Technical Notes

for

Cardiac Surgery in Pennsylvania 2006

Calendar Years 2005-2006 Data

The Pennsylvania Health Care Cost Containment Council
August 2008

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 calendar year 2006 (January 1, 2006 to December 31, 2006) and combined calendar years 2005 and 2006 (January 1, 2005 to December 31, 2006). This document describes the methodology and development of the report and includes information on statewide results, cases excluded from analysis, and risk-adjustment models.

- This report presents data on the outcomes associated with heart valve surgery and CABG surgery. The report includes two sets of outcomes for hospitals: 1) outcomes for combined 2005-2006 data, and 2) outcomes for 2006 only. The report includes one set of outcomes for surgeons based on combined 2005-2006 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 hospital.

- 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.

- Average Medicare payment is reported for 2006 data only for hospitals with at least 13 cases.

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

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DATA COLLECTION AND VERIFICATION

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

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

Medicare payment data was provided by the Centers for Medicare and Medicaid Services (CMS). Hospitals had an opportunity to view the average Medicare payment reported for their facility prior to the public release of the information. Due to CMS privacy restrictions, hospitals did not have an opportunity to review the Medicare payment data at the individual case level.

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

Hospital and Cardiothoracic Surgeon Verification of Data

Discharge records for patients who underwent an open heart procedure in 2005 and/or 2006 were subjected to extensive data verification and quality assurance checks. Hospitals were requested to confirm the accuracy of discharge records, provide six additional diagnoses and three additional 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 surgery and not accounted for through risk adjustment. The medical records were reviewed to determine whether special requests for exclusion (SRE) would be granted. In addition, because of their importance as risk factors, hospitals and surgeons had the opportunity to submit medical records for cases in which cardiogenic shock and/or acute renal failure were present at or immediately prior to the surgery.

STUDY POPULATION

The CABG and valve study population included those patients discharged from Pennsylvania general acute care hospitals in calendar year 2005 or 2006 after undergoing CABG and/or valve surgery as identified by the presence of an appropriate ICD-9-CM procedure code(s) in either the principal or secondary procedure position 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 2005-2006 data, and 2) outcomes for 2006 only. The report includes one set of outcomes for surgeons based on combined 2005-2006 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 total 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 analysis.

In-Hospital Mortality

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

Operative Mortality

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

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

7-Day Readmissions

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

30-Day Readmissions

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

Post-Surgical Length of Stay

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

Average Hospital Charge

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

Average Medicare Payment

Average Medicare Payment is the mean total expected payment per DRG that CMS reported for a Medicare patient in the fee-for-service system. Payments from Medicare Advantage plans (Medicare HMOs) are not included. Average Medicare payments vary across different hospitals, because Medicare takes into account differences among facilities in labor costs, teaching programs, and services to the poor, in determining what it will pay for care. Since Medicare payments are revised and updated annually, PHC4 is reporting only Medicare average payments for 2006 cardiac cases, rather than averaging payment amounts for the 2005-2006 period.

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 that were more seriously ill or at a greater risk than others. Risk adjusting the data was important because sicker patients might be more likely to die, stay in the hospital longer, or be readmitted. Through logistic or linear regression modeling, risk factors (e.g., the age and sex of the patient and factors that indicate the illness level of the patient) were "tested" to determine which factors predicted patient outcomes (i.e., in-hospital mortality, operative mortality, 7-day and 30-day readmissions, and post-surgical length of stay). Note that a separate risk-adjustment model was built for each of these outcome measures and for each time period analyzed. The risk-adjustment models were then used to calculate the risk-adjusted ratings displayed in the report.

Each hospital and surgeon with at least 30 cases in a particular procedure group (after exclusions) received ratings for in-hospital mortality, operative mortality, 7-day readmissions, and 30-day readmissions. The ratings indicate whether the hospital or the surgeon's mortality or readmissions rate was 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. ***2005-2006 Frequencies for Development Sample, Cross-Validation Sample, and Full Data Set***

	Development Sample	Cross-Validation Sample	Full Data Set
In-hospital mortality			
Number of cases	16,984	16,982	33,966
Number of in-hospital deaths	488	479	967
Mortality rate (%)	2.9	2.8	2.8
Operative mortality			
Number of cases	15,386	15,383	30,769
Number of operative deaths	546	513	1,059
Mortality rate (%)	3.5	3.3	3.4
7-day readmissions			
Number of cases	14,956	14,954	29,910
Number of readmissions within 7 days	927	876	1,803
Readmissions rate (%)	6.2	5.9	6.0
30-day readmissions			
Number of cases	14,956	14,954	29,910
Number of readmissions within 30 days	2,259	2,150	4,409
Readmissions rate (%)	15.1	14.4	14.7

Table 1b. ***2006 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	8,317	8,316	16,633
Number of in-hospital deaths	219	238	457
Mortality rate (%)	2.6	2.9	2.7
Operative mortality			
Number of cases	7,513	7,510	15,023
Number of operative deaths	246	264	510
Mortality rate (%)	3.3	3.5	3.4
7-day readmissions			
Number of cases	7,307	7,306	14,613
Number of readmissions within 7 days	461	422	883
Readmissions rate (%)	6.3	5.8	6.0
30-day readmissions			
Number of cases	7,307	7,306	14,613
Number of readmissions within 30 days	1,086	1,022	2,108
Readmissions rate (%)	14.9	14.0	14.4

Building the Risk-Adjustment Models

Identifying possible risk factors. The first step in building the risk-adjustment models for in-hospital mortality, operative mortality, 7-day readmissions, and 30-day readmissions was to identify possible risk factors, that is, those factors that potentially contributed to these events. In doing so, both clinical and demographic factors identified in the literature were considered, taking into account the availability and usability of the variables in the database. Also considered were factors tested in previous cardiac-related reports released by PHC4, as well as, MediQual's Key Clinical Findings (KCFs; see Appendix G). These possible risk-adjustment factors are called candidate variables. Appendices E and F provide definitions and data for candidate variables that were considered in the present analyses.

Once the candidate variables were identified, models for each outcome measure were developed using the following processes: model selection, cross-validation, and calculation of model adequacy measures.

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

The variables in Tables 3a, 3b, 4a, and 4b were entered into the models and tested for their impact in each model. Using a backward stepwise technique, candidate variables that had the least impact in the model were eliminated one at a time, until all variables remaining in the model were statistically significant. All tests of significance ($p < 0.10$) were based on the likelihood ratio. Tables 5a and 5b note the tested variables that were found to be significant in the mortality models. Tables 6a and 6b note the tested variables that were found to be significant in the readmissions models.

***Table 2a.* 2005-2006 Development Models: Candidate Variables Entered Into the Models that were Developed Primarily by MediQual**

Demographic Variables	Laboratory Variables
Age in Years	Albumin < 2.5
Age # Years > 65	Albumin 2.5-3
Female	BUN > 40
	Creatinine > 1.4
	Glucose > 165

Clinical Variables Other Than Laboratory Variables	
AMI Other Inferior Wall Initial Episode	History of Peripheral Vascular Disease
ASA Class 5	MI/AMI Other Anterior Wall
ASA Emergency Flag	Mild Moderate or Severe AMS
CAD > 70, 5-7 Vessels Grp	Other CV Procedure Group
Current Med Immunosuppressants	Percent of Left Main Stenosis
Current Med Insulin	Procedure Group
Ejection Fraction	PTCA/Stent/Tear Same Day as CABG/Valve Surgery
Heart Failure	Septal Other Anomalous Repair Heart [1]
History of CABG or Valve Surgery	SIRS Group

***Table 2b.* 2006 Development Models: Candidate Variables Entered Into the Models that were Developed Primarily by MediQual**

Demographic Variables	Laboratory Variables
Age in Years	Albumin < 2.5 [1]
Age # Years > 65	Albumin 2.5-3 [1]
Female	BUN > 40
	Creatinine > 1.4
	Glucose > 165

Clinical Variables Other Than Laboratory Variables	
AMI Other Inferior Wall Initial Episode	History of Peripheral Vascular Disease
ASA Class 5	MI/AMI Other Anterior Wall
ASA Emergency Flag	Mild Moderate or Severe AMS
CAD > 70, 5-7 Vessels Grp	Other CV Procedure Group
Current Med Immunosuppressants [1, 2]	Percent of Left Main Stenosis
Current Med Insulin	Procedure Group
Ejection Fraction	PTCA/Stent/Tear Same Day as CABG/Valve Surgery
Heart Failure	Septal Other Anomalous Repair Heart [1, 2]
History of CABG or Valve Surgery	SIRS Group [1, 2]

[1] This variable was not retained in the in-hospital mortality model because the analysis did not suggest that the variable would be predictive of in-hospital mortality (i.e., the variable's coefficient was negative).

[2] This variable was not retained in the operative mortality model because the analysis did not suggest that the variable would be predictive of operative mortality (i.e., the variable's coefficient was negative).

Table 3a. 2005-2006 Development Models: Variables Tested as Potential Predictors for Mortality

Candidate Variables	Results for Mortality	
	In-Hospital	Operative
Clinical Variables Other Than Laboratory Variables		
AMI Except Other Anterior or Other Inferior Wall	✓	✓
Cachexia	✓	✓
Cardiogenic Shock, Preoperative	✓	✓
Cardiomyopathy	ns	not tested[1]
Chronic Lung Disease	not tested[1]	ns
Chronic Pulmonary Hypertension	ns	ns
Coagulopathy	ns	ns
Diabetes With Long-Term/Unspecified Complications	not tested[1]	ns
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery	ns	not retained[2]
Hypertension with Complications	✓	✓
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery	✓	ns
Liver Disease	not tested[1]	✓
Lupus	✓	✓
Multiple Valve Procedures	✓	✓
Renal Failure/Dialysis (category)	ns	ns

Table 3b. 2006 Development Models: Variables Tested as Potential Predictors for Mortality

Candidate Variables	Results for Mortality	
	In-Hospital	Operative
Demographic Variables		
Race/Ethnicity	✓	not tested[3]
Race	not tested[4]	✓
Clinical Variables Other Than Laboratory Variables		
AMI Except Other Anterior or Other Inferior Wall	✓	✓
Cachexia	✓	✓
Cardiogenic Shock, Preoperative	✓	✓
Cardiomyopathy	ns	not tested[1]
CPR Prior to Date of CABG/Valve Surgery	✓	ns
Chronic Pulmonary Hypertension	ns	ns
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery	ns	not tested[1]
Hypertension with Complications	ns	✓
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery	ns	ns
Liver Disease	✓	✓
Lupus	not retained[2]	ns
Multiple Valve Procedures	ns	✓
Renal Failure/Dialysis (category)	ns	ns

✓ : significant predictor ($p < 0.10$)
ns: not significant
[1] This variable was not tested because the preliminary analysis did not suggest that the variable would be predictive of the relevant outcome.
[2] This variable was not retained in the model because the analysis did not suggest that the variable would be predictive of the relevant outcome (i.e., the variable's coefficient was negative).
[3] This variable was not tested in the model because the race variable was a stronger predictor of the relevant outcome than the race/ethnicity variable.
[4] This variable was not tested in the model because the race/ethnicity variable was a stronger predictor of the relevant outcome than the race variable.

Table 4a. *2005-2006 Development Models: Variables Tested as Potential Predictors of Readmissions*

Candidate Variables	Results for Readmissions	
	7-Day	30-Day
Year	not tested[1]	✓
Demographic Variables		
Age in Years	ns	ns
Age # Years > 65	✓	✓
Female	ns	✓
Race	✓	✓
Clinical Variables Other Than Laboratory Variables		
AMI Except Other Anterior or Other Inferior Wall	ns	ns
ASA Class 5	not tested[1]	not retained[2]
Cancer	not tested[1]	✓
Cardiogenic Shock, Preoperative	not tested[1]	ns
Cardiomyopathy	not tested[1]	ns
Cerebrovascular Disease	not tested[1]	ns
Chronic Lung Disease	ns	✓
Chronic Pulmonary Hypertension	ns	ns
Diabetes	✓	✓
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery	ns	not tested[1]
Fibrosis in Mediastinum and Heart	not tested[1]	not retained[2]
Heart Failure	✓	✓
History of CABG or Valve Surgery	not tested[1]	ns
History of Peripheral Vascular Disease	✓	✓
History of PTCA/Stent	✓	not tested[1]
Hypertension with Complications	ns	not retained[2]
Lupus	not tested[1]	ns
Morbid Obesity	✓	✓
MediQual Predicted Length of Stay	✓	✓
Multiple Valve Procedures	ns	✓
Other CV Procedure Group	ns	ns
Procedure Group	✓	NA
Renal Failure/Dialysis (category)	not tested[3]	ns
Renal Failure/Dialysis (binary)	ns	not tested[4]

✓ : significant predictor ($p < 0.10$)

NA: not applicable. Procedure group was not a statistically significant variable in the development model, but it was retained in the model.

ns: not significant

[1] This variable was not tested because the preliminary analysis did not suggest that the variable would be predictive of the relevant outcome.

[2] This variable was not retained in the model because the analysis did not suggest that the variable would be predictive of the relevant outcome (i.e., the variable's coefficient was negative).

[3] This variable was not tested in the model because the binary renal failure/dialysis variable was a stronger predictor of the relevant outcome than the category renal failure/dialysis variable.

[4] This variable was not tested in the model because the category renal failure/dialysis variable was a stronger predictor of the relevant outcome than the binary renal failure/dialysis variable.

Table 4b. 2006 Development Models: Variables Tested as Potential Predictors of Readmissions

Candidate Variables	Results for Readmissions	
	7-Day	30-Day
Demographic Variables		
Age in Years	ns	not retained[2]
Age # Years > 65	ns	✓
Female	not tested[1]	ns
Race/Ethnicity	✓	ns
Clinical Variables Other Than Laboratory Variables		
Anemia	not tested[1]	ns
ASA Emergency	not retained[2]	not tested[1]
Cerebrovascular Disease	not tested[1]	✓
Chronic Lung Disease	ns	ns
Chronic Pulmonary Hypertension	ns	ns
Diabetes	not tested[3]	✓
Diabetes with Long Term/Unspecified Complications	ns	not tested[4]
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery	ns	not tested[1]
Heart Failure	✓	✓
History of CABG or Valve Surgery	not tested[1]	ns
Hypertension with Complications	ns	ns
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery	ns	not tested[1]
MediQual Predicted Length of Stay	✓	✓
Multiple Valve Procedures	not tested[1]	ns
Other CV Procedure Group	ns	not tested[1]
Procedure Group	✓	✓
Renal Failure/Dialysis (category)	not tested[1]	ns

✓ : significant predictor ($p < 0.10$)
ns: not significant
[1] This variable was not tested because the preliminary analysis did not suggest that the variable would be predictive of the relevant outcome.
[2] This variable was not retained in the model because the analysis did not suggest that the variable would be predictive of the relevant outcome (i.e., the variable's coefficient was negative).
[3] This variable was not tested in the model because the diabetes with long term/unspecified complications variable was a stronger predictor of the relevant outcome than the diabetes variable.
[4] This variable was not tested in the model because the diabetes variable was a stronger predictor of the relevant outcome than the diabetes with long term/unspecified complications variable.

Cross-validation. After the development models were built for in-hospital mortality, operative mortality, 7-day readmissions, and 30-day readmissions, the models were cross-validated. That is, the models built in the model selection process (i.e., the development models) were re-estimated using the cases in the cross-validation samples. Regression analyses were performed to determine whether the selected candidate variables would remain predictive of the relevant outcomes for the cross-validation sample. As long as the coefficient of a variable did not change from positive to negative, the variable was retained in the final model that applied to the full data set. Note that during the cross-validation process of the mortality models, the variables developed primarily by MediQual were entered in the models but not considered for cross-validation. See Tables 5a, 5b, 6a, and 6b for the cross-validation results.

Table 5a. 2005-2006 Cross-Validation Results: p Values for Significant Candidate Variables in the Mortality Models

Significant Variables in Development Model	In-Hospital Mortality			Operative Mortality		
	Development Model	Cross-Validation Model	Full Data Set	Development Model	Cross-Validation Model	Full Data Set
Clinical Variables Other Than Laboratory Variables						
AMI Except Other Anterior or Other Inferior Wall	< 0.001	0.022	< 0.001	< 0.001	0.026	< 0.001
Cachexia	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cardiogenic Shock, Preoperative	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Hypertension with Complications	0.006	0.020	< 0.001	0.015	< 0.001	< 0.001
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery	0.030	0.048	0.002	ns	–	–
Liver Disease	not tested[1]	–	–	0.005	0.027	< 0.001
Lupus	0.041	0.031	0.003	0.016	0.215	0.009
Multiple Valve Procedures	< 0.001	0.003	< 0.001	0.001	0.003	< 0.001

Table 5b. 2006 Cross-Validation Results: p Values for Significant Candidate Variables in the Mortality Models

Significant Variables in Development Model	In-Hospital Mortality			Operative Mortality		
	Development Model	Cross-Validation Model	Full Data Set	Development Model	Cross-Validation Model	Full Data Set
Demographic Variables						
Race/Ethnicity	0.051	0.055	0.001	not tested[1]	–	–
Race	not tested[2]	–	–	0.076	0.338	0.061
Clinical Variables Other Than Laboratory Variables						
AMI Except Other Anterior or Other Inferior Wall	0.012	0.015	0.001	0.015	0.003	< 0.001
Cachexia	0.010	< 0.001	< 0.001	< 0.001	0.001	< 0.001
Cardiogenic Shock, Preoperative	0.037	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
CPR Prior to Date of CABG/Valve Surgery	0.081	0.591	0.109	ns	–	–
Hypertension with Complications	ns	–	–	0.012	0.133	0.006
Liver Disease	0.009	0.002	< 0.001	0.011	0.084	0.002
Multiple Valve Procedures	ns	–	–	0.001	0.155	0.001

ns: not significant

[1] This variable was not tested in the model because the race variable was a stronger predictor of the relevant outcome than the race/ethnicity variable.

[2] This variable was not tested in the model because the race/ethnicity variable was a stronger predictor of the relevant outcome than the race variable.

Table 6a. ***2005-2006 Cross-Validation Results: p Values for Significant Candidate Variables in the Readmissions Models***

Significant Variables in Development Model	7-Day Readmissions			30-Day Readmissions		
	Development Model	Cross-Validation Model	Full Data Set	Development Model	Cross-Validation Model	Full Data Set
Year	not tested[1]	–	–	0.030	0.635	0.054
Demographic Variables						
Age # Years > 65	0.003	0.039	< 0.001	< 0.001	0.002	< 0.001
Female	ns	–	–	0.092	< 0.001	< 0.001
Race	0.012	0.529	0.023	0.008	0.126	0.001
Clinical Variables Other Than Laboratory Variables						
Cancer	not tested[1]	–	–	0.043	0.919	0.109
Chronic Lung Disease	ns	–	–	0.093	< 0.001	< 0.001
Diabetes	0.014	0.134	0.023	< 0.001	< 0.001	< 0.001
Heart Failure	0.008	0.148	0.004	0.001	0.003	< 0.001
History of Peripheral Vascular Disease	0.054	0.018	0.002	< 0.001	0.096	< 0.001
History of PTCA/Stent	0.011	0.144	0.004	not tested[1]	–	–
Morbid Obesity	0.020	0.527	0.039	< 0.001	0.105	< 0.001
MediQual Predicted Length of Stay	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Multiple Valve Procedures	ns	–	–	0.014	0.941	0.074
Procedure Group	0.068	0.183	0.026	NA	NA	NA

Table 6b. ***2006 Cross-Validation Results: p Values for Significant Candidate Variables in the Readmissions Models***

Significant Variables in Development Model	7-Day Readmissions			30-Day Readmissions		
	Development Model	Cross-Validation Model	Full Data Set	Development Model	Cross-Validation Model	Full Data Set
Demographic Variables						
Age # Years > 65	ns	–	–	< 0.001	0.159	< 0.001
Race/Ethnicity	0.070	0.956	0.138	ns	–	–
Clinical Variables Other Than Laboratory Variables						
Cerebrovascular Disease	not tested[1]	–	–	0.015	0.264	0.014
Diabetes	not tested[1]	–	–	0.025	< 0.001	< 0.001
Heart Failure	0.099	0.443	0.080	< 0.001	0.021	< 0.001
MediQual Predicted Length of Stay	0.001	0.014	< 0.001	< 0.001	< 0.001	< 0.001
Procedure Group	NA	NA	NA	NA	NA	NA

NA: not applicable. Procedure group was not a statistically significant variable in the development model, but it was retained in the model.

ns: not significant

[1] This variable was not tested because the preliminary analysis did not suggest that the variable would be predictive of the relevant outcome.

Measure of model adequacy. To evaluate the model performance for both the development and cross-validation samples, the estimated coefficients from the development model were applied to both samples. The coefficients from the final model were applied to the full data set. The *c* statistic was used to measure model adequacy. The *c* statistic, the measure of "goodness of fit" used to describe a logistic regression model, is a common measure for models with binary dependent variables. For binary outcomes, the *c* statistic is defined as the area under the receiver operating characteristic (ROC) curve[1]. The *c* statistic ranges between 0.5 and 1.0, with higher values associated with better discrimination, and can be expressed as a percentage ranging from 50 to 100 percent. In some respects, the *c* statistic is similar to the R^2 commonly used in linear regression. Both the *c* statistic and R^2 approach 1.0 for models that perfectly discriminate. However, unlike R^2, the *c* statistic is not dependent on the frequency of the outcome. The *c* statistics for the models are listed in Table 7.

Table 7. c Statistics for Development, Cross-Validation, and Full Data Set Models

Measure	Development Model %	Cross-Validation Model %	Full Data Set Model %
2005-2006 Models			
In-Hospital Mortality	82.7	81.5	82.3
Operative Mortality	82.2	77.1	80.2
7-Day Readmissions	61.5	58.2	60.0
30-Day Readmissions	63.1	60.3	61.8
2006 Models			
In-Hospital Mortality	81.8	81.3	82.0
Operative Mortality	81.5	77.5	80.1
7-Day Readmissions	60.4	58.5	59.3
30-Day Readmissions	61.4	60.8	61.3

Coefficients and Odds Ratios

The coefficients and odds ratios for each risk factor included in the final models are listed in Tables 8a, 8b, 9a, and 9b. 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 Preoperative Cardiogenic Shock is 3.223 for the 2005-2006 in-hospital mortality model, meaning that a patient with cardiogenic shock prior to surgery was more than three times as likely to die during the hospital admission as patients who did not have this risk factor. Odds ratios are not applicable for continuous variables such as age in years and percent of left main stenosis.

[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 8a. 2005-2006 Coefficients and Odds Ratios of Final Mortality Models

Predictor Variables	In-Hospital Mortality		Operative Mortality	
	Coefficient	Odds Ratio	Coefficient	Odds Ratio
Constant	-6.5014		-6.0964	
Demographic Variables				
Age in Years	0.0140	NA	0.0136	NA
Age # Years > 65	0.0373	NA	0.0392	NA
Female	0.3934	1.482	0.3514	1.421
Laboratory Variables				
Albumin < 2.5	0.1829	1.201	0.0941	1.099
Albumin 2.5-3	0.1084	1.114	0.1369	1.147
BUN > 40	0.3819	1.465	0.4022	1.495
Creatinine > 1.4	0.2553	1.291	0.2240	1.251
Glucose > 165	0.1494	1.161	0.0633	1.065
Clinical Variables Other Than Laboratory Variables				
AMI Other Inferior Wall Initial Episode	0.7777	2.176	0.7898	2.203
AMI Except Other Anterior or Other Inferior Wall	0.4028	1.496	0.4203	1.522
ASA Class 5	1.3327	3.791	1.3210	3.747
ASA Emergency Flag	0.6150	1.850	0.5583	1.748
Cachexia	1.1462	3.146	1.1902	3.288
CAD > 70, 5-7 Vessels Grp	0.0601	1.062	0.1236	1.132
Cardiogenic Shock, Preoperative	1.1705	3.223	1.1747	3.237
Current Med Immunosuppressants	0.1529	1.165	0.1646	1.179
Current Med Insulin	0.3000	1.350	0.2583	1.295
Ejection Fraction				
<25%	0.4736	1.606	0.5813	1.788
25-45%	0.2388	1.270	0.2228	1.250
>45%	*	*	*	*
Heart Failure	0.6499	1.915	0.5520	1.737
History of CABG or Valve Surgery	0.7029	2.020	0.5894	1.803
History of Peripheral Vascular Disease	0.2248	1.252	0.2161	1.241
Hypertension with Complications	0.3674	1.444	0.4078	1.504
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery	0.3958	1.486	ns	–
Liver Disease	not tested[1]	–	1.1824	3.262
Lupus	1.3333	3.794	1.1524	3.166
MI/AMI Other Anterior Wall	0.4036	1.497	0.4669	1.595
Mild Moderate or Severe AMS	0.4411	1.554	0.5118	1.668
Multiple Valve Procedures	0.5824	1.790	0.4995	1.648
Other CV Procedure Group	0.3519	1.422	0.2179	1.243
Percent of Left Main Stenosis	0.00147	NA	0.00114	NA
Procedure Group				
CABG without Valve	*	*	*	*
Valve without CABG	0.3086	1.362	0.2920	1.339
Valve with CABG	0.7934	2.211	0.7476	2.112
PTCA/Stent/Tear Same Day as CABG/Valve Surgery	0.7037	2.021	0.4665	1.594
Septal Other Anomalous Repair Heart	not retained[2]	–	0.1340	1.143
SIRS Group	0.0618	1.064	0.1322	1.141

NA: Not applicable. This factor was tested as a continuous variable.
ns: Not significant in development model.

[1] This variable was not tested because the preliminary analysis did not suggest that the variable would be predictive of the relevant outcome.

[2] This variable was not retained in the model because the analysis did not suggest that the variable would be predictive of the relevant outcome (i.e., the variable's coefficient was negative).

* This is the reference level for the variable.

Table 8b. 2006 Coefficients and Odds Ratios of Final Mortality Models

Predictor Variables	In-Hospital Mortality		Operative Mortality	
	Coefficient	Odds Ratio	Coefficient	Odds Ratio
Constant	-6.7741		-6.1127	
Demographic Variables				
Age in Years	0.0166	NA	0.0128	NA
Age # Years > 65	0.0312	NA	0.0348	NA
Female	0.3343	1.397	0.3041	1.355
Race/Ethnicity			not tested[1]	–
Hispanic	1.4721	4.358		
White, non-Hispanic	*	*		
Black, non-Hispanic	0.2625	1.300		
Other/Unknown	0.3071	1.360		
Race	not tested[2]	–		
White			*	*
Black			0.4328	1.542
Other/Unknown			0.2585	1.295
Laboratory Variables				
Albumin < 2.5	not retained[3]	–	0.2407	1.272
Albumin 2.5-3	not retained[3]	–	0.1868	1.205
BUN > 40	0.6467	1.909	0.5111	1.667
Creatinine > 1.4	0.1939	1.214	0.1094	1.116
Glucose > 165	0.2229	1.250	0.1423	1.153
Clinical Variables Other Than Laboratory Variables				
AMI Other Inferior Wall Initial Episode	0.9131	2.492	0.9430	2.568
AMI Except Other Anterior or Other Inferior Wall	0.4827	1.620	0.5080	1.662
ASA Class 5	1.1532	3.168	1.1345	3.110
ASA Emergency Flag	0.6324	1.882	0.5710	1.770
Cachexia	1.0151	2.760	1.0978	2.997
CAD > 70, 5-7 Vessels Grp	0.2291	1.257	0.1132	1.120
Cardiogenic Shock, Preoperative	1.3927	4.026	1.4356	4.202
CPR Prior to CABG/Valve Surgery	1.1013	3.008	ns	–
Current Med Insulin	0.1948	1.215	0.2107	1.235
Ejection Fraction				
<25%	0.7126	2.039	0.8409	2.319
25-45%	0.3303	1.391	0.3322	1.394
>45%	*	*	*	*
Heart Failure	0.6604	1.935	0.4729	1.605
History of CABG or Valve Surgery	0.7448	2.106	0.6144	1.849
History of Peripheral Vascular Disease	0.1424	1.153	0.1856	1.204
Hypertension with Complications	ns	–	0.3721	1.451
Liver Disease	1.5913	4.910	1.3527	3.868
MI/AMI Other Anterior Wall	0.3881	1.474	0.4818	1.619
Mild Moderate or Severe AMS	0.6523	1.920	0.6321	1.882
Multiple Valve Procedures	ns	–	0.5500	1.733
Other CV Procedure Group	0.3423	1.408	0.0913	1.096
Percent of Left Main Stenosis	0.00285	NA	0.00300	NA
Procedure Group				
CABG without Valve	*	*	*	*
Valve without CABG	0.6045	1.830	0.5096	1.665
Valve with CABG	0.8713	2.390	0.6957	2.005
PTCA/Stent/Tear Same Day as CABG/Valve Surgery	0.5919	1.807	0.5029	1.653

NA: Not applicable. This factor was tested as a continuous variable.
ns: Not significant in development model.
[1] This variable was not tested in the model because the race variable was a stronger predictor of the relevant outcome than the race/ethnicity variable.
[2] This variable was not tested in the model because the race/ethnicity variable was a stronger predictor of the relevant outcome than the race variable.
[3] This variable was not retained in the model because the analysis did not suggest that the variable would be predictive of the relevant outcome (i.e., the variable's coefficient was negative).
* This is the reference level for the variable.

Table 9a. 2005-2006 Coefficients and Odds Ratios of Final Readmissions Models

Predictor Variables	7-Day Readmissions		30-Day Readmissions	
	Coefficient	**Odds Ratio**	**Coefficient**	**Odds Ratio**
Constant	-3.5095		-2.6347	
Year	not tested[1]	–		
2005			*	*
2006			-0.0637	0.938
Demographic Variables				
Age # Years > 65	0.0138	NA	0.0152	NA
Female	ns	–	0.1294	1.138
Race				
White	*	*	*	*
Black	0.2175	1.243	0.2778	1.320
Other or Unknown	0.2194	1.245	0.0575	1.059
Clinical Variables Other Than Laboratory Variables				
Cancer	not tested[1]	–	0.1685	1.183
Chronic Lung Disease	ns	–	0.1750	1.191
Diabetes				
No Diabetes	*	*	*	*
Diabetes without Complication	0.1280	1.137	0.1802	1.197
Diabetes with Complication	0.1889	1.208	0.3600	1.433
Heart Failure	0.1811	1.199	0.1854	1.204
History of Peripheral Vascular Disease	0.2036	1.226	0.1839	1.202
History of PTCA/Stent	0.2372	1.268	not tested[1]	–
Morbid Obesity	0.2359	1.266	0.3553	1.427
MediQual Predicted Length of Stay	0.0403	NA	0.0446	NA
Multiple Valve Procedures	ns	–	0.1347	1.144
Procedure Group				
CABG without Valve	*	*	*	*
Valve without CABG	0.1590	1.172	0.1680	1.183
Valve with CABG	0.1447	1.156	0.1050	1.111

NA: Not applicable. This factor was tested as a continuous variable.
ns: Not significant in development model.
[1] This variable was not tested because the preliminary analysis did not suggest that the variable would be predictive of the relevant outcome.
* This is the reference level for the variable.

Table 9b. 2006 Coefficients and Odds Ratios of Final Readmissions Models

Predictor Variables	7-Day Readmissions		30-Day Readmissions	
	Coefficient	**Odds Ratio**	**Coefficient**	**Odds Ratio**
Constant	-3.3264		-2.5902	
Demographic Variables				
Age # Years > 65	ns	–	0.0133	NA
Race/Ethnicity				
White, non-Hispanic	*	*	ns	–
Black, non-Hispanic	0.0771	1.080		
Hispanic	0.7246	2.064		
Other/Unknown	0.0389	1.040		
Clinical Variables Other Than Laboratory Variables				
Cerebrovascular Disease	not tested[1]	–	0.2408	1.272
Diabetes	not tested[1]	–		
No Diabetes			*	*
Diabetes without Complication			0.1965	1.217
Diabetes with Complication			0.3644	1.440
Heart Failure	0.1543	1.167	0.2821	1.326
MediQual Predicted Length of Stay	0.0424	NA	0.0463	NA
Procedure Group				
CABG without Valve	*	*	*	*
Valve without CABG	0.1891	1.208	0.1715	1.187
Valve with CABG	0.1754	1.192	0.0764	1.079

NA: Not applicable. This factor was tested as a continuous variable.
ns: Not significant in development model.
[1] This variable was not tested because the preliminary analysis did not suggest that the variable would be predictive of the relevant outcome.
* This is the reference level for the variable.

Calculation of Statistical Ratings

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

Determining Actual (Observed) Rates

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

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

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

Determining Expected Rates

The first step in calculating the expected rates was to estimate the probability of each of the relevant events occurring for each patient, that is: 1) the probability of in-hospital death, 2) the probability of death in the hospital or within 30 days, 3) the probability of being readmitted within 7 days, and 4) the probability of being readmitted within 30 days. The probability of each of these events occurring was estimated by using the statistical technique of logistic regression. In logistic regression each category for each clinical or demographic risk factor was assigned a coefficient or "weight." A factor category's weight was higher (or lower) if patients with that factor category tended to have a higher (or lower) chance of the event occurring. These weights, determined using the statewide CABG and 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 and 5b 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. *2006 Calculations of Statistical Ratings for In-Hospital Mortality Analysis*

Total Cases: Number of hospitalizations after exclusions.

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

Percentage: Total number of deaths / Total Cases

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

Percentage: Total number of expected deaths / Total Cases

To calculate a patient's probability of death:

Step 1: Calculate βX:

βX = -6.7741*(constant)* + 0.0166(Age in Years) + 0.0312(Age # Years > 65) + 0.3343(Female) + 0.6467(BUN > 40) + coefficient(other variables in in-hospital mortality model)

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

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

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

To compute Standard Deviation of Mortality:

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

VARPAT = (PD) (1-PD)

Step 2: Calculate the Standard Deviation of Mortality

SUMVAR = sum of VARPAT across all cases

Standard Deviation of Mortality = square root of SUMVAR

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

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 10.

Table 10. Case Counts and Average Post-Surgical Length of Stay in Days

	Development Sample	Cross-Validation Sample	Full Data Set
2005-2006 Model			
Number of cases	16,325	16,323	32,648
Average post-surgical length of stay *(arithmetic)*	7.3	7.3	7.3
Average post-surgical length of stay *(geometric)*	6.4	6.3	6.3
2006 Model			
Number of cases	8,007	8,005	16,012
Average post-surgical length of stay *(arithmetic)*	7.3	7.4	7.3
Average post-surgical length of stay *(geometric)*	6.4	6.4	6.4

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 Tables 11a and 11b.

Table 11a. 2005-2006 Development Model: Variables Tested as Potential Predictors of Post-Surgical Length of Stay

Candidate Variables	Results
Year	ns
Demographic Variables	
Age in Years	✓
Age # Years > 65	✓
Female	✓
Race	✓
Clinical Variables Other Than Laboratory Variables	
Acute Myocardial Infarction (AMI)	ns
Anemia	✓
Cachexia	✓
Cancer	✓
Cardiogenic Shock, Preoperative	✓
Cardiomyopathy	✓
CPR Prior to Date of CABG/Valve Surgery	✓
Chronic Lung Disease	✓
Chronic Pulmonary Hypertension	✓
Coagulopathy	✓
Diabetes with Long Term/Unspecified Complications	✓
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery	✓
Fibrosis in Mediastinum and Heart	ns
Heart Failure	✓
History of CABG or Valve Surgery	ns
Hypertension with Complications	✓
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery	✓
Liver Disease	✓
MediQual Predicted Length of Stay	✓
Multiple Valve Procedures	✓
Other Open Heart Procedure	✓
Procedure Group	✓
Renal Failure/Dialysis (category)	✓

✓ : significant predictor ($p < 0.10$)
ns: not significant

Table 11b. ***2006 Development Model: Variables Tested as Potential Predictors of Post-Surgical Length of Stay***

Candidate Variables	Results
Demographic Variables	
Age in Years	✓
Age # Years > 65	✓
Female	✓
Race	✓
Clinical Variables Other Than Laboratory Variables	
Acute Myocardial Infarction (AMI)	ns
Anemia	✓
Cachexia	✓
Cancer	ns
Cardiogenic Shock, Preoperative	✓
Cardiomyopathy	✓
CPR Prior to Date of CABG/Valve Surgery	✓
Chronic Lung Disease	✓
Chronic Pulmonary Hypertension	✓
Diabetes with Long Term/Unspecified Complications	✓
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery	✓
Fibrosis in Mediastinum and Heart	ns
Heart Failure	✓
History of CABG or Valve Surgery	ns
Hypertension with Complications	✓
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery	✓
MediQual Predicted Length of Stay	✓
Multiple Valve Procedures	✓
Other Open Heart Procedure	✓
Procedure Group	✓
Renal Failure/Dialysis (binary)	✓

✓ : significant predictor ($p < 0.10$)
ns: not significant

Cross-validation. After the development model was built for post-surgical length of stay, the model was cross-validated. That is, the model built in the model selection process (i.e., the development model) was re-estimated using the cases in the cross-validation sample. Regression analysis was performed to determine whether the selected candidate variables would remain predictive of the relevant outcome for the cross-validation sample. As long as the coefficient of a variable did not change from positive to negative, the variable was retained in the final model that applied to the full data set. See Tables 12a and 12b.

Table 12a. 2005-2006 Cross-Validation Results: p Values for Significant Candidate Variables in the Post-Operative Length of Stay Development Model

Significant Variables in Development Model	Development Model	Cross-Validation Model
Demographic Variables		
Age in Years	< 0.0001	< 0.0001
Age # Years > 65	< 0.0001	0.0001
Female	< 0.0001	< 0.0001
Race	< 0.0001	< 0.0001
Clinical Variables Other Than Laboratory Variables		
Anemia	< 0.0001	0.0021
Cachexia	< 0.0001	< 0.0001
Cancer	0.0846	0.9816
Cardiogenic Shock, Preoperative	< 0.0001	< 0.0001
Cardiomyopathy	0.0007	0.0001
CPR Prior to Date of CABG/Valve Surgery	0.0591	0.4527
Chronic Lung Disease	< 0.0001	< 0.0001
Chronic Pulmonary Hypertension	0.0013	0.0159
Coagulopathy	0.0101	0.0081
Diabetes with Long Term/Unspecified Complications	0.0002	0.0020
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery	0.0165	0.8173
Heart Failure	< 0.0001	< 0.0001
Hypertension with Complications	0.0101	0.0052
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery	< 0.0001	< 0.0001
Liver Disease	0.0043	0.0542
MediQual Predicted Length of Stay	< 0.0001	< 0.0001
Multiple Valve Procedures	< 0.0001	< 0.0001
Other Open Heart Procedure	< 0.0001	< 0.0001
Procedure Group	< 0.0001	< 0.0001
Renal Failure/Dialysis (category)	< 0.0001	0.0002

Table 12b. 2006 Cross-Validation Results: p Values for Significant Candidate Variables in the Post-Operative Length of Stay Development Model

Significant Variables in Development Model	Development Model	Cross-Validation Model
Demographic Variables		
Age in Years	< 0.0001	< 0.0001
Age # Years > 65	0.0024	0.0131
Female	0.0015	< 0.0001
Race	< 0.0001	< 0.0001
Clinical Variables Other Than Laboratory Variables		
Anemia	0.0068	0.0395
Cachexia	< 0.0001	< 0.0001
Cardiogenic Shock, Preoperative	< 0.0001	< 0.0001
Cardiomyopathy	0.0003	0.0138
CPR Prior to Date of CABG/Valve Surgery	0.0416	0.9472
Chronic Lung Disease	< 0.0001	< 0.0001
Chronic Pulmonary Hypertension	0.0270	0.0007
Diabetes with Long Term/Unspecified Complications	0.0030	0.0031
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery	0.0269	0.1654
Heart Failure	< 0.0001	< 0.0001
Hypertension with Complications	0.0666	0.2030
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery	< 0.0001	< 0.0001
MediQual Predicted Length of Stay	< 0.0001	< 0.0001
Multiple Valve Procedures	< 0.0001	< 0.0001
Other Open Heart Procedure	< 0.0001	< 0.0001
Procedure Group	< 0.0001	< 0.0001
Renal Failure/Dialysis (binary)	0.0019	0.0008

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 13.

Table 13. R-Squared Statistics for Development, Cross-Validation, and Full Data Set Post-Surgical Length of Stay Model Models

Post-Surgical Length of Stay Model	Development Model %	Cross-Validation Model %	Full Data Set Model %
2005-2006 Model	28.2	26.8	27.5
2006 Model	28.4	27.2	27.9

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. Tables 14a and 14b display the coefficients and associated *p* values for the variables included in the final model.

Table 14a. 2005-2006 Coefficients of Predictors in the Final Post-Surgical Length of Stay Model

Predictor Variables	Coefficient	*p* value
Constant	1.190114403	
Demographic Variables		
Age in Years	0.004605448	< 0.0001
Age # Years > 65	0.004093331	< 0.0001
Female	0.036146736	< 0.0001
Race		< 0.0001
White	*	
Black	0.149059913	
Other/Unknown	0.081292189	
Clinical Variables Other Than Laboratory Variables		
Anemia	0.031609525	< 0.0001
Cachexia	0.455916996	< 0.0001
Cancer	0.018276288	0.2312
Cardiogenic Shock, Preoperative	0.345749609	< 0.0001
Cardiomyopathy	-0.036690615	< 0.0001
CPR Prior to Date of CABG/Valve Surgery	0.049875582	0.3568
Chronic Lung Disease	0.067891621	< 0.0001
Chronic Pulmonary Hypertension	-0.037543971	0.0001
Coagulopathy	0.126116776	0.0002
Diabetes with Long Term/Unspecified Complications	0.046060157	< 0.0001
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery	-0.031023167	0.0653
Heart Failure	0.179263095	< 0.0001
Hypertension with Complications	0.037572271	0.0001
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery	0.098231786	< 0.0001
Liver Disease	0.106665673	0.0006
MediQual Predicted Length of Stay	0.023054245	< 0.0001
Multiple Valve Procedures	0.145143047	< 0.0001
Other Open Heart Procedure	0.092107958	< 0.0001
Procedure Group		< 0.0001
CABG without Valve	0.154614204	
Valve without CABG	0.065051405	
Valve with CABG	*	
Renal Failure/Dialysis (category)		< 0.0001
No	-0.061355555	
Chronic	0.019779318	
Acute/Dialysis	*	

* This is the reference level for the variable.

Table 14b. 2006 Coefficients of Predictors in the Final Post-Surgical Length of Stay Model

Predictor Variables	Coefficient	*p* value
Constant	1.155301502	
Demographic Variables		
Age in Years	0.004339525	< 0.0001
Age # Years > 65	0.004211980	< 0.0001
Female	0.039085527	< 0.0001
Race		< 0.0001
White	*	
Black	0.139937815	
Other/Unknown	0.073357627	
Clinical Variables Other Than Laboratory Variables		
Anemia	0.029104980	0.0007
Cachexia	0.472836547	< 0.0001
Cardiogenic Shock, Preoperative	0.416740982	< 0.0001
Cardiomyopathy	-0.043774764	< 0.0001
CPR Prior to Date of CABG/Valve Surgery	0.097953223	0.1861
Chronic Lung Disease	0.053386807	< 0.0001
Chronic Pulmonary Hypertension	-0.052480842	< 0.0001
Diabetes with Long Term/Unspecified Complications	0.056838538	< 0.0001
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery	-0.059924772	0.0110
Heart Failure	0.179934901	< 0.0001
Hypertension with Complications	0.029884277	0.0269
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery	0.112643188	< 0.0001
MediQual Predicted Length of Stay	0.022555853	< 0.0001
Multiple Valve Procedures	0.140331859	< 0.0001
Other Open Heart Procedure	0.122165209	< 0.0001
Procedure Group		< 0.0001
CABG without Valve	0.153725428	
Valve without CABG	0.072363983	
Valve with CABG	*	
Renal Failure/Dialysis (binary)	0.067780046	< 0.0001

* This is the reference level for the variable.

Calculation of Risk-Adjusted Post-Surgical Length of Stay

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

Actual Length of Stay

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

Expected Length of Stay

Coefficients in the final model were summed to compute each individual patient's expected length of stay, given the risk factors of the patient. The coefficient for a category represented the estimated difference in mean (log) length of stay for the category compared to the base category of that factor. Thus, the coefficient for the base category of a factor was always zero. When dealing with categorical variables in the length of stay model there was no particular importance to the order of these categories. The constant term in the model represents the predicted value for all categorical factors at the base level. The coefficients for the other levels within a factor represent adjustments to that "baseline." No adjustment was required at the base level for any factor, because it was already accounted for in the constant. For example, a patient without heart failure had a zero or baseline coefficient; while a patient with heart failure would be adjusted upward by 0.179263095 (see Table 14a). 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 0.179263095 independent of what the specific coefficients were for each). For quantitative factor age, there is always an adjustment because the baseline is zero.

Risk-Adjusted Post-Surgical Length of Stay

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

The following example illustrates the complete calculation.

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

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

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

Actual Mean LOS: Geometric mean of the length of stay across Total Cases

Calculate geometric mean length of stay (GMLOS):

Step 1: Calculate the natural log (**ln**) of GMLOS:

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

Step 2: Convert **ln**(GMLOS) to GMLOS (i.e., convert to days):

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

Expected Mean LOS: Geometric mean of the *expected* length of stay for Total Cases

Calculate geometric mean of the *expected* length of stay (GM*E*LOS):

Step 1: Calculate each patient's *E***ln**LOS:

$$E\mathbf{ln}\text{LOS} = (\text{constant}) + (\text{risk factor category coefficients relevant to each patient})$$

Step 2: Calculate the **ln**GM*E*LOS:

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

Step 3: Convert the **ln**(GM*E*LOS) to GM*E*LOS (i.e., convert to days):

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

Calculate a patient's *expected* length of stay (*E*LOS):

Convert the *E***ln**LOS to *E*LOS (i.e., convert to days):

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

Risk-Adjusted Length of Stay: Average length of stay / expected average length of stay x state average length of stay for a given reporting group.

ln = natural logarithm (base e)

AVERAGE HOSPITAL CHARGE ANALYSIS

Average charges were trimmed for outliers and case-mix adjusted separately for the three procedure groups (CABG without valve, valve without CABG, and valve with CABG) and for the two years (2005 and 2006). Average charge is reported for hospitals only.

Construction of Reference Database

After standard, invalid charges, and low volume exclusions were applied, the charge data for each procedure group was analyzed by region and by groups based on DRG assignment. Patients who underwent CABG without valve procedures were comprised of the following DRG (Diagnostic Related Group) groups:

DRG Group 1	DRG 106	Coronary Bypass with PTCA
DRG Group 2	DRG 107[1]	Coronary Bypass with Cardiac Catheterization
	DRG 547[2]	Coronary Bypass with Cardiac Catheterization with Major Cardiovascular Diagnosis
	DRG 548[2]	Coronary Bypass with Cardiac Catheterization without Major Cardiovascular Diagnosis
DRG Group 3	DRG 108	Other Cardiothoracic Procedures
DRG Group 4	DRG 109[1]	Coronary Bypass without Cardiac Catheterization
	DRG 549[2]	Coronary Bypass without Cardiac Catheterization with Major Cardiovascular Diagnosis
	DRG 550[2]	Coronary Bypass without Cardiac Catheterization without Major Cardiovascular Diagnosis

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

DRG Group 5	DRG 104	Cardiac Valve and Other Major Cardiothoracic Procedures with Cardiac Catheterization
DRG Group 6	DRG 105	Cardiac Valve and Other Major Cardiothoracic Procedures without Cardiac Catheterization

Trim Methodology

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

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

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

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

[1] Invalid beginning 10/01/2005
[2] Effective 10/01/2005

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 15a through 16c 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 15a. 2005 CABG without Valve: Trim Points for Average Charge

DRG Group	Upper Trim Point*	Outlier %	Average Charge After Trimming
Group 1 (DRG 106)			
Region 1	$514,164	1.0	$134,452
Region 2	$460,003	<0.1	$161,463
Region 3	**	**	**
Region 4	$288,637	7.7	$122,030
Region 5	$234,503	6.3	$91,068
Region 6	$230,857	3.8	$87,315
Region 7	$293,723	<0.1	$123,375
Region 8	$686,110	1.8	$205,550
Region 9	$934,467	<0.1	$287,957
Group 2 (DRG 107, 547, 548)			
Region 1	$317,711	1.2	$86,948
Region 2	$284,794	2.0	$113,957
Region 3	$129,349	2.4	$66,111
Region 4	$207,730	0.9	$77,294
Region 5	$177,625	1.7	$72,596
Region 6	$163,778	0.7	$67,838
Region 7	$238,417	3.7	$92,297
Region 8	$548,168	1.2	$152,740
Region 9	$668,819	1.8	$205,447
Group 3 (DRG 108)			
Region 1	$372,017	1.7	$134,704
Region 2	$235,309	<0.1	$110,554
Region 3	$188,483	3.8	$76,024
Region 4	**	**	**
Region 5	$375,028	<0.1	$92,815
Region 6	$173,116	3.2	$79,725
Region 7	$213,911	2.1	$84,490
Region 8	$400,727	5.3	$128,140
Region 9	**	**	**
Group 4 (DRG 109, 549, 550)			
Region 1	$351,541	0.8	$84,838
Region 2	$171,866	3.3	$79,561
Region 3	$85,710	1.5	$49,117
Region 4	$144,733	3.2	$60,635
Region 5	$130,571	2.9	$53,890
Region 6	$109,859	1.7	$45,808
Region 7	$165,279	7.9	$64,609
Region 8	$359,548	0.5	$109,407
Region 9	$622,695	0.9	$173,226

* Charges of less than $10,000 were considered invalid. Therefore, with the exception of Group 4 in Region 3, there were no lower trim points. The lower trim point for Group 4 in Region 3 was $11,204.

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

Table 15b. 2005 Valve without CABG: Trim Points for Average Charge

DRG Group	Upper Trim Point*	Outlier %	Average Charge After Trimming
Group 5 (DRG 104)			
Region 1	$520,142	1.3	$149,014
Region 2	$444,688	2.8	$163,666
Region 3	$227,337	2.5	$92,233
Region 4	$387,862	<0.1	$127,811
Region 5	$245,921	3.4	$96,121
Region 6	$229,462	2.4	$95,536
Region 7	$371,970	1.1	$125,590
Region 8	$667,513	1.1	$217,027
Region 9	$859,504	<0.1	$266,726
Group 6 (DRG 105)			
Region 1	$413,432	0.5	$111,255
Region 2	$246,473	5.8	$100,838
Region 3	$170,114	3.2	$72,736
Region 4	$334,194	1.1	$113,065
Region 5	$148,180	3.6	$66,438
Region 6	$173,366	0.9	$71,698
Region 7	$241,280	3.3	$90,595
Region 8	$466,089	1.4	$155,036
Region 9	$581,332	1.9	$183,671

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

Table 15c. 2005 Valve with CABG: Trim Points for Average Charge

DRG Group	Upper Trim Point*	Outlier %	Average Charge After Trimming
Group 5 (DRG 104)			
Region 1	$614,589	0.7	$167,189
Region 2	$415,786	<0.1	$174,479
Region 3	$193,951	3.6	$103,572
Region 4	$409,935	2.7	$145,684
Region 5	$323,966	<0.1	$118,208
Region 6	$286,539	1.9	$119,407
Region 7	$506,466	0.6	$156,178
Region 8	$773,188	1.0	$218,425
Region 9	$1,054,601	<0.1	$324,165
Group 6 (DRG 105)			
Region 1	$524,766	1.5	$136,022
Region 2	$313,659	1.0	$129,502
Region 3	$201,594	2.4	$90,290
Region 4	$386,353	6.1	$114,249
Region 5	$197,783	3.0	$79,890
Region 6	$188,111	6.4	$79,527
Region 7	$363,162	2.4	$107,683
Region 8	$595,191	2.9	$168,638
Region 9	$780,464	2.7	$241,443

* Charges of less than $10,000 were considered invalid. Therefore, with the exception of Group 5 in Region 3, there were no lower trim points. The lower trim point for Group 5 in Region 3 was $10,668.

Table 16a. 2006 CABG without Valve: Trim Points for Average Charge

DRG Group	Upper Trim Point*	Outlier %	Average Charge After Trimming
Group 1 (DRG 106)			
Region 1	$573,699	0.8	$140,657
Region 2	$471,255	<0.1	$183,773
Region 3	$238,867	<0.1	$93,568
Region 4	**	**	**
Region 5	$212,657	<0.1	$101,650
Region 6	$280,687	7.4	$90,689
Region 7	$433,246	3.7	$158,598
Region 8	$764,180	<0.1	$225,903
Region 9	$812,409	<0.1	$276,612
Group 2 (DRG 107, 547, 548)			
Region 1	$383,377	0.8	$98,394
Region 2	$280,097	2.4	$123,625
Region 3	$143,458	1.0	$66,771
Region 4	$211,901	2.9	$80,957
Region 5	$168,707	2.1	$73,326
Region 6	$173,407	1.0	$71,121
Region 7	$299,472	2.7	$116,438
Region 8	$540,590	1.6	$158,643
Region 9	$752,441	1.2	$213,549
Group 3 (DRG 108)			
Region 1	$537,705	<0.1	$193,948
Region 2	$249,070	<0.1	$111,597
Region 3	$105,498	4.3	$63,759
Region 4	**	**	**
Region 5	**	**	**
Region 6	$207,281	4.2	$77,479
Region 7	$255,014	5.4	$107,797
Region 8	$402,256	<0.1	$136,990
Region 9	**	**	**
Group 4 (DRG 109, 549, 550)			
Region 1	$361,859	0.8	$86,598
Region 2	$180,276	2.0	$84,274
Region 3	$102,104	4.2	$47,555
Region 4	$129,777	3.5	$58,722
Region 5	$127,008	2.2	$55,069
Region 6	$120,693	1.6	$49,677
Region 7	$242,157	4.1	$88,614
Region 8	$429,738	1.3	$117,034
Region 9	$664,140	1.6	$178,241

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

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

Table 16b. 2006 Valve without CABG: Trim Points for Average Charge

DRG Group	Upper Trim Point*	Outlier %	Average Charge After Trimming
Group 5 (DRG 104)			
Region 1	$681,979	0.7	$170,054
Region 2	$630,248	<0.1	$185,027
Region 3	$275,339	<0.1	$103,944
Region 4	$561,278	<0.1	$151,752
Region 5	$303,749	1.1	$106,555
Region 6	$259,295	2.3	$93,707
Region 7	$390,767	<0.1	$151,961
Region 8	$667,785	1.1	$226,562
Region 9	$850,934	0.5	$260,699
Group 6 (DRG 105)			
Region 1	$443,370	0.7	$111,175
Region 2	$288,459	1.0	$115,938
Region 3	$150,333	3.3	$72,230
Region 4	$382,761	3.7	$134,020
Region 5	$173,656	1.0	$70,527
Region 6	$179,101	3.6	$69,893
Region 7	$411,157	0.7	$128,749
Region 8	$448,707	3.5	$156,732
Region 9	$518,634	2.8	$187,759

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

Table 16c. 2006 Valve with CABG: Trim Points for Average Charge

DRG Group	Upper Trim Point*	Outlier %	Average Charge After Trimming
Group 5 (DRG 104)			
Region 1	$709,278	1.4	$171,490
Region 2	$578,777	3.6	$209,784
Region 3	$202,646	1.5	$109,477
Region 4	$618,795	2.6	$169,944
Region 5	$307,986	2.1	$123,093
Region 6	$266,767	3.3	$111,687
Region 7	$559,442	1.8	$195,259
Region 8	$681,227	1.3	$237,629
Region 9	$1,079,584	2.2	$330,928
Group 6 (DRG 105)			
Region 1	$620,743	0.6	$141,040
Region 2	$394,799	<0.1	$154,501
Region 3	$192,382	2.3	$92,746
Region 4	$410,041	1.8	$129,858
Region 5	$206,713	1.5	$84,449
Region 6	$215,070	<0.1	$78,791
Region 7	$443,228	5.3	$145,165
Region 8	$655,470	1.0	$180,922
Region 9	$969,732	1.0	$275,205

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

Case-Mix Adjustment of Average Hospital Charge

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

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

Example 3. ***2005-2006 Calculations Used in Determining Case-Mixed Average Charge for a Hospital***

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 within the reporting group.

Region 1 - Southwestern PA, valve without CABG, DRG104, 2005:.. $149,014
or
Region 1 - Southwestern PA, valve without CABG, DRG105, 2005:.. $111,255
or
Region 1 - Southwestern PA, valve without CABG, DRG104, 2006:.. $170,054
or
Region 1 - Southwestern PA, valve without CABG, DRG105, 2006:.. $111,175

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

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

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

***Example 4.* 2006 Calculations Used in Determining Case-Mixed Average Charge for a Hospital**

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, DRG104, 2006:.. $170,054
or
Region 1 - Southwestern PA, valve without CABG, DRG105, 2006:.. $111,175

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

Of the 16,633 discharges included in the 2006 CABG/valve analysis, the Pennsylvania Uniform Claims and Billing Form UB-92 data submitted to PHC4 by hospitals identified Medicare as the payor for 9,814 (59.0%) discharges. Payment records submitted to PHC4 by CMS were available for 6,707 discharges. Of these, 197 discharges that had either a CMS payment amount equal to zero or a prior payment from a primary payor other than Medicare were deleted from the analysis, leaving 6,510 Medicare fee-for-service cases in the analysis. Medicare DRG payments are calculated from data made available by CMS for each discharge, from the sum of the Medicare Part A Hospital Insurance fund payments, inpatient deductibles, and coinsurance day amounts. The average of the actual DRG payments is calculated within each hospital's procedure group. In order to comply with CMS confidentiality restrictions, payment averages and number of cases are not reported if there are fewer than 13 cases in one of the cells represented in a total.

APPENDICES

APPENDIX A: EXCLUSION DEFINTIONS

Table A. *Organ Transplants*

ICD-9-CM Code	Description
Procedure code in any position:	
33.50	Lung transplantation, not otherwise specified
33.51	Unilateral lung transplantation
33.52	Bilateral lung transplantation
33.6	Combined heart and lung transplant
37.51	Heart transplantation
37.52	Implantation of total replacement of heart system
37.53	Replacement or repair of thoracic unit of total replacement heart system
41.xx*	Bone marrow transplant
46.97	Transplant of intestine
50.51	Auxiliary liver transplant
50.59	Other transplant of liver
52.8x*	Pancreatic transplant
55.61	Renal autotransplantation
55.69	Other kidney transplantation

*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 B. ***Study DRGs (Diagnostic Related Groups): Cases not in the following DRGs were excluded from the study***

CABG without Valve

DRG 103	Heart Transplant or Implant of Heart Assist System
DRG 104	Cardiac Valve Procedures and Other Major Cardiothoracic Procedures with Cardiac Catheterization
DRG 105	Cardiac Valve Procedures and Other Major Cardiothoracic Procedures without Cardiac Catheterization
DRG 106	Coronary Bypass with PTCA
DRG 107[1]	Coronary Bypass with Cardiac Catheterization
DRG 108	Other Cardiothoracic Procedures
DRG 109[1]	Coronary Bypass without Cardiac Catheterization
DRG 515	Cardiac Defibrillator Implant without Cardiac Catheterization
DRG 525	Other Heart Assist System Implant
DRG 535	Cardiac Defibrillator Implant with Cardiac Catheterization with Acute Myocardial Infarction, Heart Failure, or Shock
DRG 536	Cardiac Defibrillator Implant with Cardiac Catheterization without Acute Myocardial Infarction, Heart Failure, or Shock
DRG 541[2] and MDC 5	ECMO or tracheostomy with Mechanical Ventilation 96+ Hours or Principal Diagnosis Except Face, Mouth, Neck with Major O.R. Procedures
DRG 547[3]	Coronary Bypass with Cardiac Catheterization with Major Cardiovascular Diagnosis
DRG 548[3]	Coronary Bypass with Cardiac Catheterization without Major Cardiovascular Diagnosis
DRG 549[3]	Coronary Bypass without Cardiac Catheterization with Major Cardiovascular Diagnosis
DRG 550[3]	Coronary Bypass without Cardiac Catheterization without Major Cardiovascular Diagnosis

Valve without CABG

DRG 103	Heart Transplant or Implant of Heart Assist System
DRG 104	Cardiac Valve Procedures and Other Major Cardiothoracic Procedures with Cardiac Catheterization
DRG 105	Cardiac Valve Procedures and Other Major Cardiothoracic Procedures without Cardiac Catheterization
DRG 108	Other Cardiothoracic Procedures
DRG 515	Cardiac Defibrillator Implant without Cardiac Catheterization
DRG 525	Other Heart Assist System Implant
DRG 535	Cardiac Defibrillator Implant with Cardiac Catheterization with Acute Myocardial Infarction, Heart Failure, or Shock
DRG 536	Cardiac Defibrillator Implant with Cardiac Catheterization without Acute Myocardial Infarction, Heart Failure, or Shock
DRG 541[2] and MDC 5	ECMO or tracheostomy with Mechanical Ventilation 96+ Hours or Principal Diagnosis Except Face, Mouth, Neck with Major O.R. Procedures

Valve *with* CABG

DRG 103	Heart Transplant or Implant of Heart Assist System
DRG 104	Cardiac Valve Procedures and Other Major Cardiothoracic Procedures with Cardiac Catheterization
DRG 105	Cardiac Valve Procedures and Other Major Cardiothoracic Procedures without Cardiac Catheterization
DRG 108	Other Cardiothoracic Procedures
DRG 515	Cardiac Defibrillator Implant without Cardiac Catheterization
DRG 525	Other Heart Assist System Implant
DRG 535	Cardiac Defibrillator Implant with Cardiac Catheterization with Acute Myocardial Infarction, Heart Failure, or Shock
DRG 536	Cardiac Defibrillator Implant with Cardiac Catheterization without Acute Myocardial Infarction, Heart Failure, or Shock
DRG 541[2] and MDC 5	ECMO or tracheostomy with Mechanical Ventilation 96+ Hours or Principal Diagnosis Except Face, Mouth, Neck with Major O.R. Procedures

[1] Invalid 10/01/2005
[2] DRG 541 has an updated description and an additional procedure, extracorporeal membrane oxygenation (code 39.65), effective 10/01/2005
[3] Effective 10/01/2005

APPENDIX A: EXCLUSION DEFINTIONS *continued*

Table C. *Clinical Complexity Codes*

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

Position	ICD-9-CM Code and Description	
Clinical Complexity Exclusions Applicable to CABG without Valve		
px	32.22	Lung volume reduction surgery **performed at the same time as CABG surgery**
px	35.31	Operations on papillary muscle
px	35.32	Operations on chordae tendineae
px	35.34	Infundibulectomy
px	35.35	Operations on trabeculae carneae cordis
px	35.39	Operations on other structures adjacent to valves of heart
px	35.42	Creation of septal defect in heart
px	35.50	Repair of unspecified septal defect of heart with prosthesis
px	35.51	Repair of atrial septal defect with prosthesis, open technique
px	35.53	Repair of ventricular septal defect with prosthesis, open technique
px	35.54	Repair of endocrinal cushion defect with prosthesis
px	35.60	Repair of unspecified septal defect of heart with tissue graft
px	35.61	Repair of atrial septal defect with tissue graft
px	35.62	Repair of ventricular septal defect with tissue graft
px	35.63	Repair of endocardial cushion defect with tissue graft
px	35.70	Other and unspecified repair of unspecified septal defect of heart
px	35.71	Other and unspecified repair of atrial septal defect
px	35.72	Other and unspecified repair of ventricular septal defect
px	35.73	Other and unspecified repair of endocardial cushion defect
px	35.81	Total repair of Tetralogy of Fallot
px	35.82	Total repair of total anomalous pulmonary venous connection
px	35.83	Total repair of truncus arteriosus
px	35.84	Total correction of transposition of great vessels, not elsewhere classified
px	35.91	Intratrial transposition of venous return
px	35.92	Creation of conduit between right ventricle and pulmonary artery
px	35.93	Creation of conduit between left ventricle and aorta
px	35.94	Creation of conduit between atrium and pulmonary artery
px	35.95	Revision of corrective procedure on heart
px	35.98	Other operations on septa of heart
px	36.91	Repair of aneurysm of coronary vessel
px	37.32	Excision of aneurysm of heart
px	37.33	Excision or destruction of other lesion or tissue of heart, open approach
px	37.35	Partial ventriculectomy
px	38.12	Carotid endarterectomy
px	38.34	Resection of aorta with anastomosis
px	38.35	Resection of other thoracic vessel with anastomosis
px	38.36	Resection of abdominal arteries with anastomosis
px	38.44	Resection of abdominal aorta with replacement
px	38.45	Resection of thoracic vessel with replacement
px	38.46	Resection of abdominal arteries with replacement
px	39.51	Clipping of aneurysm
px	39.52	Other repair of aneurysm
px	39.71	Endovascular implantation of graft in abdominal aorta
px	39.73	Endovascular implantation of graft in thoracic aorta
dx/px	423.2/ 37.31	Diagnosis of constrictive pericarditis and undergoing pericardiectomy
dx	441.00	Dissection of aorta, unspecified site
dx	441.01	Dissection of aorta, thoracic
dx	996.81	Complications of transplanted kidney
dx	996.82	Complications of transplanted liver
dx	996.83	Complications of transplanted heart

APPENDIX A: EXCLUSION DEFINTIONS *continued*

Table C. *Clinical Complexity Codes,* continued

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

Position	ICD-9-CM Code	Description
dx	996.84	Complications of transplanted lung
dx	996.85	Complications of transplanted bone marrow
dx	996.86	Complications of transplanted pancreas
dx	996.87	Complications of transplanted intestines
dx	V42.0	History of kidney transplant
dx	V42.1	History of heart transplant
dx	V42.6	History of lung transplant
dx	V42.7	History of liver transplant
dx	V42.81	Bone marrow replaced by transplant
dx	V42.83	Pancreas replaced by transplant
dx	V42.84	Intestines replaced by transplant
Clinical Complexity Exclusions Applicable to Valve without CABG		
pdx	038.x, 038.xx[1]	Septicemia
px	32.22	Lung volume reduction surgery performed at the same time as valve surgery
px	35.42	Creation of septal defect in heart
px	35.50	Repair of unspecified septal defect of heart with prosthesis
px	35.51	Repair of atrial septal defect with prosthesis, open technique
px	35.53	Repair of ventricular septal defect with prosthesis, open technique
px	35.54	Repair of endocardial cushion defect with prosthesis
px	35.60	Repair of unspecified septal defect of heart with tissue graft
px	35.61	Repair of atrial septal defect with tissue graft
px	35.62	Repair of ventricular septal defect with tissue graft
px	35.63	Repair of endocardial cushion defect with tissue graft
px	35.70	Other and unspecified repair of unspecified septal defect of heart
px	35.72	Other and unspecified repair of ventricular septal defect
px	35.73	Other and unspecified repair of endocardial cushion defect
px	35.81	Total repair of Tetralogy of Fallot
px	35.82	Total repair of total anomalous pulmonary venous connection
px	35.83	Total repair of truncus arteriosus
px	35.84	Total correction of transposition of great vessels, not elsewhere classified
px	35.91	Intratrial transposition of venous return
px	35.92	Creation of conduit between right ventricle and pulmonary artery
px	35.93	Creation of conduit between left ventricle and aorta
px	35.94	Creation of conduit between atrium and pulmonary artery
px	37.32	Excision of aneurysm of heart
px	37.35	Partial ventriculectomy
px	38.12	Carotid endarterectomy
px	38.34	Resection of aorta with anastomosis
px	38.35	Resection of other thoracic vessel with anastomosis
px	38.36	Resection of abdominal arteries with anastomosis
px	38.44	Resection of abdominal aorta with replacement
px	38.45	Resection of thoracic vessel with replacement
px	38.46	Resection of abdominal arteries with replacement
px	39.51	Clipping of aneurysm
px	39.52	Other repair of aneurysm
px	39.71	Endovascular implantation of graft in abdominal aorta
px	39.73	Endovascular implantation of graft in thoracic aorta

[1] 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 C. *Clinical Complexity Codes,* continued

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

Position	ICD-9-CM Code and Description	
dx	277.3[1]/ 425.7	Amyloidosis plus nutritional & metabolic cardiomyopathy
dx	277.30[2]/ 425.7	Amyloidosis, unspecified plus nutritional & metabolic cardiomyopathy
dx	277.39[2]/ 425.7	Other amyloidosis plus nutritional & metabolic cardiomyopathy
dx	414.10	Aneurysm of heart (wall)
dx	414.19	Other aneurysm of heart
pdx	421.0	Acute and subacute bacterial endocarditis
pdx	421.1	Acute and subacute infective endocarditis in diseases classified elsewhere
pdx	421.9	Acute endocarditis, unspecified
dx/px	423.2/ 37.31	Diagnosis of constrictive pericarditis and undergoing pericardiectomy
pdx	424.90	Endocarditis, valve unspecified, unspecified cause
pdx	424.91	Endocarditis in diseases classified elsewhere
pdx	424.99	Other endocarditis, valve unspecified
dx	441.00	Dissection of aorta, unspecified site
dx	441.01	Dissection of aorta, thoracic
pdx	996.02	Mechanical complication of cardiac device, implant, and graft due to heart valve prosthesis
pdx	996.61	Infection and inflammatory reaction due to cardiac device, implant, and graft
pdx	996.71	Other complication of internal prosthetic device due to heart valve prosthesis
dx	996.81	Complications of transplanted kidney
dx	996.82	Complications of transplanted liver
dx	996.83	Complications of transplanted heart
dx	996.84	Complications of transplanted lung
dx	996.85	Complications of transplanted bone marrow
dx	996.86	Complications of transplanted pancreas
dx	996.87	Complications of transplanted intestines
dx	V42.0	History of kidney transplant
dx	V42.1	History of heart transplant
dx	V42.6	History of lung transplant
dx	V42.7	History of liver transplant
dx	V42.81	Bone marrow replaced by transplant
dx	V42.83	Pancreas replaced by transplant
dx	V42.84	Intestines replaced by transplant
Clinical Complexity Exclusions Applicable to Valve with CABG		
pdx	038.x, 038.xx[3]	Septicemia
px	32.22	Lung volume reduction surgery **performed at the same time as valve with CABG surgery**
px	35.42	Creation of septal defect in heart
px	35.50	Repair of unspecified septal defect of heart with prosthesis
px	35.51	Repair of atrial septal defect with prosthesis, open technique
px	35.53	Repair of ventricular septal defect with prosthesis, open technique
px	35.54	Repair of endocardial cushion defect with prosthesis
px	35.60	Repair of unspecified septal defect of heart with tissue graft
px	35.61	Repair of atrial septal defect with tissue graft
px	35.62	Repair of ventricular septal defect with tissue graft
px	35.63	Repair of endocardial cushion defect with tissue graft
px	35.70	Other and unspecified repair of unspecified septal defect of heart
px	35.72	Other and unspecified repair of ventricular septal defect
px	35.73	Other and unspecified repair of endocardial cushion defect

[1] Invalid 10/01/2006

[2] Effective 10/01/2006

[3] 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 C. *Clinical Complexity Codes,* continued

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

Position	ICD-9-CM Code	Description
px	35.81	Total repair of Tetralogy of Fallot
px	35.82	Total repair of total anomalous pulmonary venous connection
px	35.83	Total repair of truncus arteriosus
px	35.84	Total correction of transposition of great vessels, not elsewhere classified
px	35.91	Intratrial transposition of venous return
px	35.92	Creation of conduit between right ventricle and pulmonary artery
px	35.93	Creation of conduit between left ventricle and aorta
px	35.94	Creation of conduit between atrium and pulmonary artery
px	35.95	Revision of corrective procedure on heart
px	35.98	Other operations on septa of heart
px	36.91	Repair of aneurysm of coronary vessel
px	37.32	Excision of aneurysm of heart
px	37.35	Partial ventriculectomy
px	38.12	Carotid endarterectomy
px	38.34	Resection of aorta with anastomosis
px	38.35	Resection of other thoracic vessel with anastomosis
px	38.36	Resection of abdominal arteries with anastomosis
px	38.44	Resection of abdominal aorta with replacement
px	38.45	Resection of thoracic vessel with replacement
px	38.46	Abdominal arteries with replacement
px	39.51	Clipping of aneurysm
px	39.52	Other repair of aneurysm
px	39.71	Endovascular implantation of graft in abdominal aorta
px	39.73	Endovascular implantation of graft in thoracic aorta
dx	277.3[1]/ 425.7	Amyloidosis plus nutritional & metabolic cardiomyopathy
dx	277.30[2]/ 425.7	Amyloidosis, unspecified plus nutritional & metabolic cardiomyopathy
dx	277.39[2]/ 425.7	Other amyloidosis plus nutritional & metabolic cardiomyopathy
dx	414.10	Aneurysm of heart (wall)
dx	414.19	Other aneurysm of heart
pdx	421.0	Acute and subacute bacterial endocarditis
pdx	421.1	Acute and subacute infective endocarditis in diseases classified elsewhere
pdx	421.9	Acute endocarditis, unspecified
dx/px	423.2/ 37.31	Diagnosis of constrictive pericarditis and undergoing pericardiectomy
pdx	424.90	Endocarditis, valve unspecified, unspecified cause
pdx	424.91	Endocarditis in diseases classified elsewhere
pdx	424.99	Other endocarditis, valve unspecified
dx	441.00	Dissection of aorta, unspecified site
dx	441.01	Dissection of aorta, thoracic
pdx	996.02	Mechanical complication of cardiac device, implant, and graft due to heart valve prosthesis
pdx	996.61	Infection and inflammatory reaction due to cardiac device, implant, and graft
pdx	996.71	Other complication of internal prosthetic device due to heart valve prosthesis
dx	996.81	Complications of transplanted kidney
dx	996.82	Complications of transplanted liver
dx	996.83	Complications of transplanted heart
dx	996.84	Complications of transplanted lung
dx	996.85	Complications of transplanted bone marrow
dx	996.86	Complications of transplanted pancreas
dx	996.87	Complications of transplanted intestines

[1] Invalid 10/01/2006

[2] Effective 10/01/2006

APPENDIX A: EXCLUSION DEFINTIONS *continued*

Table C. *Clinical Complexity Codes,* continued

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

Position	ICD-9-CM Code	Description
dx	V42.0	History of kidney transplant
dx	V42.1	History of heart transplant
dx	V42.6	History of lung transplant
dx	V42.7	History of liver transplant
dx	V42.81	Bone marrow replaced by transplant
dx	V42.83	Pancreas replaced by transplant
dx	V42.84	Intestines replaced by transplant

APPENDIX B: EXCLUSION DATA

Specific cases were excluded from the analysis. Exclusion criteria that were relevant to all outcome measures (i.e., standard exclusions) were first applied to the in-hospital mortality analysis (see Tables A1 and A2 below). For the other outcome measures in the report, additional exclusion criteria were applied as appropriate.

Table A1. 2005-2006 Exclusions for In-Hospital Mortality Analysis

	Cases		In-Hospital Mortality	
	#	%	#	%
Total cases prior to in-hospital mortality exclusions	*37,855*	*100.0*	*1,309*	*3.5*
Exclusions:				
• Patients < 30 years of age	259	0.7	10	3.9
• Patients who left against medical advice	27	0.1	0	0.0
• Clinically complex cases[1]	3,603	9.5	332	9.2
Total exclusions	*3,889*	*10.3*	*342*	*8.8*
Total cases remaining in analysis	***33,966***	***89.7***	***967***	***2.8***

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

Table A2. 2006 Exclusions for In-Hospital Mortality Analysis

	Cases		In-Hospital Mortality	
	#	%	#	%
Total cases prior to in-hospital mortality exclusions	*18,584*	*100.0*	*627*	*3.4*
Exclusions:				
• Patients < 30 years of age	132	0.7	3	2.3
• Patients who left against medical advice	9	<0.1	0	0.0
• Clinically complex cases[1]	1,810	9.7	167	9.2
Total exclusions	*1,951*	*10.5*	*170*	*8.7*
Total cases remaining in analysis	***16,633***	***89.5***	***457***	***2.8***

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

Table B1. 2005-2006 Additional Exclusions for Operative Mortality Analysis

	Cases		Operative Mortality	
	#	%	#	%
Total cases after in-hospital mortality exclusions	*33,966*	*100.0*	—	—
Additional Exclusions:				
• Cases with invalid/inconsistent data[1]	199	0.6	—	—
• Out-of state residents[2]	2,998	8.8	—	—
Total exclusions	*3,197*	*9.4*	—	—
Total cases remaining in analysis	***30,769***	***90.6***	***1,059***	***3.4***

[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 B2. *2006 Additional Exclusions for Operative Mortality Analysis*

	Cases		Operative Mortality	
	#	%	#	%
Total cases after in-hospital mortality exclusions	*16,633*	*100.0*	—	—
Additional Exclusions:				
• Cases with invalid/inconsistent data[1]	108	0.7	—	—
• Out-of state residents[2]	1,502	9.0	—	—
Total exclusions	*1,610*	*9.7*	—	—
Total cases remaining in analysis	***15,023***	***90.3***	***510***	***3.4***

[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.

Table C1. *2005-2006 Additional Exclusions for 7-day and 30-day Readmissions Analyses*

	Cases		Readmissions	
	#	%	7-day %	30-day %
Total cases after in-hospital mortality exclusions	*33,966*	*100.0*	—	—
Additional exclusions:				
• Patients who died during hospitalization in which surgery was performed	967	2.8	—	—
• Cases with invalid/inconsistent data[1]	185	0.5	—	—
• Out-of state residents[2]	2,904	8.5	—	—
Total exclusions	*4,056*	*11.9*	—	—
Total cases remaining in analysis	***29,910***	***88.1***	***6.0***	***14.7***

[1] Cases with invalid/inconsistent 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 home, and be readmitted there. Therefore, readmission data would not be available for these patients.

Table C2. *2006 Additional Exclusions for 7-day and 30-day Readmissions Analyses*

	Cases		Readmissions	
	#	%	7-day %	30-day %
Total cases after in-hospital mortality exclusions	*16,633*	*100.0*	—	—
Additional exclusions:				
• Patients who died during hospitalization in which surgery was performed	457	2.8	—	—
• Cases with invalid/inconsistent data[1]	101	0.6	—	—
• Out-of state residents[2]	1,462	8.8	—	—
Total exclusions	*2,020*	*12.1*	—	—
Total cases remaining in analysis	***14,613***	***87.9***	***6.0***	***14.4***

[1] Cases with invalid/inconsistent 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 home, and be readmitted there. Therefore, readmission data would not be available for these patients.

APPENDIX B: EXCLUSION DATA *continued*

Table D1. 2005-2006 Additional Exclusions for Post-Surgical Length of Stay (LOS) Analysis

	Cases		Average Post-Surgical LOS in Days
	#	%	
Total cases after in-hospital mortality exclusions	*33,966*	*100.0*	—
Additional exclusions:			
• Patients who died during hospitalization in which surgery was performed	967	2.8	—
• Cases that were length of stay outliers	351	1.0	—
Total exclusions	*1,318*	*3.9*	—
Total cases remaining in analysis	***32,648***	***96.1***	***7.3***

Table D2. 2006 Additional Exclusions for Post-Surgical Length of Stay (LOS) Analysis

	Cases		Average Post-Surgical LOS in Days
	#	%	
Total cases after in-hospital mortality exclusions	*16,633*	*100.0*	—
Additional exclusions:			
• Patients who died during hospitalization in which surgery was performed	457	2.7	—
• Cases that were length of stay outliers	164	1.0	—
Total exclusions	*621*	*3.7*	—
Total cases remaining in analysis	***16,012***	***96.3***	***7.3***

Table E1. 2005-2006 Additional Exclusions for Average Hospital Charge Analysis

	Cases		Average Charge
	#	%	
Total cases after in-hospital mortality exclusions	*33,966*	*100.0*	--
Additional exclusions:			
• Patients with invalid or missing charges[1]	5	<0.1	--
• Cases that were charge outliers[2]	554	1.6	--
• Cases in low volume DRGs[3]	1,075	3.2	*$478,622*
Total exclusions	*1,634*	*4.8*	--
Total cases remaining in analysis	***32,332***	***95.2***	***$119,828***

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

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

[3] If a particular procedure type, DRG, and region combination had less than 10 cases, it was excluded from the analysis.

APPENDIX B: EXCLUSION DATA *continued*

Table E2. ***2006 Additional Exclusions for Average Hospital Charge Analysis***

	Cases		Average Charge
	#	%	
Total cases after in-hospital mortality exclusions	*16,633*	*100.0*	--
Additional exclusions:			
• Patients with invalid or missing charges[1]	2	<0.1	--
• Cases that were charge outliers[2]	254	1.5	--
• Cases in low volume DRGs[3]	529	3.2	*$486,766*
Total exclusions	*785*	*4.7*	--
Total cases remaining in analysis	***15,848***	***95.3***	***$124,747***

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

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

[3] If a particular procedure type, DRG, and region combination had less than 10 cases, it was excluded from the analysis.

APPENDIX C: REASONS FOR READMISSION DEFINITIONS

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. 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[1], 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[2], 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

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

[1] Effective 10/01/2005

[2] This code is invalid. One record with this code as the principal diagnosis was counted as a readmission for heart failure.

APPENDIX C: REASONS FOR READMISSION DEFINITIONS *continued*

Atherosclerosis

Coronary Atherosclerosis

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

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, 423.8, 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

Other Arteries Excluding Precerebral and Cerebral Arteries

444.81, 444.89, 444.9, 445.81, 445.89, 593.81

Venous Embolism and Thrombosis

Lower Extremity Venous Embolism and Thrombosis

453.40, 453.41, 453.42

Renal Vein Embolism and Thrombosis

453.3

Other Venous Embolism and Thrombosis

453.8, 453.9

APPENDIX C: REASONS FOR READMISSION DEFINITIONS *continued*

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, 415.19

Postoperative Pulmonary Embolism and Infarction

415.11

Pleural Effusion and Atelectasis

511.0, 511.8, 511.9, 518.0

Pneumothorax

Pneumothorax

512.0, 512.8

Postoperative Pneumothorax

512.1

Pulmonary Edema

514, 518.4, 518.5

Acute Respiratory Failure

518.81, 518.82, 518.84, 799.1

Other Diseases and Symptoms of the Respiratory System

518.1, 519.1[1], 519.19[2], 519.2, 733.6, 786.00, 786.02, 786.04, 786.05, 786.06, 786.09, 786.2, 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

[1] Invalid 10/01/2006
[2] Effective 10/01/2006

APPENDIX C: REASONS FOR READMISSION DEFINITIONS *continued*

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[1], 338.18[1]

Other Diseases and Symptoms of the Nervous System

336.1, 436, 780.2, 780.4, 780.97[1]

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[1], 528.02[1], 528.09[1], 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, 535.10, 535.11, 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

URINARY SYSTEM

Acute Glomerulonephritis and Pyelonephritis

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

Nephrotic Syndrome

581.0, 581.1, 581.2, 581.3, 581.89, 581.9

Acute Renal Failure

584.5, 584.6, 584.7, 584.8, 584.9

Other Diseases and Symptoms of the Urinary System

593.9, 599.7, 788.20, 788.29

COMPLICATIONS OF SURGICAL AND MEDICAL CARE

Mechanical Complication of Cardiac Device, Implant and Graft

Mechanical Complication of Cardiac Pacemaker and AICD

996.00, 996.01, 996.04

Mechanical Complication of Heart Valve Prosthesis

996.02

Mechanical Complication of Coronary Artery Bypass Graft

996.03

Other and Unspecified Mechanical Complication

996.09, 996.1, 996.59

[1] Effective 10/01/2006

APPENDIX C: REASONS FOR READMISSION DEFINITIONS *continued*

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

Other Complications of Surgical and Medical Care

Nervous System Complication

997.00, 997.01, 997.09

Circulatory System Complication

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

Respiratory System Complication

519.00, 519.02, 519.09, 997.3

Digestive System Complication

536.40, 536.42, 536.49, 997.4

Urinary System Complication

997.5

Other Complications

998.89, 998.9, 999.8

INFECTIONS

Postoperative Infections

998.51, 998.59, 999.3

Sepsis and Bacteremia

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

Pneumonia

Pneumonia

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

Aspiration Pneumonia

507.0

Empyema and Abscess of Lung

510.0, 510.9, 513.0, 513.1

APPENDIX C: REASONS FOR READMISSION DEFINITIONS *continued*

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

Other Infection Related Conditions and Symptoms

567.2[1], 567.21[2], 567.29[2], 567.9, 590.2, 780.6

FLUID AND ELECTROLYTE IMBALANCE

Hyperosmolality and Hyposmolality

276.0, 276.1

Acidosis and Alkalosis

276.2, 276.3, 276.4

Dehydration and Hypovolemia

276.5[1], 276.50[2], 276.51[2], 276.52[2]

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, 280.8, 280.9, 285.29, 285.8, 285.9

Coagulation Defects

Hemorrhagic Disorders due to Anticoagulants

286.5

Thrombocytopenia

287.0, 287.3[1], 287.31[2], 287.4, 287.5, 446.6

Other Coagulation Defects

286.6, 286.7, 286.9, 289.82, 790.92

[1] Invalid 10/01/2005

[2] Effective 10/01/2005

APPENDIX D: READMISSIONS DATA

The following table shows the number and percent of readmissions for heart-related conditions, and infections and complications that were likely related to the CABG and/or valve surgery within 7 days and 30 days of discharge.

2005-2006 Reasons for Readmission Data	**7-Day N = 1,803 (6.0%)**		**30-Day N = 4,409 (14.7%)**	
	#	**%**	**#**	**%**
CIRCULATORY SYSTEM	**796**	**44.1**	**1,933**	**43.8**
Cardiac Dysrhythmias	199	11.0	472	10.7
Heart Block	6	0.3	14	0.3
Paroxysmal Tachycardia	6	0.3	13	0.3
Atrial Fibrillation and Atrial Flutter	159	8.8	366	8.3
Ventricular Fibrillation and Ventricular Flutter	3	0.2	6	0.1
Premature Heart Beats	1	0.1	4	0.1
Other Cardiac Dysrhythmias	24	1.3	69	1.6
Heart Failure	313	17.4	703	15.9
Functional Disturbances Follow Cardiac Surgery (Postcardiotomy Syndrome)	55	3.1	128	2.9
Hypertension and Hypotension	36	2.0	97	2.2
Essential Hypertension	2	0.1	6	0.1
Hypertensive Heart Disease	1	0.1	11	0.2
Hypertensive Chronic Kidney Disease	4	0.2	7	0.2
Hypertensive Heart and Chronic Kidney Disease	2	0.1	7	0.2
Secondary Hypertension	0	0.0	0	0.0
Hypotension	27	1.5	66	1.5
Myocardial Infarction and Ischemia	37	2.1	100	2.3
Acute Myocardial Infarction, Initial Episode	25	1.4	71	1.6
Acute Myocardial Infarction, Unspecified or Subsequent Episode	0	0.0	0	0.0
Other Forms of Myocardial Ischemia	12	0.7	29	0.7
Angina Pectoris and Chest Pain	61	3.4	144	3.3
Atherosclerosis	28	1.6	102	2.3
Coronary Atherosclerosis	24	1.3	81	1.8
Other Atherosclerosis	4	0.2	21	0.5
Heart Aneurysm and Dissection	0	0.0	0	0.0
Pericarditis, Endocarditis and Myocarditis	33	1.8	76	1.7

APPENDIX D: READMISSIONS DATA *continued*

2005-2006 Reasons for Readmission Data	**7-Day N = 1,803 (6.0%)**		**30-Day N = 4,409 (14.7%)**	
	#	**%**	**#**	**%**
Heart Valve Disease	3	0.2	6	0.1
Mitral Valve Disease	1	0.1	1	0.0
Aortic Valve Disease	1	0.1	1	0.0
Tricuspid Valve Disease	0	0.0	0	0.0
Pulmonary Valve Disease	0	0.0	0	0.0
Multiple Valve Disease	0	0.0	2	0.0
Other Endocardial Structure Disease	1	0.1	2	0.0
Cardiomyopathies	0	0.0	1	0.0
Other Aneurysm and Dissection	2	0.1	18	0.4
Aortic Aneurysm and Dissection	2	0.1	17	0.4
Other Arterial Aneurysm	0	0.0	1	0.0
Other Arterial Dissection	0	0.0	0	0.0
Arterial Embolism and Thrombosis	4	0.2	13	0.3
Abdominal and Thoracic Aorta	0	0.0	0	0.0
Arteries of the Extremities	1	0.1	9	0.2
Other Arteries Excluding Precerebral and Cerebral Arteries	3	0.2	4	0.1
Venous Embolism and Thrombosis	13	0.7	41	0.9
Lower Extremity Venous Embolism and Thrombosis	8	0.4	32	0.7
Renal Vein Embolism and Thrombosis	0	0.0	0	0.0
Other Venous Embolism and Thrombosis	5	0.3	9	0.2
Phlebitis and Thrombophlebitis	5	0.3	8	0.2
Lower Extremity Phlebitis and Thrombophlebitis	1	0.1	3	0.1
Upper Extremity Phlebitis and Thrombophlebitis	4	0.2	5	0.1
Other Vessel Phlebitis and Thrombophlebitis	0	0.0	0	0.0
Occlusion and Stenosis	5	0.3	18	0.4
Precerebral Artery Occlusion and Stenosis	0	0.0	2	0.0
Cerebral Artery Occlusion and Stenosis	2	0.1	8	0.2
Retinal Artery Occlusion and Visual Loss	3	0.2	8	0.2
Other Diseases and Symptoms of the Circulatory System	2	0.1	6	0.1
RESPIRATORY SYSTEM	**211**	**11.7**	**489**	**11.1**
Pulmonary Embolism and Infarction	52	2.9	140	3.2
Pulmonary Embolism and Infarction	31	1.7	88	2.0
Postoperative Pulmonary Embolism and Infarction	21	1.2	52	1.2
Pleural Effusion and Atelectasis	85	4.7	205	4.6

APPENDIX D: READMISSIONS DATA *continued*

2005-2006 Reasons for Readmission Data	7-Day N = 1,803 (6.0%)		30-Day N = 4,409 (14.7%)	
	#	%	#	%
Pneumothorax	5	0.3	10	0.2
Pneumothorax	2	0.1	4	0.1
Postoperative Pneumothorax	3	0.2	6	0.1
Pulmonary Edema	5	0.3	8	0.2
Acute Respiratory Failure	42	2.3	75	1.7
Other Diseases and Symptoms of the Respiratory System	22	1.2	51	1.2
NERVOUS SYSTEM	**96**	**5.3**	**185**	**4.2**
Stroke	61	3.4	102	2.3
Ischemic Stroke	46	2.6	72	1.6
Hemorrhagic Stroke	2	0.1	4	0.1
Transient Cerebral Ischemia	8	0.4	20	0.5
Postoperative Stroke	5	0.3	6	0.1
Encephalopathies	3	0.2	6	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	1	0.1	1	0.0
Postoperative Pain	1	0.1	1	0.0
Other Diseases and Symptoms of the Nervous System	30	1.7	75	1.7
DIGESTIVE SYSTEM	**51**	**2.8**	**139**	**3.2**
Ischemic Bowel and Vascular Insufficiency of the Intestine	4	0.2	13	0.3
Intestinal Obstruction and Ileus	6	0.3	14	0.3
Ulceration, Bleeding and Perforation of the Digestive System	35	1.9	94	2.1
Acute Liver Failure	0	0.0	0	0.0
Other Diseases and Symptoms of the Digestive System	6	0.3	18	0.4
URINARY SYSTEM	**34**	**1.9**	**90**	**2.0**
Acute Glomerulonephritis and Pyelonephritis	2	0.1	3	0.1
Nephrotic Syndrome	0	0.0	0	0.0
Acute Renal Failure	31	1.7	81	1.8
Other Diseases and Symptoms of the Urinary System	1	0.1	6	0.1

APPENDIX D: READMISSIONS DATA *continued*

2005-2006 Reasons for Readmission Data	7-Day N = 1,803 (6.0%)		30-Day N = 4,409 (14.7%)	
	#	%	#	%
COMPLICATIONS OF SURGICAL AND MEDICAL CARE	**246**	**13.6**	**486**	**11.0**
Mechanical Complication of Cardiac Device, Implant and Graft	2	0.1	11	0.2
Mechanical Complication of Cardiac Pacemaker and AICD	1	0.1	5	0.1
Mechanical Complication of Heart Valve Prosthesis	0	0.0	1	0.0
Mechanical Complication of Coronary Artery Bypass Graft	0	0.0	2	0.0
Other and Unspecified Mechanical Complication	1	0.1	3	0.1
Other Complication of Internal Prosthetic Device, Implant and Graft	7	0.4	21	0.5
Other Complication of Heart Valve Prosthesis	2	0.1	6	0.1
Other Complication of Other Cardiac Device, Implant and Graft	5	0.3	15	0.3
Other Complication of Vascular Device, Implant and Graft	0	0.0	0	0.0
Shock	1	0.1	1	0.0
Postoperative Shock	0	0.0	0	0.0
Cardiogenic Shock	1	0.1	1	0.0
Other Shock	0	0.0	0	0.0
Hemorrhage and Hematoma Complicating a Procedure	12	0.7	33	0.7
Foreign Body Accidentally Left or Accidental Laceration During a Procedure	1	0.1	2	0.0
Dehiscence and Rupture of Operation Wound	19	1.1	44	1.0
Other Complications of Surgical and Medical Care	204	11.3	374	8.5
Nervous System Complication	0	0.0	0	0.0
Circulatory System Complication	117	6.5	209	4.7
Respiratory System Complication	68	3.8	131	3.0
Digestive System Complication	6	0.3	7	0.2
Urinary System Complication	1	0.1	3	0.1
Other Complications	12	0.7	24	0.5
INFECTIONS	**305**	**16.9**	**926**	**21.0**
Postoperative Infections	149	8.3	506	11.5
Sepsis and Bacteremia	37	2.1	97	2.2
Pneumonia	56	3.1	143	3.2
Pneumonia	51	2.8	131	3.0
Aspiration Pneumonia	5	0.3	12	0.3
Empyema and Abscess of Lung	0	0.0	3	0.1
Infection due to Device, Implant and Graft	7	0.4	25	0.6
Cardiac Device, Implant and Graft	4	0.2	15	0.3
Vascular Device, Implant and Graft	3	0.2	10	0.2
Other and Unspecified Infections due to Device, Implant and Graft	0	0.0	0	0.0

APPENDIX D: READMISSIONS DATA *continued*

2005-2006 Reasons for Readmission Data	7-Day N = 1,803 (6.0%)		30-Day N = 4,409 (14.7%)	
	#	%	#	%
Urinary Tract Infection	12	0.7	45	1.0
Cellulitis	14	0.8	39	0.9
Osteomyelitis	1	0.1	1	0.0
Intestinal Infection due to Clostridium difficile	11	0.6	42	1.0
Other Infection Related Conditions and Symptoms	18	1.0	25	0.6
FLUID AND ELECTROLYTE IMBALANCE	**32**	**1.8**	**86**	**2.0**
Hyperosmolality and Hyposmolality	3	0.2	13	0.3
Acidosis and Alkalosis	0	0.0	1	0.0
Dehydration and Hypovolemia	26	1.4	63	1.4
Fluid Overload	0	0.0	1	0.0
Hyperpotassemia and Hypopotassemia	2	0.1	7	0.2
Other Electrolyte and Fluid Disorders	1	0.1	1	0.0
ANEMIA AND COAGULATION DEFECTS	**32**	**1.8**	**75**	**1.7**
Anemia	12	0.7	23	0.5
Acute Posthemorrhagic Anemia	2	0.1	4	0.1
Anemia	10	0.6	19	0.4
Coagulation Defects	20	1.1	52	1.2
Hemorrhagic Disorders due to Anticoagulants	0	0.0	3	0.1
Thrombocytopenia	5	0.3	8	0.2
Other Coagulation Defects	15	0.8	41	0.9

2006 Reasons for Readmission Data	7-Day N = 883 (6.0%)		30-Day N = 2,108 (14.4%)	
	#	%	#	%
CIRCULATORY SYSTEM	**393**	**44.5**	**910**	**43.2**
Cardiac Dysrhythmias	102	11.6	225	10.7
Heart Block	2	0.2	4	0.2
Paroxysmal Tachycardia	4	0.5	7	0.3
Atrial Fibrillation and Atrial Flutter	82	9.3	178	8.4
Ventricular Fibrillation and Ventricular Flutter	3	0.3	4	0.2
Premature Heart Beats	0	0.0	1	0.0
Other Cardiac Dysrhythmias	11	1.2	31	1.5

APPENDIX D: READMISSIONS DATA *continued*

2006 Reasons for Readmission Data	7-Day N = 883 (6.0%)		30-Day N = 2,108 (14.4%)	
	#	%	#	%
Heart Failure	152	17.2	327	15.5
Functional Disturbances Follow Cardiac Surgery (Postcardiotomy Syndrome)	23	2.6	56	2.7
Hypertension and Hypotension	17	1.9	49	2.3
Essential Hypertension	2	0.2	4	0.2
Hypertensive Heart Disease	1	0.1	5	0.2
Hypertensive Chronic Kidney Disease	3	0.3	3	0.1
Hypertensive Heart and Chronic Kidney Disease	1	0.1	4	0.2
Secondary Hypertension	0	0.0	0	0.0
Hypotension	10	1.1	33	1.6
Myocardial Infarction and Ischemia	16	1.8	42	2.0
Acute Myocardial Infarction, Initial Episode	10	1.1	27	1.3
Acute Myocardial Infarction, Unspecified or Subsequent Episode	0	0.0	0	0.0
Other Forms of Myocardial Ischemia	6	0.7	15	0.7
Angina Pectoris and Chest Pain	32	3.6	69	3.3
Atherosclerosis	16	1.8	51	2.4
Coronary Atherosclerosis	13	1.5	38	1.8
Other Atherosclerosis	3	0.3	13	0.6
Heart Aneurysm and Dissection	0	0.0	0	0.0
Pericarditis, Endocarditis and Myocarditis	19	2.2	42	2.0
Heart Valve Disease	0	0.0	2	0.1
Mitral Valve Disease	0	0.0	0	0.0
Aortic Valve Disease	0	0.0	0	0.0
Tricuspid Valve Disease	0	0.0	0	0.0
Pulmonary Valve Disease	0	0.0	0	0.0
Multiple Valve Disease	0	0.0	2	0.1
Other Endocardial Structure Disease	0	0.0	0	0.0
Cardiomyopathies	0	0.0	1	0.0
Other Aneurysm and Dissection	0	0.0	4	0.2
Aortic Aneurysm and Dissection	0	0.0	3	0.1
Other Arterial Aneurysm	0	0.0	1	0.0
Other Arterial Dissection	0	0.0	0	0.0
Arterial Embolism and Thrombosis	1	0.1	6	0.3
Abdominal and Thoracic Aorta	0	0.0	0	0.0
Arteries of the Extremities	1	0.1	6	0.3
Other Arteries Excluding Precerebral and Cerebral Arteries	0	0.0	0	0.0

APPENDIX D: READMISSIONS DATA *continued*

2006 Reasons for Readmission Data	7-Day N = 883 (6.0%)		30-Day N = 2,108 (14.4%)	
	#	%	#	%
Venous Embolism and Thrombosis	7	0.8	22	1.0
Lower Extremity Venous Embolism and Thrombosis	4	0.5	16	0.8
Renal Vein Embolism and Thrombosis	0	0.0	0	0.0
Other Venous Embolism and Thrombosis	3	0.3	6	0.3
Phlebitis and Thrombophlebitis	4	0.5	7	0.3
Lower Extremity Phlebitis and Thrombophlebitis	1	0.1	3	0.1
Upper Extremity Phlebitis and Thrombophlebitis	3	0.3	4	0.2
Other Vessel Phlebitis and Thrombophlebitis	0	0.0	0	0.0
Occlusion and Stenosis	3	0.3	5	0.2
Precerebral Artery Occlusion and Stenosis	0	0.0	0	0.0
Cerebral Artery Occlusion and Stenosis	2	0.2	2	0.1
Retinal Artery Occlusion and Visual Loss	1	0.1	3	0.1
Other Diseases and Symptoms of the Circulatory System	1	0.1	2	0.1
RESPIRATORY SYSTEM	**104**	**11.8**	**243**	**11.5**
Pulmonary Embolism and Infarction	25	2.8	65	3.1
Pulmonary Embolism and Infarction	17	1.9	39	1.9
Postoperative Pulmonary Embolism and Infarction	8	0.9	26	1.2
Pleural Effusion and Atelectasis	46	5.2	106	5.0
Pneumothorax	3	0.3	6	0.3
Pneumothorax	1	0.1	2	0.1
Postoperative Pneumothorax	2	0.2	4	0.2
Pulmonary Edema	2	0.2	4	0.2
Acute Respiratory Failure	18	2.0	37	1.8
Other Diseases and Symptoms of the Respiratory System	10	1.1	25	1.2
NERVOUS SYSTEM	**46**	**5.2**	**94**	**4.5**
Stroke	28	3.2	50	2.4
Ischemic Stroke	20	2.3	32	1.5
Hemorrhagic Stroke	1	0.1	1	0.0
Transient Cerebral Ischemia	3	0.3	12	0.6
Postoperative Stroke	4	0.5	5	0.2
Encephalopathies	1	0.1	3	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	1	0.1	1	0.0
Postoperative Pain	1	0.1	1	0.0

APPENDIX D: READMISSIONS DATA *continued*

2006 Reasons for Readmission Data	7-Day N = 883 (6.0%)		30-Day N = 2,108 (14.4%)	
	#	%	#	%
Other Diseases and Symptoms of the Nervous System	15	1.7	39	1.9
DIGESTIVE SYSTEM	**26**	**2.9**	**68**	**3.2**
Ischemic Bowel and Vascular Insufficiency of the Intestine	3	0.3	7	0.3
Intestinal Obstruction and Ileus	4	0.5	8	0.4
Ulceration, Bleeding and Perforation of the Digestive System	15	1.7	42	2.0
Acute Liver Failure	0	0.0	0	0.0
Other Diseases and Symptoms of the Digestive System	4	0.5	11	0.5
URINARY SYSTEM	**19**	**2.2**	**50**	**2.4**
Acute Glomerulonephritis and Pyelonephritis	1	0.1	2	0.1
Nephrotic Syndrome	0	0.0	0	0.0
Acute Renal Failure	17	1.9	47	2.2
Other Diseases and Symptoms of the Urinary System	1	0.1	1	0.0
COMPLICATIONS OF SURGICAL AND MEDICAL CARE	**118**	**13.4**	**235**	**11.1**
Mechanical Complication of Cardiac Device, Implant and Graft	1	0.1	7	0.3
Mechanical Complication of Cardiac Pacemaker and AICD	1	0.1	4	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	0	0.0	7	0.3
Other Complication of Heart Valve Prosthesis	0	0.0	3	0.1
Other Complication of Other Cardiac Device, Implant and Graft	0	0.0	4	0.2
Other Complication of Vascular Device, Implant and Graft	0	0.0	0	0.0
Shock	1	0.1	1	0.0
Postoperative Shock	0	0.0	0	0.0
Cardiogenic Shock	1	0.1	1	0.0
Other Shock	0	0.0	0	0.0
Hemorrhage and Hematoma Complicating a Procedure	6	0.7	15	0.7
Foreign Body Accidentally Left or Accidental Laceration During a Procedure	0	0.0	1	0.0
Dehiscence and Rupture of Operation Wound	11	1.2	21	1.0

APPENDIX D: READMISSIONS DATA *continued*

2006 Reasons for Readmission Data	7-Day N = 883 (6.0%)		30-Day N = 2,108 (14.4%)	
	#	%	#	%
Other Complications of Surgical and Medical Care	99	11.2	183	8.7
Nervous System Complication	0	0.0	0	0.0
Circulatory System Complication	58	6.6	107	5.1
Respiratory System Complication	38	4.3	68	3.2
Digestive System Complication	0	0.0	1	0.0
Urinary System Complication	0	0.0	1	0.0
Other Complications	3	0.3	6	0.3
INFECTIONS	**147**	**16.6**	**438**	**20.8**
Postoperative Infections	70	7.9	235	11.1
Sepsis and Bacteremia	19	2.2	49	2.3
Pneumonia	25	2.8	64	3.0
Pneumonia	22	2.5	57	2.7
Aspiration Pneumonia	3	0.3	7	0.3
Empyema and Abscess of Lung	0	0.0	1	0.0
Infection due to Device, Implant and Graft	3	0.3	12	0.6
Cardiac Device, Implant and Graft	2	0.2	8	0.4
Vascular Device, Implant and Graft	1	0.1	4	0.2
Other and Unspecified Infections due to Device, Implant and Graft	0	0.0	0	0.0
Urinary Tract Infection	9	1.0	21	1.0
Cellulitis	8	0.9	27	1.3
Osteomyelitis	1	0.1	1	0.0
Intestinal Infection due to Clostridium difficile	3	0.3	17	0.8
Other Infection Related Conditions and Symptoms	9	1.0	11	0.5
FLUID AND ELECTROLYTE IMBALANCE	**9**	**1.0**	**27**	**1.3**
Hyperosmolality and Hyposmolality	3	0.3	6	0.3
Acidosis and Alkalosis	0	0.0	0	0.0
Dehydration and Hypovolemia	6	0.7	19	0.9
Fluid Overload	0	0.0	1	0.0
Hyperpotassemia and Hypopotassemia	0	0.0	1	0.0
Other Electrolyte and Fluid Disorders	0	0.0	0	0.0
ANEMIA AND COAGULATION DEFECTS	**21**	**2.4**	**43**	**2.0**
Anemia	6	0.7	12	0.6
Acute Posthemorrhagic Anemia	1	0.1	3	0.1
Anemia	5	0.6	9	0.4

APPENDIX D: READMISSIONS DATA *continued*

2006 Reasons for Readmission Data	7-Day N = 883 (6.0%)		30-Day N = 2,108 (14.4%)	
	#	%	#	%
Coagulation Defects	15	1.7	31	1.5
Hemorrhagic Disorders due to Anticoagulants	0	0.0	2	0.1
Thrombocytopenia	4	0.5	4	0.2
Other Coagulation Defects	11	1.2	25	1.2

APPENDIX E: CANDIDATE VARIABLE DEFINITIONS

This appendix includes definitions of all variables that were tested and/or retained for the mortality, readmissions, and length of stay models. When variables were defined by the presence of ICD-9-CM codes in the discharge record, the ICD-9-CM codes are listed. Note that not every variable in this appendix was tested in every model. Moreover, when a variable had more than one overlapping definition, only one definition was used for a particular model. The columns to the right indicate which variable definitions were used in a particular group of models.

Variable Name Description	2005-2006 Models		
	Mortality	**Read-missions**	**Length of Stay**
Year Year of discharge		30-day only	
Demographic Variables			
Age in Years	X		X
Age # Years > 65 Number of years older than 65.	X	X	X
Female	X	30-day only	X
Race *Category 1:* White *Category 2:* Black *Category 3:* Other/Unknown		X	X
Laboratory Variables			
Albumin < 2.5[1] Laboratory value for albumin was less than or equal to 2.5 g/dL, as indicated by Albumin g/dL A (value in the range 1.0 – 2.4 g/dL).	X		
Albumin 2.5-3[1] Laboratory value for albumin was in the range 2.5 - 3.0 g/dL, as indicated by any of the following: • Albumin g/dL B (value in the range 2.5 – 2.7g/dL), *or* • Albumin g/dL C (value in the range 2.8 – 3.0 g/dL).	X		
BUN > 40[1] Laboratory value for blood urea nitrogen (BUN) was greater than 40 mg/dL, as indicated by any of the following: • BUN mg/dL D (value in the range 41- 55 mg/dL), *or* • BUN mg/dL E (value in the range 56 – 250 mg/dL).	X		
Creatinine > 1.4[1] Laboratory value for creatinine was greater than 1.4 mg/dL, as indicated by any of the following: • Creatinine mg/dL B (value in the range: 1.5 – 2.0 mg/dL), • Creatinine mg/dL C (value in the range: 2.1 – 2.5 mg/dL), • Creatinine mg/dL D (value in the range: 2.6 – 3.0 mg/dL), *or* • Creatinine mg/dL E (value in the range: 3.1 – 25.0 mg/dL).	X		
Glucose > 165[1] Laboratory value for glucose was greater than 165 mg/dL, as indicated by either of the following: • Glucose mg/dL D (value in the range: 166 – 240 mg/dL), *or* • Glucose mg/dL E (value in the range: 241 – 2000 mg/dL).	X		
Clinical Variables Other Than Laboratory Variables			
AMI Other Inferior Wall Initial Episode AMI of other inferior wall, as indicated by: • 410.41 in any position in MediQual data, *or* • 410.41 in the principal diagnosis position in PHC4 data.	X		

[1] This variable was developed by MediQual for their CABG/valve in-hospital mortality model using the MediQual *Atlas Outcomes*™ System data.

APPENDIX E: CANDIDATE VARIABLE DEFINITIONS *continued*

Variable Name Description	2005-2006 Models		
	Mortality	**Read-missions**	**Length of Stay**
AMI Except Other Anterior or Other Inferior Wall Any of the following codes in any position in PHC4 data: 410.01, 410.21, 410.31, 410.51, 410.61, 410.71, 410.81, or 410.91 in the principal diagnosis position in PHC4 data.	X		
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, 284.0, 284.8, 284.9, 285.0, 285.21, 285.22, 285.29, 285.8, 285.9.			X
ASA Class 5[1] High risk operation, as indicated by an anesthesia class of 5 for the first open heart procedure. This physical status classification system was created by the American Society of Anesthesiologists. Scale: 1 – 5, where 5 is the highest risk category.	X		
ASA Emergency Flag[1] Emergency operation, as indicated by an anesthesia emergency flag for the first open heart procedure. This physical status classification system was created by the American Society of Anesthesiologists.	X		
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[3]	X		X
CAD > 70, 5-7 Vessels Group[1] Coronary Artery Disease (CAD) with greater than 70% occlusion in 5 to 7 coronary arteries.	X		
Cancer Any of the following codes in any position in PHC4 data: 140.0 - 208.9, 230.0 - 239.9.		30-day only	X
Cardiogenic Shock, Preoperative Medical record review to determine if cardiogenic shock was present prior to CABG and/or valve surgery.	X		X
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.			X
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.			X
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.		30-day only	X
Chronic Pulmonary Hypertension Any of the following codes in any position in PHC4 data: 416.0, 416.1, 416.8, 416.9.			X
Coagulopathy Any of the following codes in any position in PHC4 data: 286.0, 286.1, 286.2, 286.3, 286.4, 287.3[2], 287.30[3], 287.31[3], 287.32[3], 287.33[3], 287.39[3], 289.81.			X
Current Med Immunosuppressants[1] Based on the presence of the Current Med Immunosuppressive History KCF.	X		
Current Med Insulin[1] Based on the presence of the Current Med Insulin History KCF.	X		
Diabetes *Category 1:* No diabetes *Category 2:* Diabetes without complication was indicated by the presence of code 250.0x in any position in PHC4 data. *Category 3:* Diabetes with complication was indicated by any code in the following range in PHC4 data: 250.1x - 250.9x.		X	

[1] This variable was developed by MediQual for their CABG/valve in-hospital mortality model using the MediQual *Atlas Outcomes*™ System data.
[2] Invalid 10/01/2005
[3] Effective 10/01/2005

APPENDIX E: CANDIDATE VARIABLE DEFINITIONS *continued*

Variable Name Description	2005-2006 Models		
	Mortality	**Read-missions**	**Length of Stay**
Diabetes with Long Term/Unspecified Complications Diabetes with long term or unspecified complications, as indicated by any of the following codes in any position in PHC4 data: 250.4x - 250.9x.			X
Ejection Fraction[1] *Category 1:* EF > 45% was based on the presence of an ejection fraction or fractional shortening greater than 45% as a transfer, preadmission, or admission KCF. *Category 2:* 25% to 45% was based on the presence of an ejection fraction or fractional shortening greater than 25% and less than or equal to 45% as a transfer, preadmission, or admission KCF. Also included cases without an EF finding. *Category 3:* EF < 25% was based on the presence of an ejection fraction or fractional shortening less than 25% as a transfer, preadmission, or admission KCF.	X		
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery This procedure is indicated by the presence of code 37.33 on the same date as CABG/valve surgery in any position in PHC4 data. If valve and CABG surgeries were performed during the same admission but on different dates the date of the first surgery was used.			X
Heart Failure Heart failure, as indicated by either of the following: • The presence of congestive heart failure (CHF) as a preadmission or admission KCF in MediQual data*, or* • Any of the following codes in any position in PHC4 data: 398.91, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.40, 428.41, 428.42, 428.43, 428.9. *For those cases having one of the above heart failure codes and a hypertension with congestive heart failure code (402.x1, 404.x1, 404.x3) in the same record, the case was assigned to hypertension with complications.*	X		
Heart Failure[2] Any of the following codes in any position in PHC4 data: 398.91, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.40, 428.41, 428.42, 428.43, 428.9. *For those cases having one of the above heart failure codes and a hypertension with congestive heart failure code (402.x1, 404.x1, 404.x3) in the same record, the case was assigned to hypertension with complications.*		X	X
History of CABG or Valve Surgery History of CABG and/or valve surgery, as indicated by any of the following: • The presence of the Previous CABG History KCF in MediQual data, *or* • 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.	X		
History of PTCA/Stent History of a PTCA or stent as indicated by code V45.82 in any position in PHC4 data.		7-day only	
History of Peripheral Vascular Disease History of peripheral vascular disease was indicated by either: • The presence of the Peripheral Vascular Disease History KCF in MediQual data, *or* • 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, 440.8, 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.	X		

[1] This variable was developed by MediQual for their CABG/valve in-hospital mortality model using the MediQual *Atlas Outcomes*™ System data.

[2] This variable definition does not include the MediQual KCF. The KCF was included in the MediQual Predicted Length of Stay variable.

APPENDIX E: CANDIDATE VARIABLE DEFINITIONS *continued*

Variable Name Description	2005-2006 Models Mortality	Read-missions	Length of Stay
History of Peripheral Vascular Disease[1] 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, 440.8, 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[2], 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.		X	
Hypertension with Complications Any of the following codes in any position in PHC4 data: 402.01, 402.11, 402.91, 403.01, 403.11, 403.91, 404.01, 404.11, 404.91, 404.02, 404.12, 404.92, 404.03, 404.13, 404.93, 405.01, 405.09, 405.11, 405.19, 405.91, 405.99.	X		
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery An intra-aortic balloon pump inserted prior to the date of CABG/valve surgery, as indicated by the following code in any position in PHC4 data: 37.61.	In-hospital only		X
Liver Disease Any of the following codes in any position in PHC4 data: 456.0, 456.20, 456.21, 571.0, 571.3, 571.40, 571.41, 571.49, 571.5, 571.6, 571.8, 571.9, 572.3, 573.3.	Operative only		X
Lupus Erythematosus, Systemic Code 710.0 in any position in PHC4 data.	X		
MI/AMI Other Anterior Wall Myocardial infarction/acute myocardial infarction of other anterior wall, as indicated by either one of the following: • The presence of myocardial infarction as either a preadmission or admission KCF *and* the diagnosis code 410.11 in any position in MediQual data, *or* • 410.11 as the principal diagnosis code in PHC4 data.	X		
Mild Moderate or Severe AMS[3] Altered mental status is based on the presence of the following preadmission or admission KCF in MediQual data: • Mild – Disoriented, lethargy, or Glascow Coma Score from 10 – 14, • Moderate – Glascow Coma Score from 5 – 9, *or* • Severe – Coma/stupor or Glascow Coma Score < 5.	X		
Morbid Obesity Code 278.01 in any position in PHC4 data.		X	
MediQual Predicted Length of Stay The predicted length of stay derived from MediQual's Predicted Length of Stay model for CABG/valve. This variable consists of demographic and clinical data including laboratory findings.		X	X
Multiple Valve Procedures Any combination of valve procedure codes (i.e., two or more 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, 35.10, 35.11, 35.12, 35.13, 35.14, 35.33, 35.99.	X	30-day only	X
Other CV Procedure Group Other cardiovascular procedures indicated by any of the following codes in any position: • 36.31, 36.32, 36.39, 36.91, 36.99, 37.10, 37.11, 37.32, 37.33, 38.44, 38.45, 38.46, 39.51, 39.52. in MediQual data, *or* • 35.00, 35.01, 35.02, 35.03, 35.04, 35.31, 35.32, 35.34, 35.35, 35.39, 35.50, 35.51, 35.53, 35.54, 35.60, 35.61, 35.62, 35.63, 35.70, 35.71, 35.72, 35.73, 35.81, 35.82, 35.83, 35.84, 35.91, 35.92, 35.93, 35.94, 35.95, 35.98, 36.2, 36.31, 36.32, 36.39, 36.91, 36.99, 37.10, 37.11, 37.12, 37.31, 37.32, 37.33, 37.41, 37.49, 37.51, 37.52, 37.53 in PHC4 data.	X		

[1] This variable definition does not include the MediQual KCF. The KCF was included in the MediQual Predicted Length of Stay variable.
[2] Effective 10/01/2005
[3] This variable was developed by MediQual for their CABG/valve in-hospital mortality model using the MediQual *Atlas Outcomes*™ System data.

APPENDIX E: CANDIDATE VARIABLE DEFINITIONS *continued*

Variable Name Description	2005-2006 Models		
	Mortality	**Read-missions**	**Length of Stay**
Other Open Heart Procedure Other heart procedures, as indicated by any of the following procedure codes in any position in PHC4 data: 35.00, 35.01, 35.02, 35.03, 35.04, 35.31, 35.32, 35.34, 35.35, 35.39, 35.50, 35.51, 35.53, 35.54, 35.60, 35.61, 35.62, 35.63, 35.70, 35.71, 35.72, 35.73, 35.81, 35.82, 35.83, 35.84, 35.91, 35.92, 35.93, 35.94, 35.95, 35.98, 36.2, 36.31, 36.32, 36.39, 36.91, 36.99, 37.10, 37.11, 37.12, 37.31, 37.32, 37.33, 37.41, 37.49, 37.51, 37.52, 37.53.			X
Percent of Left Main Stenosis[1] Percent of occlusion in the left main coronary artery (continuous variable).	X		
Procedure Group *Category 1:* CABG without valve: any of the following codes with ***no*** valve procedure codes: 36.10, 36.11, 36.12, 36.13, 36.14, 36.15, 36.16, 36.17, 36.19. *Category 2:* Valve without CABG: any of the following codes with ***no*** CABG codes: 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: cases with at least one CABG code from ***and*** at least one valve code.	X	X	X
PTCA/Stent/Tear Same Day as CABG/Valve Surgery Based on either of the following: • A CABG procedure or valve procedure performed on the same day as PTCA with the presence of "vessel tear" as either a preadmission or admission KCF in MediQual data, *or* • Any of the following procedure codes in any position in PHC4 data on the same date as a CABG/valve procedure: 36.01[2], 36.02[2], 36.05[2], 36.06, 36.07, 36.09, 00.66[3]	X		
Renal Failure/Dialysis (category) *Category 1:* No renal failure or dialysis *Category 2:* Chronic renal failure: 585[2], 585.1[3] - 585.9[3] in any position in PHC4 data. *Category 3:* Preoperative acute renal failure code 584.5 - 584.9 in any position in the PHC4 data and review of the medical record to determine if acute renal failure was present prior to the CABG/valve surgery *or* dialysis code 39.95 or 54.98 in any position prior to the date of the CABG/valve surgery.			X
Septal Other Anomalous Repair Heart[1] Repair of septal defect in heart, as indicated by any of the following codes: 35.41, 35.42, 35.50, 35.51, 35.52, 35.53, 35.54, 35.55, 35.60, 35.61, 35.62, 35.63, 35.70, 35.71, 35.72, 35.73, 35.81, 35.82, 35.83, 35.84, 35.91, 35.92, 35.93, 35.94, 35.95, 35.98.	Operative only		
SIRS Group[1] This variable was indicated by the presence of any two of four criteria that define SIRS (Systemic Inflammatory Response Syndrome): • Temperature > 38℃ (> 100.4℉) or < 36℃ (< 96.8℉) • Heart rate > 89 beats/minute • Respiration rate > 19/minute or $PaCO_2$ < 32 mmHg • White blood cell count > 12.0 K/µl or < 4.0 K/µl or > 10% bands	X		

[1] This variable was developed by MediQual for their CABG/valve in-hospital mortality model using the MediQual *Atlas Outcomes*™ System data.
[2] Invalid 10/01/2005
[3] Effective 10/01/2005

APPENDIX E: CANDIDATE VARIABLE DEFINITIONS *continued*

Variable Name Description	2006 Models		
	Mortality	Read-missions	Length of Stay
Demographic Variables			
Age in Years	X		X
Age # Years > 65 Number of years older than 65.	X	30-day only	X
Female	X		X
Race/Ethnicity *Category 1:* Hispanic *Category 2:* White, non-Hispanic *Category 3:* Black, non-Hispanic *Category 4:* Other/Unknown	In-hospital only	7-day only	
Race *Category 1:* White *Category 2:* Black *Category 3:* Other/Unknown	Operative only		X
Laboratory Variables			
Albumin < 2.5[1] Laboratory value for albumin was less than or equal to 2.5 g/dL, as indicated by Albumin g/dL A (value in the range 1.0 – 2.4 g/dL).	Operative only		
Albumin 2.5-3[1] Laboratory value for albumin was in the range 2.5 - 3.0 g/dL, as indicated by any of the following: • Albumin g/dL B (value in the range 2.5 – 2.7g/dL), *or* • Albumin g/dL C (value in the range 2.8 – 3.0 g/dL).	Operative only		
BUN > 40[1] Laboratory value for blood urea nitrogen (BUN) was greater than 40 mg/dL, as indicated by any of the following: • BUN mg/dL D (value in the range 41- 55 mg/dL), *or* • BUN mg/dL E (value in the range 56 – 250 mg/dL).	X		
Creatinine > 1.4[1] Laboratory value for creatinine was greater than 1.4 mg/dL, as indicated by any of the following: • Creatinine mg/dL B (value in the range: 1.5 – 2.0 mg/dL), • Creatinine mg/dL C (value in the range: 2.1 – 2.5 mg/dL), • Creatinine mg/dL D (value in the range: 2.6 – 3.0 mg/dL), *or* • Creatinine mg/dL E (value in the range: 3.1 – 25.0 mg/dL).	X		
Glucose > 165[1] Laboratory value for glucose was greater than 165 mg/dL, as indicated by either of the following: • Glucose mg/dL D (value in the range: 166 – 240 mg/dL), *or* • Glucose mg/dL E (value in the range: 241 – 2000 mg/dL).	X		
Clinical Variables Other Than Laboratory Variables			
AMI Other Inferior Wall Initial Episode AMI of other inferior wall, as indicated by: • 410.41 in any position in MediQual data, *or* • 410.41 in the principal diagnosis position in PHC4 data.	X		
AMI Except Other Anterior or Other Inferior Wall Any of the following codes in any position in PHC4 data: 410.01, 410.21, 410.31, 410.51, 410.61, 410.71, 410.81, or 410.91 in the principal diagnosis position in PHC4 data.	X		

[1] This variable was developed by MediQual for their CABG/valve in-hospital mortality model using the MediQual *Atlas Outcomes*™ System data.

APPENDIX E: CANDIDATE VARIABLE DEFINITIONS *continued*

Variable Name Description	2006 Models		
	Mortality	Read-missions	Length of Stay
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, 284.0, 284.8, 284.9, 285.0, 285.21, 285.22, 285.29, 285.8, 285.9.			X
ASA Class 5[1] High risk operation, as indicated by an anesthesia class of 5 for the first open heart procedure. This physical status classification system was created by the American Society of Anesthesiologists. Scale: 1 – 5, where 5 is the highest risk category.	X		
ASA Emergency Flag[1] Emergency operation, as indicated by an anesthesia emergency flag for the first open heart procedure. This physical status classification system was created by the American Society of Anesthesiologists.	X		
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[2] .	X		X
CAD > 70, 5-7 Vessels Group[1] Coronary Artery Disease (CAD) with greater than 70% occlusion in 5 to 7 coronary arteries.	X		
Cardiogenic Shock, Preoperative Medical record review to determine if cardiogenic shock was present prior to CABG and/or valve surgery.	X		X
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.			X
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.	In-hospital only		X
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.		30-day only	
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.			X
Chronic Pulmonary Hypertension Any of the following codes in any position in PHC4 data: 416.0, 416.1, 416.8, 416.9.			X
Current Med Insulin[1] Based on the presence of the Current Med Insulin History KCF.	X		
Diabetes *Category 1:* No diabetes *Category 2:* Diabetes without complication was indicated by the presence of code 250.0x in any position in PHC4 data. *Category 3:* Diabetes with complication was indicated by any code in the following range in PHC4 data: 250.1x - 250.9x.		30-day only	
Diabetes with Long Term/Unspecified Complications Diabetes with long term or unspecified complications, as indicated by any of the following codes in any position in PHC4 data: 250.4x - 250.9x.			X

[1] This variable was developed by MediQual for their CABG/valve in-hospital mortality model using the MediQual *Atlas Outcomes*™ System data.
[2] Effective 10/01/2005

APPENDIX E: CANDIDATE VARIABLE DEFINITIONS *continued*

Variable Name Description	2006 Models		
	Mortality	Read-missions	Length of Stay
Ejection Fraction[1] *Category 1:* EF > 45% was based on the presence of an ejection fraction or fractional shortening greater than 45% as a transfer, preadmission, or admission KCF. *Category 2:* 25% to 45% was based on the presence of an ejection fraction or fractional shortening greater than 25% and less than or equal to 45% as a transfer, preadmission, or admission KCF. Also included cases without an EF finding. *Category 3:* EF < 25% was based on the presence of an ejection fraction or fractional shortening less than 25% as a transfer, preadmission, or admission KCF.	X		
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery This procedure is indicated by the presence of code 37.33 on the same date as CABG/valve surgery in any position in PHC4 data. If valve and CABG surgeries were performed during the same admission but on different dates the date of the first surgery was used.			X
Heart Failure Heart failure, as indicated by either of the following: • The presence of congestive heart failure (CHF) as a preadmission or admission KCF in MediQual data*, or* • Any of the following codes in any position in PHC4 data: 398.91, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.40, 428.41, 428.42, 428.43, 428.9. *For those cases having one of the above heart failure codes and a hypertension with congestive heart failure code (402.x1, 404.x1, 404.x3) in the same record, the case was assigned to hypertension with complications.*	X		
Heart Failure[2] Any of the following codes in any position in PHC4 data: 398.91, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.40, 428.41, 428.42, 428.43, 428.9. *For those cases having one of the above heart failure codes and a hypertension with congestive heart failure code (402.x1, 404.x1, 404.x3) in the same record, the case was assigned to hypertension with complications.*		X	X
History of CABG or Valve Surgery History of CABG and/or valve surgery, as indicated by any of the following: • The presence of the Previous CABG History KCF in MediQual data, *or* • 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.	X		
History of Peripheral Vascular Disease History of peripheral vascular disease was indicated by either: • The presence of the Peripheral Vascular Disease History KCF in MediQual data, *or* • 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, 440.8, 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.	X		
Hypertension with Complications Any of the following codes in any position in PHC4 data: 402.01, 402.11, 402.91, 403.01, 403.11, 403.91, 404.01, 404.11, 404.91, 404.02, 404.12, 404.92, 404.03, 404.13, 404.93, 405.01, 405.09, 405.11, 405.19, 405.91, 405.99.	Operative only		X
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery An intra-aortic balloon pump inserted prior to the date of CABG/valve surgery, as indicated by the following code in any position in PHC4 data: 37.61.			X

[1] This variable was developed by MediQual for their CABG/valve in-hospital mortality model using the MediQual *Atlas Outcomes*™ System data.

[2] This variable definition does not include the MediQual KCF. The KCF was included in the MediQual Predicted Length of Stay variable.

APPENDIX E: CANDIDATE VARIABLE DEFINITIONS *continued*

Variable Name Description	2006 Models		
	Mortality	Read-missions	Length of Stay
Liver Disease Any of the following codes in any position in PHC4 data: 456.0, 456.20, 456.21, 571.0, 571.3, 571.40, 571.41, 571.49, 571.5, 571.6, 571.8, 571.9, 572.3, 573.3.	X		
MI/AMI Other Anterior Wall Myocardial infarction/acute myocardial infarction of other anterior wall, as indicated by either one of the following: • The presence of myocardial infarction as either a preadmission or admission KCF *and* the diagnosis code 410.11 in any position in MediQual data, *or* • 410.11 as the principal diagnosis code in PHC4 data.	X		
Mild Moderate or Severe AMS[1] Altered mental status is based on the presence of the following preadmission or admission KCF in MediQual data: • Mild – Disoriented, lethargy, or Glascow Coma Score from 10 – 14, • Moderate – Glascow Coma Score from 5 – 9, *or* • Severe – Coma/stupor or Glascow Coma Score < 5.	X		
MediQual Predicted Length of Stay The predicted length of stay derived from MediQual's Predicted Length of Stay model for CABG/valve. This variable consists of demographic and clinical data including laboratory findings.		X	X
Multiple Valve Procedures Any combination of valve procedure codes (i.e., two or more 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, 35.10, 35.11, 35.12, 35.13, 35.14, 35.33, 35.99.	Operative only		X
Other CV Procedure Group Other cardiovascular procedures indicated by any of the following codes in any position: • 36.31, 36.32, 36.39, 36.91, 36.99, 37.10, 37.11, 37.32, 37.33, 38.44, 38.45, 38.46, 39.51, 39.52. in MediQual data, *or* • 35.00, 35.01, 35.02, 35.03, 35.04, 35.31, 35.32, 35.34, 35.35, 35.39, 35.50, 35.51, 35.53, 35.54, 35.60, 35.61, 35.62, 35.63, 35.70, 35.71, 35.72, 35.73, 35.81, 35.82, 35.83, 35.84, 35.91, 35.92, 35.93, 35.94, 35.95, 35.98, 36.2, 36.31, 36.32, 36.39, 36.91, 36.99, 37.10, 37.11, 37.12, 37.31, 37.32, 37.33, 37.41, 37.49, 37.51, 37.52, 37.53 in PHC4 data.	X		
Other Open Heart Procedure Other heart procedures, as indicated by any of the following procedure codes in any position in PHC4 data: 35.00, 35.01, 35.02, 35.03, 35.04, 35.31, 35.32, 35.34, 35.35, 35.39, 35.50, 35.51, 35.53, 35.54, 35.60, 35.61, 35.62, 35.63, 35.70, 35.71, 35.72, 35.73, 35.81, 35.82, 35.83, 35.84, 35.91, 35.92, 35.93, 35.94, 35.95, 35.98, 36.2, 36.31, 36.32, 36.39, 36.91, 36.99, 37.10, 37.11, 37.12, 37.31, 37.32, 37.33, 37.41, 37.49, 37.51, 37.52, 37.53.			X
Percent of Left Main Stenosis[1] Percent of occlusion in the left main coronary artery (continuous variable).	X		
Procedure Group *Category 1:* CABG without valve: any of the following codes with ***no*** valve procedure codes: 36.10, 36.11, 36.12, 36.13, 36.14, 36.15, 36.16, 36.17, 36.19. *Category 2:* Valve without CABG: any of the following codes with ***no*** CABG codes: 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: cases with at least one CABG code from ***and*** at least one valve code.	X	X	X

[1] This variable was developed by MediQual for their CABG/valve in-hospital mortality model using the MediQual *Atlas Outcomes*™ System data.

APPENDIX E: CANDIDATE VARIABLE DEFINITIONS *continued*

Variable Name Description	2006 Models		
	Mortality	Read-missions	Length of Stay
PTCA/Stent/Tear Same Day as CABG/Valve Surgery Based on either of the following: • A CABG procedure or valve procedure performed on the same day as PTCA with the presence of "vessel tear" as either a preadmission or admission KCF in MediQual data, *or* • Any of the following procedure codes in any position in PHC4 data on the same date as a CABG/valve procedure: 36.01[1], 36.02[1], 36.05[1], 36.06, 36.07, 36.09, 00.66[2]	X		
Renal Failure/Dialysis (binary) Renal failure (pre-op acute or chronic) or preoperative dialysis: • Chronic renal failure, as indicated by any of the following codes in PHC4 data: 585[1], 585.1 – 585.9[2] ; *or* • Pre-operative renal failure, as indicated by 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.*			X

[1] Invalid 10/01/2005
[2] Effective 10/01/2005

APPENDIX F: CANDIDATE VARIABLE DATA

2005-2006 Mortality Models – Candidate Variable Frequency				
Variable	**In-Hospital Mortality**		**Operative Mortality**	
	# of cases in analysis	***Mortality %***	***# of cases in analysis***	***Mortality %***
Age in Years & Age # Years > 65 *(tested as continuous variables)*				
30 – 39 years	333	0.6	290	1.0
40 – 49 years	2,063	1.6	1,837	1.8
50 – 59 years	6,297	1.2	5,684	1.6
60 – 69 years	9,556	1.9	8,672	2.3
70 – 79 years	11,280	3.5	10,239	4.1
80 – 89 years	4,372	6.2	3,988	7.4
90 – 99 years	65	13.8	59	18.6
Albumin 2.5 - 3				
No	32,994	2.7	29,879	3.3
Yes	972	6.8	890	7.8
Albumin < 2.5				
No	33,782	2.8	30,606	3.4
Yes	184	8.7	163	9.8
AMI Other Inferior Wall Initial Episode				
No	33,129	2.8	30,001	3.4
Yes	837	5.6	768	6.6
AMI Except Other Anterior or Other Inferior Wall				
No	29,120	2.5	26,343	3.1
Yes	4,846	4.7	4,426	5.6
ASA Class 5				
No	33,771	2.7	30,601	3.3
Yes	195	24.1	168	26.8
ASA Emergency Flag				
No	31,972	2.6	28,945	3.2
Yes	1,994	7.2	1,824	8.1
BUN > 40				
No	32,815	2.6	29,727	3.1
Yes	1,151	10.9	1,042	12.3
Cachexia				
No	33,430	2.6	30,300	3.2
Yes	536	15.3	469	18.1
CAD > 70, 5-7 Vessels Grp				
No	32,494	2.9	29,415	3.4
Yes	1,472	2.7	1,354	3.5
Cardiogenic Shock, Preoperative				
No	33,739	2.7	30,564	3.3
Yes	227	30.0	205	31.7

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2005-2006 Mortality Models – Candidate Variable Frequency				
Variable	**In-Hospital Mortality**		**Operative Mortality**	
	# of cases in analysis	*Mortality %*	*# of cases in analysis*	*Mortality %*
Cardiomyopathy				
No	29,770	2.7	26,999	3.3
Yes	4,196	3.7	3,770	4.3
Chronic Lung Disease				
No	NA	NA	24,405	3.3
Yes	NA	NA	6,364	4.1
Chronic Pulmonary Hypertension				
No	31,644	2.7	28,713	3.3
Yes	2,322	4.7	2,056	5.7
Coagulopathy				
No	33,800	2.8	30,625	3.4
Yes	166	7.2	144	9.0
Creatinine > 1.4				
No	30,316	2.3	27,437	2.9
Yes	3,650	7.0	3,332	8.1
Current Med Immunosuppressants				
No	32,948	2.8	29,851	3.4
Yes	1,018	4.0	918	4.8
Current Med Insulin				
No	30,813	2.7	27,882	3.2
Yes	3,153	4.8	2,887	5.4
Diabetes with Long Term/Unspecified Complications				
No	NA	NA	28,727	3.4
Yes	NA	NA	2,042	4.2
Ejection Fraction				
>45%	16,654	1.9	15,142	2.4
25%-45%	16,172	3.5	14,622	4.2
<25%	1,140	7.3	1,005	8.8
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery				
No	32,729	2.8	29,695	3.4
Yes	1,237	5.0	1,074	5.1
Female				
No	22,781	2.2	20,542	2.7
Yes	11,185	4.1	10,227	4.8
Glucose > 165				
No	26,579	2.4	23,981	3.0
Yes	7,387	4.3	6,788	4.9

NA: Not Applicable. This variable was not tested because the preliminary analysis did not suggest that the variable would be predictive of the relevant outcome.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2005-2006 Mortality Models – Candidate Variable Frequency				
Variable	**In-Hospital Mortality**		**Operative Mortality**	
	# of cases in analysis	***Mortality %***	***# of cases in analysis***	***Mortality %***
Heart Failure				
No	22,940	1.4	21,065	1.9
Yes	11,026	5.9	9,704	6.8
History of CABG or Valve Surgery				
No	31,324	2.5	28,400	3.2
Yes	2,642	6.4	2,369	6.9
History of Peripheral Vascular Disease				
No	27,696	2.6	25,018	3.2
Yes	6,270	3.9	5,751	4.6
Hypertension with Complications				
No	30,977	2.5	28,036	3.0
Yes	2,989	6.6	2,733	7.9
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery				
No	32,457	2.7	29,378	3.3
Yes	1,509	6.5	1,391	7.2
Liver Disease				
No	NA	NA	30,598	3.4
Yes	NA	NA	171	8.8
Lupus				
No	33,871	2.8	30,683	3.4
Yes	95	9.5	86	10.5
MI/AMI Other Anterior Wall				
No	33,312	2.8	30,176	3.4
Yes	654	5.8	593	6.7
Mild Moderate or Severe AMS				
No	32,858	2.7	29,752	3.2
Yes	1,108	8.2	1,017	9.6
Multiple Valve Procedures				
No	32,332	2.6	29,331	3.1
Yes	1,634	8.6	1,438	9.5
Other CV Procedure Group				
No	31,265	2.6	28,364	3.2
Yes	2,701	5.6	2,405	6.0

NA: Not Applicable. This variable was not tested because the preliminary analysis did not suggest that the variable would be predictive of the relevant outcome.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2005-2006 Mortality Models – Candidate Variable Frequency				
Variable	**In-Hospital Mortality**		**Operative Mortality**	
	# of cases in analysis	***Mortality %***	***# of cases in analysis***	***Mortality %***
Percent of Left Main Stenosis *(tested as a continuous variable)*				
0	24,196	2.9	21,881	3.5
1-10	166	0.6	152	1.3
11-20	809	3.2	749	3.9
21-30	1,157	2.0	1,035	2.7
31-40	877	1.7	818	2.6
41-50	1,523	3.0	1,365	3.1
51-60	1,167	2.3	1,067	2.9
61-70	1,359	2.4	1,238	2.8
71-80	1,248	2.2	1,130	3.0
81-90	858	3.1	788	3.8
>90	606	5.6	546	5.7
Procedure Group				
CABG without Valve	22,901	1.9	21,023	2.4
Valve without CABG	5,846	3.2	5,087	3.8
Valve with CABG	5,219	6.8	4,659	7.9
PTCA/Stent/Tear Same Day as CABG/Valve Surgery				
No	33,553	2.8	30,388	3.4
Yes	413	8.7	381	9.2
Renal Failure/Dialysis				
No	32,018	2.6	28,998	3.1
Chronic	1,594	6.6	1,446	7.7
Acute/Dialysis	354	11.3	325	12.6
Septal Other Anomalous Repair Heart				
No	33,554	2.8	30,417	3.4
Yes	412	5.1	352	6.5
SIRS Group				
No	22,796	2.3	20,493	2.8
Yes	11,170	4.0	10,276	4.8

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2005-2006 Readmissions Models – Candidate Variable Frequency			
Variable	**7- & 30-Day Readmissions** # of cases in analysis	**7-Day Readmissions** *Readmission %*	**30-Day Readmissions** *Readmission %*
Age in Years & Age # Years > 65 *(tested as continuous variables)*			
30-39	288	7.3	17.4
40-49	1,809	4.8	13.0
50-59	5,612	4.7	11.6
60-69	8,512	5.8	13.7
70-79	9,889	6.7	16.2
80-89	3,749	7.2	18.4
90-99	51	7.8	15.7
AMI Except Other Anterior or Other Inferior Wall			
No	25,692	5.9	14.6
Yes	4,218	6.6	15.9
ASA Class 5			
No	29,784	NA	14.7
Yes	126	NA	19.8
Cancer			
No	29,220	NA	14.7
Yes	690	NA	17.4
Cardiogenic Shock, Preoperative			
No	29,766	NA	14.7
Yes	144	NA	17.4
Cardiomyopathy			
No	26,272	NA	14.5
Yes	3,638	NA	16.5
Cerebrovascular Disease			
No	28,335	NA	14.6
Yes	1,575	NA	16.7
Chronic Lung Disease			
No	23,760	5.6	13.8
Yes	6,150	7.6	18.2
Chronic Pulmonary Hypertension			
No	27,951	5.9	14.4
Yes	1,959	7.9	19.6
Diabetes			
No Diabetes	19,644	5.7	13.5
Diabetes without Complication	8,274	6.5	16.2
Diabetes with Complication	1,992	7.6	20.6

NA: Not Applicable. This variable was not tested because the preliminary analysis did not suggest that the variable would be predictive of the relevant outcome.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2005-2006 Readmissions Models – Candidate Variable Frequency			
Variable	**7- & 30-Day Readmissions** # of cases in analysis	**7-Day Readmissions** *Readmission %*	**30-Day Readmissions** *Readmission %*
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery			
No	28,884	6.0	NA
Yes	1,026	8.2	NA
Female			
No	20,098	5.6	13.4
Yes	9,812	6.9	17.4
Fibrosis in Mediastinum and Heart			
No	29,625	NA	14.7
Yes	285	NA	19.3
Heart Failure			
No	22,562	5.3	13.0
Yes	7,348	8.1	20.2
History of CABG or Valve Surgery			
No	28,360	NA	14.6
Yes	1,550	NA	18.1
History of Peripheral Vascular Disease			
No	25,659	5.8	14.3
Yes	4,251	7.2	17.5
History of PTCA/Stent			
No	27,139	6.0	NA
Yes	2,771	6.7	NA
Hypertension with Complications			
No	27,357	5.8	14.2
Yes	2,553	8.2	20.5
Lupus			
No	29,833	NA	14.7
Yes	77	NA	22.1
Morbid Obesity			
No	28,623	6.0	14.5
Yes	1,287	7.5	20.4
MediQual Predicted Length of Stay *(tested as a continuous variable)*			
< 8.461 days	657	4.0	9.6
8.461 – 10.057 days	4,115	3.7	9.7
10.058 – 17.361 days	20,572	6.0	14.4
17.362 – 23.643 days	3,953	8.6	20.8
> 23.643 days	613	7.8	26.3

NA: Not Applicable. This variable was not tested because the preliminary analysis did not suggest that the variable would be predictive of the relevant outcome.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2005-2006 Readmissions Models – Candidate Variable Frequency			
Variable	**7- & 30-Day Readmissions**	**7-Day Readmissions**	**30-Day Readmissions**
	# of cases in analysis	***Readmission %***	***Readmission %***
Multiple Valve Procedures			
No	28,591	5.9	14.4
Yes	1,319	8.3	21.8
Other CV Procedure Group			
No	27,632	5.9	14.5
Yes	2,278	7.8	18.3
Procedure Group			
CABG without Valve	20,637	5.4	13.3
Valve without CABG	4,925	6.9	17.4
Valve with CABG	4,348	7.8	18.7
Race			
White	27,072	5.9	14.5
Black	1,264	7.7	19.9
Other/Unknown	1,574	7.1	14.8
Renal Failure/Dialysis			
No	28,264	NA	14.3
Chronic	1,356	NA	20.5
Acute/Dialysis	290	NA	26.6
Renal Failure/Dialysis (binary)			
No	28,264	5.9	NA
Yes	1,646	7.6	NA
Year			
2005	15,297	NA	15.0
2006	14,613	NA	14.4

NA: Not Applicable. This variable was not tested because the preliminary analysis did not suggest that the variable would be predictive of the relevant outcome.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2005-2006 Post-Surgical Length of Stay Model – Candidate Variable Frequency		
Variable	**Length of Stay**	
	# of cases in analysis	**Days**
Acute Myocardial Infarction (AMI)		
No	26,847	7.2
Yes	5,801	7.7
Age in Years & Age # Years > 65 *(tested as continuous variables)*		
30-39 years	326	6.1
40-49 years	2,017	5.9
50-59 years	6,166	6.1
60-69 years	9,289	6.8
70-79 years	10,749	8.0
80-89 years	4,045	8.9
90-99 years	56	9.5
Anemia		
No	27,146	7.2
Yes	5,502	7.8
Cachexia		
No	32,255	7.2
Yes	393	15.8
Cancer		
No	31,900	7.3
Yes	748	7.7
Cardiogenic Shock, Preoperative		
No	32,506	7.2
Yes	142	13.9
Cardiomyopathy		
No	28,653	7.2
Yes	3,995	7.9
CPR Prior to CABG/Valve Surgery Date		
No	32,590	7.3
Yes	58	9.2

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2005-2006 Post-Surgical Length of Stay Model – Candidate Variable Frequency		
Variable	**Length of Stay**	
	# of cases in analysis	**Days**
Chronic Lung Disease		
No	26,077	7.0
Yes	6,571	8.4
Chronic Pulmonary Hypertension		
No	30,463	7.2
Yes	2,185	8.8
Coagulopathy		
No	32,499	7.3
Yes	149	8.6
Diabetes with Long Term/Unspecified Complications		
No	30,543	7.2
Yes	2,105	8.2
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery		
No	31,483	7.2
Yes	1,165	9.5
Female		
No	22,070	6.9
Yes	10,578	8.0
Fibrosis in Mediastinum and Heart		
No	32,335	7.3
Yes	313	8.4
Heart Failure		
No	24,465	6.4
Yes	8,183	9.9
History of CABG or Valve Surgery		
No	30,939	7.2
Yes	1,709	7.9
Hypertension with Complications		
No	29,909	7.1
Yes	2,739	9.5

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2005-2006 Post-Surgical Length of Stay Model – Candidate Variable Frequency		
Variable	**Length of Stay**	
	# of cases in analysis	**Days**
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery		
No	31,264	7.2
Yes	1,384	8.7
Liver Disease		
No	32,473	7.3
Yes	175	8.5
MediQual Predicted Length of Stay *(tested as a continuous variable)*		
< 8.461 days	745	5.2
8.461 – 10.057 days	4,570	5.6
10.058 – 17.361 days	22,493	7.1
17.362 – 23.643 days	4,198	9.6
> 23.643 days	642	11.5
Multiple Valve Procedures		
No	31,183	7.1
Yes	1,465	11.1
Other Open Heart Procedure		
No	30,169	7.1
Yes	2,479	9.1
Procedure Group		
CABG without Valve	22,239	6.5
Valve without CABG	5,595	8.1
Valve with CABG	4,814	10.0
Race		
White	29,433	7.2
Black	1,352	8.7
Other/Unknown	1,863	7.8
Renal Failure/Dialysis		
No	30,881	7.1
Chronic	1,460	10.1
Acute/Dialysis	307	10.9
Year		
2005	16,636	7.2
2006	16,012	7.3

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006 Mortality Models – Candidate Variable Frequency				
Variable	**In-Hospital Mortality**		**Operative Mortality**	
	# of cases in analysis	*Mortality %*	*# of cases in analysis*	*Mortality %*
Age in Years & Age # Years > 65 *(tested as continuous variables)*				
30 – 39 years	162	0.0	140	0.0
40 – 49 years	1,028	1.9	918	2.3
50 – 59 years	3,076	1.2	2,777	1.7
60 – 69 years	4,692	2.2	4,232	2.6
70 – 79 years	5,461	3.2	4,935	3.8
80 – 89 years	2,183	5.5	1,995	6.8
90 – 99 years	31	19.4	26	23.1
Albumin 2.5 - 3				
No	16,163	2.7	14,589	3.3
Yes	470	5.7	434	8.1
Albumin < 2.5				
No	16,541	2.7	14,943	3.4
Yes	92	9.8	80	10.0
AMI Other Inferior Wall Initial Episode				
No	16,222	2.7	14,644	3.3
Yes	411	6.1	379	7.4
AMI Except Other Anterior or Other Inferior Wall				
No	14,310	2.4	12,313	2.8
Yes	2,323	4.7	2,710	6.2
ASA Class 5				
No	16,533	2.6	14,940	3.3
Yes	100	23.0	83	26.5
ASA Emergency Flag				
No	15,638	2.4	14,116	3.1
Yes	995	7.4	907	8.6
BUN > 40				
No	16,060	2.4	14,514	3.1
Yes	573	11.2	509	12.8
Cachexia				
No	16,346	2.6	14,777	3.2
Yes	287	13.2	246	17.1
CAD > 70, 5-7 Vessels Grp				
No	15,959	2.7	14,415	3.4
Yes	674	3.1	608	3.6

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006 Mortality Models – Candidate Variable Frequency

Variable	In-Hospital Mortality		Operative Mortality	
	# of cases in analysis	Mortality %	# of cases in analysis	Mortality %
Cardiogenic Shock, Preoperative				
No	16,513	2.5	14,915	3.1
Yes	120	33.3	108	38.0
Cardiomyopathy				
No	14,556	2.6	NA	NA
Yes	2,077	3.6	NA	NA
CPR Prior to CABG/Valve Surgery Date				
No	16,598	2.7	14,990	3.4
Yes	35	11.4	33	9.1
Chronic Pulmonary Hypertension				
No	15,393	2.6	13,931	3.2
Yes	1,240	5.1	1,092	6.3
Creatinine > 1.4				
No	14,862	2.3	13,438	2.9
Yes	1,771	6.5	1,585	7.9
Current Med Immunosuppressants				
No	16,108	2.7	14,555	3.4
Yes	525	3.4	468	4.1
Current Med Insulin				
No	15,055	2.6	13,588	3.2
Yes	1,578	4.5	1,435	5.4
Ejection Fraction				
>45%	8,308	1.7	7,550	2.2
25%-45%	7,796	3.4	7,015	4.2
<25%	529	8.5	458	10.7
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery				
No	15,995	2.7	NA	NA
Yes	638	4.5	NA	NA
Female				
No	11,229	2.2	10,088	2.8
Yes	5,404	3.9	4,935	4.7
Glucose > 165				
No	13,096	2.3	11,782	2.9
Yes	3,537	4.5	3,241	5.2
Heart Failure				
No	11,171	1.4	10,216	1.9
Yes	5,462	5.6	4,807	6.6

NA: Not Applicable. This variable was not tested because the preliminary analysis did not suggest that the variable would be predictive of the relevant outcome.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006 Mortality Models – Candidate Variable Frequency				
Variable	**In-Hospital Mortality**		**Operative Mortality**	
	# of cases in analysis	*Mortality %*	*# of cases in analysis*	*Mortality %*
History of CABG or Valve Surgery				
No	15,332	2.4	13,840	3.1
Yes	1,301	6.4	1,183	7.0
History of Peripheral Vascular Disease				
No	13,530	2.6	12,201	3.2
Yes	3,103	3.4	2,822	4.4
Hypertension with Complications				
No	14,851	2.4	13,419	2.9
Yes	1,782	5.9	1,604	7.4
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery				
No	15,936	2.6	14,382	3.3
Yes	697	5.9	641	6.6
Liver Disease				
No	16,532	2.7	14,940	3.4
Yes	101	10.9	83	10.8
Lupus				
No	16,587	2.7	14,981	3.4
Yes	46	8.7	42	9.5
MI/AMI Other Anterior Wall				
No	16,320	2.7	14,745	3.3
Yes	313	6.4	278	7.6
Mild Moderate or Severe AMS				
No	16,072	2.5	14,513	3.1
Yes	561	8.7	510	10.4
Multiple Valve Procedures				
No	15,804	2.4	14,295	3.1
Yes	829	8.4	728	9.2
Other CV Procedure Group				
No	15,259	2.6	13,817	3.2
Yes	1,374	4.9	1,206	5.1

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006 Mortality Models – Candidate Variable Frequency				
Variable	**In-Hospital Mortality**		**Operative Mortality**	
	# of cases in analysis	*Mortality %*	*# of cases in analysis*	*Mortality %*
Percent of Left Main Stenosis *(tested as a continuous variable)*				
0	11,821	2.8	10,667	3.4
1-10	78	1.3	71	2.8
11-20	409	2.4	379	3.7
21-30	567	1.9	509	2.4
31-40	406	2.0	374	2.9
41-50	744	3.0	668	3.6
51-60	568	2.5	511	2.9
61-70	686	2.3	627	3.0
71-80	608	3.0	542	3.9
81-90	438	2.3	398	2.8
>90	308	5.5	277	6.1
Procedure Group				
CABG without Valve	11,022	1.8	10,095	2.4
Valve without CABG	3,000	3.3	2,615	4.1
Valve with CABG	2,611	6.2	2,313	7.1
PTCA/Stent/Tear Same Day as CABG/Valve Surgery				
No	16,427	2.7	14,825	3.3
Yes	206	8.7	198	10.1
Race/Ethnicity				
Hispanic	145	6.9	NA	NA
White, non-Hispanic	14,874	2.6	NA	NA
Black, non-Hispanic	681	3.2	NA	NA
Other/Unknown	933	3.8	NA	NA
Race				
White	NA	NA	13,574	3.3
Black	NA	NA	620	5.2
Other/Unknown	NA	NA	829	4.2
Renal Failure/Dialysis				
No	15,270	2.4	13,799	2.9
Chronic	1,172	6.1	1,054	7.5
Acute/Dialysis	191	12.6	170	14.1
Septal Other Anomalous Repair Heart				
No	NA	NA	14,855	3.4
Yes	NA	NA	168	4.2

NA: Not Applicable. This variable was not tested because the preliminary analysis did not suggest that the variable would be predictive of the relevant outcome.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006 Mortality Models – Candidate Variable Frequency				
Variable	**In-Hospital Mortality**		**Operative Mortality**	
	# of cases in analysis	*Mortality %*	*# of cases in analysis*	*Mortality %*
SIRS Group				
No	11,265	2.3	10,104	2.8
Yes	5,368	3.7	4,919	4.6

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006 Readmissions Models – Candidate Variable Frequency			
Variable	**7- & 30-Day Readmissions** # of cases in analysis	**7-Day Readmissions** *Readmission %*	**30-Day Readmissions** *Readmission %*
Age in Years & Age # Years > 65 *(tested as continuous variables)*			
30-39	140	10.0	19.3
40-49	900	5.0	12.7
50-59	2,741	4.7	11.4
60-69	4,144	5.7	13.1
70-79	4,781	7.0	16.3
80-89	1,886	6.6	17.3
90-99	21	9.5	14.3
Anemia			
No	12,017	NA	14.2
Yes	2,596	NA	15.4
ASA Emergency Flag			
No	13,772	6.0	NA
Yes	841	6.8	NA
Cerebrovascular Disease			
No	13,806	NA	14.2
Yes	807	NA	18.1
Chronic Lung Disease			
No	11,588	5.8	13.7
Yes	3,025	7.1	17.1
Chronic Pulmonary Hypertension			
No	13,579	5.9	14.1
Yes	1,034	7.4	18.2
Diabetes			
No	9,567	NA	13.3
Diabetes without Complication	4,046	NA	15.8
Diabetes with Complication	1,000	NA	19.8
Diabetes with Long Term/Unspecified Complications			
No	13,620	6.0	NA
Yes	993	7.3	NA
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery			
No	14,086	6.0	NA
Yes	527	7.6	NA
Female			
No	9,865	NA	13.3
Yes	4,748	NA	16.8

NA: Not Applicable. This variable was not tested because the preliminary analysis did not suggest that the variable would be predictive of the relevant outcome.

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006 Readmissions Models – Candidate Variable Frequency			
Variable	**7- & 30-Day Readmissions** # of cases in analysis	**7-Day Readmissions** *Readmission %*	**30-Day Readmissions** *Readmission %*
Heart Failure			
No	10,884	5.4	12.5
Yes	3,729	7.9	20.1
History of CABG or Valve Surgery			
No	13,823	NA	14.2
Yes	790	NA	18.1
Hypertension with Complications			
No	13,106	5.8	13.8
Yes	1,507	8.5	19.9
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery			
No	14,009	6.0	NA
Yes	604	7.0	NA
MediQual Predicted Length of Stay *(tested as a continuous variable)*			
< 8.461 days	332	3.9	9.6
8.461 – 10.057 days	2,006	4.0	10.0
10.058 – 17.361 days	10,060	6.0	14.1
17.362 – 23.643 days	1,922	8.5	19.9
> 23.643 days	293	6.5	24.2
Multiple Valve Procedures			
No	13,946	NA	14.1
Yes	667	NA	21.1
Other CV Procedure Group			
No	13,463	5.9	NA
Yes	1,150	7.6	NA
Procedure Group			
CABG without Valve	9,915	5.4	13.0
Valve without CABG	2,526	7.2	17.0
Valve with CABG	2,172	7.8	18.1
Race/Ethnicity			
Hispanic	124	11.3	20.2
White, non-Hispanic	13,160	5.9	14.2
Black, non-Hispanic	594	7.1	18.4
Other/Unknown	735	6.3	13.6
Renal Failure/Dialysis			
No	13,473	NA	13.8
Chronic	991	NA	20.5
Acute/Dialysis	149	NA	27.5

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006 Post-Surgical Length of Stay Model – Candidate Variable Frequency		
	Length of Stay	
Variable	# of cases in analysis	Days
Acute Myocardial Infarction (AMI)		
No	13,227	7.2
Yes	2,785	7.9
Age in Years & Age # Years > 65 *(tested as continuous variables)*		
30-39 years	159	6.4
40-49 years	1,004	5.9
50-59 years	3,015	6.2
60-69 years	4,555	6.8
70-79 years	5,221	8.0
80-89 years	2,033	9.0
90-99 years	25	10.4
Anemia		
No	13,145	7.2
Yes	2,867	7.8
Cachexia		
No	15,791	7.2
Yes	221	16.1
Cancer		
No	15,643	7.3
Yes	369	7.6
Cardiogenic Shock, Preoperative		
No	15,939	7.3
Yes	73	15.1
Cardiomyopathy		
No	14,034	7.3
Yes	1,978	7.8
CPR Prior to CABG/Valve Surgery Date		
No	15,981	7.3
Yes	31	9.7
Chronic Lung Disease		
No	12,755	7.1
Yes	3,257	8.2
Chronic Pulmonary Hypertension		
No	14,851	7.2
Yes	1,161	8.6

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006 Post-Surgical Length of Stay Model – Candidate Variable Frequency		
	Length of Stay	
Variable	# of cases in analysis	Days
Diabetes with Long Term/Unspecified Complications		
No	14,955	7.3
Yes	1,057	8.3
Excision of Other Lesion/Heart Tissue, Open Approach – Same Date as CABG/Valve Surgery		
No	15,411	7.3
Yes	601	9.3
Female		
No	10,891	6.9
Yes	5,121	8.2
Fibrosis in Mediastinum and Heart		
No	15,847	7.3
Yes	165	9.0
Heart Failure		
No	11,847	6.4
Yes	4,165	9.9
History of CABG or Valve Surgery		
No	15,158	7.3
Yes	854	8.2
Hypertension with Complications		
No	14,366	7.1
Yes	1,646	9.5
Intra-Aortic Balloon Pump (IABP) Prior to Date of CABG/Valve Surgery		
No	15,369	7.3
Yes	643	8.8
MediQual Predicted Length of Stay *(tested as a continuous variable)*		
< 8.461 days	371	5.1
8.461 – 10.057 days	2,235	5.7
10.058 – 17.361 days	11,028	7.2
17.362 – 23.643 days	2,067	9.7
> 23.643 days	311	11.2
Multiple Valve Procedures		
No	15,264	7.2
Yes	748	11.0

APPENDIX F: CANDIDATE VARIABLE DATA *continued*

2006 Post-Surgical Length of Stay Model – Candidate Variable Frequency		
Variable	**Length of Stay**	
	# of cases in analysis	**Days**
Other Open Heart Procedure		
No	14,748	7.2
Yes	1,264	9.2
Procedure Group		
CABG without Valve	10,715	6.5
Valve without CABG	2,868	8.1
Valve with CABG	2,429	10.1
Race		
White	14,412	7.2
Black	652	8.8
Other/Unknown	948	7.8
Renal Failure/Dialysis (binary)		
No	14,768	7.1
Yes	1,244	10.1

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

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

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

For PHC4's in-hospital and operative mortality models, data on the individual KCFs that were found by MediQual to be predictive of in-hospital mortality were obtained and the variables were retained in PHC4's mortality models, unless the coefficient was negative. For PHC4's readmissions models, individual KCFs from MediQual's mortality model and MediQual's predicted length of stay score were tested as candidate variables. For PHC4's post-surgical length of stay model, MediQual's predicted length of stay was tested as a candidate variable.