Technical Notes

for

Cardiac Surgery in Pennsylvania

Calendar Years 2008-2009 Data

The Pennsylvania Health Care Cost Containment Council
March 2011

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 2008 and 2009 (January 1, 2008 to December 31, 2009) and calendar year 2009 only (January 1, 2009 to December 31, 2009). 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 valve surgery. The report includes two sets of outcomes for hospitals: 1) outcomes for combined 2008-2009 data, and 2) outcomes for 2009 only. The report includes one set of outcomes for surgeons based on the combined 2008-2009 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 in a particular reporting group.
- 2008 average Medicare payment is reported for hospitals with at least 13 cases in a particular reporting group. If the number of cases included in the payment analysis for either the Valve without CABG or the Valve with CABG reporting group is less than 13, payment data was only reported for the Total Valve reporting group.

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 2008 and 2009 discharge data analyzed 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 general acute care (GAC) hospitals. The discharge data, which was submitted via the Uniform Claims and Billing Form (UB), 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 *Atlas Outcomes*™ system to abstract information from the medical record that described each patient's state of health on admission.

The 2008 Medicare payment data was provided by the Centers for Medicare and Medicaid Services (CMS).

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. 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 2008 and/or 2009 were subjected to extensive data verification and quality assurance checks. Hospitals were requested to confirm the accuracy of discharge records, provide additional diagnosis 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 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.

Hospitals were given an opportunity to verify the average Medicare payment reported for their facilities prior to the public release of the information.

STUDY POPULATION

The CABG and valve study population included those patients discharged from Pennsylvania GAC hospitals in calendar year 2008 or 2009 after undergoing CABG and/or valve surgery as identified by the presence of an appropriate ICD-9-CM (International Classification of Diseases, 9th Revision, Clinical Modification) 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 2008-2009 data, and 2) outcomes for 2009 only. The report includes one set of outcomes for surgeons based on the combined 2008-2009 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 this 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 within 1 to 7 days. 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 and their associated ICD-9-CM codes that were included in the readmissions analysis. Appendix D displays the number of readmissions for each category.

30-Day Readmissions

Similar to the 7-day readmissions rating, the 30-day readmissions 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 within 1 to 30 days. Readmissions were counted using the same principal diagnosis criteria used for 7-day readmissions. See Appendix C for a list of diagnosis categories and their associated ICD-9-CM codes that were included in the readmissions analysis. 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. This average is displayed as a geometric mean.

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.

Average Medicare Payment

Average Medicare Payment includes patients covered by Medicare Fee-For-Service (FFS) and is the mean of the Medicare FFS payments as provided to PHC4 from the Centers for Medicare and Medicaid Services (CMS). Average Medicare payments vary across hospitals; because, in determining what it will pay for care, Medicare takes into account differences among facilities in labor costs, physician teaching programs, and services to the poor. Average Medicare payments are only reported for 2008, because that was the most recent year of data available when analyses for the 2008-2009 cardiac surgery report were performed.

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). For example, this process answered questions, such as, "Was the gender of the patient important in predicting whether he/she was readmitted to the hospital?". Two important factors tested were the patient's "Atlas Predicted Probability of Death" and "Atlas Predicted Length of Stay" as calculated using the *Atlas Outcomes*™ severity adjustment system. This information indicated how severely ill the patient was on admission to the hospital and predicted how likely that was to affect mortality and length of stay. These values were generated for each patient from clinical information, including lab values, in the medical record (see Appendix G for a detailed explanation).

Separate risk-adjustment models were built for each outcome measure 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. 2008-2009 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	15,479	15,477	30,956
Number of in-hospital deaths	383	393	776
Mortality rate (%)	2.5	2.5	2.5
Operative Mortality			
Number of cases	13,966	13,964	27,930
Number of operative deaths	401	440	841
Mortality rate (%)	2.9	3.2	3.0
7-Day Readmissions			
Number of cases	13,630	13,630	27,260
Number of readmissions within 7 days	891	901	1,792
Readmissions rate (%)	6.5	6.6	6.6
30-Day Readmissions			
Number of cases	13,630	13,630	27,260
Number of readmissions within 30 days	2,181	2,069	4,250
Readmissions rate (%)	16.0	15.2	15.6

Table 1b. 2009 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	7,664	7,661	15,325
Number of in-hospital deaths	171	184	355
Mortality rate (%)	2.2	2.4	2.3
Operative Mortality			
Number of cases	6,934	6,936	13,870
Number of operative deaths	212	187	399
Mortality rate (%)	3.1	2.7	2.9
7-Day Readmissions			
Number of cases	6,780	6,782	13,562
Number of readmissions within 7 days	399	462	861
Readmissions rate (%)	5.9	6.8	6.3
30-Day Readmissions			
Number of cases	6,780	6,782	13,562
Number of readmissions within 30 days	1,009	1,033	2,042
Readmissions rate (%)	14.9	15.2	15.1

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. Definitions for these possible risk-adjustment factors, referred to as candidate variables, are available in Appendix E. Frequency data for the candidate variables is available in Appendix F.

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 single year (2009) model. Potential candidate variables were subject to univariate analysis to determine which variables should be tested for inclusion in the models. 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. The variables listed in Tables 2a, 2b, 3a, and 3b 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 the tables referenced above (Tables 2a, 2b, 3a, and 3b).

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. 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 was applied to the full data set. See Tables 2a, 2b, 3a, and 3b for the cross-validation and full data set results.

Table 2a. Candidate Variables Tested as Potential Predictors of Mortality, 2008-2009 Data

The results of variable testing for the 2008-2009 mortality models are displayed in the table below. The variables found to be significant predictors and their associated *p*-values are in bold text.

Candidate Variables Variables in bold text were included in the final model.	**In-Hospital** **Model Test Results** ***p*-values for variables significant in the model**			**Operative** **Model Test Results** ***p*-values for variables significant in the model**		
	Develop-ment	Cross-Validation	Full Data Set	Develop-ment	Cross-Validation	Full Data Set
Demographic Variables						
Age in Years	**0.005**	**0.218**	**0.004**	**0.098**	**0.181**	**0.035**
Age # of Years > 65	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Female	ne	ne	ne	ns[m]	ns[m]	ns[m]
Race Category	**0.095**	**0.042**	**0.017**	nt[m]	nt[m]	nt[m]
Clinical Variables						
Acute Myocardial Infarction	**0.002**	**0.102**	**0.001**	ns[m]	ns[m]	ns[m]
Atlas Predicted Probability of Death [A]	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Cachexia	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Cancer	nt[m]	nt[m]	nt[m]	ns[m]	ns[m]	ns[m]
Cardiac Adhesions	nt[m]	nt[m]	nt[m]	ns[m]	ns[m]	ns[m]
Cardiogenic Shock, Pre-Operative	**<0.001**	**<0.001**	**<0.001**	**0.003**	**0.001**	**<0.001**
Cardiomyopathy	**0.055**	**0.430**	**0.049**	ns[m]	ns[m]	ns[m]
Chronic Pulmonary Hypertension	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Excision of Other Lesion/Heart Tissue/LAA, Open Approach – Same Date as Valve with or without CABG	ns[m]	ns[m]	ns[m]	nt[m]	nt[m]	nt[m]
Heart Failure	ns[m]	ns[m]	ns[m]	**0.024**	**<0.001**	**<0.001**
History of CABG or Valve Surgery	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
History of Peripheral Vascular Disease	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Hypertension with Complications	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery	**0.070**	**0.202**	**0.030**	**0.065**	**0.043**	**0.007**
Liver Disease	**0.001**	**<0.001**	**<0.001**	nt[m]	nt[m]	nt[m]
Multiple Valve Procedures	**<0.001**	**0.025**	**<0.001**	**<0.001**	**0.025**	**<0.001**
Other Open Heart Procedure	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Procedure Group	**0.003**	**0.869**	**0.028**	**<0.001**	**0.020**	**<0.001**
PTCA/Stent/Tear Same Day CABG/Valve Surgery	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Renal Failure/Dialysis (category)	**0.003**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

[A] This variable was based on data obtained from Atlas. Logit transformation was performed.

ne This variable was removed from the development model, because its coefficient was negative during the preliminary analysis of the development sample.

ns[m] Not significant. In the development model this variable was *not* a significant ($p < 0.10$) predictor of the relevant outcome; therefore, it was not tested in the cross-validation model and not included in the final model.

nt[m] Not tested. This variable was not tested in the model because the univariate analysis did not suggest that the variable would be predictive of the relevant outcome.

Table 2b. Candidate Variables Tested as Potential Predictors of Mortality, 2009 Data

The results of variable testing for the 2009 mortality models are displayed in the table below. The variables found to be significant predictors and their associated *p*-values are in bold text.

Candidate Variables Variables in bold text were included in the final model.	**In-Hospital** **Model Test Results** ***p*-values for variables significant in the model**			**Operative** **Model Test Results** ***p*-values for variables significant in the model**		
	Develop-ment	Cross-Validation	Full Data Set	Develop-ment	Cross-Validation	Full Data Set
Demographic Variables						
Age in Years	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Age # of Years > 65	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Female	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Clinical Variables						
Acute Myocardial Infarction	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Atlas Predicted Probability of Death [A]	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Cachexia	**0.001**	**0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Cancer	ne	ne	ne	ne	ne	ne
Cardiac Adhesions	nt[m]	nt[m]	nt[m]	ns[m]	ns[m]	ns[m]
Cardiogenic Shock, Pre-Operative	**0.028**	**<0.001**	**<0.001**	**<0.001**	**0.112**	**<0.001**
Cardiomyopathy	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Chronic Lung Disease	nt[m]	nt[m]	nt[m]	ns[m]	ns[m]	ns[m]
Chronic Pulmonary Hypertension	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Excision of Other Lesion/Heart Tissue/LAA, Open Approach – Same Date as Valve with or without CABG	ns[m]	ns[m]	ns[m]	nt[m]	nt[m]	nt[m]
Heart Failure	ns[m]	ns[m]	ns[m]	**0.010**	**0.067**	**0.002**
History of CABG or Valve Surgery	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Hypertension with Complications	ns[m]	ns[m]	ns[m]	**0.063**	**0.147**	**0.019**
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery	ns[m]	ns[m]	ns[m]	ne	ne	ne
Liver Disease	**0.010**	**0.008**	**<0.001**	ns[m]	ns[m]	ns[m]
Multiple Valve Procedures	**0.014**	**<0.001**	**<0.001**	**0.002**	**0.001**	**<0.001**
Other Open Heart Procedure	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Procedure Group	**Entered and retained in model**			**Entered and retained in model**		
Renal Failure/Dialysis (category)	**0.070**	**0.016**	**0.001**	ns[m]	ns[m]	ns[m]

[A] This variable was based on data obtained from Atlas. Logit transformation was performed.

ne This variable was removed from the development model, because its coefficient was negative during the preliminary analysis of the development sample.

ns[m] Not significant. In the development model this variable was *not* a significant ($p < 0.10$) predictor of the relevant outcome; therefore, it was not tested in the cross-validation model and not included in the final model.

nt[m] Not tested. This variable was not tested in the model because the univariate analysis did not suggest that the variable would be predictive of the relevant outcome.

Table 3a. *Candidate Variables Tested as Potential Predictors of Readmission, 2008-2009 Data*

The results of variable testing for the 2008-2009 readmission models are displayed in the table below. The variables found to be significant predictors and their associated *p*-values are in bold text.

Candidate Variables Variables in bold text were included in the final model.	**7-Day** **Model Test Results** ***p*-values for variables significant in the model**			**30-Day** **Model Test Results** ***p*-values for variables significant in the model**		
	Develop-ment	Cross-Validation	Full Data Set	Develop-ment	Cross-Validation	Full Data Set
Demographic Variables						
Year	nt[m]	nt[m]	nt[m]	**0.008**	**0.029**	**0.001**
Age in Years	ns[m]	ns[m]	ns[m]	**0.007**	**0.148**	**0.004**
Age # of Years > 65	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Female	**0.011**	**0.147**	**0.005**	**<0.001**	**<0.001**	**<0.001**
Race Category	**0.044**	**0.003**	**<0.001**	**<0.001**	**0.005**	**<0.001**
Clinical Variables						
Anemia	nt[m]	nt[m]	nt[m]	ns[m]	ns[m]	ns[m]
Atlas Predicted Length of Stay [A]	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Cachexia	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Cancer	nt[m]	nt[m]	nt[m]	**0.003**	**0.156**	**0.002**
Cardiac Adhesions	ns[m]	ns[m]	ns[m]	nt[m]	nt[m]	nt[m]
Cardiomyopathy	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Cerebrovascular Disease	nt[m]	nt[m]	nt[m]	ne	ne	ne
Chronic Lung Disease	**0.034**	**0.140**	**0.012**	**0.007**	**0.392**	**0.013**
Chronic Pulmonary Hypertension	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Coagulopathy	nt[m]	nt[m]	nt[m]	**0.050**	**0.471**	**0.056**
Depression	nt[m]	nt[m]	nt[m]	ns[m]	ns[m]	ns[m]
Diabetes (category)	ns[m]	ns[m]	ns[m]	**<0.001**	**0.054**	**<0.001**
Excision of Other Lesion/Heart Tissue/LAA, Open Approach – Same Date as Valve with or without CABG	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Heart Failure	ns[m]	ns[m]	ns[m]	**0.035**	**<0.001**	**<0.001**
History of CABG or Valve Surgery	nt[m]	nt[m]	nt[m]	**0.083**	**0.037**	**0.008**
History of Cerebral Vascular Accident (CVA) or Stroke	nt[m]	nt[m]	nt[m]	**0.061**	**0.024**	**0.004**
History of Chronic Steroid Use	**0.004**	**0.667**	**0.013**	ne	ne	ne
History of Peripheral Vascular Disease	nt[m]	nt[m]	nt[m]	ne	ne	ne
Hypertension with Complications	**0.004**	**0.398**	**0.008**	**<0.001**	**0.009**	**<0.001**
Multiple Valve Procedures	**0.044**	**0.370**	**0.040**	**<0.001**	**0.029**	**<0.001**
Obesity, Morbid	**0.046**	**0.002**	**<0.001**	**0.003**	**0.002**	**<0.001**
Other Open Heart Procedure	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Procedure Group	**0.084**	**0.408**	**0.066**	**0.002**	**0.264**	**0.001**
Renal Failure/Dialysis (category)	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]

[A] This variable was based on data obtained from Atlas.

ne This variable was removed from the development model, because its coefficient was negative during the preliminary analysis of the development sample.

ns[m] Not significant. In the development model this variable was *not* a significant ($p < 0.10$) predictor of the relevant outcome; therefore, it was not tested in the cross-validation model and not included in the final model.

nt[m] Not tested. This variable was not tested in the model because the univariate analysis did not suggest that the variable would be predictive of the relevant outcome.

Table 3b. *Candidate Variables Tested as Potential Predictors of Readmission, 2009 Data*

The results of variable testing for the 2009 readmission models are displayed in the table below. The variables found to be significant predictors and their associated *p*-values are in bold text.

Candidate Variables Variables in bold text were included in the final model.	**7-Day** **Model Test Results** ***p*-values for variables significant in the model**			**30-Day** **Model Test Results** ***p*-values for variables significant in the model**		
	Develop-ment	Cross-Validation	Full Data Set	Develop-ment	Cross-Validation	Full Data Set
Demographic Variables						
Age in Years	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Age # of Years > 65	**0.001**	**0.023**	**<0.001**	**0.003**	**0.015**	**<0.001**
Female	**0.016**	**0.166**	**0.009**	**<0.001**	**<0.001**	**<0.001**
Race (category)	ns[m]	ns[m]	ns[m]	**0.061**	**<0.001**	**<0.001**
Clinical Variables						
Anemia	nt[m]	nt[m]	nt[m]	ns[m]	ns[m]	ns[m]
Atlas Predicted Length of Stay [A]	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Cachexia	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Cancer	nt[m]	nt[m]	nt[m]	**0.020**	**0.203**	**0.012**
Cardiac Adhesions	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Cardiogenic Shock, Pre-Operative	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Cardiomyopathy	nt[m]	nt[m]	nt[m]	ns[m]	ns[m]	ns[m]
Chronic Lung Disease	ns[m]	ns[m]	ns[m]	nt[m]	nt[m]	nt[m]
Chronic Pulmonary Hypertension	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Diabetes (category)	nt[m]	nt[m]	nt[m]	ns[m]	ns[m]	ns[m]
Diabetes With Long-Term/Unspecified Complications	ns[m]	ns[m]	ns[m]	nt[m]	nt[m]	nt[m]
Heart Failure	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
History of CABG or Valve Surgery	nt[m]	nt[m]	nt[m]	ns[m]	ns[m]	ns[m]
History of Cerebral Vascular Accident (CVA) or Stroke	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Hypertension with Complications	**0.004**	**0.869**	**0.066**	**<0.001**	**0.508**	**<0.001**
Multiple Valve Procedures	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Obesity, Morbid	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Other Open Heart Procedure	nt[m]	nt[m]	nt[m]	**0.044**	**0.598**	**0.068**
Procedure Group	**Entered and retained in model**			**Entered and retained in model**		
PTCA/Stent Same Day as CABG/Valve Surgery	nt[m]	nt[m]	nt[m]	ns[m]	ns[m]	ns[m]
Renal Failure/Dialysis (category)	ns[m]	ns[m]	ns[m]	**0.006**	**0.021**	**<0.001**

[A] This variable was based on data obtained from Atlas.

ns[m] Not significant. In the development model this variable was *not* a significant ($p < 0.10$) predictor of the relevant outcome; therefore, it was not tested in the cross-validation model and not included in the final model.

nt[m] Not tested. This variable was not tested in the model because 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 (Coefficient of Determination) 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 4.

Table 4. c Statistics for Development, Cross-Validation, and Full Data Set Models

Measure	Development Model %	Cross-Validation Model %	Full Data Set Model %
2008-2009 Models			
In-Hospital Mortality	82.8	80.0	81.7
Operative Mortality	80.7	79.1	80.0
7-Day Readmissions	63.0	62.1	62.6
30-Day Readmissions	64.4	63.5	64.1
2009 Models			
In-Hospital Mortality	83.8	80.9	82.4
Operative Mortality	82.1	80.0	81.0
7-Day Readmissions	64.4	62.7	63.9
30-Day Readmissions	65.2	63.5	64.7

Coefficients and Odds Ratios

The coefficients and odds ratios for each risk factor included in the final models are listed in Tables 5a, 5b, 6a, and 6b. 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 3.411 for the 2008-2009 in-hospital mortality model, meaning that a patient with cardiogenic shock prior to surgery was slightly more than three times as likely to die during the hospital admission as patients who did not have this risk factor. Because they are not always meaningful, odds ratios are not applicable for continuous variables such as age in years and Atlas 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 5a. *Coefficients and Odds Ratios of Final Mortality Models, 2008-2009 Data*

Predictor Variables	In-Hospital Mortality		Operative Mortality	
	Coefficient	Odds Ratio	Coefficient	Odds Ratio
Constant	-2.6007		-2.2859	
Demographic Variables				
Age in Years	0.0122	NA	0.0085	NA
Race				
Black	0.3141	1.369	nt[m]	–
Other	0.3191	1.376		
White	*	*	*	*
Clinical Variables				
Acute Myocardial Infarction	0.3419	1.408	ns[m]	–
Atlas Predicted Probability of Death [A]	0.7225	NA	0.7179	NA
Cachexia	0.8432	2.324	0.9085	2.481
Cardiogenic Shock, Pre-Operative	1.2269	3.411	1.0452	2.844
Cardiomyopathy	0.1774	1.194	ns[m]	–
Heart Failure	ns[m]	–	0.3507	1.420
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery	0.3206	1.378	0.3739	1.453
Liver Disease	1.4341	4.196	nt[m]	–
Multiple Valve Procedures	0.6513	1.918	0.6541	1.924
Procedure Group				
CABG without Valve	0.1541	1.167	0.4890	1.631
Valve without CABG	*	*	*	*
Valve with CABG	0.2821	1.326	0.4252	1.530
Renal Failure Dialysis (category)				
All cases not assigned to chronic and acute/dialysis categories	*	*	*	*
Chronic	0.6715	1.957	0.4010	1.493
Acute/dialysis	1.1268	3.086	0.9958	2.707

[A] This variable was based on data obtained from Atlas. Logit transformation was performed.

* This is the reference level for the variable.

NA Not applicable. This variable was tested as a continuous variable.

ns[m] Not significant. In the development model this variable was *not* a significant ($p < 0.10$) predictor of the relevant outcome; therefore, it was not tested in the cross-validation model and not included in the final model.

nt[m] Not tested. This variable was not tested in the model because the univariate analysis did not suggest that the variable would be predictive of the relevant outcome.

Table 5b. *Coefficients and Odds Ratios of Final Mortality Models, 2009 Data*

Predictor Variables	In-Hospital Mortality		Operative Mortality	
	Coefficient	**Odds Ratio**	**Coefficient**	**Odds Ratio**
Constant	-1.3630		-1.6721	
Clinical Variables				
Atlas Predicted Probability of Death [A]	0.8640	NA	0.7737	NA
Cachexia	0.8502	2.340	0.9552	2.599
Cardiogenic Shock, Preoperative	1.2818	3.603	1.2354	3.440
Heart Failure	ns[m]	–	0.3629	1.437
Hypertension with Complications	ns[m]	–	0.2938	1.342
Liver Disease	1.5911	4.609	ns[m]	–
Multiple Valve Procedures	0.7487	2.114	0.7758	2.172
Procedure Group				
CABG without Valve	0.3903	1.477	0.5915	1.807
Valve without CABG	*	*	*	*
Valve with CABG	0.3955	1.485	0.4881	1.629
Renal Failure Dialysis (category)				
All cases not assigned to chronic and acute/dialysis categories	*	*	ns[m]	–
Chronic	0.6409	1.898		
Acute/dialysis	0.8077	2.243		

[A] This variable was based on data obtained from Atlas. Logit transformation was performed.

* This is the reference level for the variable.

NA Not applicable. This variable was tested as a continuous variable.

ns[m] Not significant. In the development model this variable was *not* a significant ($p < 0.10$) predictor of the relevant outcome; therefore, it was not tested in the cross-validation model and not included in the final model.

Table 6a. *Coefficients and Odds Ratios of Final Readmissions Models, 2008-2009 Data*

Predictor Variables	7-Day Readmissions		30-Day Readmissions	
	Coefficient	**Odds Ratio**	**Coefficient**	**Odds Ratio**
Constant	-3.6018		-2.1011	
Demographic Variables				
Year	nt[m]	–	-0.1174	0.889
Age in Years	ns[m]	–	-0.0098	NA
Age # of Years > 65	0.0245	NA	0.0334	NA
Female	0.1499	1.162	0.2613	1.299
Race				
Black	0.4235	1.527	0.3672	1.444
Other	0.1092	1.115	0.1471	1.159
White	*	*	*	*
Clinical Variables				
Atlas Predicted Length of Stay [A]	0.0521	NA	0.0490	NA
Cancer	nt[m]	–	0.2935	1.341
Chronic Lung Disease	0.1534	1.166	0.1067	1.113
Coagulopathy	nt[m]	–	0.3615	1.436
Diabetes	ns[m]	–		
No Diabetes			*	*
Diabetes without Complication			0.1214	1.129
Diabetes with Complication			0.3140	1.369
Heart Failure	ns[m]		0.1975	1.218
History of CABG/Valve Surgery	nt[m]	–	0.1834	1.201
History of Cerebral Vascular Accident (CVA) or Stroke	nt[m]	–	0.1842	1.202
History of Chronic Steroid Use	0.7160	2.046	ne	–
Hypertension with Complications	0.1825	1.200	0.2169	1.242
Multiple Valve Procedures	0.2162	1.241	0.2943	1.342
Obesity, Morbid	0.3532	1.424	0.2982	1.347
Procedure Group				
CABG without Valve	0.0169	1.017	-0.0085	0.992
Valve without CABG	*	*	*	*
Valve with CABG	0.1657	1.180	0.1678	1.183

[A] This variable was based on data obtained from Atlas.

* This is the reference group for the variable.

NA Not applicable. This variable was tested as a continuous variable.

ne This variable was removed from the development model, because its coefficient was negative during the preliminary analysis of the development sample.

ns[m] Not significant. In the development model this variable was *not* a significant ($p < 0.10$) predictor of the relevant outcome; therefore, it was not tested in the cross-validation model and not included in the final model.

nt[m] Not tested. This variable was not tested in the model because the univariate analysis did not suggest that the variable would be predictive of the relevant outcome.

Table 6b. *Coefficients and Odds Ratios of Final Readmissions Models, 2009 Data*

Predictor Variables	7-Day Readmissions		30-Day Readmissions	
	Coefficient	**Odds Ratio**	**Coefficient**	**Odds Ratio**
Constant	-3.7879		-2.8740	
Demographic Variables				
Age # of Years > 65	0.0209	NA	0.0142	NA
Female	0.1982	1.219	0.3424	1.408
Race	ns[m]	–		
Black			0.4135	1.512
Other			0.2180	1.244
White			*	*
Clinical Variables				
Atlas Predicted Length of Stay [A]	0.0772	NA	0.0713	NA
Cancer	nt[m]	–	0.3376	1.402
Hypertension with Complications	0.1768	1.193	0.2868	1.332
Other Open Heart Procedure	nt[m]	–	0.1584	1.172
Procedure Group				
CABG without Valve	-0.0401	0.961	-0.0331	0.967
Valve without CABG	*	*	*	*
Valve with CABG	0.1252	1.133	0.2054	1.228
Renal Failure Dialysis (category)	ns[m]	–		
All cases not assigned to chronic and acute/dialysis categories			*	*
Chronic			0.6593	1.934
Acute/dialysis			0.2741	1.315

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

* This is the reference group for the variable.

NA Not applicable. This variable was tested as a continuous variable.

ns[m] Not significant. In the development model this variable was *not* a significant ($p < 0.10$) predictor of the relevant outcome; therefore, it was not tested in the cross-validation model and not included in the final model.

nt[m] Not tested. This variable was not tested in the model because 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 or 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 of the procedure, 3) the probability of being readmitted within 7 days of discharge, and 4) the probability of being readmitted within 30 days of discharge. 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 5a, 5b, 6a, and 6b 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.* 2009 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)
Rate:	Total number of deaths / Total number of cases
Expected Deaths:	Sum of each patient's probability of death (PD)
Rate:	Sum of each patient's probability of death (PD) / Total number of cases
	To calculate a patient's probability of death: Step 1: Calculate βX: βX = -1.3630 + 0.8502 (Cachexia) + 1.2818 (Cardiogenic Shock, Preoperative) + 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 ≈ 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 7.

Table 7. Case Counts and Average Post-Surgical Length of Stay in Days

	Development Sample	Cross-Validation Sample	Full Data Set
2008-2009 Model			
Number of cases	14,958	14,955	29,913
Average post-surgical length of stay *(arithmetic)*	7.4	7.4	7.4
Average post-surgical length of stay *(geometric)*	6.5	6.5	6.5
2009 Model			
Number of cases	7,426	7,425	14,851
Average post-surgical length of stay *(arithmetic)*	7.4	7.5	7.5
Average post-surgical length of stay *(geometric)*	6.5	6.6	6.6

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 8.

Cross-validation. After the development model was built for post-surgical length of stay, the model was cross-validated. 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 8 for cross-validation and full data set results.

Table 8. Candidate Variables Tested as Potential Predictors of Average Post-Surgical Length of Stay

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

Candidate Variables Variables in bold text were included in the final model.	**2008-2009 Data** **Model Test Results *p*-values for variables significant in the model**			**2009 Data** **Model Test Results *p*-values for variables significant in the model**		
	Develop-ment	Cross-Validation	Full Data Set	Develop-ment	Cross-Validation	Full Data Set
Demographic Variables						
Year	ns[m]	ns[m]	ns[m]	NA	NA	NA
Age in Years	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Age # of Years > 65	**0.0068**	**<0.0001**	**<0.0001**	**<0.0001**	**0.0226**	**<0.0001**
Female	**<0.0001**	**<0.0001**	**<0.0001**	**0.0007**	**0.0007**	**<0.0001**
Race/Ethnicity	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Clinical Variables						
Acute Myocardial Infarction	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Anemia	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Atlas Predicted Length of Stay [A]	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Cachexia	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Cancer	**0.0007**	**0.3832**	**0.0026**	**0.0035**	**0.0142**	**0.0001**
Cardiac Adhesions	ns[m]	ns[m]	ns[m]	nt[m]	nt[m]	nt[m]
Cardiogenic Shock, Pre-Operative	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Cardiopulmonary Resuscitation (CPR) Prior to CABG/Valve Surgery Date	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Cardiomyopathy	**0.0076**	**0.0437**	**0.0012**	ne	ne	ne
Cerebrovascular Disease	nt[m]	nt[m]	nt[m]	ns[m]	ns[m]	ns[m]
Chronic Lung Disease	**<0.0001**	**<0.0001**	**<0.0001**	**0.0023**	**0.0012**	**<0.0001**
Chronic Pulmonary Hypertension	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Coagulopathy	**0.0021**	**0.1477**	**0.0012**	nt[m]	nt[m]	nt[m]
Depression	**0.0034**	**0.0228**	**0.0002**	**0.0019**	**0.1850**	**0.0018**
Diabetes with Long Term/Unspecified Complications	**<0.0001**	**0.0072**	**<0.0001**	**0.0015**	**0.0626**	**0.0003**
Excision or Other Lesion/Heart Tissue, Open Approach – Same Date as Valve with or without CABG	ne	ne	ne	ns[m]	ns[m]	ns[m]
Fibrosis in Mediastinum and Heart	ns[m]	ns[m]	ns[m]	nt[m]	nt[m]	nt[m]
Heart Failure	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
History of CABG or Valve Surgery	**0.0031**	**0.0013**	**<0.0001**	**0.0054**	**0.3025**	**0.0083**
History of Cerebral Vascular Accident (CVA) or Stroke	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
History of Chronic Steroid Use	nt[m]	nt[m]	nt[m]	ns[m]	ns[m]	ns[m]
History of Peripheral Vascular Disease	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]	ns[m]
Hypertension with Complications	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery	**<0.0001**	**<0.0001**	**<0.0001**	**0.0099**	**0.0038**	**0.0001**
Liver Disease	**0.0053**	**0.0703**	**0.0010**	nt[m]	nt[m]	nt[m]
Multiple Valve Procedures	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Obesity, Morbid	**<0.0001**	**<0.0001**	**<0.0001**	**0.0001**	**0.0001**	**<0.0001**
Other Open Heart Procedure	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Procedure Group	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
PTCA/Stent Same Day as CABG/Valve Surgery	**<0.0001**	**0.0108**	**<0.0001**	nt[m]	nt[m]	nt[m]
Renal Failure/Dialysis (binary)	**<0.0001**	**<0.0001**	**<0.0001**	**0.0002**	**0.0015**	**<0.0001**

[A] This variable was based on data obtained from Atlas.

NA Not applicable.

ne This variable was removed from the development model, because its coefficient was negative during the preliminary analysis of the development sample.

ns[m] Not significant. In the development model this variable was *not* a significant ($p < 0.10$) predictor of the relevant outcome; therefore, it was not tested in the cross-validation model and not included in the final model.

nt[m] Not tested. This variable was not tested in the model because 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 9.

Table 9. 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 %
2008-2009 Model	29.9	31.5	30.8
2009 Model	30.7	30.5	30.6

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 10 displays the coefficients for the variables included in the final models.

Table 10. Coefficients of Predictors in the Final Post-Surgical Length of Stay Models

Predictor Variables	2008-2009 Data	2009 Data
Intercept	1.259210987	1.279913415
Demographic Variables		
Age in Years	0.004043877	0.003779455
Age # of Years > 65	0.004240565	0.004559670
Female	0.031774542	0.035192429
Race/Ethnicity		
Hispanic	-0.257969368	-0.244378187
White (non-Hispanic)	-0.075236111	-0.086467924
Black (non-Hispanic)	0.067506345	0.059402054
Other/Unknown	*	*
Clinical Variables		
Anemia	0.049074664	0.050202442
Atlas Predicted Length of Stay [A]	0.021434040	0.023079399
Cachexia	0.497339131	0.429848530
Cancer	0.041335068	0.073364654
Cardiogenic Shock, Pre-Operative	0.402377127	0.459882810
Cardiomyopathy	0.021592333	ne
Chronic Lung Disease	0.049911529	0.037954343
Coagulopathy	0.090235097	nt[m]
Depression	0.032730806	0.038313268
Diabetes with Long Term/Unspecified Complications	0.052312887	0.046343670
Heart Failure	0.140709022	0.138888175
History of CABG or Valve Surgery	0.043162150	0.036986013
Hypertension with Complications	0.077707183	0.079003376
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery	0.091899847	0.062087030
Liver Disease	0.080499293	nt[m]
Multiple Valve Procedures	0.140636662	0.154063657
Obesity, Morbid	0.086397038	0.076360907
Other Open Heart Procedure	0.085184157	0.077963275
Procedure Group		
CABG without Valve	*	*
Valve without CABG	0.052662401	0.038619603
Valve with CABG	0.138050113	0.128457116
PTCA/Stent Same Day as CABG/Valve Surgery	0.116778021	nt[m]
Renal Failure/Dialysis (binary)	0.126892045	0.100308531

[A] This variable was based on data obtained from Atlas.

* This is the reference level for the variable.

ne This variable was removed from the development model, because its coefficient was negative during the preliminary analysis of the development sample.

nt[m] Not tested. This variable was not tested in the model because 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, in 2009 a patient without heart failure had a zero or baseline coefficient; while a patient with heart failure would be adjusted upward by 0.138888175 (see Table 10). 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 0.138888175 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. 2009 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 = 1.279913415 + 0.003779455 (Age in Years) + 0.004559670 (Age # Years > 65) + 0.035192429 (Female) + 0.459882810 (Cardiogenic Shock, Pre-Operative) + coefficient (other variables in post-surgical length of stay model) . . .

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 for the three procedure groups (CABG without Valve, Valve without CABG, and Valve with CABG) and for the two years (2008 and 2009) separately. 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 (MS-DRG) assignment.

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

DRG Group 1	MS-DRG 231	Coronary Bypass with PTCA with MCC
	MS-DRG 232	Coronary Bypass with PTCA without MCC
DRG Group 2	MS-DRG 233	Coronary Bypass with Cardiac Catheterization with MCC
	MS-DRG 234	Coronary Bypass with Cardiac Catheterization without MCC
DRG Group 3	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
DRG Group 4	MS-DRG 235	Coronary Bypass without Cardiac Catheterization with MCC
	MS-DRG 236	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	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
DRG Group 6	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

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.

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. Cases with charges that were 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.

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 11a through 12c 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 11a. *CABG without Valve: Trim Points for Average Charge, 2008*

DRG GROUP	Upper Trim Point*	Outlier %	Median Charge After Trimming	Average Charge After Trimming
Group 1 (MS-DRG 231, 232)				
Region 1	$685,560	0.0	$100,717	$152,075
Region 2	$458,611	0.0	$150,534	$151,041
Region 3	$169,880	11.1	$94,270	$88,621
Region 4	**	**	**	**
Region 5	$223,384	0.0	$104,980	$111,586
Region 6	$255,533	0.0	$108,716	$114,501
Region 7	$517,773	0.0	$166,277	$182,130
Region 8	$689,867	0.0	$256,621	$258,224
Region 9	$960,301	0.0	$264,461	$284,178
Group 2 (MS-DRG 233, 234)				
Region 1	$413,908	1.6	$79,216	$108,090
Region 2	$313,667	1.9	$136,705	$139,248
Region 3	$153,274	1.3	$69,556	$71,445
Region 4	$291,676	2.1	$94,335	$104,540
Region 5	$177,068	3.5	$78,368	$82,502
Region 6	$178,333	1.4	$71,638	$77,332
Region 7	$404,611	2.2	$123,886	$145,336
Region 8	$572,320	1.2	$161,844	$185,604
Region 9	$695,014	2.3	$195,086	$221,755
Group 3 (MS-DRG 228, 229, 230)				
Region 1	$925,733	0.0	$218,179	$234,635
Region 2	$374,571	0.0	$118,115	$137,916
Region 3	$144,137	0.0	$77,922	$78,467
Region 4	**	**	**	**
Region 5	**	**	**	**
Region 6	$209,601	0.0	$87,105	$87,250
Region 7	$397,752	7.1	$124,469	$135,804
Region 8	**	**	**	**
Region 9	**	**	**	**
Group 4 (MS-DRG 235, 236)				
Region 1	$356,163	1.3	$68,762	$93,254
Region 2	$224,734	1.9	$101,111	$102,522
Region 3	$105,593	2.7	$49,375	$52,243
Region 4	$201,261	3.4	$73,259	$80,765
Region 5	$142,310	1.5	$58,046	$61,804
Region 6	$114,710	2.6	$51,329	$53,869
Region 7	$263,666	2.8	$90,930	$101,454
Region 8	$349,634	4.0	$98,005	$119,078
Region 9	$643,945	1.8	$160,113	$196,451

* Charges of less than $10,000 were considered invalid. Therefore, with the exception of DRG Group 1 in Region 3, there were no lower trim points. The lower trim point for DRG Group 1 in Region 3 was $15,906.

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

Table 11b. Valve without CABG: Trim Points for Average Charge, 2008

DRG GROUP	Upper Trim Point*	Outlier %	Median Charge After Trimming	Average Charge After Trimming
Group 5 (MS-DRG 216, 217, 218)				
Region 1	$687,936	0.8	$140,713	$181,403
Region 2	$656,859	0.0	$179,034	$199,672
Region 3	$251,105	0.0	$102,346	$108,784
Region 4	$639,135	6.3	$177,164	$177,183
Region 5	$281,984	7.4	$102,172	$108,746
Region 6	$341,312	0.0	$109,561	$119,402
Region 7	$577,256	5.6	$169,899	$188,772
Region 8	$699,917	0.7	$210,826	$240,044
Region 9	$748,835	2.1	$239,820	$270,035
Group 6 (MS-DRG 219, 220, 221)				
Region 1	$420,680	0.9	$87,730	$114,485
Region 2	$394,683	1.0	$134,847	$141,535
Region 3	$167,910	4.7	$75,730	$82,213
Region 4	$379,854	2.6	$147,383	$144,329
Region 5	$173,557	4.1	$71,705	$76,706
Region 6	$239,036	3.8	$77,933	$84,165
Region 7	$365,096	3.1	$120,572	$135,045
Region 8	$413,175	2.7	$145,867	$162,041
Region 9	$518,363	2.2	$179,383	$204,618

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

Table 11c. Valve with CABG: Trim Points for Average Charge, 2008

DRG GROUP	Upper Trim Point*	Outlier %	Median Charge After Trimming	Average Charge After Trimming
Group 5 (MS-DRG 216, 217, 218)				
Region 1	$746,580	0.9	$130,532	$181,529
Region 2	$674,490	0.0	$205,776	$237,562
Region 3	$235,247	2.8	$112,333	$115,023
Region 4	$679,194	0.0	$178,380	$200,685
Region 5	$292,522	2.2	$118,090	$125,101
Region 6	$361,070	1.1	$121,854	$134,307
Region 7	$799,629	0.0	$206,039	$246,485
Region 8	$650,183	4.3	$207,632	$228,227
Region 9	$886,257	5.5	$267,735	$293,690
Group 6 (MS-DRG 219, 220, 221)				
Region 1	$657,001	0.6	$101,818	$158,664
Region 2	$389,968	2.4	$146,432	$153,792
Region 3	$206,419	0.0	$86,438	$91,189
Region 4	$352,413	5.9	$127,075	$132,311
Region 5	$225,657	2.0	$84,712	$90,918
Region 6	$215,870	2.4	$83,597	$91,983
Region 7	$482,979	1.7	$134,478	$163,435
Region 8	$567,785	7.8	$169,071	$176,800
Region 9	$783,357	2.6	$218,716	$263,773

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

Table 12a. CABG without Valve: Trim Points for Average Charge, 2009

DRG GROUP	Upper Trim Point*	Outlier %	Median Charge After Trimming	Average Charge After Trimming
Group 1 (MS-DRG 231, 232)				
Region 1	$673,186	0.0	$119,424	$165,484
Region 2	$401,006	0.0	$175,835	$172,697
Region 3	**	**	**	**
Region 4	**	**	**	**
Region 5	$281,144	0.0	$102,922	$112,351
Region 6	$266,882	0.0	$97,402	$106,044
Region 7	$507,748	2.1	$183,075	$199,880
Region 8	$864,169	0.0	$225,346	$273,645
Region 9	$1,273,265	0.0	$241,800	$288,943
Group 2 (MS-DRG 233, 234)				
Region 1	$350,182	2.0	$85,431	$105,775
Region 2	$322,247	1.0	$145,075	$147,953
Region 3	$167,716	1.4	$75,159	$78,247
Region 4	$377,125	2.2	$103,845	$112,715
Region 5	$192,005	3.0	$85,124	$88,351
Region 6	$183,086	2.4	$79,141	$82,863
Region 7	$489,088	2.3	$138,021	$165,542
Region 8	$627,983	2.0	$184,484	$205,463
Region 9	$738,465	1.7	$207,013	$236,982
Group 3 (MS-DRG 228, 229, 230)				
Region 1	$906,295	0.0	$194,804	$201,487
Region 2	**	**	**	**
Region 3	$187,259	0.0	$80,827	$83,842
Region 4	**	**	**	**
Region 5	**	**	**	**
Region 6	$200,509	0.0	$98,252	$98,706
Region 7	**	**	**	**
Region 8	**	**	**	**
Region 9	**	**	**	**
Group 4 (MS-DRG 235, 236)				
Region 1	$386,298	0.9	$71,303	$97,449
Region 2	$233,876	2.1	$109,034	$110,282
Region 3	$99,960	0.0	$56,184	$58,018
Region 4	$270,574	0.9	$86,139	$94,027
Region 5	$138,972	2.4	$60,166	$63,929
Region 6	$151,127	0.4	$55,986	$62,445
Region 7	$359,275	2.0	$96,833	$120,839
Region 8	$440,384	2.7	$111,624	$136,949
Region 9	$567,588	2.5	$161,593	$189,982

* Charges of less than $10,000 were considered invalid. Therefore, with the exception of DRG Group 4 in Region 3, there were no lower trim points. The lower trim point for DRG Group 4 in Region 3 was $12,072.

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

Table 12b. Valve without CABG: Trim Points for Average Charge, 2009

DRG GROUP	Upper Trim Point*	Outlier %	Median Charge After Trimming	Average Charge After Trimming
Group 5 (MS-DRG 216, 217, 218)				
Region 1	$690,377	1.0	$142,484	$182,446
Region 2	$449,768	0.0	$207,829	$208,755
Region 3	$234,396	3.0	$102,157	$110,620
Region 4	$627,373	0.0	$156,996	$184,812
Region 5	$283,210	2.3	$112,077	$113,741
Region 6	$256,294	1.0	$92,404	$102,947
Region 7	$496,405	6.6	$189,101	$204,399
Region 8	$715,745	0.8	$209,351	$241,793
Region 9	$738,241	3.1	$233,859	$272,321
Group 6 (MS-DRG 219, 220, 221)				
Region 1	$451,167	0.8	$95,210	$124,007
Region 2	$351,619	4.3	$130,364	$135,314
Region 3	$213,579	0.0	$80,121	$90,360
Region 4	$486,275	0.0	$147,346	$163,210
Region 5	$192,209	1.6	$76,650	$84,883
Region 6	$210,771	2.9	$77,475	$83,706
Region 7	$506,785	1.5	$141,803	$162,433
Region 8	$535,045	1.5	$162,424	$184,946
Region 9	$674,078	2.0	$189,556	$233,470

* 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, 2009

DRG GROUP	Upper Trim Point*	Outlier %	Median Charge After Trimming	Average Charge After Trimming
Group 5 (MS-DRG 216, 217, 218)				
Region 1	$739,378	0.3	$143,130	$191,831
Region 2	$541,731	2.5	$221,111	$223,528
Region 3	$220,434	0.0	$112,665	$119,607
Region 4	$902,635	0.0	$185,626	$230,640
Region 5	$315,467	0.8	$122,750	$133,365
Region 6	$347,585	4.5	$125,432	$134,347
Region 7	$733,849	0.0	$224,910	$247,735
Region 8	$753,897	2.2	$238,626	$266,600
Region 9	$795,132	0.7	$281,678	$302,801
Group 6 (MS-DRG 219, 220, 221)				
Region 1	$679,427	1.1	$117,623	$167,239
Region 2	$439,336	1.1	$161,256	$170,692
Region 3	$154,868	5.1	$85,059	$88,163
Region 4	$620,891	2.1	$165,631	$174,902
Region 5	$251,188	1.8	$89,407	$98,261
Region 6	$273,614	2.7	$90,220	$100,814
Region 7	$646,866	1.5	$163,482	$198,238
Region 8	$660,130	3.0	$182,572	$203,673
Region 9	$625,491	5.8	$221,839	$239,275

* Charges of less than $10,000 were considered invalid. Therefore, with the exception of DRG Group 5, Region 3 and DRG Group 6, Region 3, there were no lower trim points. The lower trim points were $10,635 and $19,341, respectively.

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 examples illustrate how case-mix adjusted charges were computed for a hospital in Region 1 for the valve without CABG reporting group:

Example 3. *Determining Case-Mixed Average Charge for a Hospital, 2008-2009 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, 2008: $181,403
or
Region 1 - Southwestern PA, valve without CABG, DRG Group 6, 2008: $114,485
or
Region 1 - Southwestern PA, valve without CABG, DRG Group 5, 2009: $182,446
or
Region 1 - Southwestern PA, valve without CABG, DRG Group 6, 2009: $124,007

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

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

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

Example 4. *Determining Case-Mixed Average Charge for a Hospital, 2009 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, 2009: $182,446
or
Region 1 - Southwestern PA, valve without CABG, DRG Group 6, 2009: $124,007

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)

AVERAGE MEDICARE PAYMENT ANALYSIS

The Medicare payment data for 2008 was provided to PHC4 by the Centers for Medicare and Medicaid Services (CMS) and then matched by PHC4 to the cases in the cardiac surgery report. Cases were included in the Medicare payment analysis when 1) the hospital identified Medicare Fee-For-Service (FFS) as the primary payer, and 2) the case could be linked to a valid Medicare FFS payment.

Hospitals identified Medicare FFS as the primary payer for 5,808 cardiac surgery cases, of these 5,496 were matched to valid Medicare FFS payments. Invalid payments were identified by applying the interquartile range method to the CMS national average MS-DRG payment. This non-parametric methodology was used because past PHC4 analysis demonstrated that when Medicare FFS was the primary payer CMS payments were greater than $10,000. The minimum CMS national average payment for the MS-DRGs included in the cardiac surgery analysis was $18,254. Payments considered invalid were identified as follows:

Q1 = the first quartile (25th percentile average of the CMS national payment for MS-DRGs included in the cardiac surgery analysis) = $26,026

Q3 = the third quartile (75th percentile average CMS national payment for MS-DRGs included in the cardiac surgery analysis) = $37,095

IQR = Q3 – Q1 = $11,069

Invalid Payment = Q1 – (1.5 x IQR) = $9,423

In addition to the criteria above, cases could not be included in the analysis when the hospital was no longer open or the number of cases for a hospital within a particular reporting group did not comply with CMS confidentiality restrictions. The CMS confidentiality restrictions require that each average Medicare payment calculation include 13 or more cases. For example, the average Medicare payment for a hospital's CABG without Valve reporting group had to include at least 13 cases. If there were less than 13 cases, the cases were not included in the analysis.

There were 5,374 cases included in the average Medicare payment analysis. The average Medicare payment was calculated using the dollar amount that CMS provided for the Medicare Part A hospital insurance fund payment, that is, the FFS payment. Patient liabilities (e.g., coinsurance and deductible dollar amounts) were not included. The average payment was calculated by summing the Medicare FFS payment amounts for the cases in a particular reporting group and dividing the sum by the number of cases in that reporting group.

The average Medicare payment is reported for each reporting group (CABG without Valve, Valve without CABG, Valve with CABG, and Total Valve) with 13 or more cases, with one exception: if the number of cases included in the payment analysis for either the Valve without CABG or the Valve with CABG reporting group is less than 13, payment data for both of these reporting groups will not be reported.

Hospitals were given an opportunity to verify the average Medicare payment reported for their facilities prior to the public release of the information.

APPENDICES

APPENDIX A: EXCLUSION DEFINTIONS

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

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 internal biventricular heart replacement system
37.53	Replacement or repair of thoracic unit of total replacement heart system
41.00	Bone marrow transplant, not otherwise specified
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. Exclusions: CABG *without* Valve (ICD-9-CM Clinical Complexity Codes)

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

Code Type	Code Position	ICD-9-CM Code	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

APPENDIX A: EXCLUSION DEFINTIONS *continued*

Table B1. Exclusions: CABG *without* Valve (ICD-9-CM Clinical Complexity Codes)

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

Code Type	Code Position	ICD-9-CM Code and Description	
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	37.36⌗	Excision or destruction of left atrial appendage (LAA)
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
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

⌗ Effective 10/01/2008

APPENDIX A: EXCLUSION DEFINTIONS *continued*

Table B2. Exclusions: Valve *without* CABG (ICD-9-CM Clinical Complexity Codes)

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	277.30/425.7	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

* 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 B2. Exclusions: Valve *without* CABG (ICD-9-CM Clinical Complexity Codes)

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	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

EXCLUSIONS CONTINUED ON NEXT PAGE

APPENDIX A: EXCLUSION DEFINTIONS *continued*

Table B3. Exclusions: Valve *with* CABG (ICD-9-CM Clinical Complexity Codes)

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 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
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	277.30 /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

* 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 B3. Exclusions: Valve *with* CABG (ICD-9-CM Clinical Complexity Codes)

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	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

DRG CRITERIA ON NEXT PAGE

APPENDIX A: EXCLUSION DEFINTIONS *continued*

Table C1. DRG Criteria for Study Population Definition (Quarter 1, 2008 – Quarter 4, 2009)

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 and MDC 5[1]	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
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 and MDC 5[1]	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

[1] Major Diagnostic Category (MDC) 5: Diseases and Disorders of the Circulatory System

APPENDIX A: EXCLUSION DEFINTIONS *continued*

Table C1. DRG Criteria for Study Population Definition (Quarter 1, 2008 – Quarter 4, 2009)

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 and MDC 5[1]	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

[1] Major Diagnostic Category (MDC) 5: Diseases and Disorders of the Circulatory System

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	
	#	%	#	%
2008-2009 Data				
Total cases prior to in-hospital mortality exclusions	34,949	100.0	1,071	3.1
Exclusions:				
• *Patients < 30 years of age*	*235*	*0.7*	*4*	*1.7*
• *Patients who left against medical advice*	*23*	*0.1*	*0*	*0.0*
• *Clinically complex cases*[1]	*3,735*	*10.7*	*291*	*7.8*
Total exclusions	*3,993*	*11.4*	*295*	*7.4*
Total cases remaining in analysis	**30,956**	**88.6**	**776**	**2.5**
2009 Data				
Total cases prior to in-hospital mortality exclusions	17,275	100.0	497	2.9
Exclusions:				
• *Patients < 30 years of age*	*103*	*0.6*	*1*	*1.0*
• *Patients who left against medical advice*	*17*	*0.1*	*0*	*0.0*
• *Clinically complex cases*[1]	*1,830*	*10.6*	*141*	*7.7*
Total exclusions	*1,950*	*11.3*	*142*	*7.3*
Total cases remaining in analysis	**15,325**	**88.7**	**355**	**2.3**

[1] Clinically complex cases included organ transplant cases (see Appendix A: Table A), clinically complex cases based on ICD-9-CM codes (see Appendix A: Tables B1, B2, and B3), cases *not* in the study DRGs (See Appendix A: Tables C1 and C2 for DRGs included in the study), and cases granted special request for exclusion.

Table B. Exclusions for Operative Mortality Analysis

	Cases		Operative Mortality	
	#	%	#	%
2008-2009 Data				
Total cases after in-hospital mortality exclusions	30,956	100.0	–	–
Additional Exclusions:				
• *Cases with invalid/inconsistent data*[1]	*192*	*0.6*	–	–
• *Out-of state residents*[2]	*2,834*	*9.2*	–	–
Total exclusions	*3,026*	*9.8*	–	–
Total cases remaining in analysis	**27,930**	**90.2**	**841**	**3.0**
2009 Data				
Total cases after in-hospital mortality exclusions	15,325	100.0	–	–
Additional Exclusions:				
• *Cases with invalid/inconsistent data*[1]	*89*	*0.6*	–	–
• *Out-of state residents*[2]	*1,366*	*8.9*	–	–
Total exclusions	*1,455*	*9.5*	–	–
Total cases remaining in analysis	**13,870**	**90.5**	**399**	**2.9**

[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	
	#	%	#	%	#	%
2008-2009 Data						
Total cases after in-hospital mortality exclusions	30,956	100.0	–	–	–	–
Additional exclusions:						
• *Patients who died during hospitalization in which surgery was performed*	*776*	*2.5*	–	–	–	–
• *Cases with invalid data*[1]	*182*	*0.6*	–	–	–	–
• *Out-of state residents*[2]	*2,738*	*8.8*	–	–	–	–
Total exclusions	*3,696*	*11.9*	–	–	–	–
Total cases remaining in analysis	**27,260**	**88.1**	**1,792**	**6.6**	**4,250**	**15.6**
2009 Data						
Total cases after in-hospital mortality exclusions	15,325	100.0	–	–	–	–
Additional exclusions:						
• *Patients who died during hospitalization in which surgery was performed*	*355*	*2.3*	–	–	–	–
• *Cases with invalid/inconsistent data*[1]	*87*	*0.6*	–	–	–	–
• *Out-of state residents*[2]	*1,321*	*8.6*	–	–	–	–
Total exclusions	*1,763*	*11.5*	–	–	–	–
Total cases remaining in analysis	**13,562**	**88.5**	**861**	**6.3**	**2,042**	**15.1**

[1] Cases with invalid data (i.e., social security number, date of birth, or sex) 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 state of residence and be readmitted to a hospital in their home state. 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
	#	%	
2008-2009 Data			
Total cases after in-hospital mortality exclusions	30,956	100.0	7.8
Additional exclusions:			
• *Patients who died during hospitalization in which surgery was performed*	*776*	*2.5*	*12.1*
• *Cases that were length of stay outliers*[1]	*267*	*0.9*	*42.9*
Total exclusions	*1,043*	*3.4*	*20.0*
Total cases remaining in analysis	**29,913**	**96.6**	**7.4**
2009 Data			
Total cases after in-hospital mortality exclusions	15,325	100.0	7.8
Additional exclusions:			
• *Patients who died during hospitalization in which surgery was performed*	*355*	*2.3*	*10.8*
• *Cases that were length of stay outliers*[1]	*119*	*0.8*	*41.4*
Total exclusions	*474*	*3.1*	*18.5*
Total cases remaining in analysis	**14,851**	**96.9**	**7.5**

[1] Length of stay outliers include those cases with post-surgical lengths of stay as follows: CABG without Valve – less than two days or greater than 30 days; Valve without CABG – less than three days or greater than 50 days; Valve with CABG – less than three days or greater than 50 days.

APPENDIX B: EXCLUSION DATA *continued*

Table E. *Exclusions for Average Hospital Charge Analysis*

	Cases		Average Charge
	#	%	
2008-2009 Data			
Total cases after in-hospital mortality exclusions	30,956	100.0	$160,580
Additional exclusions:			
• *Patients with invalid or missing charges*[1]	*1*	*<0.1*	*$9,105*
• *Case in tracheostomy DRGs*[2]	*716*	*2.3*	*$589,087*
• *Cases in low volume DRGs*[3]	*317*	*1.0*	*$418,048*
• *Cases that were charge outliers*[4]	*573*	*1.9*	*$545,171*
Total exclusions	*1,607*	*5.2*	
Total cases remaining in analysis	**29,349**	**94.8**	**$139,842**
2008 Data			
Total cases after in-hospital mortality exclusions	15,631	100.0	$157,190
Additional exclusions:			
• *Patients with invalid or missing charges*[1]	*1*	*<0.1*	*$9,105*
• *Case in tracheostomy DRGs*[2]	*381*	*2.4*	*$594,504*
• *Cases in low volume DRGs*[3]	*180*	*1.2*	*$408,212*
• *Cases that were charge outliers*[4]	*305*	*2.0*	*$530,517*
Total exclusions	*867*	*5.5*	
Total cases remaining in analysis	**14,764**	**94.5**	**$135,142**
2009 Data			
Total cases after in-hospital mortality exclusions	15,325	100.0	$164,038
Additional exclusions:			
• *Patients with invalid or missing charges*[1]	*0*	*0.0*	
• *Case in tracheostomy DRGs*[2]	*335*	*2.2*	*$582,926*
• *Cases in low volume DRGs*[3]	*137*	*0.9*	*$430,970*
• *Cases that were charge outliers*[4]	*268*	*1.7*	*$561,849*
Total exclusions	*740*	*4.8*	
Total cases remaining in analysis	**14,585**	**95.2**	**$144,599**

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

[2] Tracheostomy cases were assigned to MS-DRG 003 and MDC 5.

[3] DRGs with low volume and DRGs when a particular combination of region, procedure type, and DRG had less than 10 cases.

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

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, 414.3

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

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

453.6[1], 453.8[2], 453.81[1], 453.82[1], 453.83[1], 453.84[1], 453.85[1], 453.86[1], 453.87[1], 453.89[1], 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, 511.89, 511.9, 518.0

Pneumothorax

Pneumothorax

512.0, 512.8

Postoperative Pneumothorax

512.1

Pulmonary Edema

514, 518.4, 518.5

[1] Effective 10/1/2009
[2] Invalid 10/1/2009

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, 519.19, 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

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, 599.70, 599.71, 599.72, 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, 997.39

Digestive System Complication

536.40, 536.42, 536.49, 997.4

Urinary System Complication

997.5

Other Complications

998.89, 998.9, 999.82, 999.88, 999.89

INFECTIONS

Postoperative Infections

997.31, 998.51, 998.59, 999.31, 999.39

Sepsis and Bacteremia

038.0, 038.10, 038.11, 038.12, 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, 482.42, 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

Intestinal Infection due to Clostridium difficile

008.45

APPENDIX C: REASONS FOR READMISSION DEFINITIONS *continued*

Other Infection Related Conditions and Symptoms

567.21, 567.29, 567.9, 590.2, 780.60, 780.61, 780.62

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, 289.84, 446.6

Other Coagulation Defects

286.6, 286.7, 286.9, 289.82, 790.92

APPENDIX D: READMISSIONS DATA

2008 – 2009 Data	7-Day N = 1,792 6.6%		30-Day N = 4,250 15.6%	
	#	%	#	%
CIRCULATORY SYSTEM	**860**	**48.0**	**2,059**	**48.4**
Cardiac Dysrhythmias	156	8.7	380	8.9
Heart Block	3	0.2	10	0.2
Paroxysmal Tachycardia	13	0.7	29	0.7
Atrial Fibrillation and Atrial Flutter	112	6.3	279	6.6
Ventricular Fibrillation and Ventricular Flutter	6	0.3	8	0.2
Premature Heart Beats	1	0.1	1	0.0
Other Cardiac Dysrhythmias	21	1.2	53	1.2
Heart Failure	293	16.4	593	14.0
Functional Disturbances Follow Cardiac Surgery (Postcardiotomy Syndrome)	55	3.1	127	3.0
Hypertension and Hypotension	34	1.9	90	2.1
Essential Hypertension	1	0.1	4	0.1
Hypertensive Heart Disease	4	0.2	10	0.2
Hypertensive Chronic Kidney Disease	1	0.1	5	0.1
Hypertensive Heart and Chronic Kidney Disease	3	0.2	6	0.1
Secondary Hypertension	0	0.0	0	0.0
Hypotension	25	1.4	65	1.5
Myocardial Infarction and Ischemia	20	1.1	79	1.9
Acute Myocardial Infarction, Initial Episode	15	0.8	63	1.5
Acute Myocardial Infarction, Unspecified or Subsequent Episode	2	0.1	3	0.1
Other Forms of Myocardial Ischemia	3	0.2	13	0.3
Angina Pectoris and Chest Pain	249	13.9	589	13.9
Atherosclerosis	12	0.7	62	1.5
Coronary Atherosclerosis	10	0.6	53	1.2
Other Atherosclerosis	2	0.1	9	0.2
Heart Aneurysm and Dissection	0	0.0	0	0.0
Pericarditis, Endocarditis and Myocarditis	17	0.9	50	1.2
Heart Valve Disease	0	0.0	6	0.1
Mitral Valve Disease	0	0.0	4	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	1	0.0
Other Endocardial Structure Disease	0	0.0	1	0.0
Cardiomyopathies	1	0.1	1	0.0
Other Aneurysm and Dissection	2	0.1	6	0.1

APPENDIX D: READMISSIONS DATA *continued*

2008 – 2009 Data	7-Day N = 1,792 6.6%		30-Day N = 4,250 15.6%	
	#	%	#	%
Aortic Aneurysm and Dissection	1	0.1	4	0.1
Other Arterial Aneurysm	1	0.1	2	0.0
Other Arterial Dissection	0	0.0	0	0.0
Arterial Embolism and Thrombosis	2	0.1	7	0.2
Abdominal and Thoracic Aorta	0	0.0	0	0.0
Arteries of the Extremities	2	0.1	6	0.1
Other Arteries Excluding Precerebral and Cerebral Arteries	0	0.0	1	0.0
Venous Embolism and Thrombosis	12	0.7	41	1.0
Lower Extremity Venous Embolism and Thrombosis	10	0.6	34	0.8
Renal Vein Embolism and Thrombosis	0	0.0	0	0.0
Other Venous Embolism and Thrombosis	2	0.1	7	0.2
Phlebitis and Thrombophlebitis	2	0.1	3	0.1
Lower Extremity Phlebitis and Thrombophlebitis	1	0.1	2	0.0
Upper Extremity Phlebitis and Thrombophlebitis	1	0.1	1	0.0
Other Vessel Phlebitis and Thrombophlebitis	0	0.0	0	0.0
Occlusion and Stenosis	2	0.1	13	0.3
Precerebral Artery Occlusion and Stenosis	0	0.0	0	0.0
Cerebral Artery Occlusion and Stenosis	1	0.1	12	0.3
Retinal Artery Occlusion and Visual Loss	1	0.1	1	0.0
Other Diseases and Symptoms of the Circulatory System	3	0.2	12	0.3
RESPIRATORY SYSTEM	**193**	**10.8**	**425**	**10.0**
Pulmonary Embolism and Infarction	48	2.7	98	2.3
Pulmonary Embolism and Infarction	32	1.8	65	1.5
Postoperative Pulmonary Embolism and Infarction	16	0.9	33	0.8
Pleural Effusion and Atelectasis	79	4.4	205	4.8
Pneumothorax	7	0.4	12	0.3
Pneumothorax	2	0.1	3	0.1
Postoperative Pneumothorax	5	0.3	9	0.2
Pulmonary Edema	5	0.3	9	0.2
Acute Respiratory Failure	27	1.5	59	1.4
Other Diseases and Symptoms of the Respiratory System	27	1.5	42	1.0
NERVOUS SYSTEM	**142**	**7.9**	**298**	**7.0**
Stroke	110	6.1	226	5.3
Ischemic Stroke	30	1.7	51	1.2
Hemorrhagic Stroke	2	0.1	6	0.1
Transient Cerebral Ischemia	74	4.1	164	3.9
Postoperative Stroke	4	0.2	5	0.1

APPENDIX D: READMISSIONS DATA *continued*

2008 – 2009 Data	7-Day N = 1,792 6.6%		30-Day N = 4,250 15.6%	
	#	%	#	%
Encephalopathies	1	0.1	4	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	0	0.0	0	0.0
Postoperative Pain	10	0.6	13	0.3
Other Diseases and Symptoms of the Nervous System	21	1.2	55	1.3
DIGESTIVE SYSTEM	**54**	**3.0**	**127**	**3.0**
Ischemic Bowel and Vascular Insufficiency of the Intestine	4	0.2	5	0.1
Intestinal Obstruction and Ileus	7	0.4	9	0.2
Ulceration, Bleeding and Perforation of the Digestive System	35	2.0	88	2.1
Acute Liver Failure	0	0.0	1	0.0
Other Diseases and Symptoms of the Digestive System	8	0.4	24	0.6
URINARY SYSTEM	**27**	**1.5**	**83**	**2.0**
Acute Glomerulonephritis and Pyelonephritis	0	0.0	3	0.1
Nephrotic Syndrome	0	0.0	0	0.0
Acute Renal Failure	22	1.2	69	1.6
Other Diseases and Symptoms of the Urinary System	5	0.3	11	0.3
COMPLICATIONS OF SURGICAL AND MEDICAL CARE	**227**	**12.7**	**418**	**9.8**
Mechanical Complication of Cardiac Device, Implant and Graft	4	0.2	12	0.3
Mechanical Complication of Cardiac Pacemaker and AICD	3	0.2	8	0.2
Mechanical Complication of Heart Valve Prosthesis	0	0.0	0	0.0
Mechanical Complication of Coronary Artery Bypass Graft	1	0.1	2	0.0
Other and Unspecified Mechanical Complication	0	0.0	2	0.0
Other Complication of Internal Prosthetic Device, Implant and Graft	11	0.6	24	0.6
Other Complication of Heart Valve Prosthesis	0	0.0	5	0.1
Other Complication of Other Cardiac Device, Implant and Graft	9	0.5	15	0.4
Other Complication of Vascular Device, Implant and Graft	2	0.1	4	0.1
Shock	2	0.1	2	0.0
Postoperative Shock	0	0.0	0	0.0
Cardiogenic Shock	1	0.1	1	0.0
Other Shock	1	0.1	1	0.0
Hemorrhage and Hematoma Complicating a Procedure	21	1.2	41	1.0
Foreign Body Accidentally Left or Accidental Laceration During a Procedure	0	0.0	0	0.0
Dehiscence and Rupture of Operation Wound	21	1.2	56	1.3
Other Complications of Surgical and Medical Care	168	9.4	283	6.7
Nervous System Complication	1	0.1	2	0.0

APPENDIX D: READMISSIONS DATA *continued*

2008 – 2009 Data	7-Day N = 1,792 6.6%		30-Day N = 4,250 15.6%	
	#	%	#	%
Circulatory System Complication	106	5.9	164	3.9
Respiratory System Complication	49	2.7	94	2.2
Digestive System Complication	5	0.3	7	0.2
Urinary System Complication	1	0.1	4	0.1
Other Complications	6	0.3	12	0.3
INFECTIONS	**243**	**13.6**	**726**	**17.1**
Postoperative Infections	95	5.3	346	8.1
Sepsis and Bacteremia	49	2.7	98	2.3
Pneumonia	50	2.8	127	3.0
Pneumonia	41	2.3	105	2.5
Aspiration Pneumonia	9	0.5	22	0.5
Empyema and Abscess of Lung	1	0.1	2	0.0
Infection due to Device, Implant and Graft	2	0.1	20	0.5
Cardiac Device, Implant and Graft	2	0.1	15	0.4
Vascular Device, Implant and Graft	0	0.0	5	0.1
Other and Unspecified Infections due to Device, Implant and Graft	0	0.0	0	0.0
Urinary Tract Infection	19	1.1	43	1.0
Cellulitis	6	0.3	30	0.7
Osteomyelitis	0	0.0	1	0.0
Intestinal Infection due to Clostridium difficile	10	0.6	39	0.9
Other Infection Related Conditions and Symptoms	11	0.6	20	0.5
FLUID AND ELECTROLYTE IMBALANCE	**19**	**1.1**	**58**	**1.4**
Hyperosmolality and Hyposmolality	2	0.1	4	0.1
Acidosis and Alkalosis	1	0.1	1	0.0
Dehydration and Hypovolemia	10	0.6	40	0.9
Fluid Overload	2	0.1	5	0.1
Hyperpotassemia and Hypopotassemia	4	0.2	8	0.2
Other Electrolyte and Fluid Disorders	0	0.0	0	0.0
ANEMIA AND COAGULATION DEFECTS	**27**	**1.5**	**56**	**1.3**
Anemia	18	1.0	29	0.7
Acute Posthemorrhagic Anemia	7	0.4	12	0.3
Anemia	11	0.6	17	0.4
Coagulation Defects	9	0.5	27	0.6
Hemorrhagic Disorders due to Anticoagulants	0	0.0	0	0.0
Thrombocytopenia	2	0.1	5	0.1
Other Coagulation Defects	7	0.4	22	0.5

APPENDIX D: READMISSIONS DATA *continued*

2009 Data	7-Day N = 861 6.3%		30-Day N = 2,042 15.1%	
	#	%	#	%
CIRCULATORY SYSTEM	**360**	**41.8**	**858**	**42.0**
Cardiac Dysrhythmias	88	10.2	221	10.8
Heart Block	1	0.1	6	0.3
Paroxysmal Tachycardia	4	0.5	14	0.7
Atrial Fibrillation and Atrial Flutter	65	7.5	164	8.0
Ventricular Fibrillation and Ventricular Flutter	4	0.5	6	0.3
Premature Heart Beats	1	0.1	1	0.0
Other Cardiac Dysrhythmias	13	1.5	30	1.5
Heart Failure	160	18.6	319	15.6
Functional Disturbances Follow Cardiac Surgery (Postcardiotomy Syndrome)	25	2.9	56	2.7
Hypertension and Hypotension	18	2.1	51	2.5
Essential Hypertension	0	0.0	2	0.1
Hypertensive Heart Disease	0	0.0	4	0.2
Hypertensive Chronic Kidney Disease	0	0.0	3	0.1
Hypertensive Heart and Chronic Kidney Disease	3	0.3	6	0.3
Secondary Hypertension	0	0.0	0	0.0
Hypotension	15	1.7	36	1.8
Myocardial Infarction and Ischemia	12	1.4	42	2.1
Acute Myocardial Infarction, Initial Episode	10	1.2	36	1.8
Acute Myocardial Infarction, Unspecified or Subsequent Episode	1	0.1	1	0.0
Other Forms of Myocardial Ischemia	1	0.1	5	0.2
Angina Pectoris and Chest Pain	28	3.3	56	2.7
Atherosclerosis	9	1.0	37	1.8
Coronary Atherosclerosis	7	0.8	31	1.5
Other Atherosclerosis	2	0.2	6	0.3
Heart Aneurysm and Dissection	0	0.0	0	0.0
Pericarditis, Endocarditis and Myocarditis	11	1.3	29	1.4
Heart Valve Disease	0	0.0	2	0.1
Mitral Valve Disease	0	0.0	2	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	0	0.0
Other Aneurysm and Dissection	1	0.1	4	0.2
Aortic Aneurysm and Dissection	1	0.1	4	0.2

APPENDIX D: READMISSIONS DATA *continued*

2009 Data	7-Day N = 861 6.3%		30-Day N = 2,042 15.1%	
	#	%	#	%
Other Arterial Aneurysm	0	0.0	0	0.0
Other Arterial Dissection	0	0.0	0	0.0
Arterial Embolism and Thrombosis	0	0.0	3	0.1
Abdominal and Thoracic Aorta	0	0.0	0	0.0
Arteries of the Extremities	0	0.0	3	0.1
Other Arteries Excluding Precerebral and Cerebral Arteries	0	0.0	0	0.0
Venous Embolism and Thrombosis	5	0.6	24	1.2
Lower Extremity Venous Embolism and Thrombosis	3	0.3	20	1.0
Renal Vein Embolism and Thrombosis	0	0.0	0	0.0
Other Venous Embolism and Thrombosis	2	0.2	4	0.2
Phlebitis and Thrombophlebitis	1	0.1	2	0.1
Lower Extremity Phlebitis and Thrombophlebitis	0	0.0	1	0.0
Upper Extremity Phlebitis and Thrombophlebitis	1	0.1	1	0.0
Other Vessel Phlebitis and Thrombophlebitis	0	0.0	0	0.0
Occlusion and Stenosis	1	0.1	7	0.3
Precerebral Artery Occlusion and Stenosis	0	0.0	0	0.0
Cerebral Artery Occlusion and Stenosis	0	0.0	6	0.3
Retinal Artery Occlusion and Visual Loss	1	0.1	1	0.0
Other Diseases and Symptoms of the Circulatory System	1	0.1	5	0.2
RESPIRATORY SYSTEM	**104**	**12.1**	**236**	**11.6**
Pulmonary Embolism and Infarction	30	3.5	55	2.7
Pulmonary Embolism and Infarction	21	2.4	40	2.0
Postoperative Pulmonary Embolism and Infarction	9	1.0	15	0.7
Pleural Effusion and Atelectasis	39	4.5	120	5.9
Pneumothorax	2	0.2	7	0.3
Pneumothorax	1	0.1	2	0.1
Postoperative Pneumothorax	1	0.1	5	0.2
Pulmonary Edema	4	0.5	5	0.2
Acute Respiratory Failure	14	1.6	29	1.4
Other Diseases and Symptoms of the Respiratory System	15	1.7	20	1.0
NERVOUS SYSTEM	**48**	**5.6**	**94**	**4.6**
Stroke	29	3.4	51	2.5
Ischemic Stroke	22	2.6	37	1.8
Hemorrhagic Stroke	0	0.0	2	0.1
Transient Cerebral Ischemia	4	0.5	8	0.4
Postoperative Stroke	3	0.3	4	0.2
Encephalopathies	0	0.0	3	0.1

APPENDIX D: READMISSIONS DATA *continued*

2009 Data	7-Day N = 861 6.3%		30-Day N = 2,042 15.1%	
	#	%	#	%
Cerebral Edema and Brain Compression	0	0.0	0	0.0
Anoxic Brain Damage	0	0.0	0	0.0
Coma and Stupor	0	0.0	0	0.0
Postoperative Pain	8	0.9	10	0.5
Other Diseases and Symptoms of the Nervous System	11	1.3	30	1.5
DIGESTIVE SYSTEM	**26**	**3.0**	**70**	**3.4**
Ischemic Bowel and Vascular Insufficiency of the Intestine	1	0.1	1	0.0
Intestinal Obstruction and Ileus	3	0.3	4	0.2
Ulceration, Bleeding and Perforation of the Digestive System	19	2.2	54	2.6
Acute Liver Failure	0	0.0	0	0.0
Other Diseases and Symptoms of the Digestive System	3	0.3	11	0.5
URINARY SYSTEM	**14**	**1.6**	**44**	**2.2**
Acute Glomerulonephritis and Pyelonephritis	0	0.0	2	0.1
Nephrotic Syndrome	0	0.0	0	0.0
Acute Renal Failure	12	1.4	37	1.8
Other Diseases and Symptoms of the Urinary System	2	0.2	5	0.2
COMPLICATIONS OF SURGICAL AND MEDICAL CARE	**143**	**16.6**	**252**	**12.3**
Mechanical Complication of Cardiac Device, Implant and Graft	2	0.2	8	0.4
Mechanical Complication of Cardiac Pacemaker and AICD	2	0.2	5	0.2
Mechanical Complication of Heart Valve Prosthesis	0	0.0	0	0.0
Mechanical Complication of Coronary Artery Bypass Graft	0	0.0	1	0.0
Other and Unspecified Mechanical Complication	0	0.0	2	0.1
Other Complication of Internal Prosthetic Device, Implant and Graft	4	0.5	11	0.5
Other Complication of Heart Valve Prosthesis	0	0.0	3	0.1
Other Complication of Other Cardiac Device, Implant and Graft	3	0.3	6	0.3
Other Complication of Vascular Device, Implant and Graft	1	0.1	2	0.1
Shock	2	0.2	2	0.1
Postoperative Shock	0	0.0	0	0.0
Cardiogenic Shock	1	0.1	1	0.0
Other Shock	1	0.1	1	0.0
Hemorrhage and Hematoma Complicating a Procedure	16	1.9	31	1.5
Foreign Body Accidentally Left or Accidental Laceration During a Procedure	0	0.0	0	0.0
Dehiscence and Rupture of Operation Wound	15	1.7	30	1.5
Other Complications of Surgical and Medical Care	104	12.1	170	8.3
Nervous System Complication	1	0.1	1	0.0
Circulatory System Complication	66	7.7	103	5.0

APPENDIX D: READMISSIONS DATA *continued*

2009 Data	7-Day N = 861 6.3%		30-Day N = 2,042 15.1%	
	#	%	#	%
Respiratory System Complication	27	3.1	50	2.4
Digestive System Complication	5	0.6	6	0.3
Urinary System Complication	1	0.1	3	0.1
Other Complications	4	0.5	7	0.3
INFECTIONS	**138**	**16.0**	**423**	**20.7**
Postoperative Infections	45	5.2	193	9.5
Sepsis and Bacteremia	29	3.4	60	2.9
Pneumonia	32	3.7	72	3.5
Pneumonia	23	2.7	56	2.7
Aspiration Pneumonia	9	1.0	16	0.8
Empyema and Abscess of Lung	0	0.0	0	0.0
Infection due to Device, Implant and Graft	1	0.1	15	0.7
Cardiac Device, Implant and Graft	1	0.1	11	0.5
Vascular Device, Implant and Graft	0	0.0	4	0.2
Other and Unspecified Infections due to Device, Implant and Graft	0	0.0	0	0.0
Urinary Tract Infection	13	1.5	25	1.2
Cellulitis	5	0.6	22	1.1
Osteomyelitis	0	0.0	1	0.0
Intestinal Infection due to Clostridium difficile	5	0.6	19	0.9
Other Infection Related Conditions and Symptoms	8	0.9	16	0.8
FLUID AND ELECTROLYTE IMBALANCE	**8**	**0.9**	**29**	**1.4**
Hyperosmolality and Hyposmolality	2	0.2	3	0.1
Acidosis and Alkalosis	0	0.0	0	0.0
Dehydration and Hypovolemia	5	0.6	20	1.0
Fluid Overload	1	0.1	3	0.1
Hyperpotassemia and Hypopotassemia	0	0.0	3	0.1
Other Electrolyte and Fluid Disorders	0	0.0	0	0.0
ANEMIA AND COAGULATION DEFECTS	**20**	**2.3**	**36**	**1.8**
Anemia	12	1.4	18	0.9
Acute Posthemorrhagic Anemia	6	0.7	10	0.5
Anemia	6	0.7	8	0.4
Coagulation Defects	8	0.9	18	0.9
Hemorrhagic Disorders due to Anticoagulants	0	0.0	0	0.0
Thrombocytopenia	2	0.2	3	0.1
Other Coagulation Defects	6	0.7	15	0.7

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	2008-2009 Models		2009 Models	
Year Calendar year in which surgery was performed.	In-Hospital M		In-Hospital M	
	Operative M		Operative M	
	7-Day R		7-Day R	
	30-Day R	✓	30-Day R	
	PS-LOS	T	PS-LOS	
Demographic Variables				
Age in Years This continuous variable is the patient's age in years.	In-Hospital M	✓	In-Hospital M	T
	Operative M	✓	Operative M	T
	7-Day R	T	7-Day R	T
	30-Day R	✓	30-Day R	T
	PS-LOS	✓	PS-LOS	✓
Age # Years > 65 This continuous variable is the number of years that the patient is over age 65.	In-Hospital M	T	In-Hospital M	T
	Operative M	T	Operative M	T
	7-Day R	✓	7-Day R	✓
	30-Day R	✓	30-Day R	✓
	PS-LOS	✓	PS-LOS	✓
Female	In-Hospital M	T	In-Hospital M	T
	Operative M	T	Operative M	T
	7-Day R	✓	7-Day R	✓
	30-Day R	✓	30-Day R	✓
	PS-LOS	✓	PS-LOS	✓
Race/Ethnicity *Category 1:* Hispanic *Category 2:* White, non-Hispanic *Category 3:* Black, non-Hispanic *Category 4:* Other/Unknown	In-Hospital M		In-Hospital M	
	Operative M		Operative M	
	7-Day R		7-Day R	
	30-Day R		30-Day R	
	PS-LOS	✓	PS-LOS	✓
Race (category) *Category 1:* White *Category 2:* Black *Category 3:* Other/Unknown	In-Hospital M	✓	In-Hospital M	
	Operative M		Operative M	
	7-Day R	✓	7-Day R	T
	30-Day R	✓	30-Day R	✓
	PS-LOS		PS-LOS	
Clinical Variables				
Acute Myocardial Infarction 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	✓	In-Hospital M	T
	Operative M	T	Operative M	T
	7-Day R		7-Day R	
	30-Day R		30-Day R	
	PS-LOS	T	PS-LOS	T
Anemia 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, 284.01, 284.09, 284.1, 284.2, 284.81, 284.89 284.9, 285.0, 285.21, 285.22, 285.29, 285.3‡‡ 285.8, 285.9.	In-Hospital M		In-Hospital M	
	Operative M		Operative M	
	7-Day R		7-Day R	
	30-Day R	T	30-Day R	T
	PS-LOS	✓	PS-LOS	✓

‡‡ Effective 10/1/2009

_✓_ = 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	2008-2009 Models	2009 Models
Angina 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 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
Atlas Predicted LOS (continuous) [A]	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 ✓
Atlas Predicted Probability of Death (continuous) [A]	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 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 **T** 30-Day R **T** PS-LOS ✓	In-Hospital M ✓ Operative M ✓ 7-Day R **T** 30-Day R **T** PS-LOS ✓
Cancer Any of the following codes in any position in PHC4 data: Malignant neoplasms including primary and secondary (140.0-209.36, 209.70-209.79[1]), Cancer In Situ and Neoplasms of Uncertain Behavior (230.0-239.9[2]).	In-Hospital M Operative M **T** 7-Day R 30-Day R ✓ PS-LOS ✓	In-Hospital M **T** Operative M **T** 7-Day R 30-Day R ✓ PS-LOS ✓
Cardiac Adhesions The following code in any position in PHC4 data: 423.1 (Adhesive Pericarditis).	In-Hospital M Operative M **T** 7-Day R **T** 30-Day R PS-LOS **T**	In-Hospital M Operative M T 7-Day R T 30-Day R T PS-LOS
Cardiogenic Shock, Preoperative The following code in any position in PHC4 data: 785.51. *and* Chart review to determine that the cardiogenic shock was present prior to the CABG/valve surgery.	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 ✓
Cardiomyopathy 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 ✓ 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 **T** PS-LOS **T**
Cardiopulmonary Resuscitation (CPR) Prior to CABG/Valve Surgery Date 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 **T**	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS **T**

[1] This range includes new codes effective 10/1/2009: 209.3x, 209.7x and 10/1/2008: 209.0x, 209.1x, 209.2x, 209.3x.

[2] This range includes new codes effective 10/1/2009: 239.81-239.89

[A] This variable was based on data obtained from Atlas.

_✓_ = 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	2008-2009 Models	2009 Models
Cerebrovascular Disease 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 **T** PS-LOS _____	In-Hospital M _____ Operative M _____ 7-Day R _____ 30-Day R _____ PS-LOS **T**
Chronic Lung Disease 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 _____ Operative M _____ 7-Day R ✓ 30-Day R ✓ PS-LOS ✓	In-Hospital M _____ Operative M **T** 7-Day R **T** 30-Day R _____ PS-LOS ✓
Chronic Pulmonary Hypertension 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 **T** Operative M **T** 7-Day R **T** 30-Day R **T** PS-LOS **T**
Coagulopathy 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 _____
Depression 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) *Category 1:* No diabetes *Category 2:* Diabetes without complications, as indicated by code 249.0x‡ or 250.0x in any position in PHC4 data. *Category 3:* Diabetes with complications, as indicated by any code in the range 249.1x – 249.9x‡ or 250.1x – 250.9x 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 **T** PS-LOS _____
Diabetes With Long-Term/Unspecified Complications Diabetes with long-term or unspecified complications, as indicated by any code in the range 249.4x-249.9x‡ or 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 **T** 30-Day R _____ PS-LOS ✓
Excision or Other Lesion/Heart Tissue/LAA, Open Approach – Same Date as Valve with or without CABG The presence of code 37.33 or 37.36‡ in any position in PHC4 data with a procedure date on the same date as the valve surgery. Note: Procedure code 37.33 or 37.36 date should be the <u>same day</u> 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 **T** Operative M _____ 7-Day R **T** 30-Day R **T** PS-LOS **T**	In-Hospital M **T** Operative M _____ 7-Day R _____ 30-Day R _____ PS-LOS **T**
Fibrosis in Mediastinum and Heart Any of the following codes in any position in PHC4 data: 429.0, 429.1, 519.3.	In-Hospital M _____ Operative M _____ 7-Day R _____ 30-Day R _____ PS-LOS **T**	In-Hospital M _____ Operative M _____ 7-Day R _____ 30-Day R _____ PS-LOS _____
Heart Failure 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 <u>and</u> 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 **T** Operative M ✓ 7-Day R **T** 30-Day R ✓ PS-LOS ✓	In-Hospital M **T** Operative M ✓ 7-Day R **T** 30-Day R **T** PS-LOS ✓

‡ Effective 10/1/2008

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APPENDIX E: DEFINITIONS FOR POTENTIAL CANDIDATE VARIABLES *continued*

Variable Definitions	2008-2009 Models		2009 Models	
History of CABG or Valve Surgery 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 PS-LOS	**T** **T** ✓ ✓	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS	**T** **T** **T** ✓
History of a Cerebral Vascular Accident (CVA) or Stroke Any of the following codes in any position in PHC4 data: 438.0, 438.10, 438.11, 438.12, 438.13‡‡, 438.14‡‡, 438.19, 438.20, 438.21, 438.22, 438.30, 438.31, 438.32, 438.40, 438.41, 438.42, 438.50, 438.51, 438.52, 438.53, 438.6, 438.7, 438.81, 438.82, 438.83, 438.84, 438.85, 438.89, 438.9, V12.54	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS	 ✓ **T**	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS	 **T** **T** **T**
History of Chronic Steroid Use 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	 ✓ **T** 	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS	 **T**
History of Peripheral Vascular Disease 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 30-Day R PS-LOS	**T** **T** **T** **T**	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS	 **T**
History of PTCA/Stent 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	
Hypercholesterolemia 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 Any of the following codes in any position in PHC4 data: 401.0, 401.1, 401.9.	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	
Hypertension with Complications Any of the following codes in any position in PHC4 data: 402.xx, 403.xx, 404.xx, 405.xx.	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS	**T** **T** ✓ ✓ ✓	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS	**T** ✓ ✓ ✓ ✓
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery 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 7-Day R 30-Day R PS-LOS	✓ ✓ ✓	In-Hospital M Operative M 7-Day R 30-Day R PS-LOS	**T** **T** ✓

‡‡ Effective 10/1/2009

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APPENDIX E: DEFINITIONS FOR POTENTIAL CANDIDATE VARIABLES *continued*

Variable Definitions	2008-2009 Models	2009 Models
Ischemic Heart Disease 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 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, 571.42‡, 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 **T** 7-Day R 30-Day R PS-LOS
Lupus Erythematosus, Systemic 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 Operative M 7-Day R 30-Day R PS-LOS
Multiple Valve Procedures Any combination of valve procedures, as indicated by any two 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 ✓ PS-LOS ✓	In-Hospital M ✓ Operative M ✓ 7-Day R **T** 30-Day R **T** PS-LOS ✓
Myocardial Infarction, Old 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
Obesity *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 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 **T** 30-Day R **T** PS-LOS ✓
Other Open Heart Procedure 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, 37.36, 37.41, 37.49, 37.51, 37.52, 37.53.	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 ✓
Procedure Group *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 ✓

‡ Effective 10/1/2008

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APPENDIX E: DEFINITIONS FOR POTENTIAL CANDIDATE VARIABLES *continued*

Variable Definitions	2008-2009 Models	2009 Models
PTCA/Stent Same Day as CABG/Valve Surgery 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 **T** Operative M **T** 7-Day R 30-Day R PS-LOS ✓	In-Hospital M Operative M 7-Day R 30-Day R **T** PS-LOS
Renal Failure/Dialysis (category) *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 **T** 30-Day R **T** PS-LOS	In-Hospital M ✓ Operative M **T** 7-Day R **T** 30-Day R ✓ PS-LOS
Renal Failure/Dialysis (binary) 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) 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
Valve Replacement 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 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

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APPENDIX F: CANDIDATE VARIABLE DATA

Mortality, 2008-2009

Candidate Variable	In-Hospital				Operative			
	Cases in Analysis		Mortality		Cases in Analysis		Mortality	
	#	%	#	%	#	%	#	%
Year								
2009	15,631	50.5	421	2.7	14,060	50.3	442	3.1
2008	15,325	49.5	355	2.3	13,870	49.7	399	2.9
Total	30,956	100.0	776	2.5	27,930	100.0	841	3.0
Demographic Variables								
Age in Years (tested as a continuous variable)								
Age: 30 - 39	338	1.1	2	0.6	298	1.1	2	0.7
Age: 40 - 49	1,784	5.8	26	1.5	1,613	5.8	22	1.4
Age: 50 - 59	5,678	18.3	63	1.1	5,162	18.5	75	1.5
Age: 60 - 69	9,157	29.6	168	1.8	8,265	29.6	188	2.3
Age: 70 - 79	9,601	31.0	289	3.0	8,662	31.0	313	3.6
Age: 80 - 89	4,307	13.9	219	5.1	3,856	13.8	233	6.0
Age: 90 - 99	91	0.3	9	9.9	74	0.3	8	10.8
	Average Age = 67.1 (Female 69.4; Male 66.0)							
Age # of Years > 65 (tested as a continuous variable)								
0	13,233	42.7	181	1.4	11,964	42.8	201	1.7
1	995	3.2	28	2.8	906	3.2	29	3.2
2	922	3.0	15	1.6	834	3.0	18	2.2
3	918	3.0	18	2.0	829	3.0	22	2.7
4	889	2.9	17	1.9	805	2.9	17	2.1
5	967	3.1	22	2.3	872	3.1	24	2.8
6	932	3.0	19	2.0	827	3.0	22	2.7
7	974	3.1	23	2.4	883	3.2	23	2.6
8	938	3.0	24	2.6	852	3.1	28	3.3
9	937	3.0	32	3.4	847	3.0	36	4.3
10	929	3.0	31	3.3	848	3.0	34	4.0
11	970	3.1	27	2.8	880	3.2	29	3.3
12	1,046	3.4	35	3.3	938	3.4	37	3.9
13	1,012	3.3	36	3.6	917	3.3	39	4.3
14	896	2.9	40	4.5	798	2.9	41	5.1
15	802	2.6	26	3.2	720	2.6	29	4.0
16	744	2.4	33	4.4	672	2.4	34	5.1
17	692	2.2	33	4.8	632	2.3	42	6.6
18	587	1.9	37	6.3	515	1.8	35	6.8
19	488	1.6	23	4.7	439	1.6	24	5.5
20	373	1.2	25	6.7	339	1.2	25	7.4
21	274	0.9	18	6.6	242	0.9	17	7.0
22	143	0.5	4	2.8	123	0.4	7	5.7
23	128	0.4	11	8.6	113	0.4	12	10.6
24	76	0.2	9	11.8	61	0.2	8	13.1
25	37	0.1	1	2.7	32	0.1	1	3.1
26	26	0.1	5	19.2	20	0.1	4	20.0
27	14	<0.1	1	7.1	11	<0.1	1	9.1
28	9	<0.1	2	22.2	6	<0.1	1	16.7
29	5	<0.1	0	0.0	5	<0.1	1	20.0
Female								
no	20,694	66.8	417	2.0	18,659	66.8	461	2.5
yes	10,262	33.2	359	3.5	9,271	33.2	380	4.1
Race/Ethnicity								
Hispanic	801	2.6	14	1.7	747	2.7	16	2.1
White (non-Hispanic)	27,035	87.3	649	2.4	24,504	87.7	720	2.9
Black (non-Hispanic)	1,399	4.5	43	3.1	1,289	4.6	47	3.6
Other/Unknown	1,721	5.6	70	4.1	1,390	5.0	58	4.2

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Mortality, 2008-2009

Candidate Variable		In-Hospital				Operative			
		Cases in Analysis		Mortality		Cases in Analysis		Mortality	
		#	%	#	%	#	%	#	%
Race (category)									
Black		1,422	4.6	44	3.1	1,309	4.7	47	3.6
Other/Unknown		2,056	6.6	76	3.7	1,706	6.1	66	3.9
White		27,478	88.8	656	2.4	24,915	89.2	728	2.9
Clinical Variables									
Acute Myocardial Infarction									
no		25,622	82.8	554	2.2	23,079	82.6	606	2.6
yes		5,334	17.2	222	4.2	4,851	17.4	235	4.8
Anemia									
no		23,782	76.8	599	2.5	21,599	77.3	646	3.0
yes		7,174	23.2	177	2.5	6,331	22.7	195	3.1
Angina									
no		23,818	76.9	701	2.9	21,485	76.9	748	3.5
yes		7,138	23.1	75	1.1	6,445	23.1	93	1.4
Angina, Unstable									
no		25,739	83.1	719	2.8	23,223	83.1	769	3.3
yes		5,217	16.9	57	1.1	4,707	16.9	72	1.5
Atlas Predicted Probability of Death[A]									
0	*0.000 – 0.001*	0	0.0	0	0.0	0	0.0	0	0.0
1	*0.002 – 0.011*	10,301	33.3	44	0.4	9,393	33.6	57	0.6
2	*0.012 – 0.057*	16,451	53.1	341	2.1	14,821	53.1	389	2.6
3	*0.058 – 0.499*	4,169	13.5	377	9.0	3,685	13.2	380	10.3
4	*0.500 – 1.000*	35	0.1	14	40.0	31	0.1	15	48.4
Cachexia									
no		29,876	96.5	663	2.2	27,023	96.8	726	2.7
yes		1,080	3.5	113	10.5	907	3.2	115	12.7
Cancer									
no		30,069	97.1	749	2.5	27,133	97.1	807	3.0
yes		887	2.9	27	3.0	797	2.9	34	4.3
Cardiac Adhesions									
no		30,660	99.0	760	2.5	27,651	99.0	821	3.0
yes		296	1.0	16	5.4	279	1.0	20	7.2
Cardiogenic Shock, Pre-Operative									
no		30,776	99.4	724	2.4	27,773	99.4	795	2.9
yes		180	0.6	52	28.9	157	0.6	46	29.3
Cardiomyopathy									
no		25,956	83.8	571	2.2	23,522	84.2	635	2.7
yes		5,000	16.2	205	4.1	4,408	15.8	206	4.7
Cardiopulmonary Resuscitation (CPR) Prior to CABG/Valve Surgery Date									
no		30,895	99.8	772	2.5	27,870	99.8	837	3.0
yes		61	0.2	4	6.6	60	0.2	4	6.7
Cerebrovascular Disease									
no		29,061	93.9	727	2.5	26,222	93.9	793	3.0
yes		1,895	6.1	49	2.6	1,708	6.1	48	2.8
Chronic Lung Disease									
no		24,909	80.5	600	2.4	22,419	80.3	648	2.9
yes		6,047	19.5	176	2.9	5,511	19.7	193	3.5
Chronic Pulmonary Hypertension									
no		27,646	89.3	636	2.3	25,038	89.6	687	2.7
yes		3,310	10.7	140	4.2	2,892	10.4	154	5.3

[A] This variable was based on data obtained from Atlas.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Mortality, 2008-2009

Candidate Variable	In-Hospital				Operative			
	Cases in Analysis		Mortality		Cases in Analysis		Mortality	
	#	%	#	%	#	%	#	%
Coagulopathy								
no	30,748	99.3	770	2.5	27,741	99.3	831	3.0
yes	208	0.7	6	2.9	189	0.7	10	5.3
Depression								
no	28,764	92.9	750	2.6	25,954	92.9	808	3.1
yes	2,192	7.1	26	1.2	1,976	7.1	33	1.7
Diabetes (category)								
No diabetes	19,480	62.9	494	2.5	17,497	62.6	522	3.0
Diabetes without complication	9,210	29.8	222	2.4	8,353	29.9	248	3.0
Diabetes with complications	2,266	7.3	60	2.6	2,080	7.4	71	3.4
Diabetes With Long-Term/Unspecified Complications								
no	28,713	92.8	716	2.5	25,868	92.6	770	3.0
yes	2,243	7.2	60	2.7	2,062	7.4	71	3.4
Excision of Other Lesion/Heart Tissue/LAA, Open Approach – Same Date as Valve with or without CABG								
no	29,540	95.4	720	2.4	26,691	95.6	790	3.0
yes	1,416	4.6	56	4.0	1,239	4.4	51	4.1
Fibrosis in Mediastinum and Heart								
no	30,911	99.9	776	2.5	27,888	99.8	841	3.0
yes	45	0.1	0	0.0	42	0.2	0	0.0
Heart Failure								
no	22,607	73.0	368	1.6	20,765	74.3	411	2.0
yes	8,349	27.0	408	4.9	7,165	25.7	430	6.0
History of CABG or Valve Surgery								
no	29,114	94.0	689	2.4	26,279	94.1	748	2.8
yes	1,842	6.0	87	4.7	1,651	5.9	93	5.6
History of Cerebral Vascular Accident (CVA) or Stroke								
no	28,887	93.3	745	2.6	26,065	93.3	796	3.1
yes	2,069	6.7	31	1.5	1,865	6.7	45	2.4
History of Chronic Steroid Use								
no	30,814	99.5	773	2.5	27,802	99.5	837	3.0
yes	142	0.5	3	2.1	128	0.5	4	3.1
History of Peripheral Vascular Disease								
no	26,030	84.1	626	2.4	23,454	84.0	679	2.9
yes	4,926	15.9	150	3.0	4,476	16.0	162	3.6
History of PTCA/Stent								
no	26,990	87.2	707	2.6	24,320	87.1	759	3.1
yes	3,966	12.8	69	1.7	3,610	12.9	82	2.3
Hypercholesterolemia								
no	10,253	33.1	468	4.6	9,188	32.9	487	5.3
yes	20,703	66.9	308	1.5	18,742	67.1	354	1.9
Hypertension								
no	11,898	38.4	483	4.1	10,640	38.1	498	4.7
yes	19,058	61.6	293	1.5	17,290	61.9	343	2.0
Hypertension with Complications								
no	26,619	86.0	576	2.2	24,044	86.1	622	2.6
yes	4,337	14.0	200	4.6	3,886	13.9	219	5.6
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery								
no	29,572	95.5	703	2.4	26,641	95.4	761	2.9
yes	1,384	4.5	73	5.3	1,289	4.6	80	6.2

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Mortality, 2008-2009

Candidate Variable	In-Hospital				Operative			
	Cases in Analysis		Mortality		Cases in Analysis		Mortality	
	#	%	#	%	#	%	#	%
Ischemic Heart Disease								
no	30,920	99.9	775	2.5	27,898	99.9	840	3.0
yes	36	0.1	1	2.8	32	0.1	1	3.1
Liver Disease								
no	30,671	99.1	755	2.5	27,672	99.1	819	3.0
yes	285	0.9	21	7.4	258	0.9	22	8.5
Lupus Erythematosus, Systemic								
no	30,863	99.7	772	2.5	27,851	99.7	837	3.0
yes	93	0.3	4	4.3	79	0.3	4	5.1
Multiple Valve Procedures								
no	29,385	94.9	662	2.3	26,559	95.1	725	2.7
yes	1,571	5.1	114	7.3	1,371	4.9	116	8.5
Myocardial Infarction, Old								
no	26,632	86.0	699	2.6	24,022	86.0	747	3.1
yes	4,324	14.0	77	1.8	3,908	14.0	94	2.4
Obesity								
no obesity	25,484	82.3	685	2.7	22,942	82.1	733	3.2
unspecified obesity	3,739	12.1	52	1.4	3,389	12.1	63	1.9
Morbid obesity	1,733	5.6	39	2.3	1,599	5.7	45	2.8
Obesity, Morbid								
no	29,223	94.4	737	2.5	26,331	94.3	796	3.0
yes	1,733	5.6	39	2.3	1,599	5.7	45	2.8
Other Open Heart Procedure								
no	28,425	91.8	644	2.3	25,696	92.0	711	2.8
yes	2,531	8.2	132	5.2	2,234	8.0	130	5.8
Procedure Group								
CABG without Valve	19,690	63.6	340	1.7	18,081	64.7	396	2.2
Valve without CABG	6,527	21.1	178	2.7	5,619	20.1	169	3.0
Valve with CABG	4,739	15.3	258	5.4	4,230	15.2	276	6.5
PTCA/Stent Same Day as CABG/Valve Surgery								
no	30,679	99.1	757	2.5	27,683	99.1	819	3.0
yes	277	0.9	19	6.9	247	0.9	22	8.9
Renal Failure/Dialysis (category)								
All cases not assigned to chronic and acute/dialysis categories	30,066	97.1	672	2.2	27,136	97.2	747	2.8
Chronic	492	1.6	45	9.1	437	1.6	38	8.7
Acute/dialysis	398	1.3	59	14.8	357	1.3	56	15.7
Renal Failure/Dialysis (binary)								
no	30,066	97.1	672	2.2	27,136	97.2	747	2.8
yes	890	2.9	104	11.7	794	2.8	94	11.8
Pre-op Acute Renal Failure/Dialysis (binary)								
no	30,558	98.7	717	2.3	27,573	98.7	785	2.8
yes	398	1.3	59	14.8	357	1.3	56	15.7
Ventricular Assist Device (LVAD and PVAD) Prior to CABG/Valve Surgery Date								
no	30,951	100.0	774	2.5	27,926	100.0	839	3.0
yes	5	<0.1	2	40.0	4	<0.1	2	50.0

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Mortality, 2009

Candidate Variable	In-Hospital				Operative			
	Cases in Analysis		Mortality		Cases in Analysis		Mortality	
	#	%	#	%	#	%	#	%
Demographic Variables								
Age in Years (tested as a continuous variable)								
Age: 30 – 39	177	1.2	1	0.6	158	1.1	1	0.6
Age: 40 – 49	876	5.7	15	1.7	777	5.6	13	1.7
Age: 50 – 59	2,826	18.4	25	0.9	2,569	18.5	32	1.2
Age: 60 – 69	4,553	29.7	76	1.7	4,120	29.7	88	2.1
Age: 70 – 79	4,652	30.4	133	2.9	4,217	30.4	149	3.5
Age: 80 – 89	2,191	14.3	99	4.5	1,988	14.3	111	5.6
Age: 90 – 99	50	0.3	6	12.0	41	0.3	5	12.2
	Average Age = 67.1 (Female 69.4; Male 66.0)							
Age # of Years > 65 (tested as a continuous variable)								
0	6,570	42.9	75	1.1	5,933	42.8	86	1.4
1	515	3.4	14	2.7	468	3.4	15	3.2
2	448	2.9	7	1.6	409	2.9	9	2.2
3	477	3.1	12	2.5	432	3.1	16	3.7
4	422	2.8	9	2.1	382	2.8	8	2.1
5	449	2.9	8	1.8	411	3.0	10	2.4
6	468	3.1	7	1.5	412	3.0	9	2.2
7	468	3.1	12	2.6	431	3.1	14	3.2
8	437	2.9	9	2.1	400	2.9	11	2.8
9	489	3.2	16	3.3	432	3.1	18	4.2
10	442	2.9	19	4.3	406	2.9	21	5.2
11	462	3.0	10	2.2	430	3.1	12	2.8
12	493	3.2	21	4.3	440	3.2	21	4.8
13	493	3.2	16	3.2	448	3.2	17	3.8
14	451	2.9	15	3.3	407	2.9	16	3.9
15	419	2.7	10	2.4	379	2.7	14	3.7
16	363	2.4	14	3.9	330	2.4	15	4.5
17	359	2.3	13	3.6	338	2.4	19	5.6
18	292	1.9	21	7.2	255	1.8	20	7.8
19	237	1.5	9	3.8	217	1.6	10	4.6
20	205	1.3	11	5.4	190	1.4	12	6.3
21	140	0.9	12	8.6	123	0.9	10	8.1
22	74	0.5	2	2.7	65	0.5	4	6.2
23	66	0.4	3	4.5	61	0.4	3	4.9
24	36	0.2	4	11.1	30	0.2	4	13.3
25	22	0.1	0	0.0	18	0.1	0	0.0
26	14	0.1	3	21.4	12	0.1	3	25.0
27	9	0.1	1	11.1	8	0.1	1	12.5
28	3	<0.1	2	66.7	1	<0.1	1	100.0
29	2	<0.1	0	0.0	2	<0.1	0	0.0
Female								
no	10,231	66.8	192	1.9	9,262	66.8	219	2.4
yes	5,094	33.2	163	3.2	4,608	33.2	180	3.9
Race/Ethnicity								
Hispanic	398	2.6	8	2.0	365	2.6	10	2.7
White (non-Hispanic)	13,351	87.1	295	2.2	12,139	87.5	340	2.8
Black (non-Hispanic)	711	4.6	18	2.5	658	4.7	20	3.0
Other/Unknown	865	5.6	34	3.9	708	5.1	29	4.1

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Mortality, 2009

Candidate Variable	In-Hospital				Operative			
	Cases in Analysis		Mortality		Cases in Analysis		Mortality	
	#	%	#	%	#	%	#	%
Race (category)								
Black	726	4.7	18	2.5	672	4.8	20	3.0
Other/Unknown	1,036	6.8	39	3.8	866	6.2	35	4.0
White	13,563	88.5	298	2.2	12,332	88.9	344	2.8
Clinical Variables								
Acute Myocardial Infarction								
no	12,656	82.6	263	2.1	11,421	82.3	294	2.6
yes	2,669	17.4	92	3.4	2,449	17.7	105	4.3
Anemia								
no	11,977	78.2	278	2.3	10,871	78.4	312	2.9
yes	3,348	21.8	77	2.3	2,999	21.6	87	2.9
Angina								
no	11,858	77.4	324	2.7	10,726	77.3	358	3.3
yes	3,467	22.6	31	0.9	3,144	22.7	41	1.3
Angina, Unstable								
no	12,791	83.5	331	2.6	11,566	83.4	367	3.2
yes	2,534	16.5	24	0.9	2,304	16.6	32	1.4
Atlas Predicted Probability of Death[A] (tested as a continuous variable)								
0 *0.000 – 0.001*	0	0.0	0	0.0	0	0.0	0	0.0
1 *0.002 – 0.011*	5,059	33.0	16	0.3	4,627	33.4	21	0.5
2 *0.012 – 0.057*	8,153	53.2	149	1.8	7,368	53.1	187	2.5
3 *0.058 – 0.499*	2,096	13.7	182	8.7	1,860	13.4	181	9.7
4 *0.500 – 1.000*	17	0.1	8	47.1	15	0.1	10	66.7
Cachexia								
no	14,736	96.2	300	2.0	13,375	96.4	337	2.5
yes	589	3.8	55	9.3	495	3.6	62	12.5
Cancer								
no	14,867	97.0	336	2.3	13,462	97.1	378	2.8
yes	458	3.0	19	4.1	408	2.9	21	5.1
Cardiac Adhesions								
no	15,163	98.9	347	2.3	13,719	98.9	389	2.8
yes	162	1.1	8	4.9	151	1.1	10	6.6
Cardiogenic Shock, Pre-Operative								
no	15,226	99.4	325	2.1	13,786	99.4	372	2.7
yes	99	0.6	30	30.3	84	0.6	27	32.1
Cardiomyopathy								
no	12,720	83.0	257	2.0	11,558	83.3	290	2.5
yes	2,605	17.0	98	3.8	2,312	16.7	109	4.7
Cardiopulmonary Resuscitation (CPR) Prior to CABG/Valve Surgery Date								
no	15,289	99.8	352	2.3	13,835	99.7	396	2.9
yes	36	0.2	3	8.3	35	0.3	3	8.6
Cerebrovascular Disease								
no	14,403	94.0	330	2.3	13,038	94.0	371	2.8
yes	922	6.0	25	2.7	832	6.0	28	3.4
Chronic Lung Disease								
no	12,340	80.5	272	2.2	11,139	80.3	296	2.7
yes	2,985	19.5	83	2.8	2,731	19.7	103	3.8
Chronic Pulmonary Hypertension								
no	13,637	89.0	289	2.1	12,390	89.3	319	2.6
yes	1,688	11.0	66	3.9	1,480	10.7	80	5.4

[A] This variable was based on data obtained from Atlas.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Mortality, 2009

Candidate Variable	In-Hospital				Operative			
	Cases in Analysis		Mortality		Cases in Analysis		Mortality	
	#	%	#	%	#	%	#	%
Coagulopathy								
no	15,209	99.2	353	2.3	13,764	99.2	395	2.9
yes	116	0.8	2	1.7	106	0.8	4	3.8
Depression								
no	14,167	92.4	339	2.4	12,836	92.5	380	3.0
yes	1,158	7.6	16	1.4	1,034	7.5	19	1.8
Diabetes								
No diabetes	9,725	63.5	234	2.4	8,750	63.1	251	2.9
Diabetes without complication	4,487	29.3	97	2.2	4,091	29.5	116	2.8
Diabetes with complications	1,113	7.3	24	2.2	1,029	7.4	32	3.1
Diabetes With Long-Term/Unspecified Complications								
no	14,227	92.8	331	2.3	12,852	92.7	367	2.9
yes	1,098	7.2	24	2.2	1,018	7.3	32	3.1
Excision of Other Lesion/Heart Tissue/ LAA, Open Approach – Same Date as Valve with or without CABG								
no	14,561	95.0	325	2.2	13,205	95.2	372	2.8
yes	764	5.0	30	3.9	665	4.8	27	4.1
Fibrosis in Mediastinum and Heart								
no	15,312	99.9	355	2.3	13,858	99.9	399	2.9
yes	13	0.1	0	0.0	12	0.1	0	0.0
Heart Failure								
no	11,082	72.3	172	1.6	10,243	73.9	193	1.9
yes	4,243	27.7	183	4.3	3,627	26.1	206	5.7
History of CABG or Valve Surgery								
no	14,427	94.1	318	2.2	13,054	94.1	357	2.7
yes	898	5.9	37	4.1	816	5.9	42	5.1
History of Cerebral Vascular Accident (CVA) or Stroke								
no	14,241	92.9	337	2.4	12,894	93.0	374	2.9
yes	1,084	7.1	18	1.7	976	7.0	25	2.6
History of Chronic Steroid Use								
no	15,257	99.6	352	2.3	13,810	99.6	396	2.9
yes	68	0.4	3	4.4	60	0.4	3	5.0
History of Peripheral Vascular Disease								
no	12,839	83.8	286	2.2	11,595	83.6	321	2.8
yes	2,486	16.2	69	2.8	2,275	16.4	78	3.4
History of PTCA/Stent								
no	13,415	87.5	322	2.4	12,119	87.4	364	3.0
yes	1,910	12.5	33	1.7	1,751	12.6	35	2.0
Hypercholesterolemia								
no	5,051	33.0	204	4.0	4,533	32.7	217	4.8
yes	10,274	67.0	151	1.5	9,337	67.3	182	1.9
Hypertension								
no	5,957	38.9	220	3.7	5,319	38.3	229	4.3
yes	9,368	61.1	135	1.4	8,551	61.7	170	2.0
Hypertension with Complications								
no	13,061	85.2	258	2.0	11,840	85.4	286	2.4
yes	2,264	14.8	97	4.3	2,030	14.6	113	5.6
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery								
no	14,644	95.6	326	2.2	13,234	95.4	362	2.7
yes	681	4.4	29	4.3	636	4.6	37	5.8

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Mortality, 2009

Candidate Variable	In-Hospital				Operative			
	Cases in Analysis		Mortality		Cases in Analysis		Mortality	
	#	%	#	%	#	%	#	%
Ischemic Heart Disease								
no	15,306	99.9	354	2.3	13,852	99.9	398	2.9
yes	19	0.1	1	5.3	18	0.1	1	5.6
Liver Disease								
no	15,194	99.1	345	2.3	13,746	99.1	388	2.8
yes	131	0.9	10	7.6	124	0.9	11	8.9
Lupus Erythematosus, Systemic								
no	15,272	99.7	352	2.3	13,823	99.7	396	2.9
yes	53	0.3	3	5.7	47	0.3	3	6.4
Multiple Valve Procedures								
no	14,499	94.6	295	2.0	13,149	94.8	337	2.6
yes	826	5.4	60	7.3	721	5.2	62	8.6
Myocardial Infarction, Old								
no	13,207	86.2	320	2.4	11,951	86.2	355	3.0
yes	2,118	13.8	35	1.7	1,919	13.8	44	2.3
Obesity								
no obesity	12,522	81.7	311	2.5	11,314	81.6	344	3.0
unspecified obesity	1,892	12.3	25	1.3	1,716	12.4	32	1.9
Morbid obesity	911	5.9	19	2.1	840	6.1	23	2.7
Obesity, Morbid								
no	14,414	94.1	336	2.3	13,030	93.9	376	2.9
yes	911	5.9	19	2.1	840	6.1	23	2.7
Other Open Heart Procedure								
no	14,008	91.4	286	2.0	12,715	91.7	328	2.6
yes	1,317	8.6	69	5.2	1,155	8.3	71	6.1
Procedure Group								
CABG without Valve	9,591	62.6	148	1.5	8,837	63.7	183	2.1
Valve without CABG	3,365	22.0	82	2.4	2,912	21.0	81	2.8
Valve with CABG	2,369	15.5	125	5.3	2,121	15.3	135	6.4
PTCA/Stent Same Day as CABG/Valve Surgery								
no	15,188	99.1	348	2.3	13,750	99.1	390	2.8
yes	137	0.9	7	5.1	120	0.9	9	7.5
Renal Failure/Dialysis								
All cases not assigned to chronic and acute/dialysis categories	14,876	97.1	309	2.1	13,475	97.2	359	2.7
Chronic	241	1.6	20	8.3	210	1.5	15	7.1
Acute/dialysis	208	1.4	26	12.5	185	1.3	25	13.5
Renal Failure/Dialysis (binary)								
no	14,876	97.1	309	2.1	13,475	97.2	359	2.7
yes	449	2.9	46	10.2	395	2.8	40	10.1
Pre-op Acute Renal Failure/Dialysis (binary)								
no	15,117	98.6	329	2.2	13,685	98.7	374	2.7
yes	208	1.4	26	12.5	185	1.3	25	13.5
Ventricular Assist Device (LVAD and PVAD) Prior to CABG/Valve Surgery Date								
no	15,322	100.0	354	2.3	13,868	100.0	398	2.9
yes	3	<0.1	1	33.3	2	<0.1	1	50.0

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Readmissions, 2008-2009

Candidate Variable	Cases in Analysis		7-Day Readmissions		30-Day Readmissions	
	#	%	#	%	#	%
Year						
2008	13,698	50.2	931	6.8	2,208	16.1
2009	13,562	49.8	861	6.3	2,042	15.1
Total	27,260	100.0	1,792	6.6	4,250	15.6
Demographic Variables						
Age in Years (tested as a continuous variable)						
Age: 30 – 39	297	1.1	19	6.4	42	14.1
Age: 40 – 49	1,592	5.8	87	5.5	224	14.1
Age: 50 – 59	5,105	18.7	265	5.2	659	12.9
Age: 60 – 69	8,112	29.8	444	5.5	1,091	13.4
Age: 70 – 79	8,412	30.9	634	7.5	1,447	17.2
Age: 80 – 89	3,674	13.5	337	9.2	769	20.9
Age: 90 – 99	68	0.2	6	8.8	18	26.5
Age # of Years > 65 (tested as a continuous variable)						
0	11,804	43.3	623	5.3	1,551	13.1
1	880	3.2	50	5.7	121	13.8
2	819	3.0	50	6.1	113	13.8
3	813	3.0	42	5.2	115	14.1
4	790	2.9	50	6.3	116	14.7
5	854	3.1	58	6.8	142	16.6
6	810	3.0	54	6.7	117	14.4
7	865	3.2	59	6.8	134	15.5
8	832	3.1	51	6.1	124	14.9
9	817	3.0	72	8.8	138	16.9
10	819	3.0	61	7.4	141	17.2
11	856	3.1	63	7.4	157	18.3
12	907	3.3	64	7.1	170	18.7
13	885	3.2	72	8.1	164	18.5
14	767	2.8	80	10.4	160	20.9
15	697	2.6	64	9.2	139	19.9
16	646	2.4	50	7.7	122	18.9
17	601	2.2	54	9.0	125	20.8
18	488	1.8	50	10.2	99	20.3
19	418	1.5	29	6.9	90	21.5
20	322	1.2	34	10.6	78	24.2
21	228	0.8	27	11.8	52	22.8
22	119	0.4	14	11.8	27	22.7
23	102	0.4	13	12.7	28	27.5
24	53	0.2	2	3.8	9	17.0
25	31	0.1	2	6.5	5	16.1
26	17	0.1	1	5.9	6	35.3
27	10	<0.1	1	10.0	3	30.0
28	5	<0.1	2	40.0	4	80.0
29	5	<0.1	0	0.0	0	0.0
Female						
no	18,296	67.1	1,077	5.9	2,494	13.6
yes	8,964	32.9	715	8.0	1,756	19.6
Race/Ethnicity						
Hispanic	735	2.7	43	5.9	104	14.1
White (non-Hispanic)	23,939	87.8	1,535	6.4	3,638	15.2
Black (non-Hispanic)	1,248	4.6	122	9.8	282	22.6
Other/Unknown	1,338	4.9	92	6.9	226	16.9

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Readmissions, 2008-2009

Candidate Variable	Cases in Analysis		7-Day Readmissions		30-Day Readmissions	
	#	%	#	%	#	%
Race						
Black	1,268	4.7	122	9.6	284	22.4
Other/Unknown	1,648	6.0	115	7.0	284	17.2
White	24,344	89.3	1,555	6.4	3,682	15.1
Clinical Variables						
Acute Myocardial Infarction						
no	22,602	82.9	1,464	6.5	3,488	15.4
yes	4,658	17.1	328	7.0	762	16.4
Anemia						
no	21,076	77.3	1,333	6.3	3,110	14.8
yes	6,184	22.7	459	7.4	1,140	18.4
Angina						
no	20,881	76.6	1,413	6.8	3,364	16.1
yes	6,379	23.4	379	5.9	886	13.9
Angina, Unstable						
no	22,602	82.9	1,499	6.6	3,567	15.8
yes	4,658	17.1	293	6.3	683	14.7
Atlas Predicted LOS [A] (tested as a continuous variable)						
0	619	2.3	23	3.7	51	8.2
1	3,771	13.8	150	4.0	360	9.5
2	18,749	68.8	1,217	6.5	2,870	15.3
3	3,574	13.1	341	9.5	812	22.7
4	547	2.0	61	11.2	157	28.7
Cachexia						
no	26,444	97.0	1,709	6.5	4,053	15.3
yes	816	3.0	83	10.2	197	24.1
Cancer						
no	26,487	97.2	1,732	6.5	4,091	15.4
yes	773	2.8	60	7.8	159	20.6
Cardiac Adhesions						
no	26,997	99.0	1,761	6.5	4,197	15.5
yes	263	1.0	31	11.8	53	20.2
Cardiogenic Shock, Pre-Operative						
no	27,144	99.6	1,778	6.6	4,221	15.6
yes	116	0.4	14	12.1	29	25.0
Cardiomyopathy						
no	23,019	84.4	1,468	6.4	3,475	15.1
yes	4,241	15.6	324	7.6	775	18.3
Cardiopulmonary Resuscitation (CPR) Prior to CABG/Valve Surgery Date						
no	27,204	99.8	1,789	6.6	4,243	15.6
yes	56	0.2	3	5.4	7	12.5
Cerebrovascular Disease						
no	25,592	93.9	1,671	6.5	3,956	15.5
yes	1,668	6.1	121	7.3	294	17.6
Chronic Lung Disease						
no	21,899	80.3	1,362	6.2	3,272	14.9
yes	5,361	19.7	430	8.0	978	18.2

[A] The ranges (number of days) for the predicted length of stay categories were calculated for each combination of procedure group and calendar year. This variable was based on data obtained by Atlas.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Readmissions, 2008-2009

Candidate Variable	Cases in Analysis		7-Day Readmissions		30-Day Readmissions	
	#	%	#	%	#	%
Chronic Pulmonary Hypertension						
no	24,489	89.8	1,546	6.3	3,668	15.0
yes	2,771	10.2	246	8.9	582	21.0
Coagulopathy						
no	27,077	99.3	1,779	6.6	4,210	15.5
yes	183	0.7	13	7.1	40	21.9
Depression						
no	25,308	92.8	1,647	6.5	3,898	15.4
yes	1,952	7.2	145	7.4	352	18.0
Diabetes						
No diabetes	17,072	62.6	1,062	6.2	2,446	14.3
Diabetes without complication	8,162	29.9	557	6.8	1,357	16.6
Diabetes with complications	2,026	7.4	173	8.5	447	22.1
Diabetes With Long-Term/Unspecified Complications						
no	25,252	92.6	1,621	6.4	3,807	15.1
yes	2,008	7.4	171	8.5	443	22.1
Excision of Other Lesion/Heart Tissue/ LAA, Open Approach – Same Date as Valve with or without CABG						
no	26,065	95.6	1,686	6.5	4,000	15.3
yes	1,195	4.4	106	8.9	250	20.9
Fibrosis in Mediastinum and Heart						
no	27,218	99.8	1,790	6.6	4,247	15.6
yes	42	0.2	2	4.8	3	7.1
Heart Failure						
no	20,434	75.0	1,182	5.8	2,764	13.5
yes	6,826	25.0	610	8.9	1,486	21.8
History of CABG or Valve Surgery						
no	25,690	94.2	1,670	6.5	3,940	15.3
yes	1,570	5.8	122	7.8	310	19.7
History of Cerebral Vascular Accident (CVA) or Stroke						
no	25,423	93.3	1,640	6.5	3,889	15.3
yes	1,837	6.7	152	8.3	361	19.7
History of Chronic Steroid Use						
no	27,135	99.5	1,775	6.5	4,222	15.6
yes	125	0.5	17	13.6	28	22.4
History of Peripheral Vascular Disease						
no	22,915	84.1	1,485	6.5	3,496	15.3
yes	4,345	15.9	307	7.1	754	17.4
History of PTCA/Stent						
no	23,713	87.0	1,545	6.5	3,718	15.7
yes	3,547	13.0	247	7.0	532	15.0
Hypercholesterolemia						
no	8,789	32.2	684	7.8	1,613	18.4
yes	18,471	67.8	1,108	6.0	2,637	14.3
Hypertension						
no	10,233	37.5	746	7.3	1,826	17.8
yes	17,027	62.5	1,046	6.1	2,424	14.2
Hypertension with Complications						
no	23,542	86.4	1,443	6.1	3,412	14.5
yes	3,718	13.6	349	9.4	838	22.5
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery						
no	26,035	95.5	1,708	6.6	4,049	15.6
yes	1,225	4.5	84	6.9	201	16.4

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Readmissions, 2008-2009

Candidate Variable	Cases in Analysis		7-Day Readmissions		30-Day Readmissions	
	#	%	#	%	#	%
Ischemic Heart Disease						
no	27,229	99.9	1,791	6.6	4,248	15.6
yes	31	0.1	1	3.2	2	6.5
Liver Disease						
no	27,021	99.1	1,772	6.6	4,199	15.5
yes	239	0.9	20	8.4	51	21.3
Lupus Erythematosus, Systemic						
no	27,185	99.7	1,784	6.6	4,230	15.6
yes	75	0.3	8	10.7	20	26.7
Multiple Valve Procedures						
no	25,984	95.3	1,663	6.4	3,928	15.1
yes	1,276	4.7	129	10.1	322	25.2
Myocardial Infarction, Old						
no	23,422	85.9	1,534	6.5	3,625	15.5
yes	3,838	14.1	258	6.7	625	16.3
Obesity						
no obesity	22,356	82.0	1,438	6.4	3,426	15.3
unspecified obesity	3,342	12.3	218	6.5	505	15.1
Morbid obesity	1,562	5.7	136	8.7	319	20.4
Obesity, Morbid						
no	25,698	94.3	1,656	6.4	3,931	15.3
yes	1,562	5.7	136	8.7	319	20.4
Other Open Heart Procedure						
no	25,138	92.2	1,619	6.4	3,827	15.2
yes	2,122	7.8	173	8.2	423	19.9
Procedure Group						
CABG without Valve	17,776	65.2	1,036	5.8	2,439	13.7
Valve without CABG	5,480	20.1	388	7.1	954	17.4
Valve with CABG	4,004	14.7	368	9.2	857	21.4
PTCA/Stent Same Day as CABG/Valve Surgery						
no	27,031	99.2	1,775	6.6	4,209	15.6
yes	229	0.8	17	7.4	41	17.9
Renal Failure/Dialysis (category)						
All cases not assigned to chronic and acute/dialysis categories	26,551	97.4	1,715	6.5	4,066	15.3
Chronic	403	1.5	38	9.4	97	24.1
Acute/dialysis	306	1.1	39	12.7	87	28.4
Renal Failure/Dialysis (binary)						
no	26,551	97.4	1,715	6.5	4,066	15.3
yes	709	2.6	77	10.9	184	26.0
Pre-op Acute Renal Failure/Dialysis (binary)						
no	26,954	98.9	1,753	6.5	4,163	15.4
yes	306	1.1	39	12.7	87	28.4
Ventricular Assist Device (LVAD and PVAD) Prior to CABG/Valve Surgery Date						
no	27,258	100.0	1,791	6.6	4,249	15.6
yes	2	0.0	1	50.0	1	50.0

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Readmissions, 2009

Candidate Variable	Cases in Analysis		7-Day Readmissions		30-Day Readmissions	
	#	%	#	%	#	%
Demographic Variables						
Age in Years (tested as a continuous variable)						
Age: 30 – 39	158	1.2	9	5.7	20	12.7
Age: 40 – 49	765	5.6	39	5.1	105	13.7
Age: 50 – 59	2,548	18.8	127	5.0	319	12.5
Age: 60 – 69	4,050	29.9	215	5.3	530	13.1
Age: 70 – 79	4,100	30.2	290	7.1	661	16.1
Age: 80 – 89	1,904	14.0	177	9.3	399	21.0
Age: 90 – 99	37	0.3	4	10.8	8	21.6
Age # of Years > 65 (tested as a continuous variable)						
0	5,869	43.3	298	5.1	752	12.8
1	455	3.4	23	5.1	59	13.0
2	402	3.0	25	6.2	53	13.2
3	421	3.1	25	5.9	61	14.5
4	374	2.8	19	5.1	49	13.1
5	404	3.0	22	5.4	64	15.8
6	405	3.0	23	5.7	50	12.3
7	421	3.1	31	7.4	62	14.7
8	393	2.9	21	5.3	56	14.2
9	417	3.1	40	9.6	69	16.5
10	389	2.9	30	7.7	62	15.9
11	421	3.1	34	8.1	82	19.5
12	422	3.1	23	5.5	69	16.4
13	433	3.2	29	6.7	69	15.9
14	395	2.9	37	9.4	78	19.7
15	370	2.7	33	8.9	73	19.7
16	317	2.3	18	5.7	60	18.9
17	325	2.4	29	8.9	68	20.9
18	239	1.8	22	9.2	45	18.8
19	209	1.5	13	6.2	44	21.1
20	182	1.3	24	13.2	46	25.3
21	115	0.8	18	15.7	31	27.0
22	63	0.5	8	12.7	13	20.6
23	58	0.4	10	17.2	15	25.9
24	26	0.2	2	7.7	4	15.4
25	18	0.1	2	11.1	3	16.7
26	10	0.1	1	10.0	2	20.0
27	7	0.1	1	14.3	3	42.9
28	0	0.0	0	0.0	0	0.0
29	2	< 0.1	0	0.0	0	0.0
Female						
no	9,091	67.0	505	5.6	1,165	12.8
yes	4,471	33.0	356	8.0	877	19.6
Race/Ethnicity						
Hispanic	357	2.6	16	4.5	47	13.2
White (non-Hispanic)	11,882	87.6	726	6.1	1,734	14.6
Black (non-Hispanic)	641	4.7	62	9.7	142	22.2
Other/Unknown	682	5.0	57	8.4	119	17.4
Race						
Black	655	4.8	62	9.5	143	21.8
Other/Unknown	835	6.2	67	8.0	144	17.2
White	12,072	89.0	732	6.1	1,755	14.5

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Readmissions, 2009

Candidate Variable	Cases in Analysis		7-Day Readmissions		30-Day Readmissions	
	#	%	#	%	#	%
Clinical Variables						
Acute Myocardial Infarction						
no	11,194	82.5	704	6.3	1,676	15.0
yes	2,368	17.5	157	6.6	366	15.5
Anemia						
no	10,627	78.4	658	6.2	1,508	14.2
yes	2,935	21.6	203	6.9	534	18.2
Angina						
no	10,446	77.0	697	6.7	1,652	15.8
yes	3,116	23.0	164	5.3	390	12.5
Angina, Unstable						
no	11,279	83.2	729	6.5	1,735	15.4
yes	2,283	16.8	132	5.8	307	13.4
Atlas Predicted LOS [A] (tested as a continuous variable)						
0	298	2.2	8	2.7	21	7.0
1	1,887	13.9	62	3.3	164	8.7
2	9,326	68.8	587	6.3	1,376	14.8
3	1,774	13.1	173	9.8	402	22.7
4	277	2.0	31	11.2	79	28.5
Cachexia						
no	13,114	96.7	814	6.2	1,932	14.7
yes	448	3.3	47	10.5	110	24.6
Cancer						
no	13,171	97.1	831	6.3	1,961	14.9
yes	391	2.9	30	7.7	81	20.7
Cardiac Adhesions						
no	13,419	98.9	844	6.3	2,012	15.0
yes	143	1.1	17	11.9	30	21.0
Cardiogenic Shock, Pre-Operative						
no	13,500	99.5	852	6.3	2,027	15.0
yes	62	0.5	9	14.5	15	24.2
Cardiomyopathy						
no	11,332	83.6	699	6.2	1,662	14.7
yes	2,230	16.4	162	7.3	380	17.0
Cardiopulmonary Resuscitation (CPR) Prior to CABG/Valve Surgery Date						
no	13,530	99.8	859	6.3	2,039	15.1
yes	32	0.2	2	6.3	3	9.4
Cerebrovascular Disease						
no	12,752	94.0	808	6.3	1,909	15.0
yes	810	6.0	53	6.5	133	16.4
Chronic Lung Disease						
no	10,906	80.4	668	6.1	1,600	14.7
yes	2,656	19.6	193	7.3	442	16.6
Chronic Pulmonary Hypertension						
no	12,138	89.5	725	6.0	1,737	14.3
yes	1,424	10.5	136	9.6	305	21.4
Coagulopathy						
no	13,458	99.2	855	6.4	2,024	15.0
yes	104	0.8	6	5.8	18	17.3

[A] The ranges (number of days) for the predicted length of stay categories were calculated for each combination of procedure group and calendar year. This variable was based on data obtained by Atlas.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Readmissions, 2009

Candidate Variable	Cases in Analysis		7-Day Readmissions		30-Day Readmissions	
	#	%	#	%	#	%
Depression						
no	12,542	92.5	795	6.3	1,875	14.9
yes	1,020	7.5	66	6.5	167	16.4
Diabetes						
No diabetes	8,547	63.0	526	6.2	1,194	14.0
Diabetes without complication	4,007	29.5	248	6.2	626	15.6
Diabetes with complications	1,008	7.4	87	8.6	222	22.0
Diabetes With Long-Term/Unspecified Complications						
no	12,565	92.6	776	6.2	1,823	14.5
yes	997	7.4	85	8.5	219	22.0
Excision of Other Lesion/Heart Tissue/ LAA, Open Approach – Same Date as Valve with or without CABG						
no	12,921	95.3	809	6.3	1,908	14.8
yes	641	4.7	52	8.1	134	20.9
Fibrosis in Mediastinum and Heart						
no	13,550	99.9	861	6.4	2,042	15.1
yes	12	0.1	0	0.0	0	0.0
Heart Failure						
no	10,086	74.4	560	5.6	1,319	13.1
yes	3,476	25.6	301	8.7	723	20.8
History of CABG or Valve Surgery						
no	12,781	94.2	794	6.2	1,888	14.8
yes	781	5.8	67	8.6	154	19.7
History of Cerebral Vascular Accident (CVA) or Stroke						
no	12,602	92.9	782	6.2	1,859	14.8
yes	960	7.1	79	8.2	183	19.1
History of Chronic Steroid Use						
no	13,505	99.6	856	6.3	2,031	15.0
yes	57	0.4	5	8.8	11	19.3
History of Peripheral Vascular Disease						
no	11,351	83.7	717	6.3	1,674	14.7
yes	2,211	16.3	144	6.5	368	16.6
History of PTCA/Stent						
no	11,838	87.3	742	6.3	1,772	15.0
yes	1,724	12.7	119	6.9	270	15.7
Hypercholesterolemia						
no	4,360	32.1	335	7.7	793	18.2
yes	9,202	67.9	526	5.7	1,249	13.6
Hypertension						
no	5,137	37.9	379	7.4	916	17.8
yes	8,425	62.1	482	5.7	1,126	13.4
Hypertension with Complications						
no	11,614	85.6	680	5.9	1,608	13.8
yes	1,948	14.4	181	9.3	434	22.3
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery						
no	12,953	95.5	816	6.3	1,937	15.0
yes	609	4.5	45	7.4	105	17.2
Ischemic Heart Disease						
no	13,545	99.9	860	6.3	2,040	15.1
yes	17	0.1	1	5.9	2	11.8
Liver Disease						
no	13,448	99.2	855	6.4	2,023	15.0
yes	114	0.8	6	5.3	19	16.7

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Readmissions, 2009

Candidate Variable	Cases in Analysis		7-Day Readmissions		30-Day Readmissions	
	#	%	#	%	#	%
Lupus Erythematosus, Systemic						
no	13,518	99.7	857	6.3	2,032	15.0
yes	44	0.3	4	9.1	10	22.7
Multiple Valve Procedures						
no	12,891	95.1	788	6.1	1,875	14.5
yes	671	4.9	73	10.9	167	24.9
Myocardial Infarction, Old						
no	11,675	86.1	735	6.3	1,725	14.8
yes	1,887	13.9	126	6.7	317	16.8
Obesity						
no obesity	11,047	81.5	694	6.3	1,652	15.0
unspecified obesity	1,692	12.5	101	6.0	234	13.8
Morbid obesity	823	6.1	66	8.0	156	19.0
Obesity, Morbid						
no	12,739	93.9	795	6.2	1,886	14.8
yes	823	6.1	66	8.0	156	19.0
Other Open Heart Procedure						
no	12,466	91.9	773	6.2	1,822	14.6
yes	1,096	8.1	88	8.0	220	20.1
Procedure Group						
CABG without Valve	8,701	64.2	468	5.4	1,117	12.8
Valve without CABG	2,848	21.0	205	7.2	486	17.1
Valve with CABG	2,013	14.8	188	9.3	439	21.8
PTCA/Stent Same Day as CABG/Valve Surgery						
no	13,449	99.2	852	6.3	2,018	15.0
yes	113	0.8	9	8.0	24	21.2
Renal Failure/Dialysis (category)						
All cases not assigned to chronic and acute/dialysis categories	13,203	97.4	818	6.2	1,933	14.6
Chronic	196	1.4	19	9.7	57	29.1
Acute/dialysis	163	1.2	24	14.7	52	31.9
Renal Failure/Dialysis (binary)						
no	13,203	97.4	818	6.2	1,933	14.6
yes	359	2.6	43	12.0	109	30.4
Pre-op Acute Renal Failure/Dialysis (binary)						
no	13,399	98.8	837	6.2	1,990	14.9
yes	163	1.2	24	14.7	52	31.9
Ventricular Assist Device (LVAD and PVAD) Prior to CABG/Valve Surgery Date						
no	13,561	100.0	860	6.3	2,041	15.1
yes	1	<0.1	1	100.0	1	100.0

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Post-Surgical Length of Stay, 2008-2009

Candidate Variable	Number of Cases			Arithmetic Avg. Post-Surgical LOS		
	Development Sample	**Cross-validation Sample**	Full	Development Sample	Cross-validation Sample	Full
Year *should this be here?*						
2008	7,534	7,528	15,062	7.3	7.4	7.4
2009	7,424	7,427	14,851	7.5	7.4	7.5
Total	Not calculated	Not calculated	29,913	Not calculated	Not calculated	7.4
Demographic Variables						
Age in Years (tested as a continuous variable)						
Age: 30 - 39	173	160	333	5.8	6.6	6.2
Age: 40 - 49	850	901	1,751	5.9	6.0	6.0
Age: 50 - 59	2,748	2,819	5,567	6.4	6.3	6.3
Age: 60 - 69	4,507	4,409	8,916	6.9	7.0	7.0
Age: 70 - 79	4,596	4,631	9,227	8.0	8.1	8.0
Age: 80 - 89	2,043	1,995	4,038	9.2	9.3	9.2
Age: 90 - 99	41	40	81	11.6	11.7	11.6
Age Number of Years > 65 (tested as a continuous variable)						
0	6,499	6,448	12,947	6.5	6.5	6.5
1	485	476	961	7.0	7.3	7.2
2	441	463	904	7.1	7.1	7.1
3	412	479	891	7.5	7.4	7.4
4	441	423	864	7.0	7.2	7.1
5	461	474	935	7.7	7.1	7.4
6	454	455	909	7.6	7.2	7.4
7	497	446	943	7.4	7.6	7.5
8	455	450	905	7.2	8.3	7.7
9	445	451	896	7.8	8.1	7.9
10	453	442	895	8.2	8.2	8.2
11	456	479	935	8.3	8.1	8.2
12	482	518	1,000	8.3	8.5	8.4
13	468	494	962	8.7	8.5	8.6
14	425	422	847	8.3	9.3	8.8
15	382	391	773	8.7	8.7	8.7
16	325	374	699	9.1	8.7	8.9
17	338	312	650	9.2	9.1	9.1
18	281	266	547	9.4	9.6	9.5
19	244	214	458	9.2	9.5	9.3
20	185	159	344	9.1	9.4	9.2
21	133	119	252	8.9	10.0	9.4
22	63	74	137	10.0	11.3	10.7
23	59	55	114	10.3	10.8	10.6
24	33	31	64	9.4	10.7	10.0
25	18	18	36	10.8	14.2	12.5
26	10	10	20	11.8	10.4	11.1
27	7	6	13	13.6	9.3	11.6
28	4	3	7	11.3	8.7	10.1
29	2	3	5	12.0	8.7	10.0
Female						
no	10,043	10,067	20,110	7.1	7.1	7.1
yes	4,915	4,888	9,803	8.1	8.2	8.1
Race/Ethnicity						
Hispanic	384	396	780	5.6	5.9	5.8
White (non-Hispanic)	13,084	13,084	26,168	7.3	7.4	7.4
Black (non-Hispanic)	640	691	1,331	8.5	8.9	8.7
Other/Unknown	850	784	1,634	8.2	8.2	8.2

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Post-Surgical Length of Stay, 2008-2009

Candidate Variable	Number of Cases			Arithmetic Avg. Post-Surgical LOS		
	Development Sample	Cross-validation Sample	Full	Development Sample	Cross-validation Sample	Full
Race						
Black	650	703	1,353	8.4	8.9	8.6
Other/Unknown	994	964	1,958	8.0	7.9	7.9
White	13,314	13,288	26,602	7.3	7.3	7.3
Clinical Variables						
Acute Myocardial Infarction						
no	12,476	12,414	24,890	7.3	7.4	7.3
yes	2,482	2,541	5,023	7.8	7.8	7.8
Anemia						
no	11,470	11,507	22,977	7.2	7.2	7.2
yes	3,488	3,448	6,936	8.1	8.2	8.1
Angina						
no	11,434	11,455	22,889	7.7	7.8	7.7
yes	3,524	3,500	7,024	6.4	6.4	6.4
Angina, Unstable						
no	12,408	12,380	24,788	7.6	7.7	7.6
yes	2,550	2,575	5,125	6.4	6.4	6.4
Atlas Predicted LOS [A] (tested as a continuous variable)						
0	359	330	689	5.1	5.1	5.1
1	2,052	2,123	4,175	5.7	5.7	5.7
2	10,240	10,337	20,577	7.2	7.3	7.3
3	2,011	1,871	3,882	9.7	9.9	9.8
4	296	294	590	11.7	11.9	11.8
Cachexia						
no	14,534	14,509	29,043	7.2	7.2	7.2
yes	424	446	870	15.4	16.8	16.1
Cancer						
no	14,531	14,530	29,061	7.4	7.4	7.4
yes	427	425	852	8.4	8.2	8.3
Cardiac Adhesions						
no	14,826	14,811	29,637	7.4	7.4	7.4
yes	132	144	276	9.6	8.2	8.9
Cardiogenic Shock, Pre-Operative						
no	14,893	14,901	29,794	7.4	7.4	7.4
yes	65	54	119	14.3	14.3	14.3
Cardiomyopathy						
no	12,563	12,616	25,179	7.1	7.2	7.2
yes	2,395	2,339	4,734	8.7	8.7	8.7
Cardiopulmonary Resuscitation (CPR) Prior to CABG/Valve Surgery Date						
no	14,925	14,931	29,856	7.4	7.4	7.4
yes	33	24	57	9.6	8.2	9.0
Cerebrovascular Disease						
no	14,063	14,015	28,078	7.4	7.4	7.4
yes	895	940	1,835	7.2	7.6	7.4

[A] The ranges (number of days) for the predicted length of stay categories were calculated for each combination of procedure group and calendar year. This variable was based on data obtained from Atlas.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Post-Surgical Length of Stay, 2008-2009

Candidate Variable	Number of Cases			Arithmetic Avg. Post-Surgical LOS		
	Development Sample	Cross-validation Sample	Full	Development Sample	Cross-validation Sample	Full
Chronic Lung Disease						
no	12,035	12,078	24,113	7.2	7.3	7.2
yes	2,923	2,877	5,800	8.3	8.2	8.2
Chronic Pulmonary Hypertension						
no	13,390	13,374	26,764	7.2	7.2	7.2
yes	1,568	1,581	3,149	9.4	9.6	9.5
Coagulopathy						
no	14,858	14,855	29,713	7.4	7.4	7.4
yes	100	100	200	9.9	8.2	9.1
Depression						
no	13,894	13,873	27,767	7.4	7.4	7.4
yes	1,064	1,082	2,146	7.7	7.6	7.7
Diabetes						
No diabetes	9,442	9,363	18,805	7.3	7.4	7.3
Diabetes without complication	4,440	4,488	8,928	7.3	7.4	7.4
Diabetes with complications	1,076	1,104	2,180	8.5	8.2	8.4
Diabetes With Long-Term/Unspecified Complications						
no	13,893	13,863	27,756	7.3	7.4	7.3
yes	1,065	1,092	2,157	8.5	8.2	8.4
Excision of Other Lesion/Heart Tissue/LAA, Open Approach – Same Date as Valve with or without CABG						
no	14,291	14,271	28,562	7.3	7.4	7.3
yes	667	684	1,351	9.0	9.2	9.1
Fibrosis in Mediastinum and Heart						
no	14,938	14,930	29,868	7.4	7.4	7.4
yes	20	25	45	10.5	7.8	9.0
Heart Failure						
no	11,051	11,049	22,100	6.6	6.6	6.6
yes	3,907	3,906	7,813	9.7	9.9	9.8
History of CABG or Valve Surgery						
no	14,091	14,085	28,176	7.3	7.4	7.4
yes	867	870	1,737	8.6	8.5	8.6
History of Cerebral Vascular Accident (CVA) or Stroke						
no	13,924	13,969	27,893	7.4	7.4	7.4
yes	1,034	986	2,020	7.6	7.8	7.7
History of Chronic Steroid Use						
no	14,898	14,877	29,775	7.4	7.4	7.4
yes	60	78	138	8.0	8.2	8.1
History of Peripheral Vascular Disease						
no	12,624	12,556	25,180	7.3	7.4	7.4
yes	2,334	2,399	4,733	7.7	7.8	7.7
History of PTCA/Stent						
no	13,026	13,007	26,033	7.5	7.6	7.5
yes	1,932	1,948	3,880	6.7	6.7	6.7
Hypercholesterolemia						
no	4,804	4,805	9,609	8.6	8.5	8.6
yes	10,154	10,150	20,304	6.8	6.9	6.9
Hypertension						
no	5,632	5,603	11,235	8.5	8.5	8.5
yes	9,326	9,352	18,678	6.7	6.8	6.8
Hypertension with Complications						
no	12,938	12,911	25,849	7.1	7.1	7.1
yes	2,020	2,044	4,064	9.3	9.4	9.4

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Post-Surgical Length of Stay, 2008-2009

Candidate Variable	Number of Cases			Arithmetic Avg. Post-Surgical LOS		
	Development Sample	Cross-validation Sample	Full	Development Sample	Cross-validation Sample	Full
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery						
no	14,332	14,297	28,629	7.3	7.4	7.4
yes	626	658	1,284	8.5	8.6	8.5
Ischemic Heart Disease						
no	14,937	14,941	29,878	7.4	7.4	7.4
yes	21	14	35	6.2	7.9	6.9
Liver Disease						
no	14,832	14,818	29,650	7.4	7.4	7.4
yes	126	137	263	8.2	7.5	7.9
Lupus Erythematosus, Systemic						
no	14,918	14,907	29,825	7.4	7.4	7.4
yes	40	48	88	7.5	7.5	7.5
Multiple Valve Procedures						
no	14,266	14,205	28,471	7.2	7.3	7.2
yes	692	750	1,442	11.3	10.9	11.1
Myocardial Infarction, Old						
no	12,871	12,814	25,685	7.5	7.5	7.5
yes	2,087	2,141	4,228	7.0	7.1	7.1
Obesity						
no obesity	12,283	12,280	24,563	7.5	7.5	7.5
unspecified obesity	1,835	1,836	3,671	6.9	6.8	6.8
Morbid obesity	840	839	1,679	7.6	8.1	7.8
Obesity, Morbid						
no	14,118	14,116	28,234	7.4	7.4	7.4
yes	840	839	1,679	7.6	8.1	7.8
Other Open Heart Procedure						
no	13,770	13,774	27,544	7.2	7.3	7.3
yes	1,188	1,181	2,369	9.5	9.2	9.4
Procedure Group						
CABG without Valve	9,580	9,579	19,159	6.5	6.6	6.6
Valve without CABG	3,156	3,155	6,311	8.3	8.4	8.3
Valve with CABG	2,222	2,221	4,443	9.8	9.8	9.8
PTCA/Stent Same Day as CABG/Valve Surgery						
no	14,842	14,820	29,662	7.4	7.4	7.4
yes	116	135	251	8.4	8.3	8.3
Renal Failure/Dialysis (category)						
All cases not assigned to chronic and acute/dialysis categories	14,588	14,560	29,148	7.3	7.3	7.3
Chronic	206	230	436	11.9	11.3	11.6
Acute/dialysis	164	165	329	10.9	11.2	11.1
Renal Failure/Dialysis (binary)						
no	14,588	14,560	29,148	7.3	7.3	7.3
yes	370	395	765	11.5	11.3	11.4
Pre-op Acute Renal Failure/Dialysis (binary)						
no	14,794	14,790	29,584	7.4	7.4	7.4
yes	164	165	329	10.9	11.2	11.1
Ventricular Assist Device (LVAD and PVAD) Prior to CABG/Valve Surgery Date						
no	14,957	14,953	29,910	7.4	7.4	7.4
yes	1	2	3	21.0	6.5	11.3

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Post-Surgical Length of Stay, 2009

Candidate Variable	Number of Cases			Arithmetic Avg. Post-Surgical LOS		
	Development Sample	Cross-validation Sample	Full	Development Sample	Cross-validation Sample	Full
Demographic Variables						
Age in Years (tested as a continuous variable)						
Age: 30 - 39	89	85	174	6.1	6.3	6.2
Age: 40 - 49	441	414	855	6.2	6.0	6.1
Age: 50 - 59	1,423	1,356	2,779	6.4	6.3	6.4
Age: 60 - 69	2,211	2,238	4,449	6.9	7.1	7.0
Age: 70 - 79	2,201	2,276	4,477	8.0	8.1	8.0
Age: 80 - 89	1,044	1,029	2,073	9.5	9.1	9.3
Age: 90 - 99	17	27	44	11.1	11.1	11.1
Age # of Years > 65 (tested as a continuous variable)						
0	3,268	3,174	6,442	6.5	6.5	6.5
1	255	245	500	7.0	7.5	7.2
2	201	240	441	7.2	7.4	7.3
3	235	228	463	7.6	8.0	7.8
4	205	206	411	6.8	7.2	7.0
5	210	224	434	7.2	7.8	7.5
6	233	226	459	7.4	7.7	7.5
7	222	231	453	7.8	7.5	7.6
8	212	211	423	7.7	7.9	7.8
9	229	238	467	8.4	7.9	8.2
10	208	214	422	8.8	8.2	8.5
11	230	220	450	8.0	8.0	8.0
12	235	232	467	8.3	8.1	8.2
13	230	241	471	8.4	8.5	8.5
14	192	239	431	8.3	9.0	8.7
15	209	199	408	8.7	8.7	8.7
16	186	158	344	8.9	9.0	8.9
17	161	183	344	9.5	9.0	9.2
18	132	139	271	10.5	8.6	9.5
19	113	112	225	8.9	9.6	9.3
20	87	104	191	9.8	8.5	9.1
21	67	59	126	9.9	9.6	9.8
22	38	33	71	11.1	10.0	10.5
23	33	29	62	11.6	11.4	11.5
24	18	13	31	9.0	12.8	10.6
25	8	14	22	13.9	11.4	12.3
26	5	6	11	9.2	7.8	8.5
27	3	5	8	9.0	14.8	12.6
28	1	0	1	5.0	0.0	5.0
29	0	2	2	0.0	9.5	9.5
Female						
no	5,007	4,958	9,965	7.1	7.1	7.1
yes	2,419	2,467	4,886	8.2	8.3	8.3
Race/Ethnicity						
Hispanic	197	192	389	6.0	6.0	6.0
White (non-Hispanic)	6,516	6,446	12,962	7.4	7.4	7.4
Black (non-Hispanic)	322	355	677	8.9	8.7	8.8
Other/Unknown	391	432	823	8.3	8.3	8.3
Race						
Black	330	362	692	8.8	8.7	8.7
Other/Unknown	478	510	988	8.0	8.2	8.1
White	6,618	6,553	13,171	7.3	7.3	7.3

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Post-Surgical Length of Stay, 2009

Candidate Variable	Number of Cases			Arithmetic Avg. Post-Surgical LOS		
	Development Sample	Cross-validation Sample	Full	Development Sample	Cross-validation Sample	Full
Clinical Variables						
Acute Myocardial Infarction						
no	6,174	6,148	12,322	7.4	7.4	7.4
yes	1,252	1,277	2,529	7.7	7.9	7.8
Anemia						
no	5,796	5,811	11,607	7.2	7.3	7.2
yes	1,630	1,614	3,244	8.2	8.2	8.2
Angina						
no	5,705	5,724	11,429	7.7	7.8	7.8
yes	1,721	1,701	3,422	6.5	6.4	6.4
Angina, Unstable						
no	6,172	6,182	12,354	7.6	7.7	7.7
yes	1,254	1,243	2,497	6.4	6.4	6.4
Atlas Predicted LOS						
0	162	179	341	4.8	5.2	5.0
1	1,054	1,015	2,069	5.7	5.7	5.7
2	5,111	5,099	10,210	7.3	7.3	7.3
3	943	987	1,930	9.7	9.8	9.7
4	156	145	301	11.5	12.2	11.9
Cachexia						
no	7,167	7,193	14,360	7.2	7.2	7.2
yes	259	232	491	15.0	15.3	15.1
Cancer						
no	7,219	7,198	14,417	7.4	7.4	7.4
yes	207	227	434	8.6	8.4	8.5
Cardiac Adhesions						
no	7,348	7,350	14,698	7.4	7.4	7.4
yes	78	75	153	7.8	9.9	8.8
Cardiogenic Shock, Pre-Operative						
no	7,396	7,391	14,787	7.4	7.4	7.4
yes	30	34	64	16.0	14.4	15.2
Cardiomyopathy						
no	6,202	6,166	12,368	7.1	7.3	7.2
yes	1,224	1,259	2,483	9.0	8.5	8.7
Cardiopulmonary Resuscitation (CPR) Prior to CABG/Valve Surgery Date						
no	7,405	7,413	14,818	7.4	7.5	7.5
yes	21	12	33	9.8	9.3	9.6
Cerebrovascular Disease						
no	6,992	6,966	13,958	7.4	7.5	7.4
yes	434	459	893	7.9	7.5	7.7
Chronic Lung Disease						
no	6,000	5,985	11,985	7.3	7.3	7.3
yes	1,426	1,440	2,866	8.2	8.3	8.2
Chronic Pulmonary Hypertension						
no	6,650	6,585	13,235	7.2	7.2	7.2
yes	776	840	1,616	9.5	9.5	9.5
Coagulopathy						
no	7,378	7,360	14,738	7.4	7.4	7.4
yes	48	65	113	7.8	9.9	9.0
Depression						
no	6,872	6,848	13,720	7.4	7.5	7.4
yes	554	577	1,131	8.0	7.6	7.8

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Post-Surgical Length of Stay, 2009

Candidate Variable	Number of Cases			Arithmetic Avg. Post-Surgical LOS		
	Development Sample	Cross-validation Sample	Full	Development Sample	Cross-validation Sample	Full
Diabetes						
No diabetes	4,720	4,691	9,411	7.3	7.4	7.4
Diabetes without complication	2,138	2,225	4,363	7.4	7.4	7.4
Diabetes with complications	568	509	1,077	8.5	8.3	8.4
Diabetes With Long-Term/Unspecified Complications						
no	6,862	6,927	13,789	7.4	7.4	7.4
yes	564	498	1,062	8.5	8.3	8.4
Excision of Other Lesion/Heart Tissue/LAA, Open Approach – Same Date as Valve with or without CABG						
no	7,066	7,055	14,121	7.4	7.4	7.4
yes	360	370	730	9.2	9.0	9.1
Fibrosis in Mediastinum and Heart						
no	7,419	7,419	14,838	7.4	7.5	7.5
yes	7	6	13	13.0	5.7	9.6
Heart Failure						
no	5,430	5,408	10,838	6.6	6.6	6.6
yes	1,996	2,017	4,013	9.8	9.7	9.8
History of CABG or Valve Surgery						
no	7,030	6,965	13,995	7.4	7.4	7.4
yes	396	460	856	8.6	8.6	8.6
History of Cerebral Vascular Accident (CVA) or Stroke						
no	6,915	6,878	13,793	7.4	7.4	7.4
yes	511	547	1,058	7.7	7.8	7.8
History of Chronic Steroid Use						
no	7,392	7,395	14,787	7.4	7.5	7.4
yes	34	30	64	9.5	9.6	9.6
History of Peripheral Vascular Disease						
no	6,228	6,229	12,457	7.4	7.4	7.4
yes	1,198	1,196	2,394	7.9	7.6	7.7
History of PTCA/Stent						
no	6,513	6,466	12,979	7.5	7.6	7.6
yes	913	959	1,872	6.9	6.7	6.8
Hypercholesterolemia						
no	2,378	2,388	4,766	8.6	8.5	8.6
yes	5,048	5,037	10,085	6.9	7.0	6.9
Hypertension						
no	2,846	2,802	5,648	8.5	8.6	8.5
yes	4,580	4,623	9,203	6.8	6.8	6.8
Hypertension with Complications						
no	6,404	6,313	12,717	7.1	7.1	7.1
yes	1,022	1,112	2,134	9.5	9.3	9.4
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery						
no	7,094	7,116	14,210	7.4	7.4	7.4
yes	332	309	641	8.1	8.4	8.3
Ischemic Heart Disease						
no	7,418	7,415	14,833	7.4	7.5	7.5
yes	8	10	18	5.6	8.1	7.0
Liver Disease						
no	7,364	7,366	14,730	7.4	7.5	7.5
yes	62	59	121	6.8	8.5	7.7
Lupus Erythematosus, Systemic						
no	7,400	7,402	14,802	7.4	7.5	7.5
yes	26	23	49	7.3	8.9	8.0

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

Post-Surgical Length of Stay, 2009

Candidate Variable	Number of Cases			Arithmetic Avg. Post-Surgical LOS		
	Development Sample	Cross-validation Sample	Full	Development Sample	Cross-validation Sample	Full
Multiple Valve Procedures						
no	7,069	7,020	14,089	7.2	7.3	7.3
yes	357	405	762	11.4	10.7	11.1
Myocardial Infarction, Old						
no	6,393	6,380	12,773	7.5	7.5	7.5
yes	1,033	1,045	2,078	7.0	7.0	7.0
Obesity						
no obesity	6,043	6,063	12,106	7.5	7.5	7.5
unspecified obesity	937	924	1,861	7.1	6.7	6.9
Morbid obesity	446	438	884	8.0	7.9	8.0
Obesity, Morbid						
no	6,980	6,987	13,967	7.4	7.4	7.4
yes	446	438	884	8.0	7.9	8.0
Other Open Heart Procedure						
no	6,823	6,791	13,614	7.3	7.3	7.3
yes	603	634	1,237	9.3	9.4	9.3
Procedure Group						
CABG without Valve	4,678	4,678	9,356	6.6	6.6	6.6
Valve without CABG	1,633	1,633	3,266	8.3	8.4	8.3
Valve with CABG	1,115	1,114	2,229	9.8	9.9	9.8
PTCA/Stent Same Day as CABG/Valve Surgery						
no	7,360	7,364	14,724	7.4	7.5	7.4
yes	66	61	127	8.0	8.9	8.4
Renal Failure/Dialysis (category)						
All cases not assigned to chronic and acute/dialysis categories	7,242	7,215	14,457	7.3	7.4	7.4
Chronic	106	110	216	11.1	11.3	11.2
Acute/dialysis	78	100	178	12.3	10.6	11.3
Renal Failure/Dialysis (binary)						
no	7,242	7,215	14,457	7.3	7.4	7.4
yes	184	210	394	11.6	10.9	11.3
Pre-op Acute Renal Failure/Dialysis (binary)						
no	7,348	7,325	14,673	7.4	7.4	7.4
yes	78	100	178	12.3	10.6	11.3
Ventricular Assist Device (LVAD and PVAD) Prior to CABG/Valve Surgery Date						
no	7,426	7,423	14,849	7.4	7.5	7.5
yes	0	2	2	0.0	13.5	13.5

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

Hospitals used the *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 (KCFs). The *Atlas Outcomes*™ system is based on the examination of numerous KCFs such as lab test results, vital signs, the patient's medical history, imaging results, age, sex, and operative/endoscopy findings. Hospital personnel abstract these KCFs from the medical record during specified time frames in the hospitalization. Some pre-admission data are also captured (e.g., cardiac catheterization findings), as are some history findings.

The Atlas in-hospital mortality and length of stay models focusing specifically on the patients who underwent a CABG and/or valve procedure were developed in consultation with a clinical advisory panel. The KCF variables were entered into algorithms that calculated the overall predicted probability of death or the predicted length of stay for each patient that underwent 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. PHC4 used the Atlas Predicted Probability of Death and Atlas Predicted Length of Stay, along with other patient risk factors, to risk adjust hospital- and physician-specific outcomes.

Note that if a hospital did not submit KCFs for a particular patient, the Atlas Predicted Probability of Death and the Atlas Predicted Length of Stay could not be assigned to the patient. If a discharge record was missing these values, PHC4 imputed the values using the average values for the hospital by year and procedure group.

*Variables included in the Atlas CABG/valve models used to calculate the Atlas Predicted Probability of Death and Predicted Length of Stay:

Atlas Variable Name	Predicted Probability of Death	Predicated Length of Stay
5-7 Occluded Vessels	✓	
Acute MI Diagnosis		✓
Age in Years	✓	✓
Age > 65	✓	
Albumin <=2.4	✓	
Albumin <= 2.7		✓
Albumin >2.4 and <=3.0	✓	
AMI Other Inf Init Epis	✓	
ASA Class 5	✓	
ASA Emergency Flag	✓	
Atherosclerosis		✓
Base units <= 5.0		✓
BUN mg/dL > 40	✓	
BUN mg/dL > 55		✓
CABG+Valve	✓	✓
CABG/PTCA/Tear Same Day	✓	
Cardiomyopathy		✓
CHF	✓	
Chronic Pulmonary Heart Disease		✓

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

Atlas Variable Name	Predicted Probability of Death	Predicated Length of Stay
Chronic Renal Disease		✓
COPD		✓
Creatinine > 1.4	✓	
Creatinine > 2.0		✓
Current Med Immunosuppressants	✓	✓
Current Med Insulin	✓	✓
Deficiency Anemia		✓
Depressive Disease		✓
Edema Skin		✓
EF<25%	✓	✓
EF>45%	✓	✓
Glucose mg/dL > 165	✓	
Glucose mg/dL > 240		✓
Heart Failure Diagnosis		✓
History of CHF		✓
History Per Vasc Disease	✓	✓
Hyp Renal w Renal Failure		✓
Male Flag	✓	✓
MI/Other Ant Wall	✓	
Mild Mod or Severe AMS	✓	✓
Nonsurgical Coronary Revascularization		✓
Other CV Procedure Group	✓	
PAP >55		✓
Percent of Left Main Stenosis	✓	
pH <= 7.30		✓
Previous CABG	✓	✓
Previous Stroke		✓
Rheum Valve Disease		✓
Sept Other Anom Rep	✓	
SIRS Group	✓	✓
Tear Vessel		✓
Valve-Only	✓	✓
WBC > 19.8		✓