated by dividing the mean actual charges by the mean expected charge for the hospital, and then multiplying this quantity by the average charge for the hospital's region for the relevant reporting group. The following example illustrates how the case-mix adjusted charge was computed for a hospital in Region 1 for the valve without CABG reporting group:

***Example 3.* Determining Case-Mixed Average Charge for a Hospital, 2006-2007 Data**

Region 1: Southwestern PA
Reporting Group: Valve without CABG

Total Cases: Number of hospitalizations for a hospital after exclusions (equal to n).

Actual Charge: Mean of the charges for each hospitalization.

Expected Charge: Mean of the predicted charges for each hospitalization.

Step 1: Calculate each hospitalization's expected charge (ExpChg):

ExpChg = the expected charge for a hospitalization, which is equal to the average charge for all hospitalizations (after exclusion) in the hospital's same region, reporting group, and DRG group within the reporting group.

Region 1 - Southwestern PA, valve without CABG, DRG Group 5, 2006: $170,054
or
Region 1 - Southwestern PA, valve without CABG, DRG Group 6, 2006: $111,175
or
Region 1 - Southwestern PA, valve without CABG, DRG Group 5, 2007: $169,419
or
Region 1 - Southwestern PA, valve without CABG, DRG Group 6, 2007: $116,406

Step 2: Calculate the mean ExpChg for a hospital (expected charge):

$$\text{Mean ExpChg} = \frac{\Sigma\ \text{ExpChg}}{n}$$

Case-Mix Adjusted Charge: $\frac{\text{Mean Actual Chg}}{\text{Mean ExpChg}}$ (Mean Region 1 Actual Charge)

Example 4. *Determining Case-Mixed Average Charge for a Hospital, 2007 Data*

Region 1: Southwestern PA
Reporting Group*:* Valve without CABG

Total Cases: Number of hospitalizations for a hospital after exclusions (equal to n).

Actual Charge: Mean of the charges for each hospitalization.

Expected Charge: Mean of the predicted charges for each hospitalization.

Step 1: Calculate each hospitalization's expected charge (ExpChg):

ExpChg = the expected charge for a hospitalization, which is equal to the average charge for all hospitalizations (after exclusion) in the hospital's same region, reporting grouping, and DRG within the reporting group.

Region 1 - Southwestern PA, valve without CABG, DRG Group 5, 2007: $169,419
or
Region 1 - Southwestern PA, valve without CABG, DRG Group 6, 2007: $116,406

Step 2: Calculate the mean ExpChg for a hospital (expected charge):

$$\text{Mean ExpChg} = \frac{\Sigma \text{ ExpChg}}{n}$$

Case-Mix Adjusted Charge: $\frac{\text{Mean Actual Chg}}{\text{Mean ExpChg}}$ (Mean Region 1 Actual Charge)

APPENDICES

APPENDIX A: EXCLUSION DEFINTIONS

Table A. Exclusions: ICD-9-CM Codes Defining Organ Transplants

Code	Description
33.50	Lung transplantation, not otherwise specified
33.51	Unilateral lung transplantation
33.52	Bilateral lung transplantation
33.6	Combined heart and lung transplant
37.51	Heart transplantation
37.52	Implantation of total replacement of heart system
37.53	Replacement or repair of thoracic unit of total replacement heart system
41.00	Autologous bone marrow transplant without purging
41.02	Allogeneic bone marrow transplant with purging
41.03	Allogeneic bone marrow transplant without purging
41.09	Autologous bone marrow transplant with purging
41.94	Transplantation of spleen
46.97	Transplant of intestine
50.51	Auxiliary liver transplant
50.59	Other transplant of liver
52.80	Pancreatic transplant, not otherwise specified
52.82	Homotransplant of pancreas
52.83	Heterotransplant of pancreas
55.61	Renal autotransplantation
55.69	Other kidney transplantation

Table B1. DRG Criteria for Study Population Definition (Quarter 1, 2006 – Quarter 3, 2007)

CMS-DRGs *Not* Excluded from the Study: CABG without Valve	
CMS-DRG 103	Heart Transplant or Implant of Heart Assist System
CMS-DRG 104	Cardiac Valve Procedures and Other Major Cardiothoracic Procedures with Cardiac Catheterization
CMS-DRG 105	Cardiac Valve Procedures and Other Major Cardiothoracic Procedures without Cardiac Catheterization
CMS-DRG 106	Coronary Bypass with PTCA
CMS-DRG 108	Other Cardiothoracic Procedures
CMS-DRG 515	Cardiac Defibrillator Implant without Cardiac Catheterization
CMS-DRG 525	Other Heart Assist System Implant
CMS-DRG 535	Cardiac Defibrillator Implant with Cardiac Catheterization with Acute Myocardial Infarction, Heart Failure, or Shock
CMS-DRG 536	Cardiac Defibrillator Implant with Cardiac Catheterization without Acute Myocardial Infarction, Heart Failure, or Shock
CMS-DRG 541 and MDC 5	ECMO or tracheostomy with Mechanical Ventilation 96+ Hours or Principal Diagnosis Except Face, Mouth, Neck with Major O.R. Procedures
CMS-DRG 547	Coronary Bypass with Cardiac Catheterization with Major Cardiovascular Diagnosis
CMS-DRG 548	Coronary Bypass with Cardiac Catheterization without Major Cardiovascular Diagnosis
CMS-DRG 549	Coronary Bypass without Cardiac Catheterization with Major Cardiovascular Diagnosis
CMS-DRG 550	Coronary Bypass without Cardiac Catheterization without Major Cardiovascular Diagnosis

APPENDIX A: EXCLUSION DEFINTIONS *continued*

Table B1. **DRG Criteria for Study Population Definition (Quarter 1, 2006 – Quarter 3, 2007)**	
CMS-DRGs *Not* Excluded from the Study: Valve without CABG	
CMS-DRG 103	Heart Transplant or Implant of Heart Assist System
CMS-DRG 104	Cardiac Valve Procedures and Other Major Cardiothoracic Procedures with Cardiac Catheterization
CMS-DRG 105	Cardiac Valve Procedures and Other Major Cardiothoracic Procedures without Cardiac Catheterization
CMS-DRG 108	Other Cardiothoracic Procedures
CMS-DRG 515	Cardiac Defibrillator Implant without Cardiac Catheterization
CMS-DRG 525	Other Heart Assist System Implant
CMS-DRG 535	Cardiac Defibrillator Implant with Cardiac Catheterization with Acute Myocardial Infarction, Heart Failure, or Shock
CMS-DRG 536	Cardiac Defibrillator Implant with Cardiac Catheterization without Acute Myocardial Infarction, Heart Failure, or Shock
CMS-DRG 541 and MDC 5	ECMO or tracheostomy with Mechanical Ventilation 96+ Hours or Principal Diagnosis Except Face, Mouth, Neck with Major O.R. Procedures
CMS-DRGs *Not* Excluded from the Study: Valve with CABG	
CMS-DRG 103	Heart Transplant or Implant of Heart Assist System
CMS-DRG 104	Cardiac Valve Procedures and Other Major Cardiothoracic Procedures with Cardiac Catheterization
CMS-DRG 105	Cardiac Valve Procedures and Other Major Cardiothoracic Procedures without Cardiac Catheterization
CMS-DRG 108	Other Cardiothoracic Procedures
CMS-DRG 515	Cardiac Defibrillator Implant without Cardiac Catheterization
CMS-DRG 525	Other Heart Assist System Implant
CMS-DRG 535	Cardiac Defibrillator Implant with Cardiac Catheterization with Acute Myocardial Infarction, Heart Failure, or Shock
CMS-DRG 536	Cardiac Defibrillator Implant with Cardiac Catheterization without Acute Myocardial Infarction, Heart Failure, or Shock
CMS-DRG 541 and MDC 5	ECMO or tracheostomy with Mechanical Ventilation 96+ Hours or Principal Diagnosis Except Face, Mouth, Neck with Major O.R. Procedures

Table B2. **DRG Criteria for Study Population Definition (Quarter 4, 2007)**	
MS-DRGs *Not* Excluded from the Study: CABG without Valve	
MS-DRG 001	Heart Transplant or Implant of Heart Assist System with MCC
MS-DRG 002	Heart Transplant or Implant of Heart Assist System without MCC
MS-DRG 003 with MDC 5	ECMO or tracheostomy with Mechanical Ventilation 96+ Hours or Principal Diagnosis Except Face, Mouth, Neck with Major O.R. Procedures
MS-DRG 215	Other Heart Assist System Implant
MS-DRG 216	Cardiac Valve and Other Major Cardiothoracic Procedures with Cardiac Catheterization with MCC
MS-DRG 217	Cardiac Valve and Other Major Cardiothoracic Procedures with Cardiac Catheterization with CC
MS-DRG 218	Cardiac Valve and Other Major Cardiothoracic Procedures with Cardiac Catheterization without CC/MCC
MS-DRG 219	Cardiac Valve and Other Major Cardiothoracic Procedures without Cardiac Catheterization with MCC
MS-DRG 220	Cardiac Valve and Other Major Cardiothoracic Procedures without Cardiac Catheterization with CC
MS-DRG 221	Cardiac Valve and Other Major Cardiothoracic Procedures without Cardiac Catheterization without CC/MCC
MS-DRG 222	Cardiac Defibrillator Implant with Cardiac Catheterization with Acute MI/Heart Failure/Shock with MCC
MS-DRG 223	Cardiac Defibrillator Implant with Cardiac Catheterization with Acute MI/Heart Failure/Shock without MCC
MS-DRG 224	Cardiac Defibrillator Implant with Cardiac Catheterization without Acute Mi/Heart Failure/Shock with MCC
MS-DRG 225	Cardiac Defibrillator Implant with Cardiac Catheterization without Acute MI/Heart Failure/Shock without MCC
MS-DRG 226	Cardiac Defibrillator Implant without Cardiac Catheterization with MCC
MS-DRG 227	Cardiac Defibrillator Implant without Cardiac Catheterization without MCC
MS-DRG 228	Other Cardiothoracic Procedures with MCC
MS-DRG 229	Other Cardiothoracic Procedures with CC
MS-DRG 230	Other Cardiothoracic Procedures without CC/MCC
MS-DRG 231	Coronary Bypass with PTCA with MCC
MS-DRG 232	Coronary Bypass with PTCA without MCC
MS-DRG 233	Coronary Bypass with Cardiac Catheterization with MCC

APPENDIX A: EXCLUSION DEFINTIONS *continued*

Table B2. **DRG Criteria for Study Population Definition (Quarter 4, 2007)**	
MS-DRG 234	Coronary Bypass with Cardiac Catheterization without MCC
MS-DRG 235	Coronary Bypass without Cardiac Catheterization with MCC
MS-DRG 236	Coronary Bypass without Cardiac Catheterization without MCC
DRGs *Not* Excluded from the Study: Valve without CABG	
MS-DRG 001	Heart Transplant or Implant of Heart Assist System with MCC
MS-DRG 002	Heart Transplant or Implant of Heart Assist System without MCC
MS-DRG 003 with MDC 5	ECMO or tracheostomy with Mechanical Ventilation 96+ Hours or Principal Diagnosis Except Face, Mouth, Neck with Major O.R. Procedures
MS-DRG 215	Other Heart Assist System Implant
MS-DRG 216	Cardiac Valve and Other Major Cardiothoracic Procedures with Cardiac Catheterization with MCC
MS-DRG 217	Cardiac Valve and Other Major Cardiothoracic Procedures with Cardiac Catheterization with CC
MS-DRG 218	Cardiac Valve and Other Major Cardiothoracic Procedures with Cardiac Catheterization without CC/MCC
MS-DRG 219	Cardiac Valve and Other Major Cardiothoracic Procedures without Cardiac Catheterization with MCC
MS-DRG 220	Cardiac Valve and Other Major Cardiothoracic Procedures without Cardiac Catheterization with CC
MS-DRG 221	Cardiac Valve and Other Major Cardiothoracic Procedures without Cardiac Catheterization without CC/MCC
MS-DRG 222	Cardiac Defibrillator Implant with Cardiac Catheterization with Acute MI/Heart Failure/Shock with MCC
MS-DRG 223	Cardiac Defibrillator Implant with Cardiac Catheterization with Acute MI/Heart Failure/Shock without MCC
MS-DRG 224	Cardiac Defibrillator Implant with Cardiac Catheterization without Acute MI/Heart Failure/Shock with MCC
MS-DRG 225	Cardiac Defibrillator Implant with Cardiac Catheterization without Acute MI/Heart Failure/Shock without MCC
MS-DRG 226	Cardiac Defibrillator Implant without Cardiac Catheterization with MCC
MS-DRG 227	Cardiac Defibrillator Implant without Cardiac Catheterization without MCC
MS-DRG 228	Other Cardiothoracic Procedures with MCC
MS-DRG 229	Other Cardiothoracic Procedures with CC
MS-DRG 230	Other Cardiothoracic Procedures without CC/MCC
DRGs *Not* Excluded from the Study: Valve with CABG	
MS-DRG 001	Heart Transplant or Implant of Heart Assist System with MCC
MS-DRG 002	Heart Transplant or Implant of Heart Assist System without MCC
MS-DRG 003 with MDC 5	ECMO or tracheostomy with Mechanical Ventilation 96+ Hours or Principal Diagnosis Except Face, Mouth, Neck with Major O.R. Procedures
MS-DRG 215	Other Heart Assist System Implant
MS-DRG 216	Cardiac Valve and Other Major Cardiothoracic Procedures with Cardiac Catheterization with MCC
MS-DRG 217	Cardiac Valve and Other Major Cardiothoracic Procedures with Cardiac Catheterization with CC
MS-DRG 218	Cardiac Valve and Other Major Cardiothoracic Procedures with Cardiac Catheterization without CC/MCC
MS-DRG 219	Cardiac Valve and Other Major Cardiothoracic Procedures without Cardiac Catheterization with MCC
MS-DRG 220	Cardiac Valve and Other Major Cardiothoracic Procedures without Cardiac Catheterization with CC
MS-DRG 221	Cardiac Valve and Other Major Cardiothoracic Procedures without Cardiac Catheterization without CC/MCC
MS-DRG 222	Cardiac Defibrillator Implant with Cardiac Catheterization with Acute MI/Heart Failure/Shock with MCC
MS-DRG 223	Cardiac Defibrillator Implant with Cardiac Catheterization with Acute MI/Heart Failure/Shock without MCC
MS-DRG 224	Cardiac Defibrillator Implant with Cardiac Catheterization without Acute MI/Heart Failure/Shock with MCC
MS-DRG 225	Cardiac Defibrillator Implant with Cardiac Catheterization without Acute MI/Heart Failure/Shock without MCC
MS-DRG 226	Cardiac Defibrillator Implant without Cardiac Catheterization with MCC
MS-DRG 227	Cardiac Defibrillator Implant without Cardiac Catheterization without MCC
MS-DRG 228	Other Cardiothoracic Procedures with MCC
MS-DRG 229	Other Cardiothoracic Procedures with CC
MS-DRG 230	Other Cardiothoracic Procedures without CC/MCC

APPENDIX A: EXCLUSION DEFINTIONS *continued*

Table C1. Exclusions: ICD-9-CM Clinical Complexity Codes for CABG *without* Valve

Key to abbreviations: px = procedure code; dx = diagnosis code

Code Type	Code Position	ICD-9-CM Code and Description	
px	Any	32.22	Lung volume reduction surgery **performed at the same time as CABG surgery**
px	Any	35.31	Operations on papillary muscle
px	Any	35.32	Operations on chordae tendineae
px	Any	35.34	Infundibulectomy
px	Any	35.35	Operations on trabeculae carneae cordis
px	Any	35.39	Operations on other structures adjacent to valves of heart
px	Any	35.42	Creation of septal defect in heart
px	Any	35.50	Repair of unspecified septal defect of heart with prosthesis
px	Any	35.51	Repair of atrial septal defect with prosthesis, open technique
px	Any	35.53	Repair of ventricular septal defect with prosthesis, open technique
px	Any	35.54	Repair of endocardial cushion defect with prosthesis
px	Any	35.60	Repair of unspecified septal defect of heart with tissue graft
px	Any	35.61	Repair of atrial septal defect with tissue graft
px	Any	35.62	Repair of ventricular septal defect with tissue graft
px	Any	35.63	Repair of endocardial cushion defect with tissue graft
px	Any	35.70	Other and unspecified repair of unspecified septal defect of heart
px	Any	35.71	Other and unspecified repair of atrial septal defect
px	Any	35.72	Other and unspecified repair of ventricular septal defect
px	Any	35.73	Other and unspecified repair of endocardial cushion defect
px	Any	35.81	Total repair of Tetralogy of Fallot
px	Any	35.82	Total repair of total anomalous pulmonary venous connection
px	Any	35.83	Total repair of truncus arteriosus
px	Any	35.84	Total correction of transposition of great vessels, not elsewhere classified
px	Any	35.91	Intratrial transposition of venous return
px	Any	35.92	Creation of conduit between right ventricle and pulmonary artery
px	Any	35.93	Creation of conduit between left ventricle and aorta
px	Any	35.94	Creation of conduit between atrium and pulmonary artery
px	Any	35.95	Revision of corrective procedure on heart
px	Any	35.98	Other operations on septa of heart
px	Any	36.91	Repair of aneurysm of coronary vessel
px	Any	37.32	Excision of aneurysm of heart
px	Any	37.33	Excision or destruction of other lesion or tissue of heart, open approach
px	Any	37.35	Partial ventriculectomy
px	Any	38.12	Carotid endarterectomy
px	Any	38.34	Resection of aorta with anastomosis
px	Any	38.35	Resection of other thoracic vessel with anastomosis
px	Any	38.36	Resection of abdominal arteries with anastomosis
px	Any	38.44	Resection of abdominal aorta with replacement
px	Any	38.45	Resection of other thoracic vessel with replacement
px	Any	38.46	Resection of abdominal arteries with replacement
px	Any	39.51	Clipping of aneurysm
px	Any	39.52	Other repair of aneurysm
px	Any	39.71	Endovascular implantation of graft in abdominal aorta
px	Any	39.73	Endovascular implantation of graft in thoracic aorta
dx/px	Any	423.2/ 37.31	Diagnosis of constrictive pericarditis and undergoing pericardiectomy
dx	Any	441.00	Dissection of aorta, unspecified site
dx	Any	441.01	Dissection of aorta, thoracic
dx	Any	996.81	Complications of transplanted kidney
dx	Any	996.82	Complications of transplanted liver
dx	Any	996.83	Complications of transplanted heart
dx	Any	996.84	Complications of transplanted lung
dx	Any	996.85	Complications of transplanted bone marrow
dx	Any	996.86	Complications of transplanted pancreas
dx	Any	996.87	Complications of transplanted intestine
dx	Any	V42.0	History of kidney transplant
dx	Any	V42.1	History of heart transplant
dx	Any	V42.6	History of lung transplant
dx	Any	V42.7	History of liver transplant

APPENDIX A: EXCLUSION DEFINTIONS *continued*

Table C1. Exclusions: ICD-9-CM Clinical Complexity Codes for CABG *without* Valve

Key to abbreviations: px = procedure code; dx = diagnosis code

Code Type	Code Position	ICD-9-CM Code and Description	
dx	Any	V42.81	Bone marrow replaced by transplant
dx	Any	V42.83	Pancreas replaced by transplant
dx	Any	V42.84	Intestine replaced by transplant

Table C2. Exclusions: ICD-9-CM Clinical Complexity Codes for Valve *without* CABG

Key to abbreviations: px = procedure code; dx = diagnosis code; pdx = principal diagnosis code

Code Type	Code Position	ICD-9-CM Code and Description	
pdx	Principal	038.x, 038.xx*	Septicemia
px	Any	32.22	Lung volume reduction surgery **performed at the same time as valve surgery**
px	Any	35.42	Creation of septal defect in heart
px	Any	35.50	Repair of unspecified septal defect of heart with prosthesis
px	Any	35.51	Repair of atrial septal defect with prosthesis, open technique
px	Any	35.53	Repair of ventricular septal defect with prosthesis, open technique
px	Any	35.54	Repair of endocardial cushion defect with prosthesis
px	Any	35.60	Repair of unspecified septal defect of heart with tissue graft
px	Any	35.61	Repair of atrial septal defect with tissue graft
px	Any	35.62	Repair of ventricular septal defect with tissue graft
px	Any	35.63	Repair of endocardial cushion defect with tissue graft
px	Any	35.70	Other and unspecified repair of unspecified septal defect of heart
px	Any	35.72	Other and unspecified repair of ventricular septal defect
px	Any	35.73	Other and unspecified repair of endocardial cushion defect
px	Any	35.81	Total repair of Tetralogy of Fallot
px	Any	35.82	Total repair of total anomalous pulmonary venous connection
px	Any	35.83	Total repair of truncus arteriosus
px	Any	35.84	Total correction of transposition of great vessels, not elsewhere classified
px	Any	35.91	Intratrial transposition of venous return
px	Any	35.92	Creation of conduit between right ventricle and pulmonary artery
px	Any	35.93	Creation of conduit between left ventricle and aorta
px	Any	35.94	Creation of conduit between atrium and pulmonary artery
px	Any	37.32	Excision of aneurysm of heart
px	Any	37.35	Partial ventriculectomy
px	Any	38.12	Carotid endarterectomy
px	Any	38.34	Resection of aorta with anastomosis
px	Any	38.35	Resection of other thoracic vessel with anastomosis
px	Any	38.36	Resection of abdominal arteries with anastomosis
px	Any	38.44	Resection of abdominal aorta with replacement
px	Any	38.45	Resection of other thoracic vessel with replacement
px	Any	38.46	Resection of abdominal arteries with replacement
px	Any	39.51	Clipping of aneurysm
px	Any	39.52	Other repair of aneurysm
px	Any	39.71	Endovascular implantation of graft in abdominal aorta
px	Any	39.73	Endovascular implantation of graft in thoracic aorta
dx	Any	277.3† / 425.7	Amyloidosis plus nutritional & metabolic cardiomyopathy
dx	Any	277.30‡ /425.7	Amyloidosis, unspecified plus nutritional & metabolic cardiomyopathy

* Codes ending in .xx refer only to 5-digit codes (do not include 4-digit codes). Codes ending in .x refer only to 4 digit codes (do not include 5-digit codes).

† Invalid 10/1/2006.

‡ Effective 10/1/2006.

APPENDIX A: EXCLUSION DEFINTIONS *continued*

Table C2. Exclusions: ICD-9-CM Clinical Complexity Codes for Valve *without* CABG

Key to abbreviations: px = procedure code; dx = diagnosis code; pdx = principal diagnosis code

Code Type	Code Position	ICD-9-CM Code	Description
dx	Any	277.39‡ / 425.7	Other amyloidosis plus nutritional & metabolic cardiomyopathy
dx	Any	414.10	Aneurysm of heart (wall)
dx	Any	414.19	Other aneurysm of heart
pdx	Principal	421.0	Acute and subacute bacterial endocarditis
pdx	Principal	421.1	Acute and subacute infective endocarditis in diseases classified elsewhere
pdx	Principal	421.9	Acute endocarditis, unspecified
dx/px	Any	423.2/ 37.31	Diagnosis of constrictive pericarditis and undergoing pericardiectomy
pdx	Principal	424.90	Endocarditis, valve unspecified, unspecified cause
pdx	Principal	424.91	Endocarditis in diseases classified elsewhere
pdx	Principal	424.99	Other endocarditis, valve unspecified
dx	Any	441.00	Dissection of aorta, unspecified site
dx	Any	441.01	Dissection of aorta, thoracic
pdx	Principal	996.02	Mechanical complication of cardiac device, implant, and graft due to heart valve prosthesis
pdx	Principal	996.61	Infection and inflammatory reaction due to cardiac device, implant, and graft
pdx	Principal	996.71	Other complication of internal prosthetic device due to heart valve prosthesis
dx	Any	996.81	Complications of transplanted kidney
dx	Any	996.82	Complications of transplanted liver
dx	Any	996.83	Complications of transplanted heart
dx	Any	996.84	Complications of transplanted lung
dx	Any	996.85	Complications of transplanted bone marrow
dx	Any	996.86	Complications of transplanted pancreas
dx	Any	996.87	Complications of transplanted intestine
dx	Any	V42.0	History of kidney transplant
dx	Any	V42.1	History of heart transplant
dx	Any	V42.6	History of lung transplant
dx	Any	V42.7	History of liver transplant
dx	Any	V42.81	Bone marrow replaced by transplant
dx	Any	V42.83	Pancreas replaced by transplant
dx	Any	V42.84	Intestine replaced by transplant

Table C3. Exclusions: ICD-9-CM Clinical Complexity Codes for Valve *with* CABG

Key to abbreviations: px = procedure code; dx = diagnosis code; pdx = principal diagnosis code

Code Type	Code Position	ICD-9-CM Code	Description
pdx	Principal	038.x, 038.xx*	Septicemia
px	Any	32.22	Lung volume reduction surgery **performed at the same time as valve with CABG surgery**
px	Any	35.42	Creation of septal defect in heart
px	Any	35.50	Repair of unspecified septal defect of heart with prosthesis
px	Any	35.51	Repair of atrial septal defect with prosthesis, open technique
px	Any	35.53	Repair of ventricular septal defect with prosthesis, open technique
px	Any	35.54	Repair of endocardial cushion defect with prosthesis
px	Any	35.60	Repair of unspecified septal defect of heart with tissue graft
px	Any	35.61	Repair of atrial septal defect with tissue graft
px	Any	35.62	Repair of ventricular septal defect with tissue graft

‡ Effective 10/1/2006.

* Codes ending in .xx refer only to 5-digit codes (do not include 4-digit codes). Codes ending in .x refer only to 4 digit codes (do not include 5-digit codes).

APPENDIX A: EXCLUSION DEFINTIONS *continued*

Table C3. Exclusions: ICD-9-CM Clinical Complexity Codes for Valve *with* CABG

Key to abbreviations: px = procedure code; dx = diagnosis code; pdx = principal diagnosis code

Code Type	Code Position	ICD-9-CM Code and Description	
px	Any	35.63	Repair of endocardial cushion defect with tissue graft
px	Any	35.70	Other and unspecified repair of unspecified septal defect of heart
px	Any	35.72	Other and unspecified repair of ventricular septal defect
px	Any	35.73	Other and unspecified repair of endocardial cushion defect
px	Any	35.81	Total repair of Tetralogy of Fallot
px	Any	35.82	Total repair of total anomalous pulmonary venous connection
px	Any	35.83	Total repair of truncus arteriosus
px	Any	35.84	Total correction of transposition of great vessels, not elsewhere classified
px	Any	35.91	Intratrial transposition of venous return
px	Any	35.92	Creation of conduit between right ventricle and pulmonary artery
px	Any	35.93	Creation of conduit between left ventricle and aorta
px	Any	35.94	Creation of conduit between atrium and pulmonary artery
px	Any	35.95	Revision of corrective procedure on heart
px	Any	35.98	Other operations on septa of heart
px	Any	36.91	Repair of aneurysm of coronary vessel
px	Any	37.32	Excision of aneurysm of heart
px	Any	37.35	Partial ventriculectomy
px	Any	38.12	Carotid endarterectomy
px	Any	38.34	Resection of aorta with anastomosis
px	Any	38.35	Resection of other thoracic vessel with anastomosis
px	Any	38.36	Resection of abdominal arteries with anastomosis
px	Any	38.44	Resection of abdominal aorta with replacement
px	Any	38.45	Resection of other thoracic vessel with replacement
px	Any	38.46	Abdominal arteries with replacement
px	Any	39.51	Clipping of aneurysm
px	Any	39.52	Other repair of aneurysm
px	Any	39.71	Endovascular implantation of graft in abdominal aorta
px	Any	39.73	Endovascular implantation of graft in thoracic aorta
dx	Any	277.3[†]/ 425.7	Amyloidosis plus nutritional & metabolic cardiomyopathy
dx	Any	277.30[‡] / 425.7	Amyloidosis, unspecified plus nutritional & metabolic cardiomyopathy
dx	Any	277.39[‡] / 425.7	Other amyloidosis plus nutritional & metabolic cardiomyopathy
dx	Any	414.10	Aneurysm of heart (wall)
dx	Any	414.19	Other aneurysm of heart
pdx	Principal	421.0	Acute and subacute bacterial endocarditis
pdx	Principal	421.1	Acute and subacute infective endocarditis in diseases classified elsewhere
pdx	Principal	421.9	Acute endocarditis, unspecified
dx/px	Any	423.2/ 37.31	Diagnosis of constrictive pericarditis and undergoing pericardiectomy
pdx	Principal	424.90	Endocarditis, valve unspecified, unspecified cause
pdx	Principal	424.91	Endocarditis in diseases classified elsewhere
pdx	Principal	424.99	Other endocarditis, valve unspecified
dx	Any	441.00	Dissection of aorta, unspecified site
dx	Any	441.01	Dissection of aorta, thoracic
pdx	Principal	996.02	Mechanical complication of cardiac device, implant, and graft due to heart valve prosthesis
pdx	Principal	996.61	Infection and inflammatory reaction due to cardiac device, implant, and graft
pdx	Principal	996.71	Other complication of internal prosthetic device due to heart valve prosthesis
dx	Any	996.81	Complications of transplanted kidney

[†] Invalid 10/1/2006.
[‡] Effective 10/1/2006.

APPENDIX A: EXCLUSION DEFINTIONS *continued*

Table C3. Exclusions: ICD-9-CM Clinical Complexity Codes for Valve *with* CABG

Key to abbreviations: px = procedure code; dx = diagnosis code; pdx = principal diagnosis code

Code Type	Code Position	ICD-9-CM Code and Description	
dx	Any	996.82	Complications of transplanted liver
dx	Any	996.83	Complications of transplanted heart
dx	Any	996.84	Complications of transplanted lung
dx	Any	996.85	Complications of transplanted bone marrow
dx	Any	996.86	Complications of transplanted pancreas
dx	Any	996.87	Complications of transplanted intestine
dx	Any	V42.0	History of kidney transplant
dx	Any	V42.1	History of heart transplant
dx	Any	V42.6	History of lung transplant
dx	Any	V42.7	History of liver transplant
dx	Any	V42.81	Bone marrow replaced by transplant
dx	Any	V42.83	Pancreas replaced by transplant
dx	Any	V42.84	Intestine replaced by transplant

APPENDIX B: EXCLUSION DATA

Specific cases were excluded from the analysis. Exclusion criteria that were relevant to all outcome measures (i.e., standard exclusions) were first applied to the in-hospital mortality analysis (see Table A below). For the other outcome measures in the report, additional exclusion criteria were applied as appropriate.

Table A. Exclusions for In-Hospital Mortality Analysis

	Cases		In-Hospital Mortality	
	#	%	#	%
2006-2007 Data				
Total cases prior to in-hospital mortality exclusions	*36,231*	*100.0*	*1,212*	*3.3*
Exclusions:				
• Patients < 30 years of age	265	0.7	8	3.0
• Patients who left against medical advice	14	< 0.1	0	0.0
• Clinically complex cases[1]	3,664	10.1	354	9.7
Total exclusions	3,943	10.9	362	9.2
Total cases remaining in analysis	***32,288***	***89.1***	***850***	***2.6***
2007 Data				
Total cases prior to in-hospital mortality exclusions	*17,647*	*100.0*	*585*	*3.3*
Exclusions:				
• Patients < 30 years of age	133	0.8	5	3.8
• Patients who left against medical advice	5	< 0.1	0	0.0
• Clinically complex cases[1]	1,854	10.5	187	10.1
Total exclusions	1,992	11.3	192	9.6
Total cases remaining in analysis	***15,655***	***88.7***	***393***	***2.5***

[1] Clinically complex cases included organ transplant cases (see Appendix A Table A), cases *not* in the study DRGs (See Appendix A, Tables B1 and B2 for DRGs in the study), and clinically complex cases based on ICD-9-CM codes (see Appendix A, Tables C1, C2, and C3), and cases granted special request for exclusion (SRE).

Table B. Exclusions for Operative Mortality Analysis

	Cases		Operative Mortality	
	#	%	#	%
2006-2007 Data				
Total cases after in-hospital mortality exclusions	*32,288*	*100.0*	–	–
Additional Exclusions:				
• Cases with invalid/inconsistent data[1]	295	0.9	–	–
• Out-of state residents[2]	2,865	8.9	–	–
Total exclusions	3,160	9.8	–	–
Total cases remaining in analysis	***29,128***	***90.2***	***958***	***3.3***
2007 Data				
Total cases after in-hospital mortality exclusions	*15,655*	*100.0*	–	–
Additional Exclusions:				
• Cases with invalid/inconsistent data[1]	187	1.2	–	–
• Out-of state residents[2]	1,363	8.7	–	–
Total exclusions	1,550	9.9	–	–
Total cases remaining in analysis	***14,105***	***90.1***	***448***	***3.2***

[1] Cases with invalid/inconsistent data (i.e., social security number, date of birth, or sex) could not be linked to death certificate information.

[2] Out-of-state residents were excluded because death certificate data was not available for these patients.

APPENDIX B: EXCLUSION DATA *continued*

Table C. Exclusions for 7-Day and 30-Day Readmissions Analysis

	Cases		7-Day Readmissions		30-Day Readmissions	
	#	%	#	%	#	%
2006-2007 Data						
Total cases after in-hospital mortality exclusions	*32,288*	*100.0*	–	–	–	–
Additional exclusions:						
• Patients who died during hospitalization in which surgery was performed	850	2.6	–	–	–	–
• Cases with invalid/inconsistent data[1]	285	0.9	–	–	–	–
• Out-of state residents[2]	2,787	8.6	–	–	–	–
Total exclusions	3,922	12.1	–	–	–	–
Total cases remaining in analysis	***28,366***	***87.9***	***1,797***	***6.3***	***4,320***	***15.2***
2007 Data						
Total cases after in-hospital mortality exclusions	*15,655*	*100.0*	–	–	–	–
Additional exclusions:						
• Patients who died during hospitalization in which surgery was performed	393	2.5	–	–	–	–
• Cases with invalid/inconsistent data[1]	184	1.2	–	–	–	–
• Out-of state residents[2]	1,325	8.5	–	–	–	–
Total exclusions	1,902	12.1	–	–	–	–
Total cases remaining in analysis	***13,753***	***87.9***	***914***	***6.6***	***2,212***	***16.1***

[1] Cases with invalid/inconsistent data (i.e., social security number, date of birth, sex, or overlapping hospitalizations) could not be linked to subsequent hospitalizations.

[2] Out-of-state residents were excluded because such patients could undergo a CABG and/or valve surgery in a Pennsylvania hospital, return to their home, and be readmitted there. Therefore, readmission data would not be available for these patients.

Table D. Exclusions for Post-Surgical Length of Stay (LOS) Analysis

	Cases		Average Post-Surgical LOS in Days
	#	%	
2006-2007 Data			
Total cases after in-hospital mortality exclusions	*32,288*	*100.0*	*7.9*
Additional exclusions:			
• Patients who died during hospitalization in which surgery was performed	850	2.6	12.8
• Cases that were length of stay outliers	299	0.9	45.4
Total exclusions	1,149	3.6	21.3
Total cases remaining in analysis	***31,139***	***96.4***	***7.4***
2007 Data			
Total cases after in-hospital mortality exclusions	*15,655*	*100.0*	*7.9*
Additional exclusions:			
• Patients who died during hospitalization in which surgery was performed	393	2.5	12.2
• Cases that were length of stay outliers	135	0.9	48.3
Total exclusions	528	3.4	21.4
Total cases remaining in analysis	***15,127***	***96.6***	***7.4***

APPENDIX B: EXCLUSION DATA *continued*

Table E. *Exclusions for Average Hospital Charge Analysis*

	Cases		Average Charge
	#	%	
2006-2007 Data			
Total cases after in-hospital mortality exclusions	*32,288*	*100.0*	*$146,038*
Additional exclusions:			
• Patients with invalid or missing charges[1]	3	< 0.1	$3,902
• Additional CMS-DRG/MS-DRG exclusions[2]	996	3.1	$505,928
• Cases that were charge outliers[3]	549	1.7	$510,175
Total exclusions	1,548	4.8	
Total cases remaining in analysis	***30,740***	***95.2***	***$127,888***
2007 Data			
Total cases after in-hospital mortality exclusions	*15,655*	*100.0*	*$150,597*
Additional exclusions:			
• Patients with invalid or missing charges[1]	1	< 0.1	$5,502
• Additional CMS-DRG/MS-DRG exclusions[2]	467	3.0	$527,663
• Cases that were charge outliers[3]	294	1.9	$529,326
Total exclusions	762	4.9	
Total cases remaining in analysis	***14,893***	***95.1***	***$131,307***

[1] Invalid/missing charges included cases with charges that were less than $10,000.

[2] CMS-DRG/MS-DRG exclusions include 1) low volume DRGs, 2) the CMS-DRG/MS-DRG when a particular procedure type, CMS-DRG/MS-DRG, and region combination had less than 10 cases, and 3) tracheostomy cases (CMS-DRG 541 for Q1-2006 to Q3-2007 and MS-DRG 003 effective Q4-2007).

[3] Charge outliers were determined using the "+/- 3.0 interquartile range" method—after accounting for differences in charges by DRG group, region, procedure type, and year.

APPENDIX C: REASONS FOR READMISSION DEFINITIONS

A readmission was counted only if the patient was readmitted with a principal diagnosis (i.e., the reason for the readmission) that indicated a heart-related condition, or an infection or a complication that was likely related to the CABG/valve surgery hospitalization. The following list of categories shows the ICD-9-CM codes that were counted as readmissions if the code was located in the principal diagnosis position.

CIRCULATORY SYSTEM

Cardiac Dysrhythmias

Heart Block

426.0, 426.10, 426.11, 426.12, 426.13, 426.2, 426.3, 426.4, 426.50, 426.51, 426.52, 426.53, 426.54, 426.6, 426.7, 426.81, 426.82, 426.89, 426.9

Paroxysmal Tachycardia

427.0, 427.1, 427.2

Atrial Fibrillation and Atrial Flutter

427.31, 427.32

Ventricular Fibrillation and Ventricular Flutter

427.41, 427.42, 427.5

Premature Heart Beats

427.60, 427.61, 427.69

Other Cardiac Dysrhythmias

427.81, 427.89, 427.9

Heart Failure

398.91, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.40, 428.41, 428.42, 428.43, 428.9

Functional Disturbances Follow Cardiac Surgery (Postcardiotomy Syndrome)

429.4

Hypertension and Hypotension

Essential Hypertension

401.0, 401.1, 401.9

Hypertensive Heart Disease

402.00, 402.01, 402.10, 402.11, 402.90, 402.91

Hypertensive Chronic Kidney Disease

403.00, 403.01, 403.10, 403.11, 403.90, 403.91

Hypertensive Heart and Chronic Kidney Disease

404.00, 404.01, 404.02, 404.03, 404.10, 404.11, 404.12, 404.13, 404.90, 404.91, 404.92, 404.93

Secondary Hypertension

405.01, 405.09, 405.11, 405.19, 405.91, 405.99

Hypotension

458.0, 458.1, 458.21, 458.29, 458.8, 458.9, 796.3

Myocardial Infarction and Ischemia

Acute Myocardial Infarction, Initial Episode

410.01, 410.11, 410.21, 410.31, 410.41, 410.51, 410.61, 410.71, 410.81, 410.91

Acute Myocardial Infarction, Unspecified or Subsequent Episode

410.00, 410.02, 410.10, 410.12, 410.20, 410.22, 410.30, 410.32, 410.40, 410.42, 410.50, 410.52, 410.60, 410.62, 410.70, 410.72, 410.80, 410.82, 410.90, 410.92

APPENDIX C: REASONS FOR READMISSION DEFINITIONS *continued*

Other Forms of Myocardial Ischemia

411.0, 411.81, 411.89, 429.79

Angina Pectoris and Chest Pain

411.1, 413.0, 413.1, 413.9, 786.50, 786.51, 786.59

Atherosclerosis

Coronary Atherosclerosis

414.00, 414.01, 414.02, 414.03, 414.04, 414.05, 414.06, 414.07, 414.2‡‡

Other Atherosclerosis

429.2, 440.0, 440.1, 440.20, 440.21, 440.22, 440.23, 440.24, 440.29, 440.30, 440.31, 440.32, 440.8, 440.9

Heart Aneurysm and Dissection

414.10, 414.11, 414.12, 414.19

Pericarditis, Endocarditis and Myocarditis

397.9, 398.0, 420.90, 420.91, 420.99, 421.0, 421.9, 422.90, 422.91, 422.92, 422.93, 422.99, 423.1, 423.2, 423.3‡‡, 423.8, 423.9, 424.90, 424.99, 429.0, 429.1

Heart Valve Disease

Mitral Valve Disease

394.0, 394.1, 394.2, 394.9, 424.0

Aortic Valve Disease

395.0, 395.1, 395.2, 395.9, 424.1

Tricuspid Valve Disease

397.0, 424.2

Pulmonary Valve Disease

397.1, 424.3

Multiple Valve Disease

396.0, 396.1, 396.2, 396.3, 396.8, 396.9

Other Endocardial Structure Disease

429.5, 429.6, 429.71, 429.81

Cardiomyopathies

425.0, 425.1, 425.3, 425.4, 425.9

Other Aneurysm and Dissection

Aortic Aneurysm and Dissection

441.00, 441.01, 441.02, 441.03, 441.1, 441.2, 441.3, 441.4, 441.5, 441.6, 441.7, 441.9

Other Arterial Aneurysm

442.0, 442.1, 442.2, 442.3, 442.81, 442.82, 442.83, 442.84, 442.89, 442.9

Other Arterial Dissection

443.21, 443.22, 443.23, 443.24, 443.29

Arterial Embolism and Thrombosis

Abdominal and Thoracic Aorta

444.0, 444.1

Arteries of the Extremities

444.21, 444.22, 445.01, 445.02

‡‡ Effective 10/1/2007

APPENDIX C: REASONS FOR READMISSION DEFINITIONS *continued*

Other Arteries Excluding Precerebral and Cerebral Arteries

444.81, 444.89, 444.9, 445.81, 445.89, 449‡‡, 593.81

Venous Embolism and Thrombosis

Lower Extremity Venous Embolism and Thrombosis

453.40, 453.41, 453.42

Renal Vein Embolism and Thrombosis

453.3

Other Venous Embolism and Thrombosis

453.8, 453.9

Phlebitis and Thrombophlebitis

Lower Extremity Phlebitis and Thrombophlebitis

451.0, 451.11, 451.19, 451.2

Upper Extremity Phlebitis and Thrombophlebitis

451.82, 451.83, 451.84

Other Vessel Phlebitis and Thrombophlebitis

451.81, 451.89, 451.9

Occlusion and Stenosis

Precerebral Artery Occlusion and Stenosis

433.00, 433.20, 433.30, 433.80, 433.90

Cerebral Artery Occlusion and Stenosis

433.10, 434.00, 434.10, 434.90

Retinal Artery Occlusion and Visual Loss

362.30, 362.31, 362.32, 362.33, 362.34, 362.35, 362.36, 362.37, 368.11, 368.12, 368.40

Other Diseases and Symptoms of the Circulatory System

398.90, 398.99, 414.8, 414.9, 423.0, 429.3, 429.82, 429.89, 429.9, V533.1, V533.2, V533.9

RESPIRATORY SYSTEM

Pulmonary Embolism and Infarction

Pulmonary Embolism and Infarction

415.0, 415.12‡‡ , 415.19

Postoperative Pulmonary Embolism and Infarction

415.11

Pleural Effusion and Atelectasis

511.0, 511.8, 511.9, 518.0

Pneumothorax

Pneumothorax

512.0, 512.8

Postoperative Pneumothorax

512.1

Pulmonary Edema

514, 518.4, 518.5

‡‡ Effective 10/1/2007

APPENDIX C: REASONS FOR READMISSION DEFINITIONS *continued*

Acute Respiratory Failure

518.81, 518.82, 518.84, 799.1

Other Diseases and Symptoms of the Respiratory System

518.1, 519.1†, 519.19‡, 519.2, 733.6, 786.00, 786.02, 786.04, 786.05, 786.06, 786.09, 786.3, 786.52, 786.6, 786.7, 786.8, 786.9, 998.81

NERVOUS SYSTEM

Stroke

Ischemic Stroke

433.01, 433.11, 433.21, 433.31, 433.81, 433.91, 434.01, 434.11, 434.91

Hemorrhagic Stroke

430, 431, 432.0, 432.1, 432.9

Transient Cerebral Ischemia

435.0, 435.1, 435.2, 435.3, 435.8, 435.9

Postoperative Stroke

997.02

Encephalopathies

348.30, 348.31, 348.39, 349.82, 437.2

Cerebral Edema and Brain Compression

348.4, 348.5

Anoxic Brain Damage

348.1

Coma and Stupor

780.01, 780.03, 780.09

Postoperative Pain

338.12‡, 338.18‡

Other Diseases and Symptoms of the Nervous System

336.1, 436, 780.2, 780.4, 780.97‡

DIGESTIVE SYSTEM

Ischemic Bowel and Vascular Insufficiency of the Intestine

557.0, 557.9

Intestinal Obstruction and Ileus

560.1, 560.81, 560.89, 560.9

Ulceration, Bleeding and Perforation of the Digestive System

528.00‡, 528.02‡, 528.09‡, 530.10, 530.12, 530.20, 530.21, 530.82, 531.00, 531.01, 531.10, 531.11, 531.20, 531.21, 531.30, 531.31, 531.40, 531.41, 531.50, 531.51, 531.60, 531.61, 531.70, 531.71, 531.90, 531.91, 532.00, 532.01, 532.10, 532.11, 532.20, 532.21, 532.30, 532.31, 532.40, 532.41, 532.50, 532.51, 532.60, 532.61, 532.70, 532.71, 532.90, 532.91, 533.00, 533.01, 533.10, 533.11, 533.20, 533.21, 533.30, 533.31, 533.40, 533.41, 533.50, 533.51, 533.60, 533.61, 533.70, 533.71, 533.90, 533.91, 534.00, 534.01, 534.10, 534.11, 534.20, 534.21, 534.30, 534.31, 534.40, 534.41, 534.50, 534.51, 534.60, 534.61, 534.70, 534.71, 534.90, 534.91, 535.00, 535.01, 535.40, 535.41, 535.50, 535.51, 535.60, 535.61, 569.3, 569.82, 569.83, 578.9

Acute Liver Failure

570, 572.2

Other Diseases and Symptoms of the Digestive System

560.30, 560.39, 568.81, 577.0, 578.0, 578.1

† Invalid 10/1/2006
‡ Effective 10/1/2006

APPENDIX C: REASONS FOR READMISSION DEFINITIONS *continued*

URINARY SYSTEM

Acute Glomerulonephritis and Pyelonephritis

580.0, 580.4, 580.89, 580.9, 590.10, 590.11, 590.80

Nephrotic Syndrome

581.0, 581.1, 581.2, 581.3, 581.89, 581.9

Acute Renal Failure

584.5, 584.6, 584.7, 584.8, 584.9

Other Diseases and Symptoms of the Urinary System

593.9, 599.7, 788.20, 788.29

COMPLICATIONS OF SURGICAL AND MEDICAL CARE

Mechanical Complication of Cardiac Device, Implant and Graft

Mechanical Complication of Cardiac Pacemaker and AICD

996.00, 996.01, 996.04

Mechanical Complication of Heart Valve Prosthesis

996.02

Mechanical Complication of Coronary Artery Bypass Graft

996.03

Other and Unspecified Mechanical Complication

996.09, 996.1, 996.59

Other Complication of Internal Prosthetic Device, Implant and Graft

Other Complication of Heart Valve Prosthesis

996.71

Other Complication of Other Cardiac Device, Implant and Graft

996.72

Other Complication of Vascular Device, Implant and Graft

996.74

Shock

Postoperative Shock

998.0

Cardiogenic Shock

785.51

Other Shock

785.50, 785.59

Hemorrhage and Hematoma Complicating a Procedure

459.0, 998.11, 998.12, 998.13

Foreign Body Accidentally Left or Accidental Laceration During a Procedure

998.2, 998.4, 998.7

Dehiscence and Rupture of Operation Wound

998.31, 998.32, 998.6, 998.83

APPENDIX C: REASONS FOR READMISSION DEFINITIONS *continued*

Other Complications of Surgical and Medical Care

Nervous System Complication

997.00, 997.01, 997.09

Circulatory System Complication

997.1, 997.2, 997.71, 997.72, 997.79, 999.1, 999.2

Respiratory System Complication

519.00, 519.02, 519.09, 997.3

Digestive System Complication

536.40, 536.42, 536.49, 997.4

Urinary System Complication

997.5

Other Complications

998.89, 998.9, 999.8

INFECTIONS

Postoperative Infections

998.51, 998.59, 999.3[††] , 999.31[‡‡] , 999.39[‡‡]

Sepsis and Bacteremia

038.0, 038.10, 038.11, 038.19, 038.2, 038.3, 038.40, 038.41, 038.42, 038.43, 038.44, 038.49, 038.8, 038.9, 785.52, 790.7, 995.90, 995.91, 995.92

Pneumonia

Pneumonia

481, 482.0, 482.1, 482.2, 482.30, 482.31, 482.32, 482.39, 482.40, 482.41, 482.49, 482.81, 482.82, 482.83, 482.84, 482.89, 482.9, 485, 486, 511.1

Aspiration Pneumonia

507.0

Empyema and Abscess of Lung

510.0, 510.9, 513.0, 513.1

Infection due to Device, Implant and Graft

Cardiac Device, Implant and Graft

996.61

Vascular Device, Implant and Graft

996.62

Other and Unspecified Infections due to Device, Implant and Graft

519.01, 536.41

Urinary Tract Infection

590.3, 590.9, 595.0, 599.0, 996.64

Cellulitis

681.00, 681.01, 681.02, 681.10, 681.11, 681.9, 682.0, 682.1, 682.2, 682.3, 682.4, 682.5, 682.6, 682.7, 682.8, 682.9

Osteomyelitis

730.03, 730.06, 730.07, 730.08, 730.09

[††] Invalid 10/1/2007
[‡‡] Effective 10/1/2007

APPENDIX C: REASONS FOR READMISSION DEFINITIONS *continued*

Intestinal Infection due to Clostridium difficile

008.45

Other Infection Related Conditions and Symptoms

567.21, 567.29, 567.9, 590.2, 780.6

FLUID AND ELECTROLYTE IMBALANCE

Hyperosmolality and Hyposmolality

276.0, 276.1

Acidosis and Alkalosis

276.2, 276.3, 276.4

Dehydration and Hypovolemia

276.50, 276.51, 276.52

Fluid Overload

276.6

Hyperpotassemia and Hypopotassemia

276.7, 276.8

Other Electrolyte and Fluid Disorders

276.9

ANEMIA AND COAGULATION DEFECTS

Anemia

Acute Posthemorrhagic Anemia

285.1

Anemia

280.0, 285.8, 285.9

Coagulation Defects

Hemorrhagic Disorders due to Anticoagulants

286.5

Thrombocytopenia

287.4, 287.5, 446.6

Other Coagulation Defects

286.6, 286.7, 286.9, 289.82, 790.92

APPENDIX D: READMISSIONS DATA

CY 2006-2007 Data	7-Day N = 1,797 (6.3 %)		30-Day N = 4,320 (15.2 %)	
	#	%	#	%
CIRCULATORY SYSTEM	**800**	**44.5**	**1,863**	**43.1**
Cardiac Dysrhythmias	200	11.1	458	10.6
Heart Block	4	0.2	12	0.3
Paroxysmal Tachycardia	4	0.2	13	0.3
Atrial Fibrillation and Atrial Flutter	164	9.1	357	8.3
Ventricular Fibrillation and Ventricular Flutter	3	0.2	7	0.2
Premature Heart Beats	0	0.0	2	< 0.1
Other Cardiac Dysrhythmias	25	1.4	67	1.6
Heart Failure	317	17.6	666	15.4
Functional Disturbances Follow Cardiac Surgery (Postcardiotomy Syndrome)	66	3.7	152	3.5
Hypertension and Hypotension	36	2.0	106	2.5
Essential Hypertension	3	0.2	6	0.1
Hypertensive Heart Disease	4	0.2	14	0.3
Hypertensive Chronic Kidney Disease	3	0.2	3	0.1
Hypertensive Heart and Chronic Kidney Disease	2	0.1	7	0.2
Secondary Hypertension	0	0.0	0	0.0
Hypotension	24	1.3	76	1.8
Myocardial Infarction and Ischemia	30	1.7	82	1.9
Acute Myocardial Infarction, Initial Episode	18	1.0	60	1.4
Acute Myocardial Infarction, Unspecified or Subsequent Episode	1	0.1	1	< 0.1
Other Forms of Myocardial Ischemia	11	0.6	21	0.5
Angina Pectoris and Chest Pain	52	2.9	131	3.0
Atherosclerosis	25	1.4	87	2.0
Coronary Atherosclerosis	22	1.2	69	1.6
Other Atherosclerosis	3	0.2	18	0.4
Heart Aneurysm and Dissection	0	0.0	0	0.0
Pericarditis, Endocarditis and Myocarditis	39	2.2	93	2.2
Heart Valve Disease	1	0.1	3	0.1
Mitral Valve Disease	1	0.1	1	< 0.1
Aortic Valve Disease	0	0.0	0	0.0
Tricuspid Valve Disease	0	0.0	0	0.0
Pulmonary Valve Disease	0	0.0	0	0.0
Multiple Valve Disease	0	0.0	2	< 0.1
Other Endocardial Structure Disease	0	0.0	0	0.0

APPENDIX D: READMISSIONS DATA *continued*

CY 2006-2007 Data	7-Day N = 1,797 (6.3 %)		30-Day N = 4,320 (15.2 %)	
	#	%	#	%
Cardiomyopathies	0	0.0	2	< 0.1
Other Aneurysm and Dissection	1	0.1	9	0.2
Aortic Aneurysm and Dissection	1	0.1	7	0.2
Other Arterial Aneurysm	0	0.0	2	< 0.1
Other Arterial Dissection	0	0.0	0	0.0
Arterial Embolism and Thrombosis	4	0.2	10	0.2
Abdominal and Thoracic Aorta	0	0.0	1	< 0.1
Arteries of the Extremities	4	0.2	9	0.2
Other Arteries Excluding Precerebral and Cerebral Arteries	0	0.0	0	0.0
Venous Embolism and Thrombosis	13	0.7	38	0.9
Lower Extremity Venous Embolism and Thrombosis	8	0.4	30	0.7
Renal Vein Embolism and Thrombosis	0	0.0	0	0.0
Other Venous Embolism and Thrombosis	5	0.3	8	0.2
Phlebitis and Thrombophlebitis	6	0.3	10	0.2
Lower Extremity Phlebitis and Thrombophlebitis	3	0.2	6	0.1
Upper Extremity Phlebitis and Thrombophlebitis	3	0.2	4	0.1
Other Vessel Phlebitis and Thrombophlebitis	0	0.0	0	0.0
Occlusion and Stenosis	6	0.3	10	0.2
Precerebral Artery Occlusion and Stenosis	2	0.1	2	< 0.1
Cerebral Artery Occlusion and Stenosis	2	0.1	4	0.1
Retinal Artery Occlusion and Visual Loss	2	0.1	4	0.1
Other Diseases and Symptoms of the Circulatory System	4	0.2	6	0.1
RESPIRATORY SYSTEM	**211**	**11.7**	**491**	**11.4**
Pulmonary Embolism and Infarction	59	3.3	133	3.1
Pulmonary Embolism and Infarction	39	2.2	86	2.0
Postoperative Pulmonary Embolism and Infarction	20	1.1	47	1.1
Pleural Effusion and Atelectasis	78	4.3	209	4.8
Pneumothorax	10	0.6	16	0.4
Pneumothorax	5	0.3	7	0.2
Postoperative Pneumothorax	5	0.3	9	0.2
Pulmonary Edema	3	0.2	6	0.1
Acute Respiratory Failure	42	2.3	80	1.9
Other Diseases and Symptoms of the Respiratory System	19	1.1	47	1.1

APPENDIX D: READMISSIONS DATA *continued*

CY 2006-2007 Data	7-Day N = 1,797 (6.3 %)		30-Day N = 4,320 (15.2 %)	
	#	%	#	%
NERVOUS SYSTEM	**85**	**4.7**	**194**	**4.5**
Stroke	44	2.4	99	2.3
Ischemic Stroke	30	1.7	62	1.4
Hemorrhagic Stroke	1	0.1	7	0.2
Transient Cerebral Ischemia	7	0.4	23	0.5
Postoperative Stroke	6	0.3	7	0.2
Encephalopathies	1	0.1	5	0.1
Cerebral Edema and Brain Compression	0	0.0	0	0.0
Anoxic Brain Damage	0	0.0	0	0.0
Coma and Stupor	3	0.2	3	0.1
Postoperative Pain	5	0.3	6	0.1
Other Diseases and Symptoms of the Nervous System	32	1.8	81	1.9
DIGESTIVE SYSTEM	**57**	**3.2**	**144**	**3.3**
Ischemic Bowel and Vascular Insufficiency of the Intestine	5	0.3	12	0.3
Intestinal Obstruction and Ileus	6	0.3	12	0.3
Ulceration, Bleeding and Perforation of the Digestive System	34	1.9	96	2.2
Acute Liver Failure	0	0.0	0	0.0
Other Diseases and Symptoms of the Digestive System	12	0.7	24	0.6
URINARY SYSTEM	**34**	**1.9**	**96**	**2.2**
Acute Glomerulonephritis and Pyelonephritis	1	0.1	3	0.1
Nephrotic Syndrome	0	0.0	1	< 0.1
Acute Renal Failure	31	1.7	88	2.0
Other Diseases and Symptoms of the Urinary System	2	0.1	4	0.1
COMPLICATIONS OF SURGICAL AND MEDICAL CARE	**242**	**13.5**	**507**	**11.7**
Mechanical Complication of Cardiac Device, Implant and Graft	6	0.3	16	0.4
Mechanical Complication of Cardiac Pacemaker and AICD	2	0.1	5	0.1
Mechanical Complication of Heart Valve Prosthesis	1	0.1	3	0.1
Mechanical Complication of Coronary Artery Bypass Graft	0	0.0	2	< 0.1
Other and Unspecified Mechanical Complication	3	0.2	6	0.1
Other Complication of Internal Prosthetic Device, Implant and Graft	9	0.5	31	0.7
Other Complication of Heart Valve Prosthesis	3	0.2	9	0.2
Other Complication of Other Cardiac Device, Implant and Graft	3	0.2	16	0.4
Other Complicaton of Vascular Device, Implant and Graft	3	0.2	6	0.1

APPENDIX D: READMISSIONS DATA *continued*

CY 2006-2007 Data	7-Day N = 1,797 (6.3 %)		30-Day N = 4,320 (15.2 %)	
	#	%	#	%
Shock	1	0.1	1	< 0.1
Postoperative Shock	0	0.0	0	0.0
Cardiogenic Shock	1	0.1	1	< 0.1
Other Shock	0	0.0	0	0.0
Hemorrhage and Hematoma Complicating a Procedure	11	0.6	36	0.8
Foreign Body Accidentally Left or Accidental Laceration During a Procedure	1	0.1	2	< 0.1
Dehiscence and Rupture of Operation Wound	27	1.5	61	1.4
Other Complications of Surgical and Medical Care	187	10.4	360	8.3
Nervous System Complication	0	0.0	1	< 0.1
Circulatory System Complication	110	6.1	209	4.8
Respiratory System Complication	66	3.7	127	2.9
Digestive System Complication	4	0.2	9	0.2
Urinary System Complication	1	0.1	2	< 0.1
Other Complications	6	0.3	12	0.3
INFECTIONS	**307**	**17.1**	**881**	**20.4**
Postoperative Infections	136	7.6	445	10.3
Sepsis and Bacteremia	51	2.8	115	2.7
Pneumonia	61	3.4	135	3.1
Pneumonia	53	2.9	117	2.7
Aspiration Pneumonia	8	0.4	18	0.4
Empyema and Abscess of Lung	1	0.1	2	< 0.1
Infection due to Device, Implant and Graft	7	0.4	22	0.5
Cardiac Device, Implant and Graft	3	0.2	12	0.3
Vascular Device, Implant and Graft	4	0.2	10	0.2
Other and Unspecified Infections due to Device, Implant and Graft	0	0.0	0	0.0
Urinary Tract Infection	16	0.9	41	0.9
Cellulitis	15	0.8	55	1.3
Osteomyelitis	1	0.1	1	< 0.1
Intestinal Infection due to Clostridium difficile	9	0.5	48	1.1
Other Infection Related Conditions and Symptoms	10	0.6	17	0.4

APPENDIX D: READMISSIONS DATA *continued*

CY 2006-2007 Data	7-Day N = 1,797 (6.3 %)		30-Day N = 4,320 (15.2 %)	
	#	%	#	%
FLUID AND ELECTROLYTE IMBALANCE	**23**	**1.3**	**67**	**1.6**
Hyperosmolality and Hyposmolality	6	0.3	11	0.3
Acidosis and Alkalosis	0	0.0	0	0.0
Dehydration and Hypovolemia	15	0.8	44	1.0
Fluid Overload	2	0.1	6	0.1
Hyperpotassemia and Hypopotassemia	0	0.0	6	0.1
Other Electrolyte and Fluid Disorders	0	0.0	0	0.0
ANEMIA AND COAGULATION DEFECTS	**38**	**2.1**	**77**	**1.8**
Anemia	15	0.8	31	0.7
Acute Posthemorrhagic Anemia	4	0.2	8	0.2
Anemia	11	0.6	23	0.5
Coagulation Defects	23	1.3	46	1.1
Hemorrhagic Disorders due to Anticoagulants	0	0.0	2	< 0.1
Thrombocytopenia	6	0.3	7	0.2
Other Coagulation Defects	17	0.9	37	0.9

APPENDIX D: READMISSIONS DATA *continued*

CY 2007 Data	7-Day N = 914 (6.6 %)		30-Day N = 2,212 (16.1 %)	
	#	%	#	%
CIRCULATORY SYSTEM	**407**	**44.5**	**953**	**43.1**
Cardiac Dysrhythmias	98	10.7	233	10.5
Heart Block	2	0.2	8	0.4
Paroxysmal Tachycardia	0	0.0	6	0.3
Atrial Fibrillation and Atrial Flutter	82	9.0	179	8.1
Ventricular Fibrillation and Ventricular Flutter	0	0.0	3	0.1
Premature Heart Beats	0	0.0	1	< 0.1
Other Cardiac Dysrhythmias	14	1.5	36	1.6
Heart Failure	165	18.1	339	15.3
Functional Disturbances Follow Cardiac Surgery (Postcardiotomy Syndrome)	43	4.7	96	4.3
Hypertension and Hypotension	19	2.1	57	2.6
Essential Hypertension	1	0.1	2	0.1
Hypertensive Heart Disease	3	0.3	9	0.4
Hypertensive Chronic Kidney Disease	0	0.0	0	0.0
Hypertensive Heart and Chronic Kidney Disease	1	0.1	3	0.1
Secondary Hypertension	0	0.0	0	0.0
Hypotension	14	1.5	43	1.9
Myocardial Infarction and Ischemia	14	1.5	40	1.8
Acute Myocardial Infarction, Initial Episode	8	0.9	33	1.5
Acute Myocardial Infarction, Unspecified or Subsequent Episode	1	0.1	1	< 0.1
Other Forms of Myocardial Ischemia	5	0.5	6	0.3
Angina Pectoris and Chest Pain	20	2.2	62	2.8
Atherosclerosis	9	1.0	36	1.6
Coronary Atherosclerosis	9	1.0	31	1.4
Other Atherosclerosis	0	0.0	5	0.2
Heart Aneurysm and Dissection	0	0.0	0	0.0
Pericarditis, Endocarditis and Myocarditis	20	2.2	51	2.3
Heart Valve Disease	1	0.1	1	< 0.1
Mitral Valve Disease	1	0.1	1	< 0.1
Aortic Valve Disease	0	0.0	0	0.0
Tricuspid Valve Disease	0	0.0	0	0.0
Pulmonary Valve Disease	0	0.0	0	0.0
Multiple Valve Disease	0	0.0	0	0.0
Other Endocardial Structure Disease	0	0.0	0	0.0
Cardiomyopathies	0	0.0	1	< 0.1

APPENDIX D: READMISSIONS DATA *continued*

CY 2007 Data	7-Day N = 914 (6.6 %)		30-Day N = 2,212 (16.1 %)	
	#	%	#	%
Other Aneurysm and Dissection	1	0.1	5	0.2
Aortic Aneurysm and Dissection	1	0.1	4	0.2
Other Arterial Aneurysm	0	0.0	1	< 0.1
Other Arterial Dissection	0	0.0	0	0.0
Arterial Embolism and Thrombosis	3	0.3	4	0.2
Abdominal and Thoracic Aorta	0	0.0	1	< 0.1
Arteries of the Extremities	3	0.3	3	0.1
Other Arteries Excluding Precerebral and Cerebral Arteries	0	0.0	0	0.0
Venous Embolism and Thrombosis	6	0.7	16	0.7
Lower Extremity Venous Embolism and Thrombosis	4	0.4	14	0.6
Renal Vein Embolism and Thrombosis	0	0.0	0	0.0
Other Venous Embolism and Thrombosis	2	0.2	2	0.1
Phlebitis and Thrombophlebitis	2	0.2	3	0.1
Lower Extremity Phlebitis and Thrombophlebitis	2	0.2	3	0.1
Upper Extremity Phlebitis and Thrombophlebitis	0	0.0	0	0.0
Other Vessel Phlebitis and Thrombophlebitis	0	0.0	0	0.0
Occlusion and Stenosis	3	0.3	5	0.2
Precerebral Artery Occlusion and Stenosis	2	0.2	2	0.1
Cerebral Artery Occlusion and Stenosis	0	0.0	2	0.1
Retinal Artery Occlusion and Visual Loss	1	0.1	1	< 0.1
Other Diseases and Symptoms of the Circulatory System	3	0.3	4	0.2
RESPIRATORY SYSTEM	**107**	**11.7**	**248**	**11.2**
Pulmonary Embolism and Infarction	34	3.7	68	3.1
Pulmonary Embolism and Infarction	22	2.4	47	2.1
Postoperative Pulmonary Embolism and Infarction	12	1.3	21	0.9
Pleural Effusion and Atelectasis	32	3.5	103	4.7
Pneumothorax	7	0.8	10	0.5
Pneumothorax	4	0.4	5	0.2
Postoperative Pneumothorax	3	0.3	5	0.2
Pulmonary Edema	1	0.1	2	0.1
Acute Respiratory Failure	24	2.6	43	1.9
Other Diseases and Symptoms of the Respiratory System	9	1.0	22	1.0

APPENDIX D: READMISSIONS DATA *continued*

CY 2007 Data	7-Day N = 914 (6.6 %)		30-Day N = 2,212 (16.1 %)	
	#	%	#	%
NERVOUS SYSTEM	**39**	**4.3**	**100**	**4.5**
Stroke	16	1.8	49	2.2
Ischemic Stroke	10	1.1	30	1.4
Hemorrhagic Stroke	0	0.0	6	0.3
Transient Cerebral Ischemia	4	0.4	11	0.5
Postoperative Stroke	2	0.2	2	0.1
Encephalopathies	0	0.0	2	0.1
Cerebral Edema and Brain Compression	0	0.0	0	0.0
Anoxic Brain Damage	0	0.0	0	0.0
Coma and Stupor	2	0.2	2	0.1
Postoperative Pain	4	0.4	5	0.2
Other Diseases and Symptoms of the Nervous System	17	1.9	42	1.9
DIGESTIVE SYSTEM	**31**	**3.4**	**76**	**3.4**
Ischemic Bowel and Vascular Insufficiency of the Intestine	2	0.2	5	0.2
Intestinal Obstruction and Ileus	2	0.2	4	0.2
Ulceration, Bleeding and Perforation of the Digestive System	19	2.1	54	2.4
Acute Liver Failure	0	0.0	0	0.0
Other Diseases and Symptoms of the Digestive System	8	0.9	13	0.6
URINARY SYSTEM	**15**	**1.6**	**46**	**2.1**
Acute Glomerulonephritis and Pyelonephritis	0	0.0	1	< 0.1
Nephrotic Syndrome	0	0.0	1	< 0.1
Acute Renal Failure	14	1.5	41	1.9
Other Diseases and Symptoms of the Urinary System	1	0.1	3	0.1
COMPLICATIONS OF SURGICAL AND MEDICAL CARE	**124**	**13.6**	**272**	**12.3**
Mechanical Complication of Cardiac Device, Implant and Graft	5	0.5	9	0.4
Mechanical Complication of Cardiac Pacemaker and AICD	1	0.1	1	< 0.1
Mechanical Complication of Heart Valve Prosthesis	1	0.1	3	0.1
Mechanical Complication of Coronary Artery Bypass Graft	0	0.0	1	< 0.1
Other and Unspecified Mechanical Complication	3	0.3	4	0.2
Other Complication of Internal Prosthetic Device, Implant and Graft	9	1.0	24	1.1
Other Complication of Heart Valve Prosthesis	3	0.3	6	0.3
Other Complication of Other Cardiac Device, Implant and Graft	3	0.3	12	0.5
Other Complicaton of Vascular Device, Implant and Graft	3	0.3	6	0.3

APPENDIX D: READMISSIONS DATA *continued*

CY 2007 Data	7-Day N = 914 (6.6 %)		30-Day N = 2,212 (16.1 %)	
	#	%	#	%
Shock	0	0.0	0	0.0
Postoperative Shock	0	0.0	0	0.0
Cardiogenic Shock	0	0.0	0	0.0
Other Shock	0	0.0	0	0.0
Hemorrhage and Hematoma Complicating a Procedure	5	0.5	21	0.9
Foreign Body Accidentally Left or Accidental Laceration During a Procedure	1	0.1	1	< 0.1
Dehiscence and Rupture of Operation Wound	16	1.8	40	1.8
Other Complications of Surgical and Medical Care	88	9.6	177	8.0
Nervous System Complication	0	0.0	1	< 0.0
Circulatory System Complication	52	5.7	102	4.6
Respiratory System Complication	28	3.1	59	2.7
Digestive System Complication	4	0.4	8	0.4
Urinary System Complication	1	0.1	1	< 0.1
Other Complications	3	0.3	6	0.3
INFECTIONS	**160**	**17.5**	**443**	**20.0**
Postoperative Infections	66	7.2	210	9.5
Sepsis and Bacteremia	32	3.5	66	3.0
Pneumonia	36	3.9	71	3.2
Pneumonia	31	3.4	60	2.7
Aspiration Pneumonia	5	0.5	11	0.5
Empyema and Abscess of Lung	1	0.1	1	< 0.1
Infection due to Device, Implant and Graft	4	0.4	10	0.5
Cardiac Device, Implant and Graft	1	0.1	4	0.2
Vascular Device, Implant and Graft	3	0.3	6	0.3
Other and Unspecified Infections due to Device, Implant and Graft	0	0.0	0	0.0
Urinary Tract Infection	7	0.8	20	0.9
Cellulitis	7	0.8	28	1.3
Osteomyelitis	0	0.0	0	0.0
Intestinal Infection due to Clostridium difficile	6	0.7	31	1.4
Other Infection Related Conditions and Symptoms	1	0.1	6	0.3

APPENDIX D: READMISSIONS DATA *continued*

CY 2007 Data	7-Day N = 914 (6.6 %)		30-Day N = 2,212 (16.1 %)	
	#	%	#	%
FLUID AND ELECTROLYTE IMBALANCE	**14**	**1.5**	**40**	**1.8**
Hyperosmolality and Hyposmolality	3	0.3	5	0.2
Acidosis and Alkalosis	0	0.0	0	0.0
Dehydration and Hypovolemia	9	1.0	25	1.1
Fluid Overload	2	0.2	5	0.2
Hyperpotassemia and Hypopotassemia	0	0.0	5	0.2
Other Electrolyte and Fluid Disorders	0	0.0	0	0.0
ANEMIA AND COAGULATION DEFECTS	**17**	**1.9**	**34**	**1.5**
Anemia	9	1.0	19	0.9
Acute Posthemorrhagic Anemia	3	0.3	5	0.2
Anemia	6	0.7	14	0.6
Coagulation Defects	8	0.9	15	0.7
Hemorrhagic Disorders due to Anticoagulants	0	0.0	0	0.0
Thrombocytopenia	2	0.2	3	0.1
Other Coagulation Defects	6	0.7	12	0.5

APPENDIX E: DEFINITIONS FOR POTENTIAL CANDIDATE VARIABLES

This appendix includes definitions of factors that were considered as potential candidate variables to be entered/tested in the risk-adjustment models. When variables were defined by the presence of ICD-9-CM codes in the discharge record, the ICD-9-CM codes are listed. As discussed earlier, not every variable was considered for every model. When definitions overlapped only one of the variables was considered and some variables were not applicable to particular models. Some variables were not tested in the model(s) because the preliminary analysis did not suggest that they would be predictive of the relevant event. The columns to the right indicate which variable definitions were entered/tested and not retained in a particular model (E or T) and which variables were entered/tested and included in a particular model (✓). When there is no entry beside a particular model the variables was not entered or tested (____).

Variable Definitions	2006-2007 Models	2007 Models
Year [P] Calendar year in which surgery was performed.	In-Hospital M ___ Operative M ___ 7-Day R ✓ 30-Day R ✓ PS-LOS ___	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS ___
Demographic Variables		
Age in Years [P] This continuous variable is the patient's age in years.	In-Hospital M ✓ Operative M ✓ 7-Day R ✓ 30-Day R T PS-LOS ✓	In-Hospital M ✓ Operative M ✓ 7-Day R ✓ 30-Day R T PS-LOS ✓
Age # Years > 65 [P] This continuous variable is the number of years that the patient is over age 65.	In-Hospital M ✓ Operative M ✓ 7-Day R T 30-Day R ✓ PS-LOS ✓	In-Hospital M ✓ Operative M ✓ 7-Day R T 30-Day R ✓ PS-LOS ✓
Female [P]	In-Hospital M ✓ Operative M ✓ 7-Day R ✓ 30-Day R ✓ PS-LOS ✓	In-Hospital M ✓ Operative M ✓ 7-Day R ✓ 30-Day R ✓ PS-LOS ✓
Race/Ethnicity [P] *Category 1:* Hispanic *Category 2:* White, non-Hispanic *Category 3:* Black, non-Hispanic *Category 4:* Other/Unknown	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS ___	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS ___
Race (category) [P] *Category 1:* White *Category 2:* Black *Category 3:* Other/Unknown	In-Hospital M T Operative M ✓ 7-Day R ___ 30-Day R T PS-LOS ✓	In-Hospital M ___ Operative M ___ 7-Day R ✓ 30-Day R ✓ PS-LOS ✓
Laboratory Variables		
Albumin < 2.5 g/dL [MQ] Laboratory value for albumin was less than 2.5 g/dL, as indicated by the following: Albumin g/dL A (iv code 70001), which indicates a lab value in the range: 1 – 2.4.	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ___	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ___
Albumin 2.5-3 g/dL [MQ] Laboratory value for albumin was in the range 2.5 – 3.0 g/dL, as indicated by any of the following: Albumin g/dL B (iv code 70001), which indicates a lab value in the range: 2.5 – 2.7. Albumin g/dL C (iv code 70002), which indicates a lab value in the range: 2.8 – 3.	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ___	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ___

[P] This variable was based on PHC4 data.

[MQ] This variable was based on data obtained from MediQual.

[C] This variable was based on both MediQual and PHC4 data.

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APPENDIX E: DEFINITIONS FOR POTENTIAL CANDIDATE VARIABLES *continued*

Variable Definitions	2006-2007 Models	2007 Models
Note: Albumin levels are used to evaluate nutritional status, liver or kidney disease.		
BUN > 40 mg/dL [MQ] Laboratory value for blood urea nitrogen (BUN) was greater than 40 mg/dL, as indicated by any of the following: BUN mg/dL D (iv code70153), which indicates a lab value in the range: 41- 55. BUN mg/dL E (iv code70154), which indicates a lab value in the range: 56 – 250. Note: Evaluation of kidney function.	In-Hospital M ✓ Operative M ✓ 7-Day R _ 30-Day R _ PS-LOS _	In-Hospital M ✓ Operative M ✓ 7-Day R _ 30-Day R _ PS-LOS _
Creatinine > 1.4 mg/dL [MQ] Laboratory value for creatinine was greater than 1.4 mg/dL, as indicated by any of the following: Creatinine mg/dL B (iv code 70231), which indicates a lab value in the range: 1.5 - 2 Creatinine mg/dL C (iv code 70232), which indicates a lab value in the range: 2.1 – 2.5 Creatinine mg/dL D (iv code 70233), which indicates a lab value in the range: 2.6 - 3 Creatinine mg/dL E (iv code 70234), which indicates a lab value in the range: 3.1 – 25 Note: Evaluation of kidney function.	In-Hospital M ✓ Operative M ✓ 7-Day R _ 30-Day R _ PS-LOS _	In-Hospital M ✓ Operative M ✓ 7-Day R _ 30-Day R _ PS-LOS _
Glucose > 165 mg/dL [MQ] Laboratory value for glucose was greater than 165 mg/dL, as indicated by any of the following: Glucose mg/dL D (iv code70103), which indicates a lab value in the range: 166 – 240. Glucose mg/dL E (iv code70104), which indicates a lab value in the range: 241 – 2000.	In-Hospital M ✓ Operative M ✓ 7-Day R _ 30-Day R _ PS-LOS _	In-Hospital M E Operative M E 7-Day R _ 30-Day R _ PS-LOS _
Clinical Variables Other than Laboratory Variables		
Acute Myocardial Infarction [P] AMI as indicated by code 410.01, 410.11, 410.21, 410.31, 410.41, 410.51, 410.61, 410.71, 410.81, or 410.91 in the *principal diagnosis position* in PHC4 data.	In-Hospital M _ Operative M _ 7-Day R _ 30-Day R _ PS-LOS ✓	In-Hospital M _ Operative M _ 7-Day R _ 30-Day R _ PS-LOS T
AMI Except Other Anterior or Other Inferior Wall [P] AMI as indicated by code 410.01, 410.21, 410.31, 410.51, 410.61, 410.71, 410.81, or 410.91 in the *principal diagnosis position* in PHC4 data.	In-Hospital M ✓ Operative M ✓ 7-Day R _ 30-Day R _ PS-LOS _	In-Hospital M ✓ Operative M ✓ 7-Day R _ 30-Day R _ PS-LOS _
AMI Other Inferior Wall Initial Episode [C] AMI of other inferior wall, as indicated by 410.41 in the principal diagnosis position in PHC4 data, or 410.41 in any position in the MediQual data (iv code: 9991).	In-Hospital M ✓ Operative M ✓ 7-Day R _ 30-Day R _ PS-LOS _	In-Hospital M ✓ Operative M ✓ 7-Day R _ 30-Day R _ PS-LOS _
Anemia [P] Any of the following codes in any position in PHC4 data: 280.0, 280.1, 280.8, 280.9, 281.0, 281.1, 281.2, 281.3, 281.4, 281.8, 281.9, 282.0, 282.1, 282.2, 282.3, 282.41, 282.42, 282.49, 282.5, 282.60, 282.61, 282.62, 282.63, 282.64, 282.68, 282.69, 282.7, 282.8, 282.9, 283.0, 283.10, 283.11, 283.19, 283.2, 283.9, 284.0†, 284.01‡, 284.09‡, 284.1‡, 284.2‡, 284.8††, 284.81‡‡, 284.89‡‡, 284.9, 285.0, 285.21, 285.22, 285.29, 285.8, 285.9.	In-Hospital M _ Operative M _ 7-Day R T 30-Day R T PS-LOS ✓	In-Hospital M _ Operative M _ 7-Day R T 30-Day R ✓ PS-LOS ✓

† Invalid 10/1/2006
‡ Effective 10/1/2006
†† Invalid 10/1/2007
‡‡ Effective 10/1/2007

[P] This variable was based on PHC4 data.

[MQ] This variable was based on data obtained from MediQual.

[C] This variable was based on both MediQual and PHC4 data.

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APPENDIX E: DEFINITIONS FOR POTENTIAL CANDIDATE VARIABLES *continued*

Variable Definitions	2006-2007 Models	2007 Models
Angina [P] Any of the following codes in any position in PHC4 data: 411.1, 413.0, 413.1, 413.9.	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS ___	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS ___
Angina, Unstable [P] The following code in any position in PHC4 data: 411.1.	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS ___	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS ___
ASA Class 5 [MQ] This dichotomous variable (iv code 5529) is based on the presence of an anesthesia class of 5 for the earliest open heart procedure episode. Physical status classification system created by American Society of Anesthesiologists. Scale: 1-5, where 5 is the highest risk category.	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ___	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ___
ASA Emergency [MQ] This dichotomous variable (iv code 5530) is based on the presence of an anesthesia emergency flag for the earliest open heart procedure episode. Physical status classification system created by American Society of Anesthesiologists. E designates an emergency operation.	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ___	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ___
Cachexia [P] Any of the following codes in any position in PHC4 data: 261, 262, 263.0, 263.1, 263.2, 263.8, 263.9, 799.4, V85.0.	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R T PS-LOS ✓	In-Hospital M ✓ Operative M T 7-Day R T 30-Day R T PS-LOS ✓
CAD > 70, 5-7 Vessels Group [MQ] This dichotomous variable (iv code: 6668) indicates the presence of coronary artery disease (CAD) with greater than 70 percent occlusion in 5 to 7 coronary arteries.	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ___	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ___
Cancer [P] Any of the following codes in any position in PHC4 data: Malignant neoplasms including primary and secondary (140.0-208.91), Cancer In Situ and Neoplasms of Uncertain Behavior 230.0-239.9[1].	In-Hospital M ___ Operative M ___ 7-Day R ✓ 30-Day R ___ PS-LOS ✓	In-Hospital M ___ Operative M ___ 7-Day R ✓ 30-Day R T PS-LOS ✓
Cardiac Adhesions [P] The following code in any position in PHC4 data: 423.1 (Adhesive Pericarditis).	In-Hospital M T Operative M T 7-Day R ___ 30-Day R T PS-LOS T	In-Hospital M T Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS T
Cardiogenic Shock, Preoperative [P] Chart review for clinical criteria.	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R T PS-LOS ✓	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ✓

[1] This range includes new codes effective Quarter 4, 2006: 238.71, 238.72, 238.73, 238.74, 238.75, 238.76, 238.79 and new codes effective Quarter 4, 2007: 200.3x, 200.4x, 200.5x, 200.6x, 200.7x, 233.3x.

[P] This variable was based on PHC4 data.

[MQ] This variable was based on data obtained from MediQual.

[C] This variable was based on both MediQual and PHC4 data.

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APPENDIX E: DEFINITIONS FOR POTENTIAL CANDIDATE VARIABLES *continued*

Variable Definitions	2006-2007 Models	2007 Models
Cardiomyopathy [P] Any of the following codes in any position in PHC4 data: 414.8, 425.1, 425.3, 425.4, 425.5, 425.8, 425.9, 429.1, 429.3.	In-Hospital M __T__ Operative M __T__ 7-Day R ____ 30-Day R __T__ PS-LOS __T__	In-Hospital M __T__ Operative M ____ 7-Day R ____ 30-Day R __T__ PS-LOS __T__
Cardiopulmonary Resuscitation (CPR) Prior to CABG/Valve Surgery Date [P] Any of the following codes in any position in PHC4 data: 93.93, 99.60, 99.62, or 99.63 prior to CABG/valve surgery date. Note: Use the earliest CPR date for analysis.	In-Hospital M ____ Operative M ____ 7-Day R ____ 30-Day R ____ PS-LOS ____	In-Hospital M ____ Operative M ____ 7-Day R ____ 30-Day R ____ PS-LOS ____
Cerebrovascular Disease [P] Any of the following codes in any position in PHC4 data: 433.00, 433.10, 433.20, 433.30, 433.80, 433.90, 434.00, 434.10, 434.90, 437.0, 437.1, 437.3, 437.4, 442.81, 446.5.	In-Hospital M ____ Operative M ____ 7-Day R ____ 30-Day R __✓__ PS-LOS ____	In-Hospital M ____ Operative M ____ 7-Day R __T__ 30-Day R __T__ PS-LOS ____
Chronic Lung Disease [P] Any of the following codes in any position in PHC4 data: 491.0, 491.1, 491.20, 491.21, 491.22, 492.0, 492.8, 493.20, 493.21, 493.22, 494.0, 494.1, 496, 500, 501, 502, 503, 504, 505, 506.4, 508.1, 518.2, 518.83.	In-Hospital M __T__ Operative M __T__ 7-Day R __T__ 30-Day R __✓__ PS-LOS __✓__	In-Hospital M __T__ Operative M ____ 7-Day R __T__ 30-Day R __✓__ PS-LOS __✓__
Chronic Pulmonary Hypertension [P] Any of the following codes in any position in PHC4 data: 416.0, 416.1, 416.8, 416.9.	In-Hospital M __T__ Operative M __T__ 7-Day R __T__ 30-Day R __T__ PS-LOS __T__	In-Hospital M ____ Operative M __T__ 7-Day R __T__ 30-Day R __✓__ PS-LOS __T__
Coagulopathy [P] Any of the following codes in any position in PHC4 data: 286.0, 286.1, 286.2, 286.3, 286.4, 287.30, 287.31, 287.32, 287.33, 287.39, 289.81.	In-Hospital M ____ Operative M ____ 7-Day R ____ 30-Day R ____ PS-LOS ____	In-Hospital M ____ Operative M ____ 7-Day R ____ 30-Day R ____ PS-LOS ____
Current Med Immunosuppressive [MQ] This dichotomous variable (iv code 892) is based on the presence of the current med immunosuppressive history finding (steroids, chemotherapy drugs).	In-Hospital M __E__ Operative M __✓__ 7-Day R ____ 30-Day R ____ PS-LOS ____	In-Hospital M __✓__ Operative M __✓__ 7-Day R ____ 30-Day R ____ PS-LOS ____
Current Med Insulin [MQ] This dichotomous variable (iv code 894) is based on the presence of the current med insulin history finding.	In-Hospital M __✓__ Operative M __✓__ 7-Day R ____ 30-Day R ____ PS-LOS ____	In-Hospital M __✓__ Operative M __✓__ 7-Day R ____ 30-Day R ____ PS-LOS ____
Depression [P] Any of the following codes in any position in PHC4 data: 296.20, 296.21, 296.22, 296.23, 296.24, 296.25, 296.26, 296.30, 296.31, 296.32, 296.33, 296.34, 296.35, 296.36, 298.0, 300.4, 309.1, 311.	In-Hospital M ____ Operative M ____ 7-Day R ____ 30-Day R __T__ PS-LOS ____	In-Hospital M ____ Operative M ____ 7-Day R ____ 30-Day R ____ PS-LOS ____
Diabetes (category) [P] *Category 1:* No diabetes *Category 2:* Diabetes without complications, as indicated by code 250.0x in any position in PHC4 data. *Category 3:* Diabetes with complications, as indicated by any code in the range 250.1x – 250.9x in any position in PHC4 data.	In-Hospital M ____ Operative M ____ 7-Day R __✓__ 30-Day R __✓__ PS-LOS ____	In-Hospital M ____ Operative M ____ 7-Day R __✓__ 30-Day R __✓__ PS-LOS ____

[P] This variable was based on PHC4 data.

[MQ] This variable was based on data obtained from MediQual.

[C] This variable was based on both MediQual and PHC4 data.

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APPENDIX E: DEFINITIONS FOR POTENTIAL CANDIDATE VARIABLES *continued*

Variable Definitions	2006-2007 Models	2007 Models
Diabetes With Long-Term/Unspecified Complications [P] Diabetes with long-term or unspecified complications, as indicated by any code in the range 250.4x-250.9x in any position in PHC4 data.	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS ✓	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS ✓
Ejection Fraction [MQ] *Category 1: EF < 25%* was based on the presence of one of the following: Ejection Fraction <25 % (iv code 25034), which indicates the presence of an ejection fraction less than or equal to 25% as a transfer, pre-admission or admission KCF. Fract Short <25 % (iv code 25035), which indicates the presence of a fractional shortening less than or equal to 25% as a transfer, pre-admission or admission KCF. *Category 2: 25% to 45%* consisted of all cases not included in Categories 1 or 3. *Category 3: EF > 45%* was based on the presence of one of the following: Ejection Fraction >45 (iv code 25040), which indicates the presence of an ejection fraction greater than 50% as a transfer, pre-admission or admission KCF. Fract Short >45 % (iv code 25041), which indicates the presence of a fractional shortening greater than 50% as a transfer, pre-admission or admission KCF.	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ___	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ___
Excision or Other Lesion/Heart Tissue, Open Approach – Same Date as Valve Surgery [P] The presence of code 37.33 in any position in PHC4 data with a procedure date on the same date as the valve surgery. Note: Px3733 date should be the same day as the Valve or Valve with CABG procedure date (if multiple valve/CABG surgeries were performed, use the earliest valve/CABG procedure date for analysis).	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R T PS-LOS T	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS T
Fibrosis in Mediastinum and Heart [P] Any of the following codes in any position in PHC4 data: 423.1, 429.0, 429.1, 519.3.	In-Hospital M T Operative M ___ 7-Day R T 30-Day R T PS-LOS T	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS T
Heart Failure [P] Any of the following codes in any position in PHC4 data: 398.91, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.40, 428.41, 428.42, 428.43, 428.9. *For those cases having one of the above heart failure codes and a hypertension with congestive heart failure code (402.x1, 404.x1, or 404.x3), the case was assigned to hypertension with complications.*	In-Hospital M ___ Operative M ___ 7-Day R ✓ 30-Day R ✓ PS-LOS ✓	In-Hospital M ___ Operative M ___ 7-Day R ✓ 30-Day R ✓ PS-LOS ✓
Heart Failure [C] Heart failure as indicated by either of the following: Any of the following codes in any position in PHC4 data: 398.91, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.40, 428.41, 428.42, 428.43, 428.9. For those cases having one of these heart failure codes and a hypertension with congestive heart failure code (402.x1, 404.x1, or 404.x3), the case was assigned to hypertension with complications. The presence of congestive heart failure (CHF) as either a preadmission or admission KCF in MediQual data (iv1500).	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ___	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ___
History of CABG or Valve Surgery [P] History of CABG and/or valve surgery, as indicated by either of the following: Any of the following codes in the principal diagnosis position in PHC4 data: 996.02, 996.03, 996.61, 996.71, 996.72 ; or Any of the following codes in any position in PHC4 data: V42.2, V43.3, V45.81, 414.02 – 414.05.	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R T PS-LOS T	In-Hospital M ___ Operative M ___ 7-Day R T 30-Day R ___ PS-LOS T

[P] This variable was based on PHC4 data.

[MQ] This variable was based on data obtained from MediQual.

[C] This variable was based on both MediQual and PHC4 data.

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APPENDIX E: DEFINITIONS FOR POTENTIAL CANDIDATE VARIABLES *continued*

Variable Definitions	2006-2007 Models	2007 Models
History of CABG or Valve Surgery [C] History of CABG and/or valve surgery, as indicated by any of the following: Any of the following codes in the principal diagnosis position in PHC4 data: 996.02, 996.03, 996.61, 996.71, 996.72 ; or Any of the following codes in any position in PHC4 data: V42.2, V43.3, V45.81, 414.02 – 414.05; or The presence of the Previous CABG History KCF in MediQual data (iv831).	In-Hospital M ✓ Operative M ✓ 7-Day R 30-Day R PS-LOS	In-Hospital M ✓ Operative M ✓ 7-Day R 30-Day R PS-LOS
History of PTCA/Stent [P] History of a PTCA or stent as indicated by code V45.82 in any position in PHC4 data.	In-Hospital M Operative M 7-Day R 30-Day R ✓ PS-LOS	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS
History of Chronic Steroid Use [P] History of chronic steroid use as indicated by code V58.65 in any position in PHC4 data.	In-Hospital M Operative M 7-Day R 30-Day R ✓ PS-LOS	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS
History of Peripheral Vascular Disease [P] Any of the following codes in any position in PHC4 data: 440.0, 440.1, 440.20, 440.21 440.22, 440.23, 440.24, 440.29, 440.30, 440.31, 440.32, 440.4[‡‡], 440.8, 440.9, 441.2, 441.4, 441.7, 441.9, 442.0, 442.1, 442.2, 442.3, 442.82, 442.83, 442.84, 443.0, 443.1, 443.81, 443.82, 443.89, 443.9, 454.0, 454.1, 454.2, 454.8, 454.9, 459.30, 459.31, 459.32, 459.33, 459.39, 459.81, 557.1, 593.81.	In-Hospital M Operative M 7-Day R T 30-Day R ✓ PS-LOS	In-Hospital M Operative M 7-Day R T 30-Day R T PS-LOS T
History of Peripheral Vascular Disease [C] History of peripheral vascular disease, as indicated by any of the following: Any of the following codes in any position in PHC4 data: 440.0, 440.1, 440.20, 440.21 440.22, 440.23, 440.24, 440.29, 440.30, 440.31, 440.32, 440.4[‡‡] 440.8, 440.9, 441.2, 441.4, 441.7, 441.9, 442.0, 442.1, 442.2, 442.3, 442.82, 442.83, 442.84, 443.0, 443.1, 443.81, 443.82, 443.89, 443.9, 454.0, 454.1, 454.2, 454.8, 454.9, 459.30, 459.31, 459.32, 459.33, 459.39, 459.81, 557.1, 593.81; or The presence of the Peripheral Vascular Disease History KCF in MediQual data (iv817).	In-Hospital M ✓ Operative M ✓ 7-Day R 30-Day R PS-LOS	In-Hospital M ✓ Operative M ✓ 7-Day R 30-Day R PS-LOS
Hypercholesterolemia [P] Any of the following codes in any position in PHC4 data: 272.0, 272.1, 272.2, 272.3, 272.4.	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS
Hypertension [P] Code 401.x in any position in PHC4 data.	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS
Hypertension with Complications [P] Any of the following codes in any position in PHC4 data: 402.xx, 403.xx, 404.xx, 405.xx.	In-Hospital M T Operative M T 7-Day R T 30-Day R T PS-LOS ✓	In-Hospital M T Operative M T 7-Day R ✓ 30-Day R ✓ PS-LOS ✓

[‡‡] Effective 10/1/2007

[P] This variable was based on PHC4 data.

[MQ] This variable was based on data obtained from MediQual.

[C] This variable was based on both MediQual and PHC4 data.

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APPENDIX E: DEFINITIONS FOR POTENTIAL CANDIDATE VARIABLES *continued*

Variable Definitions	2006-2007 Models	2007 Models
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery [P] Code 37.61 in any position in PHC4 data with a procedure date prior to the CABG/valve surgery. Note: Use the earliest IABP date for analysis.	In-Hospital M ✓ Operative M T 7-Day R _ 30-Day R _ PS-LOS ✓	In-Hospital M _ Operative M T 7-Day R _ 30-Day R _ PS-LOS ✓
Ischemic Heart Disease [P] Code 414.9 in any position in PHC4 data.	In-Hospital M _ Operative M _ 7-Day R _ 30-Day R _ PS-LOS _	In-Hospital M _ Operative M _ 7-Day R _ 30-Day R _ PS-LOS _
Liver Disease [P] Any of the following codes in any position in PHC4 data: 456.0, 456.20, 456.21, 571.0, 571.1, 571.2, 571.3, 571.40, 571.41, 571.49, 571.5, 571.6, 571.8, 571.9, 572.3, 573.3.	In-Hospital M ✓ Operative M ✓ 7-Day R _ 30-Day R ✓ PS-LOS ✓	In-Hospital M ✓ Operative M ✓ 7-Day R _ 30-Day R ✓ PS-LOS ✓
Lupus Erythematosus, Systemic [P] Code 710.0 in any position in PHC4 data.	In-Hospital M ✓ Operative M _ 7-Day R _ 30-Day R ✓ PS-LOS _	In-Hospital M T Operative M ✓ 7-Day R _ 30-Day R T PS-LOS _
MediQual Predicted LOS (continuous) [MQ]	In-Hospital M _ Operative M _ 7-Day R ✓ 30-Day R ✓ PS-LOS ✓	In-Hospital M _ Operative M _ 7-Day R ✓ 30-Day R ✓ PS-LOS ✓
MI/AMI Other Anterior Wall [C] Myocardial infarction/acute myocardial infarction of other anterior wall, as indicatd by either one of the following: Code 410.11 as a principal diagnosis in PHC4 data, or The presence of myocardial infarction as either a preadmission or admission KCF and the diagnosis code 410.11 in any position in MediQual data (iv code: 6634).	In-Hospital M ✓ Operative M ✓ 7-Day R _ 30-Day R _ PS-LOS _	In-Hospital M ✓ Operative M ✓ 7-Day R _ 30-Day R _ PS-LOS _
Mild Moderate or Severe Altered Mental Status [MQ] Altered mental status is based on the presence of the following preadmission or admission KCF in MediQual data: Mild AMS (iv code 20017) – Disoriented, lethargy, or Glascow Coma Score from 10-14; or Severe AMS (iv code 20018) – Glascow Coma Score from 5-9; or Moderate AMS (iv code 25046) – Coma/stupor or Glascow Coma Score < 5.	In-Hospital M ✓ Operative M ✓ 7-Day R _ 30-Day R _ PS-LOS _	In-Hospital M ✓ Operative M E 7-Day R _ 30-Day R _ PS-LOS _
Multiple Valve Procedures [P] Any combination of valve procedures, as indicated by any 2 or more valve procedure codes in any position in PHC4 data: 35.10, 35.11, 35.12, 35.13, 35.14, 35.20, 35.21, 35.22, 35.23, 35.24, 35.25 35.26, 35.27, 35.28, 35.33, 35.99.	In-Hospital M ✓ Operative M ✓ 7-Day R _ 30-Day R T PS-LOS ✓	In-Hospital M ✓ Operative M ✓ 7-Day R _ 30-Day R T PS-LOS ✓
Myocardial Infarction, Old [P] Code 412 in any position in PHC4 data.	In-Hospital M _ Operative M _ 7-Day R _ 30-Day R _ PS-LOS _	In-Hospital M _ Operative M _ 7-Day R _ 30-Day R _ PS-LOS _

[P] This variable was based on PHC4 data.

[MQ] This variable was based on data obtained from MediQual.

[C] This variable was based on both MediQual and PHC4 data.

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APPENDIX E: DEFINITIONS FOR POTENTIAL CANDIDATE VARIABLES *continued*

Variable Definitions	2006-2007 Models	2007 Models
Obesity [P] *Category 1:* No obesity. *Category 2:* Unspecified obesity, as indicated by code 278.00 in any position in PHC4 data. *Category 3:* Morbid obesity, as indicated by code 278.01 in any position in PHC4 data.	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS ___	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS ___
Obesity, Morbid [P] Code 278.01 in any position in PHC4 data.	In-Hospital M ___ Operative M ___ 7-Day R _T_ 30-Day R ✓ PS-LOS ___	In-Hospital M ___ Operative M ___ 7-Day R ✓ 30-Day R ✓ PS-LOS ✓
Other CV Procedure Group [C] Other cardiovascular procedures, as indicated by any of the following codes in any position: 35.00, 35.01, 35.02, 35.03, 35.04, 35.31, 35.32, 35.34, 35.35, 35.39, 35.50, 35.51, 35.53, 35.54, 35.60, 35.61, 35.62, 35.63, 35.70, 35.71, 35.72, 35.73, 35.81, 35.82, 35.83, 35.84, 35.91, 35.92, 35.93, 35.94, 35.95, 35.98, 36.2, 36.31, 36.32, 36.39, 36.91, 36.99, 37.10, 37.11, 37.12, 37.31, 37.32, 37.33, 37.41, 37.49, 37.51, 37.52, or 37.53 in PHC4 data; *or* 36.31, 36.32, 36.39, 36.91, 36.99, 37.10, 37.11, 37.32, 37.33, 38.44, 38.45, 38.46, 39.51, or 39.52 in MediQual data (iv6627).	In-Hospital M ✓ Operative M ✓ 7-Day R _T_ 30-Day R _T_ PS-LOS ___	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R _T_ PS-LOS ___
Other Open Heart Procedure [P] Any of the following codes in any position in PHC4 data: 35.00, 35.01, 35.02, 35.03, 35.04, 35.31, 35.32, 35.34, 35.35, 35.39, 35.50, 35.51, 35.53, 35.54, 35.60, 35.61, 35.62, 35.63, 35.70, 35.71, 35.72, 35.73, 35.81, 35.82, 35.83, 35.84, 35.91, 35.92, 35.93, 35.94, 35.95, 35.98, 36.2, 36.31, 36.32, 36.39, 36.91, 36.99, 37.10, 37.11, 37.12, 37.31, 37.32, 37.33, 37.41, 37.49, 37.51, 37.52, 37.53.	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS ✓	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS ✓
Percent of Left Main Stenosis [MQ] Percent of occlusion in the left main coronary artery (continuous variable, iv code 6257 in MediQual data). This variable was not considered as a potential candidate variable to be tested in the models because the value was missing for 70 percent of cases.	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS ___	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS ___
Procedure Group [P] *Category 1:* CABG without valve, as indicated by any of the following codes with *no* valve procedure codes (PHC4 data): 36.10, 36.11, 36.12, 36.13, 36.14, 36.15, 36.16, 36.17, 36.19. *Category 2:* Valve without CABG, as indicated by any of the following codes with *no* CABG codes (PHC4 data): 35.10, 35.11, 35.12, 35.13, 35.14, 35.20, 35.21, 35.22, 35.23, 35.24, 35.25, 35.26, 35.27, 35.28, 35.33, 35.99. *Category 3:* Valve with CABG, as indicated by the presence of at least one CABG code *and* at least one valve code (see above).	In-Hospital M ✓ Operative M ✓ 7-Day R ✓ 30-Day R ✓ PS-LOS ✓	In-Hospital M ✓ Operative M ✓ 7-Day R ✓ 30-Day R ✓ PS-LOS ✓
PTCA/Stent Same Day as CABG/Valve Surgery [P] Any of the following codes in any position in PHC4 data with a procedure data the same day as the CABG/valve surgery: 00.66, 36.06, 36.07, 36.09.	In-Hospital M ___ Operative M ___ 7-Day R ___ 30-Day R ___ PS-LOS ✓	In-Hospital M ___ Operative M ___ 7-Day R _T_ 30-Day R ___ PS-LOS ✓
PTCA/Stent/Tear Same Day as CABG/Valve Surgery [C] Based on either of the following: Any of the following codes in any position in PHC4 data with a procedure date the same day as the CABG/valve surgery: 00.66, 36.06, 36.07, 36.09, or A CABG procedure or valve procedure performed on the same day as a PTCA with the presence of a "vessel tear" as either a preadmission or admission KCF in MediQual data (iv6644).	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ___	In-Hospital M ✓ Operative M ✓ 7-Day R ___ 30-Day R ___ PS-LOS ___

[P] This variable was based on PHC4 data.

[MQ] This variable was based on data obtained from MediQual.

[C] This variable was based on both MediQual and PHC4 data.

_✓_ = variable included in final model
_E_ or _T_ = variable was entered/tested in the model and not retained

___ = variable not entered or tested in the model.

APPENDIX E: DEFINITIONS FOR POTENTIAL CANDIDATE VARIABLES *continued*

Variable Definitions	2006-2007 Models	2007 Models
Renal Failure/Dialysis (category) [P] *Category 1:* All cases not assigned to Category 2 and 3. *Category 2:* Chronic kidney disease, as indicated by any of the following codes in PHC4 data: 585.1 – 585.9. Note: for this variable, cases with one of these chronic kidney disease codes and a hypertensive chronic kidney disease (403.xx) or hypertensive heart and chronic kidney disease code (404.xx) will be assigned to Category 1. Additionally, cases with a chronic kidney disease code (585.1 – 585.9) and a hypertensive chronic kidney disease (403.xx) or hypertensive heart and chronic kidney disease code (404.xx) are assigned to the Hypertension with Complication variable. *Category 3:* Pre-operative acute renal failure or dialysis, as indicated by either of the following: Acute renal failure diagnosis code (584.5 – 584.9) along with medical record review confirmation that the acute renal failure occurred prior to the CABG/valve surgery; or Dialysis procedure code (39.95 or 54.98) occurred prior to the date of the CABG/valve surgery. Note: the date of dialysis should be prior to the date of the earliest CABG and/or valve procedure. If multiple dialysis procedures occurred, use the earliest date.	In-Hospital M ✓ Operative M ✓ 7-Day R 30-Day R T PS-LOS	In-Hospital M T Operative M T 7-Day R 30-Day R T PS-LOS
Renal Failure/Dialysis (binary) [P] Renal failure (pre-op acute renal failure or chronic kidney disease) or preoperative dialysis: Chronic kidney disease, as indicated by any of the following codes in PHC4 data: 585.1 – 585.9. Note: cases with a chronic kidney disease code (585.1 – 585.9) and a hypertensive chronic kidney disease (403.xx) or hypertensive heart and chronic kidney disease code (404.xx) are assigned to the Hypertension with Complication variable; *or* Acute renal failure diagnosis code (584.5 – 584.9) along with medical record review confirmation that the acute renal failure occurred prior to the CABG/valve surgery; or Dialysis procedure code (39.95 or 54.98) occurred prior to the date of the CABG/valve surgery. Note: the date of dialysis should be prior to the date of the earliest CABG and/or valve procedure. If multiple dialysis procedures occurred, use the earliest date.	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS ✓	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS ✓
Pre-op Acute Renal Failure/Dialysis (binary) [P] Pre-operative acute renal failure or dialysis, as indicated by either of the following: A code in the range 584.5 – 584.9 and chart review to determine that the renal failure was present prior to the CABG/valve surgery; or Pre-op dialysis code 39.95 or 54.98 prior to CABG/valve surgery date. Note: dialysis should be prior to the earliest CABG and/or valve procedure. If multiple dialysis procedures occurred, use the earliest date.	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS
Septal Other Anomalous Repair Heart [MQ] Repair of a septal defect in heart, as indicated by any of the following codes in the MediQual data (iv code: 6631): 35.41, 35.42, 35.50, 35.51, 35.52, 35.53, 35.54, 35.55, 35.60, 35.61, 35.62, 35.63, 35.70, 35.71, 35.72, 35.73, 35.81, 35.82, 35.83, 35.84, 35.91, 35.92, 35.93, 35.94, 35.95, 35.98.	In-Hospital M E Operative M E 7-Day R 30-Day R PS-LOS	In-Hospital M E Operative M E 7-Day R 30-Day R PS-LOS

[P] This variable was based on PHC4 data.

[MQ] This variable was based on data obtained from MediQual.

[C] This variable was based on both MediQual and PHC4 data.

✓ = variable included in final model
E or T = variable was entered/tested in the model and not retained

___ = variable not entered or tested in the model.

APPENDIX E: DEFINITIONS FOR POTENTIAL CANDIDATE VARIABLES *continued*

Variable Definitions	2006-2007 Models	2007 Models
SIRS Group [MQ] This variable (iv code 6429 in MediQual data) was based on the presence of any two of four criteria that define SIRS (Systemic Inflammatory Response Syndrome): Temperature > 38°C (> 100.4°F) or < 36°C (< 96.8°F) Heart rate > 89 beats/minute Respiration rate > 19/minute or $PaCO_2$ < 32 mmHg White blood cell count > 12.0 K/µl or < 4.0 K/µl or > 10% bands	In-Hospital M __✓__ Operative M __✓__ 7-Day R ____ 30-Day R ____ PS-LOS ____	In-Hospital M __✓__ Operative M __✓__ 7-Day R ____ 30-Day R ____ PS-LOS ____
Valve Replacement [P] Any of the following codes in any position in PHC4 data: 35.20, 35.21, 35.22, 35.23, 35.24, 35.25, 35.26, 35.27, 35.28 Note: This variable was not tested in the models due to its interaction with "multiple valve" and "procedure group" variables.	In-Hospital M ____ Operative M ____ 7-Day R ____ 30-Day R ____ PS-LOS ____	In-Hospital M ____ Operative M ____ 7-Day R ____ 30-Day R ____ PS-LOS ____
Ventricular Assist Device (LVAD and PVAD) Prior to CABG/Valve Surgery Date [P] Code 37.66 or 37.68 in any position in the PHC4 data (prior to the date of CABG/valve surgery). Note: Use the earliest VAD date for analysis.	In-Hospital M ____ Operative M ____ 7-Day R ____ 30-Day R ____ PS-LOS ____	In-Hospital M ____ Operative M ____ 7-Day R ____ 30-Day R ____ PS-LOS ____

[P] This variable was based on PHC4 data.

[MQ] This variable was based on data obtained from MediQual.

[C] This variable was based on both MediQual and PHC4 data.

__✓__ = variable included in final model
__E__ or __I__ = variable was entered/tested in the model and not retained

____ = variable not entered or tested in the model.

APPENDIX F: CANDIDATE VARIABLE DATA

2006-2007 Mortality Models: Candidate Variable Frequency

Candidate Variable	In-Hospital				Operative			
	Cases in Analysis		Mortality		Cases in Analysis		Mortality	
	#	%	#	%	#	%	#	%
Demographic Variables								
Age in Years [P] (tested as a continous variable)								
Age: 30 - 39	340	1.1	0	0.0	298	1.0	0	0.0
Age: 40 - 49	1,994	6.2	30	1.5	1,791	6.1	34	1.9
Age: 50 - 59	5,951	18.4	65	1.1	5,365	18.4	81	1.5
Age: 60 - 69	9,241	28.6	181	2.0	8,337	28.6	201	2.4
Age: 70 - 79	10,383	32.2	334	3.2	9,371	32.2	367	3.9
Age: 80 - 89	4,319	13.4	227	5.3	3,913	13.4	261	6.7
Age: 90 - 99	60	0.2	13	21.7	53	0.2	14	26.4
	Avg. Age = 67.1 (Female 69.4; Male 66.0)							
Age # of Years > 65 [P] (tested as a continous variable)								
0	13,702	42.4	188	1.4	12,340	42.4	216	1.8
1	958	3.0	17	1.8	871	3.0	21	2.4
2	972	3.0	22	2.3	873	3.0	26	3.0
3	956	3.0	32	3.3	868	3.0	32	3.7
4	938	2.9	17	1.8	839	2.9	21	2.5
5	941	2.9	21	2.2	829	2.8	23	2.8
6	958	3.0	28	2.9	854	2.9	29	3.4
7	1,007	3.1	29	2.9	910	3.1	33	3.6
8	993	3.1	23	2.3	893	3.1	23	2.6
9	1,074	3.3	31	2.9	974	3.3	35	3.6
10	1,128	3.5	40	3.5	1,038	3.6	47	4.5
11	1,140	3.5	40	3.5	1,019	3.5	44	4.3
12	1,071	3.3	41	3.8	967	3.3	44	4.6
13	1,041	3.2	37	3.6	960	3.3	42	4.4
14	1,030	3.2	44	4.3	927	3.2	47	5.1
15	818	2.5	31	3.8	747	2.6	37	5.0
16	833	2.6	35	4.2	745	2.6	36	4.8
17	726	2.2	38	5.2	660	2.3	43	6.5
18	593	1.8	35	5.9	543	1.9	44	8.1
19	505	1.6	29	5.7	458	1.6	33	7.2
20	332	1.0	28	8.4	295	1.0	32	10.8
21	224	0.7	14	6.3	210	0.7	18	8.6
22	138	0.4	8	5.8	124	0.4	9	7.3
23	78	0.2	5	6.4	70	0.2	6	8.6
24	72	0.2	4	5.6	61	0.2	3	4.9
25	24	0.1	3	12.5	22	0.1	3	13.6
26	21	0.1	6	28.6	18	0.1	7	38.9
27	10	< 0.1	2	20.0	8	< 0.1	2	25.0
28	3	< 0.1	2	66.7	3	< 0.1	2	66.7
29	2	< 0.1	0	0.0	2	< 0.1	0	0.0
Female [P]								
Male	21,745	67.3	452	2.1	19,575	67.2	509	2.6
Female	10,543	32.7	398	3.8	9,553	32.8	449	4.7
Race (category) [P]								
Black	1,366	4.2	41	3.0	1,250	4.3	55	4.4
Other/Unknown	1,973	6.1	75	3.8	1,580	5.4	63	4.0
White	28,949	89.7	734	2.5	26,298	90.3	840	3.2
Laboratory Variables								
Albumin < 2.5 g/dL [MQ]								
no	32,111	99.5	833	2.6	28,970	99.5	941	3.2
yes	177	0.5	17	9.6	158	0.5	17	10.8
Albumin 2.5 - 3 g/dL [MQ]								
no	31,292	96.9	791	2.5	28,218	96.9	888	3.1
yes	996	3.1	59	5.9	910	3.1	70	7.7

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006-2007 Mortality Models: Candidate Variable Frequency

Candidate Variable	In-Hospital				Operative			
	Cases in Analysis		Mortality		Cases in Analysis		Mortality	
	#	%	#	%	#	%	#	%
BUN > 40 mg/dL [MQ]								
no	31,254	96.8	747	2.4	28,225	96.9	855	3.0
yes	1,034	3.2	103	10.0	903	3.1	103	11.4
Creatinine > 1.4 mg/dL [MQ]								
no	28,830	89.3	637	2.2	26,042	89.4	727	2.8
yes	3,458	10.7	213	6.2	3,086	10.6	231	7.5
Glucose > 165 mg/dL [MQ]								
no	25,270	78.3	585	2.3	22,721	78.0	666	2.9
yes	7,018	21.7	265	3.8	6,407	22.0	292	4.6
Clinical Variables Other Than Laboratory Variables								
AMI Except Other Anterior or Other Inferior Wall [P]								
no	27,795	86.1	653	2.3	25,045	86.0	728	2.9
yes	4,493	13.9	197	4.4	4,083	14.0	230	5.6
AMI Other Inferior Wall Initial Episode [C]								
no	31,533	97.7	804	2.5	28,438	97.6	911	3.2
yes	755	2.3	46	6.1	690	2.4	47	6.8
ASA Class 5 [MQ]								
no	32,110	99.4	815	2.5	28,977	99.5	919	3.2
yes	178	0.6	35	19.7	151	0.5	39	25.8
ASA Emergency [MQ]								
no	30,261	93.7	727	2.4	27,289	93.7	817	3.0
yes	2,027	6.3	123	6.1	1,839	6.3	141	7.7
Cachexia [P]								
no	31,571	97.8	776	2.5	28,526	97.9	872	3.1
yes	717	2.2	74	10.3	602	2.1	86	14.3
CAD >70, 5-7 Vessels Group [MQ]								
no	31,033	96.1	815	2.6	27,998	96.1	918	3.3
yes	1,255	3.9	35	2.8	1,130	3.9	40	3.5
Cardiac Adhesions [P]								
no	31,959	99.0	833	2.6	28,826	99.0	943	3.3
yes	329	1.0	17	5.2	302	1.0	15	5.0
Cardiogenic Shock, Pre-Operative [P]								
no	32,068	99.3	787	2.5	28,930	99.3	891	3.1
yes	220	0.7	63	28.6	198	0.7	67	33.8
Cardiomyopathy [P]								
no	27,988	86.7	705	2.5	25,292	86.8	795	3.1
yes	4,300	13.3	145	3.4	3,836	13.2	163	4.2
Cerebrovascular Disease [P]								
no	30,505	94.5	810	2.7	27,495	94.4	912	3.3
yes	1,783	5.5	40	2.2	1,633	5.6	46	2.8
Chronic Lung Disease [P]								
no	25,581	79.2	640	2.5	23,000	79.0	724	3.1
yes	6,707	20.8	210	3.1	6,128	21.0	234	3.8
Chronic Pulmonary Hypertension [P]								
no	29,577	91.6	729	2.5	26,729	91.8	817	3.1
yes	2,711	8.4	121	4.5	2,399	8.2	141	5.9
Current Med Immunosuppressive [MQ]								
no	31,237	96.7	814	2.6	28,190	96.8	917	3.3
yes	1,051	3.3	36	3.4	938	3.2	41	4.4
Current Med Insulin [MQ]								
no	29,158	90.3	727	2.5	26,284	90.2	819	3.1
yes	3,130	9.7	123	3.9	2,844	9.8	139	4.9

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006-2007 Mortality Models: Candidate Variable Frequency

Candidate Variable	In-Hospital				Operative			
	Cases in Analysis		Mortality		Cases in Analysis		Mortality	
	#	%	#	%	#	%	#	%
Ejection Fraction [MQ]								
EF ≤ 25%	1,114	3.5	75	6.7	971	3.3	85	8.8
25% < EF <=45% or missing	14,704	45.5	478	3.3	13,243	45.5	539	4.1
EF > 45%	16,470	51.0	297	1.8	14,914	51.2	334	2.2
Fibrosis in Mediastinum and Heart [P]								
no	31,935	98.9	833	2.6	28,804	98.9	943	3.3
yes	353	1.1	17	4.8	324	1.1	15	4.6
Heart Failure [C]								
no	21,647	67.0	287	1.3	19,767	67.9	353	1.8
yes	10,641	33.0	563	5.3	9,361	32.1	605	6.5
History of CABG or Valve Surgery [C]								
no	29,768	92.2	694	2.3	26,860	92.2	801	3.0
yes	2,520	7.8	156	6.2	2,268	7.8	157	6.9
History of Peripheral Vascular Disease [C]								
no	26,258	81.3	630	2.4	23,647	81.2	700	3.0
yes	6,030	18.7	220	3.6	5,481	18.8	258	4.7
Hypertension with Complications [P]								
no	28,632	88.7	662	2.3	25,841	88.7	749	2.9
yes	3,656	11.3	188	5.1	3,287	11.3	209	6.4
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery [P]								
no	30,875	95.6	769	2.5	27,834	95.6	876	3.1
yes	1,413	4.4	81	5.7	1,294	4.4	82	6.3
Liver Disease [P]								
no	32,034	99.2	824	2.6	28,915	99.3	932	3.2
yes	254	0.8	26	10.2	213	0.7	26	12.2
Lupus Erythematosus, Systemic [P]								
no	32,197	99.7	842	2.6	29,045	99.7	949	3.3
yes	91	0.3	8	8.8	83	0.3	9	10.8
MI/AMI Other Anterior Wall [C]								
no	31,693	98.2	819	2.6	28,596	98.2	925	3.2
yes	595	1.8	31	5.2	532	1.8	33	6.2
Mild, Moderate or Severe Altered Mental Status [MQ]								
no	31,154	96.5	769	2.5	28,091	96.4	872	3.1
yes	1,134	3.5	81	7.1	1,037	3.6	86	8.3
Multiple Valve Procedures [P]								
no	30,657	94.9	714	2.3	27,688	95.1	825	3.0
yes	1,631	5.1	136	8.3	1,440	4.9	133	9.2
Other CV Procedure Group [C]								
no	29,664	91.9	715	2.4	26,787	92.0	823	3.1
yes	2,624	8.1	135	5.1	2,341	8.0	135	5.8
Procedure Group [P]								
CABG without Valve	21,188	65.6	373	1.8	19,406	66.6	459	2.4
Valve without CABG	5,975	18.5	195	3.3	5,189	17.8	203	3.9
Valve with CABG	5,125	15.9	282	5.5	4,533	15.6	296	6.5
PTCA/Stent/Tear Same Day as CABG/ Valve Surgery [C]								
no	31,903	98.8	818	2.6	28,770	98.8	922	3.2
yes	385	1.2	32	8.3	358	1.2	36	10.1
Renal Failure/Dialysis (category) [P]								
All cases not assigned to chronic and acute/dialysis categories	31,157	96.5	765	2.5	28,144	96.6	867	3.1
Chronic	778	2.4	48	6.2	671	2.3	52	7.7
Acute/dialysis	353	1.1	37	10.5	313	1.1	39	12.5

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006-2007 Mortality Models: Candidate Variable Frequency

Candidate Variable	In-Hospital				Operative			
	Cases in Analysis		Mortality		Cases in Analysis		Mortality	
	#	%	#	%	#	%	#	%
Septal Other Anomalous Repair Heart [MQ]								
no	31,883	98.7	839	2.6	28,785	98.8	945	3.3
yes	405	1.3	11	2.7	343	1.2	13	3.8
SIRS Group [MQ]								
no	21,822	67.6	473	2.2	19,552	67.1	533	2.7
yes	10,466	32.4	377	3.6	9,576	32.9	425	4.4

2007 Mortality Models: Candidate Variable Frequency

Candidate Variable	In-Hospital				Operative			
	Cases in Analysis		Mortality		Cases in Analysis		Mortality	
	#	%	#	%	#	%	#	%
Demographic Variables								
Age in Years [P] (tested as a continous variable)								
Age: 30 – 39	178	1.1	0	0.0	158	1.1	0	0.0
Age: 40 – 49	966	6.2	10	1.0	873	6.2	13	1.5
Age: 50 – 59	2,875	18.4	29	1.0	2,588	18.3	33	1.3
Age: 60 – 69	4,549	29.1	79	1.7	4,105	29.1	90	2.2
Age: 70 – 79	4,922	31.4	160	3.3	4,436	31.4	179	4.0
Age: 80 – 89	2,136	13.6	108	5.1	1,918	13.6	125	6.5
Age: 90 – 99	29	0.2	7	24.1	27	0.2	8	29.6
	Avg. Age = 67.1 (Female 69.5; Male 65.9)							
Age # of Years > 65 [P] (tested as a continous variable)								
0	6,742	43.1	80	1.2	6,073	43.1	90	1.5
1	490	3.1	11	2.2	446	3.2	14	3.1
2	459	2.9	9	2.0	409	2.9	11	2.7
3	437	2.8	12	2.7	395	2.8	12	3.0
4	440	2.8	6	1.4	401	2.8	9	2.2
5	426	2.7	8	1.9	383	2.7	9	2.3
6	436	2.8	10	2.3	396	2.8	10	2.5
7	481	3.1	16	3.3	435	3.1	18	4.1
8	463	3.0	9	1.9	417	3.0	9	2.2
9	518	3.3	17	3.3	465	3.3	20	4.3
10	536	3.4	20	3.7	489	3.5	23	4.7
11	547	3.5	20	3.7	479	3.4	21	4.4
12	516	3.3	20	3.9	468	3.3	22	4.7
13	478	3.1	15	3.1	438	3.1	18	4.1
14	521	3.3	25	4.8	466	3.3	29	6.2
15	406	2.6	12	3.0	368	2.6	17	4.6
16	407	2.6	16	3.9	357	2.5	15	4.2
17	364	2.3	24	6.6	327	2.3	25	7.6
18	287	1.8	18	6.3	259	1.8	22	8.5
19	242	1.5	13	5.4	215	1.5	13	6.0
20	153	1.0	13	8.5	139	1.0	19	13.7
21	121	0.8	7	5.8	112	0.8	8	7.1
22	78	0.5	2	2.6	73	0.5	2	2.7
23	39	0.2	1	2.6	34	0.2	2	5.9
24	39	0.2	2	5.1	34	0.2	2	5.9
25	11	0.1	1	9.1	11	0.1	2	18.2
26	10	0.1	3	30.0	8	0.1	3	37.5
27	3	< 0.1	1	33.3	3	< 0.1	1	33.3
28	3	< 0.1	2	66.7	3	< 0.1	2	66.7
29	2	< 0.1	0	0.0	2	< 0.1	0	0.0

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2007 Mortality Models: Candidate Variable Frequency

Candidate Variable	In-Hospital				Operative			
	Cases in Analysis		Mortality		Cases in Analysis		Mortality	
	#	%	#	%	#	%	#	%
Female [P]								
Male	10,516	67.2	205	1.9	9,487	67.3	231	2.4
Female	5,139	32.8	188	3.7	4,618	32.7	217	4.7
Laboratory Variables								
Albumin < 2.5 g/dL [MQ]								
no	15,570	99.5	385	2.5	14,027	99.4	439	3.1
yes	85	0.5	8	9.4	78	0.6	9	11.5
Albumin 2.5 - 3 g/dL [MQ]								
no	15,129	96.6	361	2.4	13,629	96.6	413	3.0
yes	526	3.4	32	6.1	476	3.4	35	7.4
BUN > 40 mg/dL [MQ]								
no	15,194	97.1	354	2.3	13,711	97.2	410	3.0
yes	461	2.9	39	8.5	394	2.8	38	9.6
Creatinine > 1.4 mg/dL [MQ]								
no	13,968	89.2	295	2.1	12,604	89.4	343	2.7
yes	1,687	10.8	98	5.8	1,501	10.6	105	7.0
Glucose > 165 mg/dL [MQ]								
no	12,174	77.8	286	2.3	10,939	77.6	324	3.0
yes	3,481	22.2	107	3.1	3,166	22.4	124	3.9
Clinical Variables Other Than Laboratory Variables								
AMI Except Other Anterior or Other Inferior Wall [P]								
no	13,485	86.1	305	2.3	12,132	86.0	342	2.8
yes	2,170	13.9	88	4.1	1,973	14.0	106	5.4
AMI Other Inferior Wall Initial Episode [C]								
no	15,311	97.8	372	2.4	13,794	97.8	429	3.1
yes	344	2.2	21	6.1	311	2.2	19	6.1
ASA Class 5 [MQ]								
no	15,577	99.5	381	2.4	14,037	99.5	431	3.1
yes	78	0.5	12	15.4	68	0.5	17	25.0
ASA Emergency [MQ]								
no	14,623	93.4	344	2.4	13,173	93.4	385	2.9
yes	1,032	6.6	49	4.7	932	6.6	63	6.8
Cachexia [P]								
no	15,225	97.3	357	2.3	13,749	97.5	404	2.9
yes	430	2.7	36	8.4	356	2.5	44	12.4
CAD >70, 5-7 Vessels Group [MQ]								
no	15,074	96.3	379	2.5	13,583	96.3	430	3.2
yes	581	3.7	14	2.4	522	3.7	18	3.4
Cardiac Adhesions [P]								
no	15,490	98.9	383	2.5	13,952	98.9	439	3.1
yes	165	1.1	10	6.1	153	1.1	9	5.9
Cardiogenic Shock, Pre-Operative [P]								
no	15,555	99.4	370	2.4	14,015	99.4	422	3.0
yes	100	0.6	23	23.0	90	0.6	26	28.9
Cardiomyopathy [P]								
no	13,432	85.8	322	2.4	12,135	86.0	362	3.0
yes	2,223	14.2	71	3.2	1,970	14.0	86	4.4
Chronic Lung Disease [P]								
no	12,361	79.0	285	2.3	11,095	78.7	326	2.9
yes	3,294	21.0	108	3.3	3,010	21.3	122	4.1
Chronic Pulmonary Hypertension [P]								
no	14,184	90.6	335	2.4	12,798	90.7	376	2.9
yes	1,471	9.4	58	3.9	1,307	9.3	72	5.5

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2007 Mortality Models: Candidate Variable Frequency

Candidate Variable	In-Hospital				Operative			
	Cases in Analysis		Mortality		Cases in Analysis		Mortality	
	#	%	#	%	#	%	#	%
Current Med Immunosuppressive [MQ]								
no	15,129	96.6	375	2.5	13,635	96.7	426	3.1
yes	526	3.4	18	3.4	470	3.3	22	4.7
Current Med Insulin [MQ]								
no	14,103	90.1	341	2.4	12,696	90.0	387	3.0
yes	1,552	9.9	52	3.4	1,409	10.0	61	4.3
Ejection Fraction [MQ]								
EF ≤ 25%	585	3.7	30	5.1	513	3.6	36	7.0
25% < EF <=45% or missing	6,908	44.1	210	3.0	6,228	44.2	241	3.9
EF > 45%	8,162	52.1	153	1.9	7,364	52.2	171	2.3
Heart Failure [C]								
no	10,476	66.9	135	1.3	9,551	67.7	159	1.7
yes	5,179	33.1	258	5.0	4,554	32.3	289	6.3
History of CABG or Valve Surgery [C]								
no	14,436	92.2	320	2.2	13,020	92.3	374	2.9
yes	1,219	7.8	73	6.0	1,085	7.7	74	6.8
History of Peripheral Vascular Disease[C]								
no	12,728	81.3	280	2.2	11,446	81.1	315	2.8
yes	2,927	18.7	113	3.9	2,659	18.9	133	5.0
Hypertension with Complications [P]								
no	13,781	88.0	311	2.3	12,422	88.1	358	2.9
yes	1,874	12.0	82	4.4	1,683	11.9	90	5.3
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery [P]								
no	14,939	95.4	353	2.4	13,452	95.4	408	3.0
yes	716	4.6	40	5.6	653	4.6	40	6.1
Liver Disease [P]								
no	15,518	99.1	382	2.5	13,989	99.2	435	3.1
yes	137	0.9	11	8.0	116	0.8	13	11.2
Lupus Erythematosus, Systemic [P]								
no	15,610	99.7	389	2.5	14,064	99.7	443	3.1
yes	45	0.3	4	8.9	41	0.3	5	12.2
MI/AMI Other Anterior Wall [C]								
no	15,373	98.2	382	2.5	13,851	98.2	436	3.1
yes	282	1.8	11	3.9	254	1.8	12	4.7
Mild, Moderate or Severe Altered Mental Status [MQ]								
no	15,082	96.3	361	2.4	13,578	96.3	415	3.1
yes	573	3.7	32	5.6	527	3.7	33	6.3
Multiple Valve Procedures [P]								
no	14,853	94.9	327	2.2	13,393	95.0	382	2.9
yes	802	5.1	66	8.2	712	5.0	66	9.3
Other CV Procedure Group [C]								
no	14,405	92.0	325	2.3	12,970	92.0	374	2.9
yes	1,250	8.0	68	5.4	1,135	8.0	74	6.5
Procedure Group [P]								
CABG without Valve	10,166	64.9	178	1.8	9,311	66.0	220	2.4
Valve without CABG	2,975	19.0	95	3.2	2,574	18.2	97	3.8
Valve with CABG	2,514	16.1	120	4.8	2,220	15.7	131	5.9
PTCA/Stent/Tear Same Day as CABG/Valve Surgery [C]								
no	15,476	98.9	379	2.4	13,945	98.9	432	3.1
yes	179	1.1	14	7.8	160	1.1	16	10.0

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2007 Mortality Models: Candidate Variable Frequency

Candidate Variable	In-Hospital				Operative			
	Cases in Analysis		Mortality		Cases in Analysis		Mortality	
	#	%	#	%	#	%	#	%
Renal Failure/Dialysis (category) [P]								
All cases not assigned to chronic and acute/dialysis categories	15,117	96.6	358	2.4	13,640	96.7	408	3.0
Chronic	376	2.4	22	5.9	322	2.3	25	7.8
Acute/dialysis	162	1.0	13	8.0	143	1.0	15	10.5
Septal Other Anomalous Repair Heart [MQ]								
no	15,454	98.7	387	2.5	13,930	98.8	442	3.2
yes	201	1.3	6	3.0	175	1.2	6	3.4
SIRS Group [MQ]								
no	10,557	67.4	217	2.1	9,448	67.0	247	2.6
yes	5,098	32.6	176	3.5	4,657	33.0	201	4.3

2006-2007 Readmissions Models: Candidate Variable Frequency

Candidate Variable	Cases in Analysis		7-Day Readmissions		30-Day Readmissions	
	#	%	#	%	#	%
Year [P]						
2006	14,613	51.5	883	6.0	2,108	14.4
2007	13,753	48.5	914	6.6	2,212	16.1
Demographic Variables						
Age in Years [P] (tested as a continous variable)						
Age: 30 - 39	298	1.1	19	6.4	53	17.8
Age: 40 - 49	1,763	6.2	81	4.6	228	12.9
Age: 50 - 59	5,304	18.7	245	4.6	627	11.8
Age: 60 - 69	8,181	28.8	494	6.0	1,140	13.9
Age: 70 - 79	9,073	32.0	645	7.1	1,547	17.1
Age: 80 - 89	3,706	13.1	307	8.3	717	19.3
Age: 90 - 99	41	0.1	6	14.6	8	19.5
Age # of Years > 65 [P] (tested as a continous variable)						
0	12,173	42.9	624	5.1	1,574	12.9
1	855	3.0	53	6.2	114	13.3
2	853	3.0	50	5.9	110	12.9
3	840	3.0	49	5.8	128	15.2
4	825	2.9	63	7.6	122	14.8
5	811	2.9	51	6.3	109	13.4
6	831	2.9	58	7.0	143	17.2
7	882	3.1	64	7.3	140	15.9
8	875	3.1	62	7.1	146	16.7
9	944	3.3	66	7.0	172	18.2
10	1,003	3.5	69	6.9	174	17.3
11	983	3.5	70	7.1	168	17.1
12	931	3.3	61	6.6	163	17.5
13	925	3.3	81	8.8	177	19.1
14	888	3.1	63	7.1	155	17.5
15	718	2.5	52	7.2	133	18.5
16	716	2.5	61	8.5	138	19.3
17	626	2.2	59	9.4	120	19.2
18	509	1.8	45	8.8	111	21.8
19	430	1.5	33	7.7	70	16.3
20	271	1.0	19	7.0	55	20.3
21	196	0.7	22	11.2	52	26.5
22	117	0.4	6	5.1	16	13.7

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006-2007 Readmissions Models: Candidate Variable Frequency

Candidate Variable	Cases in Analysis		7-Day Readmissions		30-Day Readmissions	
	#	%	#	%	#	%
23	65	0.2	5	7.7	13	20.0
24	58	0.2	5	8.6	9	15.5
25	20	0.1	4	20.0	4	20.0
26	12	< 0.1	1	8.3	3	25.0
27	6	< 0.1	1	16.7	1	16.7
28	1	< 0.1	0	0.0	0	0.0
29	2	< 0.1	0	0.0	0	0.0
Female [P]						
Male	19,171	67.6	1,110	5.8	2,616	13.6
Female	9,195	32.4	687	7.5	1,704	18.5
Race (category) [P]						
Black	1,211	4.3	103	8.5	250	20.6
Other/Unknown	1,519	5.4	95	6.3	233	15.3
White	25,636	90.4	1,599	6.2	3,837	15.0
Clinical Variables Other Than Laboratory Variables						
Anemia [P]						
no	22,593	79.6	1,390	6.2	3,335	14.8
yes	5,773	20.4	407	7.1	985	17.1
Cachexia [P]						
no	27,829	98.1	1,748	6.3	4,191	15.1
yes	537	1.9	49	9.1	129	24.0
Cancer [P]						
no	27,675	97.6	1,737	6.3	4,188	15.1
yes	691	2.4	60	8.7	132	19.1
Cardiac Adhesions [P]						
no	28,079	99.0	1,763	6.3	4,255	15.2
yes	287	1.0	34	11.8	65	22.6
Cardiogenic Shock, Pre-Operative [P]						
no	28,225	99.5	1,789	6.3	4,292	15.2
yes	141	0.5	8	5.7	28	19.9
Cardiomyopathy [P]						
no	24,659	86.9	1,539	6.2	3,646	14.8
yes	3,707	13.1	258	7.0	674	18.2
Cerebrovascular Disease [P]						
no	26,769	94.4	1,680	6.3	4,025	15.0
yes	1,597	5.6	117	7.3	295	18.5
Chronic Lung Disease [P]						
no	22,430	79.1	1,351	6.0	3,220	14.4
yes	5,936	20.9	446	7.5	1,100	18.5
Chronic Pulmonary Hypertension [P]						
no	26,081	91.9	1,611	6.2	3,832	14.7
yes	2,285	8.1	186	8.1	488	21.4
Depression [P]						
no	26,738	94.3	1,683	6.3	4,031	15.1
yes	1,628	5.7	114	7.0	289	17.8
Diabetes (category) [P]						
No diabetes	18,189	64.1	1,063	5.8	2,549	14.0
Diabetes without complication	8,220	29.0	566	6.9	1,356	16.5
Diabetes with complications	1,957	6.9	168	8.6	415	21.2
Excision or Other Lesion/Heart Tissue, Open Approach – Same Date as Valve Surgery [P]						
no	27,296	96.2	1,718	6.3	4,110	15.1
yes	1,070	3.8	79	7.4	210	19.6

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006-2007 Readmissions Models: Candidate Variable Frequency

Candidate Variable	Cases in Analysis		7-Day Readmissions		30-Day Readmissions	
	#	%	#	%	#	%
Fibrosis in Mediastinum and Heart [P]						
no	28,057	98.9	1,761	6.3	4,251	15.2
yes	309	1.1	36	11.7	69	22.3
Heart Failure [P]						
no	21,102	74.4	1,164	5.5	2,765	13.1
yes	7,264	25.6	632	8.7	1,555	21.4
History of CABG or Valve Surgery [P]						
no	26,828	94.6	1,676	6.2	4,027	15.0
yes	1,538	5.4	121	7.9	293	19.1
History of PTCA/Stent [P]						
no	25,265	89.1	1,579	6.2	3,807	15.1
yes	3,101	10.9	218	7.0	513	16.5
History of Chronic Steroid Use [P]						
no	28,254	99.6	1,791	6.3	4,293	15.2
yes	112	0.4	6	5.4	27	24.1
History of Peripheral Vascular Disease [P]						
no	24,214	85.4	1,487	6.1	3,582	14.8
yes	4,152	14.6	310	7.5	738	17.8
Hypertension with Complications [P]						
no	25,251	89.0	1,513	6.0	3,649	14.5
yes	3,115	11.0	284	9.1	671	21.5
Liver Disease [P]						
no	28,177	99.3	1,780	6.3	4,276	15.2
yes	189	0.7	17	9.0	44	23.3
Lupus Erythematosus, Systemic [P]						
no	28,290	99.7	1,792	6.3	4,299	15.2
yes	76	0.3	5	6.6	21	27.6
MediQual Predicted LOS [MQ, 1] (tested as a continous variable)						
0	628	2.2	20	3.2	53	8.4
1	3,923	13.8	167	4.3	407	10.4
2	19,508	68.8	1,221	6.3	2,910	14.9
3	3,728	13.1	337	9.0	791	21.2
4	579	2.0	52	9.0	159	27.5
Multiple Valve Procedures [P]						
no	27,046	95.3	1,687	6.2	4,013	14.8
yes	1,320	4.7	110	8.3	307	23.3
Obesity, Morbid [P]						
no	27,040	95.3	1,689	6.2	4,046	15.0
yes	1,326	4.7	108	8.1	274	20.7
Other CV Procedure Group [C]						
no	26,145	92.2	1,624	6.2	3,897	14.9
yes	2,221	7.8	173	7.8	423	19.0
Procedure Group [P]						
CABG without Valve	19,063	67.2	1,059	5.6	2,565	13.5
Valve without CABG	5,019	17.7	379	7.6	928	18.5
Valve with CABG	4,284	15.1	359	8.4	827	19.3
Renal Failure/Dialysis (category) [P]						
All cases not assigned to chronic and acute/dialysis categories	27,457	96.8	1,719	6.3	4,111	15.0
Chronic	630	2.2	52	8.3	130	20.6
Acute/dialysis	279	1.0	26	9.3	79	28.3

[1] The ranges (number of days) for the predicted length of stay categories were calculated for each combination of procedure group and calendar year.

[P] This variable was based on PHC4 data.

[MQ] This variable was based on data obtained from MediQual.

[C] This variable was based on both MediQual and PHC4 data.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2007 Readmissions Models: Candidate Variable Frequency

Candidate Variable	Cases in Analysis		7-Day Readmissions		30-Day Readmissions	
	#	%	#	%	#	%
Demographic Variables						
Age in Years [P] (tested as a continous variable)						
Age: 30 - 39	158	1.1	5	3.2	26	16.5
Age: 40 - 49	863	6.3	36	4.2	114	13.2
Age: 50 - 59	2,563	18.6	115	4.5	314	12.3
Age: 60 - 69	4,037	29.4	259	6.4	596	14.8
Age: 70 - 79	4,292	31.2	312	7.3	766	17.8
Age: 80 - 89	1,820	13.2	183	10.1	391	21.5
Age: 90 - 99	20	0.1	4	20.0	5	25.0
Age # of Years > 65 [P] (tested as a continous variable)						
0	6,006	43.7	313	5.2	820	13.7
1	435	3.2	29	6.7	59	13.6
2	401	2.9	21	5.2	52	13.0
3	384	2.8	26	6.8	62	16.1
4	395	2.9	26	6.6	57	14.4
5	375	2.7	26	6.9	59	15.7
6	389	2.8	28	7.2	71	18.3
7	419	3.0	28	6.7	70	16.7
8	410	3.0	29	7.1	68	16.6
9	449	3.3	33	7.3	81	18.0
10	472	3.4	33	7.0	83	17.6
11	463	3.4	35	7.6	86	18.6
12	450	3.3	31	6.9	88	19.6
13	423	3.1	40	9.5	79	18.7
14	442	3.2	29	6.6	81	18.3
15	357	2.6	29	8.1	74	20.7
16	344	2.5	38	11.0	67	19.5
17	307	2.2	32	10.4	61	19.9
18	241	1.8	25	10.4	57	23.7
19	203	1.5	19	9.4	40	19.7
20	127	0.9	15	11.8	33	26.0
21	105	0.8	16	15.2	34	32.4
22	71	0.5	4	5.6	12	16.9
23	33	0.2	3	9.1	8	24.2
24	32	0.2	2	6.3	5	15.6
25	10	0.1	4	40.0	4	40.0
26	5	< 0.1	0	0.0	1	20.0
27	2	< 0.1	0	0.0	0	0.0
28	1	< 0.1	0	0.0	0	0.0
29	2	< 0.1	0	0.0	0	0.0
Female [P]						
Male	9,306	67.7	541	5.8	1,305	14.0
Female	4,447	32.3	373	8.4	907	20.4
Race [P]						
Black	612	4.4	61	10.0	141	23.0
Other/Unknown	724	5.3	40	5.5	116	16.0
White	12,417	90.3	813	6.5	1,955	15.7
Clinical Variables Other Than Laboratory Variables						
Anemia [P]						
no	10,576	76.9	666	6.3	1,626	15.4
yes	3,177	23.1	248	7.8	586	18.4
Cachexia [P]						
no	13,428	97.6	876	6.5	2,123	15.8
yes	325	2.4	38	11.7	89	27.4

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2007 Readmissions Models: Candidate Variable Frequency

Candidate Variable			Cases in Analysis		7-Day Readmissions		30-Day Readmissions	
			#	%	#	%	#	%
Cancer [P]								
no			13,401	97.4	878	6.6	2,142	16.0
yes			352	2.6	36	10.2	70	19.9
Cardiomyopathy [P]								
no			11,846	86.1	758	6.4	1,822	15.4
yes			1,907	13.9	156	8.2	390	20.5
Cerebrovascular Disease [P]								
no			12,963	94.3	852	6.6	2,063	15.9
yes			790	5.7	62	7.8	149	18.9
Chronic Lung Disease [P]								
no			10,842	78.8	684	6.3	1,630	15.0
yes			2,911	21.2	230	7.9	582	20.0
Chronic Pulmonary Hypertension [P]								
no			12,502	90.9	805	6.4	1,912	15.3
yes			1,251	9.1	109	8.7	300	24.0
Diabetes (category) [P]								
No diabetes			8,622	62.7	519	6.0	1,279	14.8
Diabetes without complication			4,174	30.3	299	7.2	716	17.2
Diabetes with complications			957	7.0	96	10.0	217	22.7
Heart Failure [P]								
no			10,218	74.3	575	5.6	1,408	13.8
yes			3,535	25.7	339	9.6	804	22.7
History of CABG or Valve Surgery [P]								
no			13,005	94.6	849	6.5	2,062	15.9
yes			748	5.4	65	8.7	150	20.1
History of Peripheral Vascular Disease [P]								
no			11,687	85.0	752	6.4	1,818	15.6
yes			2,066	15.0	162	7.8	394	19.1
Hypertension with Complications [P]								
no			12,145	88.3	758	6.2	1,841	15.2
yes			1,608	11.7	156	9.7	371	23.1
Liver Disease [P]								
no			13,648	99.2	904	6.6	2,186	16.0
yes			105	0.8	10	9.5	26	24.8
Lupus Erythematosus, Systemic [P]								
no			13,715	99.7	912	6.6	2,201	16.0
yes			38	0.3	2	5.3	11	28.9
MediQual Predicted LOS [MQ, 1]								
CABG w/o Valve	Valve w/o CABG	Valve w/CABG						
< 5.421 days	< 6.733 days	< 8.406 days	296	2.2	7	2.4	21	7.1
5.421 – 6.634	6.733 – 8.436	8.406 – 9.951	1,917	13.9	86	4.5	207	10.8
6.635 – 12.015	8.437 – 15.031	9.951 – 16.668	9,448	68.7	614	6.5	1,488	15.7
12.016 – 17,784	15.032 – 21.838	16.669 – 23.043	1,806	13.1	174	9.6	408	22.6
> 17,784	> 21,838	> 23.043	286	2.1	33	11.5	88	30.8
Multiple Valve Procedures [P]			**No test**					
no			13,100	95.3	860	6.6	2,046	15.6
yes			653	4.7	54	8.3	166	25.4
Obesity, Morbid [P]								
no			13,032	94.8	846	6.5	2,044	15.7
yes			721	5.2	68	9.4	168	23.3
Other CV Procedure Group [C]								
no			12,682	92.2	828	6.5	1,995	15.7
yes			1,071	7.8	86	8.0	217	20.3

[1] The ranges (number of days) for the predicted length of stay categories were calculated for each combination of procedure group and calendar year.

[P] This variable was based on PHC4 data.

[MQ] This variable was based on data obtained from MediQual.

[C] This variable was based on both MediQual and PHC4 data.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2007 Readmissions Models: Candidate Variable Frequency

Candidate Variable	Cases in Analysis		7-Day Readmissions		30-Day Readmissions	
	#	%	#	%	#	%
Procedure Group [P]						
CABG without Valve	9,148	66.5	528	5.8	1,279	14.0
Valve without CABG	2,493	18.1	196	7.9	499	20.0
Valve with CABG	2,112	15.4	190	9.0	434	20.5
PTCA/Stent Same Day as CABG/Valve Surgery [P]						
no	13,649	99.2	902	6.6	2,189	16.0
yes	104	0.8	12	11.5	23	22.1
Renal Failure/Dialysis (category) [P]						
All cases not assigned to chronic and acute/dialysis categories	13,320	96.9	870	6.5	2,106	15.8
Chronic	303	2.2	29	9.6	68	22.4
Acute/dialysis	130	0.9	15	11.5	38	29.2

2006-2007 Post-Surgical Length of Stay Model: Candidate Variable Frequency

Candidate Variable	Number of Cases			Arithmetic Avg. Post-Surgical LOS		
	Development Sample	Cross-Validation Sample	Full Data Set	Development Sample	Cross-Validation Sample	Full Data Set
Demographic Variables						
Age in Years [P] (tested as a continous variable)						
Age: 30 - 39	170	166	336	6.2	6.3	6.3
Age: 40 - 49	1,005	949	1,954	6.0	6.1	6.0
Age: 50 - 59	2,883	2,959	5,842	6.3	6.3	6.3
Age: 60 - 69	4,475	4,508	8,983	6.9	6.9	6.9
Age: 70 - 79	5,014	4,922	9,936	8.0	8.1	8.1
Age: 80 - 89	2,002	2,039	4,041	9.2	9.1	9.1
Age: 90 - 99	21	26	47	10.1	11.5	10.9
Age Number of Years > 65 [P] (tested as a continous variable)						
0	6,670	6,739	13,409	6.4	6.4	6.4
1	495	440	935	7.1	7.1	7.1
2	462	480	942	7.4	7.0	7.2
3	462	453	915	7.0	7.4	7.2
4	444	470	914	7.3	7.0	7.2
5	480	431	911	7.2	7.5	7.3
6	476	440	916	7.9	8.0	7.9
7	501	470	971	7.5	7.6	7.6
8	506	454	960	7.8	7.8	7.8
9	490	538	1,028	8.3	7.9	8.1
10	536	540	1,076	8.2	8.1	8.2
11	541	544	1,085	8.2	8.3	8.3
12	520	501	1,021	7.8	8.7	8.3
13	470	521	991	7.8	8.4	8.1
14	494	483	977	9.2	8.9	9.0
15	375	406	781	9.0	8.9	9.0
16	383	409	792	9.2	8.8	9.0
17	339	339	678	9.2	9.4	9.3
18	282	270	552	9.2	9.7	9.4
19	241	227	468	8.9	8.9	8.9
20	146	156	302	9.7	8.8	9.2
21	107	102	209	9.8	8.8	9.3
22	60	66	126	9.4	10.2	9.8
23	39	29	68	8.8	8.2	8.6

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006-2007 Post-Surgical Length of Stay Model: Candidate Variable Frequency

Candidate Variable	Number of Cases			Arithmetic Avg. Post-Surgical LOS		
	Development Sample	Cross-Validation Sample	Full Data Set	Development Sample	Cross-Validation Sample	Full Data Set
24	30	35	65	9.4	9.5	9.4
25	11	10	21	8.1	12.8	10.3
26	7	8	15	13.6	11.6	12.5
27	3	5	8	9.3	7.4	8.1
28	0	1	1	0.0	6.0	6.0
29	0	2	2	0.0	17.5	17.5
Female [P]						
Male	10,502	10,622	21,124	7.0	7.0	7.0
Female	5,068	4,947	10,015	8.2	8.3	8.2
Race [P]						
Black	656	643	1,299	8.7	8.8	8.8
Other/Unknown	969	906	1,875	8.0	7.9	8.0
White	13,945	14,020	27,965	7.3	7.3	7.3
Clinical Variables Other Than Laboratory Variables						
Acute Myocardial Infarction [P]						
no	12,894	12,897	25,791	7.3	7.3	7.3
yes	2,676	2,672	5,348	7.9	7.9	7.9
Anemia [P]						
no	12,320	12,384	24,704	7.2	7.2	7.2
yes	3,250	3,185	6,435	8.0	8.0	8.0
Cachexia [P]						
no	15,270	15,288	30,558	7.2	7.2	7.2
yes	300	281	581	15.8	15.9	15.8
Cancer [P]						
no	15,173	15,196	30,369	7.4	7.4	7.4
yes	397	373	770	7.9	7.9	7.9
Cardiac Adhesions [P]						
no	15,427	15,405	30,832	7.4	7.4	7.4
yes	143	164	307	9.1	8.5	8.8
Cardiogenic Shock, Pre-Operative [P]						
no	15,508	15,490	30,998	7.3	7.4	7.3
yes	62	79	141	13.4	15.9	14.8
Cardiomyopathy [P]						
no	13,541	13,488	27,029	7.2	7.2	7.2
yes	2,029	2,081	4,110	8.2	8.3	8.3
Chronic Lung Disease [P]						
no	12,349	12,391	24,740	7.1	7.1	7.1
yes	3,221	3,178	6,399	8.3	8.5	8.4
Chronic Pulmonary Hypertension [P]						
no	14,300	14,279	28,579	7.2	7.2	7.2
yes	1,270	1,290	2,560	8.9	9.2	9.0
Diabetes With Long-Term/Unspecified Complications [P]						
no	14,521	14,535	29,056	7.3	7.3	7.3
yes	1,049	1,034	2,083	8.5	8.4	8.5
Excision or Other Lesion/Heart Tissue, Open Approach – Same Date as Valve Surgery [P]						
no	14,973	14,970	29,943	7.3	7.3	7.3
yes	597	599	1,196	9.6	9.6	9.6
Fibrosis in Mediastinum and Heart [P]						
no	15,417	15,391	30,808	7.4	7.4	7.4
yes	153	178	331	8.9	8.5	8.7
Heart Failure [P]						
no	11,485	11,521	23,006	6.5	6.4	6.4
yes	4,085	4,048	8,133	9.9	10.1	10.0

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006-2007 Post-Surgical Length of Stay Model: Candidate Variable Frequency

Candidate Variable	Number of Cases			Arithmetic Avg. Post-Surgical LOS		
	Development Sample	Cross-Validation Sample	Full Data Set	Development Sample	Cross-Validation Sample	Full Data Set
History of CABG or Valve Surgery [P]						
no	14,756	14,702	29,458	7.3	7.3	7.3
yes	814	867	1,681	8.2	8.4	8.3
History of Peripheral Vascular Disease [P]						
no	13,257	13,353	26,610	7.4	7.4	7.4
yes	2,313	2,216	4,529	7.2	7.4	7.3
Hypertension with Complications [P]						
no	13,870	13,865	27,735	7.1	7.1	7.1
yes	1,700	1,704	3,404	9.4	9.5	9.4
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery [P]						
no	14,909	14,922	29,831	7.3	7.3	7.3
yes	661	647	1,308	9.1	8.8	9.0
Liver Disease [P]						
no	15,465	15,452	30,917	7.4	7.4	7.4
yes	105	117	222	8.9	9.0	8.9
MediQual Predicted LOS [MQ, 1] (tested as a continous variable)						
0	368	336	704	5.1	5.2	5.1
1	2,155	2,204	4,359	5.6	5.7	5.7
2	10,727	10,722	21,449	7.2	7.2	7.2
3	2,014	2,001	4,015	9.8	9.8	9.8
4	306	306	612	11.7	11.9	11.8
Obesity, Morbid [P]						
no	14,879	14,847	29,726	7.4	7.4	7.4
yes	691	722	1,413	7.4	7.7	7.6
Multiple Valve Procedures [P]						
no	14,830	14,835	29,665	7.2	7.2	7.2
yes	740	734	1,474	11.3	11.4	11.3
Other Open Heart Procedure [P]						
no	14,385	14,354	28,739	7.2	7.2	7.2
yes	1,185	1,215	2,400	9.2	9.6	9.4
Procedure Group [P]						
CABG without Valve	10,308	10,308	20,616	6.5	6.5	6.5
Valve without CABG	2,860	2,859	5,719	8.2	8.5	8.4
Valve with CABG	2,402	2,402	4,804	10.1	10.0	10.1
PTCA/Stent Same Day as CABG/Valve Surgery [P]						
no	15,446	15,447	30,893	7.4	7.4	7.4
yes	124	122	246	8.4	8.7	8.6
Renal Failure/Dialysis (binary) [P]						
no	15,078	15,046	30,124	7.2	7.3	7.3
yes	492	523	1,015	11.1	11.2	11.1

[1] The ranges (number of days) for the predicted length of stay categories were calculated for each combination of procedure group and calendar year.

[P] This variable was based on PHC4 data.

[MQ] This variable was based on data obtained from MediQual.

[C] This variable was based on both MediQual and PHC4 data.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2007 Post-Surgical Length of Stay Model: Candidate Variable Frequency

Candidate Variable	Number of Cases			Arithmetic Avg. Post-Surgical LOS		
	Development Sample	Cross-Validation Sample	Full Data Set	Development Sample	Cross-Validation Sample	Full Data Set
Demographic Variables						
Age in Years [P] (tested as a continous variable)						
Age: 30 - 39	76	101	177	6.1	6.1	6.1
Age: 40 - 49	471	479	950	6.3	6.0	6.1
Age: 50 - 59	1,397	1,430	2,827	6.3	6.3	6.3
Age: 60 - 69	2,252	2,176	4,428	6.8	7.1	6.9
Age: 70 - 79	2,358	2,357	4,715	8.1	8.0	8.1
Age: 80 - 89	1,003	1,005	2,008	9.1	9.4	9.3
Age: 90 - 99	8	14	22	11.9	11.2	11.5
Age # of Years > 65 [P] (tested as a continous variable)						
0	3,268	3,346	6,614	6.4	6.5	6.5
1	276	200	476	7.0	7.1	7.0
2	220	223	443	7.4	7.1	7.2
3	212	208	420	7.1	7.8	7.4
4	220	209	429	7.4	7.1	7.3
5	197	214	411	6.9	7.7	7.3
6	200	219	419	8.5	7.8	8.1
7	238	224	462	7.9	7.4	7.6
8	235	215	450	8.4	7.7	8.0
9	243	251	494	7.7	8.7	8.2
10	254	258	512	7.9	8.2	8.0
11	259	262	521	8.1	8.5	8.3
12	250	242	492	9.0	8.2	8.6
13	245	217	462	7.7	7.6	7.7
14	237	255	492	9.0	8.4	8.7
15	214	179	393	9.0	9.3	9.1
16	202	184	386	9.1	9.2	9.1
17	158	178	336	9.3	10.2	9.8
18	134	135	269	9.3	9.6	9.4
19	101	128	229	8.3	9.0	8.7
20	71	68	139	8.0	9.3	8.6
21	54	60	114	10.8	9.5	10.1
22	28	44	72	10.0	8.6	9.2
23	21	13	34	9.2	8.5	9.0
24	20	16	36	11.5	8.3	10.0
25	4	6	10	11.3	9.8	10.4
26	3	4	7	13.0	12.8	12.9
27	1	1	2	11.0	6.0	8.5
28	0	1	1	0.0	6.0	6.0
29	0	2	2	0.0	17.5	17.5
Female [P]						
Male	5,148	5,085	10,233	7.0	7.0	7.0
Female	2,417	2,477	4,894	8.3	8.3	8.3
Race [P]						
Black	310	337	647	9.1	8.5	8.8
Other/Unknown	476	451	927	7.9	8.5	8.2
White	6,779	6,774	13,553	7.3	7.3	7.3
Clinical Variables Other Than Laboratory Variables						
Acute Myocardial Infarction [P]						
no	6,282	6,282	12,564	7.3	7.3	7.3
yes	1,283	1,280	2,563	7.7	8.2	8.0
Anemia [P]						
no	5,737	5,822	11,559	7.2	7.2	7.2
yes	1,828	1,740	3,568	8.1	8.2	8.1

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2007 Post-Surgical Length of Stay Model: Candidate Variable Frequency

Candidate Variable	Number of Cases			Arithmetic Avg. Post-Surgical LOS		
	Development Sample	Cross-Validation Sample	Full Data Set	Development Sample	Cross-Validation Sample	Full Data Set
Cachexia [P]						
no	7,385	7,382	14,767	7.2	7.3	7.2
yes	180	180	360	16.1	15.3	15.7
Cancer [P]						
no	7,367	7,359	14,726	7.4	7.4	7.4
yes	198	203	401	8.0	8.2	8.1
Cardiac Adhesions [P]						
no	7,488	7,488	14,976	7.4	7.4	7.4
yes	77	74	151	9.0	8.1	8.5
Cardiogenic Shock, Pre-Operative [P]						
no	7,534	7,525	15,059	7.4	7.4	7.4
yes	31	37	68	14.2	14.8	14.5
Cardiomyopathy [P]						
no	6,458	6,537	12,995	7.2	7.3	7.2
yes	1,107	1,025	2,132	8.8	8.7	8.8
Chronic Lung Disease [P]						
no	5,991	5,994	11,985	7.1	7.2	7.1
yes	1,574	1,568	3,142	8.5	8.6	8.6
Chronic Pulmonary Hypertension [P]						
no	6,859	6,869	13,728	7.2	7.2	7.2
yes	706	693	1,399	9.1	9.7	9.4
Diabetes With Long-Term/Unspecified Complications [P]						
no	7,070	7,031	14,101	7.3	7.4	7.4
yes	495	531	1,026	8.6	8.6	8.6
Excision or Other Lesion/Heart Tissue, Open Approach – Same Date as Valve Surgery [P]						
no	7,263	7,269	14,532	7.3	7.4	7.3
yes	302	293	595	9.8	9.9	9.9
Fibrosis in Mediastinum and Heart [P]						
no	7,479	7,482	14,961	7.4	7.4	7.4
yes	86	80	166	8.8	8.2	8.5
Heart Failure [P]						
no	5,629	5,530	11,159	6.5	6.4	6.5
yes	1,936	2,032	3,968	10.1	10.2	10.2
History of CABG or Valve Surgery [P]						
no	7,157	7,143	14,300	7.4	7.4	7.4
yes	408	419	827	8.2	8.4	8.3
History of Peripheral Vascular Disease [P]						
no	6,455	6,421	12,876	7.4	7.4	7.4
yes	1,110	1,141	2,251	7.5	7.6	7.5
Hypertension with Complications [P]						
no	6,681	6,688	13,369	7.1	7.2	7.2
yes	884	874	1,758	9.5	9.4	9.4
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery [P]						
no	7,227	7,235	14,462	7.3	7.4	7.4
yes	338	327	665	8.9	9.3	9.1
Liver Disease [P]						
no	7,501	7,503	15,004	7.4	7.4	7.4
yes	64	59	123	9.1	9.9	9.5

[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2007 Post-Surgical Length of Stay Model: Candidate Variable Frequency

Candidate Variable			Number of Cases			Arithmetic Avg. Post-Surgical LOS		
			Development Sample	Cross-Validation Sample	Full Data Set	Development Sample	Cross-Validation Sample	Full Data Set
MediQual Predicted LOS [MQ, 1] (tested as a continous variable)								
CABG w/o Valve	Valve w/o CABG	Valve w/CABG						
< 5.421 days	< 6.733 days	< 8.406 days	151	182	333	5.1	5.2	5.1
5.421 – 6.634	6.733 – 8.436	8.406 – 9.951	1,065	1,059	2,124	5.7	5.5	5.6
6.635 – 12.015	8.437 – 15.031	9.951 – 16.668	5,256	5,165	10,421	7.3	7.3	7.3
12.016 – 17,784	15.032 – 21.838	16.669 – 23.043	953	995	1,948	9.8	10.0	9.9
> 17,784	> 21,838	> 23.043	140	161	301	11.9	12.7	12.3
Multiple Valve Procedures [P]								
no			7,204	7,197	14,401	7.2	7.2	7.2
yes			361	365	726	11.5	11.8	11.7
Obesity, Morbid [P]								
no			7,153	7,206	14,359	7.4	7.4	7.4
yes			412	356	768	8.0	8.2	8.1
Other Open Heart Procedure [P]								
no			6,982	7,009	13,991	7.2	7.3	7.3
yes			583	553	1,136	9.9	9.5	9.7
Procedure Group [P]								
CABG without Valve			4,951	4,950	9,901	6.5	6.5	6.5
Valve without CABG			1,426	1,425	2,851	8.6	8.6	8.6
Valve with CABG			1,188	1,187	2,375	9.9	10.1	10.0
PTCA/Stent Same Day as CABG/Valve Surgery [P]								
no			7,504	7,508	15,012	7.4	7.4	7.4
yes			61	54	115	8.4	10.2	9.2
Renal Failure/Dialysis (binary) [P]								
no			7,322	7,321	14,643	7.3	7.3	7.3
yes			243	241	484	12.0	11.9	11.9

[1] The ranges (number of days) for the predicted length of stay categories were calculated for each combination of procedure group and calendar year.
[P] This variable was based on PHC4 data.
[MQ] This variable was based on data obtained from MediQual.
[C] This variable was based on both MediQual and PHC4 data.

APPENDIX G: *ATLAS OUTCOMES*™ APPROACH TO RISK-ADJUSTMENT

Hospitals used the MediQual *Atlas Outcomes*™ System to abstract patient severity information, which is an objective severity of illness grouping, and risk-adjustment system that classifies each patient's risk on admission using data known as Key Clinical Findings (KCF). The *Atlas Outcomes*™ system is based on the examination of numerous KCFs such as lab test results, EKG findings, vital signs, the patient's medical history, imaging results, pathology, age, sex, and operative/endoscopy findings. Hospital personnel abstract these KCFs during specified time frames in the hospitalization. Some pre-admission data are also captured (e.g., cardiac catheterization findings), as are some history findings.

MediQual, in consultation with their Clinical Advisory Panel, designed in-hospital mortality and length of stay models focusing specifically on the patients who underwent a CABG and/or valve procedure. These models have many similarities to other disease group models used to calculate Admission Severity Groups (ASGs) in the *Atlas Outcomes*® system, though some differences were introduced to account for the unique characteristics of this population. The KCF variables were entered into algorithms that calculated the overall predicted probability of death or the predicted length of stay for patients undergoing a CABG and/or valve procedure. The predicted probability of death was derived from a logistic regression model and has a value from 0.000 to 1.000. The predicted length of stay was derived from a linear regression model and has a value greater than zero.

For PHC4's in-hospital and operative mortality models, data on the individual KCFs that were found by MediQual to be predictive of in-hospital mortality were obtained and the variables were retained in PHC4's mortality models, unless the coefficient was negative. For PHC4's readmissions models, MediQual's Predicted Length of Stay and individual KCFs from MediQual's mortality model that were not in MediQual's Predicted Length of Stay were tested as candidate variables. For PHC4's post-surgical length of stay model, MediQual's Predicted Length of Stay was tested as a candidate variable.