Coronary Artery Bypass Graft Surgery – 2000 Data

Research Methods and Results

TABLE OF CONTENTS

Attachments

Outcome Measures Reported

In-hospital Mortality.................................. In-hospital mortality measures the deaths that occurred during the hospital admission in which the CABG surgery was performed. Hospitals provide information to PHC4 indicating whether the patient died during the hospital stay.

30-day Post-surgical Mortality .... 30-day post-surgical mortality measures the deaths that occurred within 30 days of the date of the CABG surgery. Unlike in-hospital mortality, it includes deaths regardless of "where" the patient died, i.e., it includes patients who died after being discharged from the hospital. Death certificate information was obtained from the PA Department of Health to determine whether a CABG patient died within 30 days of the CABG surgery. Upon the recommendation of the Council's Technical Advisory Group, "cause of death" was not considered in this analysis.

7-day Readmissions .... Some patients are discharged from the hospital following CABG surgery and are then readmitted at a later date. This measure represents the percent of patients who were readmitted to a general acute care hospital (in Pennsylvania) within 1-7 days of being discharged from the hospital in which the CABG surgery was performed. Readmissions were counted only if the patient was readmitted for particular reasons (as indicated by the principal diagnosis of the patient during the readmission; examples include infections, other heart-related conditions, complications from the surgery, etc.). A list of the principal diagnoses used in the readmission analysis is included in Attachment B.

30-day Readmissions .... Similar to 7-day readmissions, this measure represents the percent of patients who were readmitted to a general acute care hospital within 1-30 days of being discharged from the hospital in which the CABG surgery was performed. It was calculated using the same principal diagnoses that were used for 7-day readmissions.

Post-surgical Length of Stay...................... Post-surgical length of stay measures how long, on average, patients stayed in the hospital following CABG surgery.

Hospital average charge............................ The hospital charges reported are charges associated with the entire hospitalization (not just the treatment associated with CABG surgery) and 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.

With the exception of hospital average charge (which is trimmed for outliers and case-mix adjusted), each of the above measures is risk adjusted, which means that the measures take into account the patient's health condition before surgery. Some patients who undergo CABG surgery are 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 are more seriously ill or at a greater risk than others. Risk-adjusting the data is important because sicker patients might be more likely to die following CABG surgery, be readmitted, or stay in the hospital longer. Through logistic or linear regression modeling, risk factors (e.g., the age of the patient and other measures that indicate the illness level of the patient) were "tested" to determine which factors predict these particular outcomes (i.e., in-hospital mortality, 30-day post-surgical mortality, and 7-day and 30-day readmissions). For example, this process answer questions, such as, "Is the age of the patient important in predicting whether he/she will be readmitted to the hospital." One important factor is the patient's "probability of death," as calculated using MediQual[®] Atlas Outcomes[®]. This information indicates how severely ill the patient was on admission to the hospital. The "probability of death" for a patient is generated from clinical information, including lab values, in the medical record.

The following pages describe the process used in risk-adjusting each of these outcome measures.

Study Population

The CABG study population includes those patients discharged from Pennsylvania hospitals in calendar year 2000 after undergoing coronary artery bypass graft (CABG) surgery (as identified by one of the following ICD.9.CM procedure codes in the medical record):

Bypass, aortocoronary, for heart revascularization, unspecified 36.10
Bypass, aortocoronary, one coronary artery 36.11
Bypass, aortocoronary, two coronary arteries 36.12
Bypass, aortocoronary, three coronary arteries.. 36.13
Bypass, aortocoronary, four or more coronary arteries 36.14
Bypass, artery, single internal mammary, coronary...................................... 36.15
Bypass, artery, double internal mammary, coronary 36.16
Bypass, abdominal-coronary artery 36.17
Revascularization, with bypass anastomosis, other specified 36.19

Exclusions

Specific cases were excluded from analysis, as discussed in Attachment A.

In-hospital Mortality, 30-day Mortality, and Readmissions

Risk-Adjustment Methodology

Risk Adjustment Model

Logistic regression was used to construct the models for in-hospital mortality, 30-day post-surgical mortality, 7-day and 30-day readmission.

Data Preparation

After cases to be excluded from analysis were removed, the remaining cases were randomly split into two equal-size samples. Sample I is the development sample; Sample II is the cross validation sample. The number of relevant cases for each sample is shown below.

In-hospital mortality

	Sample I	*Sample II*	*Total*
Number of Cases	9,641	9,640	19,281
Number of In-hospital Deaths	245	215	460
Mortality Rate	2.5%	2.2%	2.4%

30-day post-surgical mortality

	Sample I	*Sample II*	*Total*
Number of Cases	8,596	8,596	17,192
Number of deaths within 30 days	245	225	470
Complication Rate	2.9%	2.6%	2.7%

7-day readmissions

	Sample I	*Sample II*	*Total*
Number of Cases	8,352	8,351	16,703
Number of Readmissions within 7 days	501	532	1,033
Readmission Rate	6.0%	6.4%	6.2%

30-day readmissions

	Sample I	*Sample II*	*Total*
Number of Cases	8,352	8,351	16,703
Number of Readmissions within 30 days	1,199	1,227	2,426
Readmission Rate	14.4%	14.7%	14.5%

Risk Adjustment Models

The first step in building the risk adjustment models for in-hospital mortality, 30-day post-surgical mortality, 7-day and 30-day readmissions was to identify *possible* risk-adjustment factors, that is, those factors that potentially contribute to these events. In doing so, both clinical and demographic factors identified in the literature were considered. Also considered were those factors tested in previous cardiac-related reports released by the Council – taking into account the availability and usability of the variables in its data base. These possible risk-adjustment factors are called *candidate variables.* Attachment C provides data for each candidate variable.

Model Selection

Model selection identifies those candidate variables that are *statistically significant predictors* of the relevant event (in this case in-hospital mortality, 30-day post-surgical mortality, 7-day and 30-day readmissions). These significant risk factors were identified using binary logistic regression. In general, the modeling step is comprised of several sub-processes including model selection, cross validation, and calculating several model adequacy measures. For the first step – model selection – a backwards stepwise logistic regression model was constructed using the cases in Sample I. All tests of significance ($p < 0.10$) were based on the likelihood ratio.

Variables Evaluated as Potential Predictors of
In-hospital Mortality, 30-day Post-Surgical Mortality, 7-day Readmissions and
30-day Readmissions

Candidate Variables	Mortality		Readmissions	
	In-hospital	30-day Post-surgical	7-day	30-day
Acute Myocardial Infarction (AMI)	ns	ns	✓	✓
Age	✓	✓	ns	✓
Age Squared	✓	ns	ns	ns
CABG Severity†	✓	✓	✓	✓
Cancer	ns	✓	ns	ns
Cardiogenic Shock	✓	✓	ns	ns
Cardiomyopathy	ns	ns	ns	ns
Complicated Hypertension	ns	ns	ns	ns
COPD	ns	ns	ns	✓
Diabetes	ns	ns	✓	✓
Dialysis	✓	✓	ns	ns
Gender	ns	ns	ns	✓
Heart Failure	✓	✓	ns	✓
Obesity	✓	ns	ns	ns
Peripheral Vascular Disease	ns	ns	ns	ns
Prior CABG and/or Valve Surgery	✓	ns	ns	ns
PTCA/Stent (same day as CABG)	ns	ns	ns	✓
Race/Ethnicity	✓	ns	✓	ns
Renal Failure	✓	ns	ns	ns

✓ = significant predictor

ns = not significant

† = CABG severity represents a patient's probability of dying during the hospital admission in which the CABG was performed. It is calculated using MediQual's® Atlas Outcomes® taking into account the patient's risk upon admission based on clinical data found in the medical record. If a case was missing the CABG severity information, it was assigned the average probability of death for that hospital (as generated from cases in that hospital that were not missing the information).

For this report, the candidate variable reflects the patient's condition during the hospital admission in which the CABG surgery was performed. For example, this table shows that having an acute myocardial infarction (heart attack) as the principal diagnosis during the hospital admission in which the CABG surgery was performed was a significant predictor of whether the patient was readmitted within 7 or 30 days but was not a significant predictor of whether the patient died either in the hospital or within 30 days.

Cross Validation

Following model selection for in-hospital mortality, 30-day post-surgical mortality, 7-day and 30-day readmissions, the models were *cross validated* using the cases in Sample II. The first step in the cross validation process was to re-estimate the model built in the model selection process, using only the variables that were significant in Sample I, to determine which factors remain significant in Sample II.

The probability values (p-values) of those variables shown to be significant predictors of each of the four outcome measures are shown in the following table.

This table shows the variables that did not cross validate (identified as those with a p-value > 0.10 for sample II). For in-hospital mortality these were: age squared, prior CABG/valve surgery, race/ethnicity and renal failure. The cancer variable that did not cross validate for 30-day post-surgical mortality. Variables that did not cross validate for 7-day readmissions include: acute myocardial infarction and race/ethnicity. Variables that did not cross validate for 30-day readmissions were: acute myocardial infarction, age and PTCA/stent (same day as CABG). Variables that did not cross validate were still used as risk adjustment factors.

Probability Values for Each *Significant* Variable

Significant Predictors	Mortality Rate				Readmission Rate			
	In-hospital		30-day		7-day		30-day	
	Sample		Sample		Sample		Sample	
	I	II	I	II	I	II	I	II
Acute Myocardial Infarction (AMI)	ns	–	ns	–	0.078	0.396	0.014	0.287
Age	0.002	0.002	0.002	0.007	ns	–	0.026	0.798
Age Squared	0.002	0.625	ns	–	ns	–	ns	–
CABG Severity	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cancer	ns	–	0.019	0.157	ns	–	ns	–
Cardiogenic Shock	0.000	0.000	0.000	0.000	ns	–	ns	–
COPD	ns	–	ns	–	ns	–	0.018	0.039
Diabetes	ns	–	ns	–	0.001	0.008	0.000	0.000
Dialysis	0.000	0.000	0.000	0.000	ns	–	ns	–
Gender	ns	–	ns	–	ns	–	0.008	0.005
Heart Failure	0.000	0.000	0.000	0.000	ns	–	0.021	0.004
Obesity	0.046	0.003	ns	–	ns	–	ns	–
Prior CABG and/or Valve Surgery	0.019	0.400	ns	–	ns	–	ns	–
PTCA/Stent (same day as CABG)	ns	–	ns	–	ns	–	0.034	0.728
Race/Ethnicity	0.022	0.278	ns	–	0.035	0.622	ns	–
Renal Failure	0.012	0.109	ns	–	ns	–	ns	–

Note: A p-value of < 0.10 was used to determine the significant risk factors for this report.

Measures of Model Adequacy

For the second step in the cross validation process, the estimated coefficients from Sample I were applied to both Sample I and Sample II. The objective was to evaluate the model performance in both Sample I and Sample II. The following measures were considered in evaluating the model performance:

Percentage Explained: This term is used to refer to the percentage of the total (-2 log likelihood) attributable to the estimated model. (The "total" comes from a model containing only a constant and no risk factors.) *Range: 0% to 100%*

R-squared: Coefficient of Determination (R^2) refers to the percentage of the total variability among relevant responses (e.g., for the in-hospital mortality model, 1 = died, 0 = discharged alive) for the patients in the sample that can be explained by the estimated model involving the specified risk factors. Using in-hospital mortality as an example, if no risk factors were considered in estimating a patient's probability of death, the overall death rate from the sample would be used to estimate **each** patient's probability of death. (The variability among mortality responses for all patients that remains after adjusting each patient's response by the overall death rate is referred to as the "total variability of mortality responses.") However, if the model including risk factors is used, the estimated probabilities of death for patients would vary according to their risk factors. *Range: 0% to 100%*

ROC Area: Using in-hospital mortality as an example, the area under the receiver operating characteristic curve measures the tendency of the estimated probabilities of death for patients in the sample that died to be ranked higher than those for patients who were discharged alive. *Range: 50% to 100%*

The values for these measures are displayed in the table below for both Sample I and Sample II. The table also includes the results from fitting the model using all of the data.

In-hospital mortality

Measure	Model Selection (*Sample I*)	Cross Validation (*Sample II*)	*All Cases*
Percentage Explained	16.4%	14.4%	15.8%
R^2	6.5%	5.3%	6.5%
ROC Area	82.3%	80.7%	81.7%

30-day Post-surgical Mortality

Measure	Model Selection *(Sample I)*	Cross Validation *(Sample II)*	All Cases
Percentage Explained	11.8%	12.0%	12.0%
R^2	5.1%	4.8%	5.0%
ROC Area	77.4%	77.6%	77.6%

7-day Readmissions

Measure	Model Selection *(Sample I)*	Cross Validation *(Sample II)*	All Cases
Percentage Explained	1.6%	1.6%	1.8%
R^2	0.7%	0.8%	0.8%
ROC Area	60.6%	60.7%	61.1%

30-day Readmissions

Measure	Model Selection *(Sample I)*	Cross Validation *(Sample II)*	All Cases
Percentage Explained	2.7%	3.1%	2.3%
R^2	2.3%	2.7%	2.0%
ROC Area	62.2%	63.3%	61.5%

Coefficients & Odds Ratios

The coefficients associated with the significant risk factors and their p-values are listed on the following tables. The entire data set was used in creating the final coefficients (i.e., Sample I and Sample II were "recombined" and the coefficients were re-estimated). Accompanying these coefficients is the odds ratio for each risk factor or risk factor category. For a binary variable, this ratio is the change in the odds for a patient with the risk factor category compared to a patient without it. (for example, for the outcome measure in-hospital mortality, it is the probability of dying in the hospital versus the probability of surviving the hospital stay.) Odds ratios are not applicable for continuous variables (age, age-squared and CABG severity).

Coefficients and Odds Ratios for Significant Predictors

In-hospital Mortality

Significant Predictors	Coefficient	p-value	Odds Ratio
Constant	-3.742	<0.001	
Age	0.026	<0.001	Not applicable*
Age Squared (divided by 1,000)	<0.001	0.011	Not applicable*
CABG Severity	0.613	<0.001	Not applicable*
Cardiogenic Shock	1.905	<0.001	6.720
Dialysis	1.704	<0.001	5.496
Heart Failure	0.716	<0.001	2.046
Obesity		<0.001	
None	0.769		2.158
Unspecified obesity	0.008		1.008
Morbid obesity	-0.777		0.460
Prior CABG and/or Valve Surgery	0.411	0.016	1.509
Race/Ethnicity		0.015	
Hispanic	0.317		1.373
white/non-Hispanic	-0.360		0.698
black/non-Hispanic	0.308		1.361
other/unknown	-0.265		0.767
Renal Failure		0.012	
None	-0.357		0.700
Chronic	-0.035		0.965
Acute	0.392		1.480

*These factors were tested as continuous variables.

30-day Post-surgical Mortality

Significant Predictors	Coefficient	p-value	Odds Ratio
Constant	-3.926	<0.001	
Age	0.024	<0.001	Not applicable*
CABG Severity	0.585	<0.001	Not applicable*
Cancer		0.004	
None	0.604		1.830
Malignant neoplasm/cancer in situ	-0.714		0.490
History of cancer	0.110		1.116
Cardiogenic Shock	1.910	<0.001	6.751
Dialysis	1.519	<0.001	4.566
Heart Failure	0.689	<0.001	1.992

*These factors were tested as continuous variables

7-day Readmissions

Significant Predictors	Coefficient	p-value	Odds Ratio
Constant	-1.063	<0.001	
Acute Myocardial Infarction	0.141	0.064	1.151
CABG Severity	0.358	<0.001	Not applicable*
Diabetes		<0.001	
none	-0.252		0.777
without complication	-0.026		0.975
with complication	0.278		1.320
Race/Ethnicity		0.178	
Hispanic	0.288		1.333
White/non-Hispanic	-0.118		0.888
Black/non-Hispanic	0.093		1.097
Other/Unknown	-0.263		0.769

*These factors were tested as continuous variables

30-day Readmissions

Significant Predictors	Coefficient	p-value	Odds Ratio
Constant	-0.879	0.006	
Acute Myocardial Infarction (AMI)	0.135	0.012	1.145
Age	0.005	0.080	Not applicable*
CABG Severity	0.306	<0.001	Not applicable*
COPD	0.190	0.002	1.209
Diabetes		<0.001	
none	-0.306		0.736
without complication	-0.001		0.999
with complication	0.307		1.359
Gender	0.192	<0.001	1.212
Heart Failure	0.215	<0.001	1.239
PTCA/Stent (same day as CABG)	-0.349	0.145	0.705

*These factors were tested as continuous variables

Calculation of Outcome Measures

Once the significant risk factors are determined (in-hospital mortality, 30-day mortality, 7-day and 30-day readmissions), the statistical ratings are calculated. In doing so, actual rates are compared to expected rates to determine whether the difference is statistically significant.

Determining Actual (observed) Rates

In-hospital mortality	This rate is determined by dividing the total number of deaths that occurred in the hospital by the total number of cases.
30-day post-surgical mortality	This rate is determined by dividing the total number of deaths within 30 days of the CABG surgery date by the total number of cases.
7-day and 30-day readmissions.........................	These rates are determined by dividing the total number of cases who were 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.

Determining Expected Rates

The first step in calculating the expected rates is 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 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 statistically significant clinical or demographic factor is assigned a coefficient or "weight." A factor category's weight is higher (or lower) if patients with that factor category tend to have a higher (or lower) chance of the event occurring. These weights, determined using the statewide data set, were used to estimate each individual patient's probability of in-hospital death, death within 30 days, or 7-day or 30-day readmission given the risk factors of the patient.

In general the equation to calculate a patient's probability of in-hospital death is:

(constant) + (age coefficient)(age) + (age^2 coefficient)(age^2) + (risk factor category coefficients relevant to each patient)

In general the equation to calculate a patient's probability of death within 30-days is:

(constant) + (age coefficient)(age) + (risk factor category coefficients relevant to each patient)

In general the equation to calculate a patient's probability of readmission within 7 days is:

(constant) + (risk factor category coefficients relevant to each patient)

In general the equation to calculate a patient's probability of readmission within 30 days is:

(constant) + (age coefficient)(age) + (risk factor category coefficients relevant to each patient)

Note: Coefficients are found in the tables on the previous pages.

The results for all patients are then summed to determine the expected number of in-hospital deaths, deaths within 30-days, and readmissions within 7-days or 30-days. This expected rate is determined by dividing the total number of expected events by the total number of cases for each measure.

The following example illustrates the calculations used in determining the statistical ratings. In-hospital mortality is used as an example. The same calculations apply to 30-day post-surgical mortality and 7 and 30-day readmissions.

Example – Calculations used in in-hospital mortality analysis

Total Cases: Number of hospitalizations after exclusions.

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

Expected Deaths: Sum of each patient's probability of death (PD)
Percentage: Total number of expected deaths / Total number of cases treated

To calculate a patient's probability of death:

Step 1: Calculate BX:

BX = -3.742 (constant) + (0.026)(patient's age) + (0.0002)(patient's age)^2 + (risk factor coefficients relevant to each patient)

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

$PD = e^{BX} / (1 + e^{BX})$ 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:

   $VARPAT = (PD)(1-PD)$

Step 2: Calculate the Standard Deviation of Mortality

   SUMVAR = sum of VARPAT across all cases

   Standard Deviation of Mortality = square root of SUMVAR

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

Statistical Rating: If .05 > p-value and test statistic > 0, then more deaths than expected (denoted as "●")
If .05 > p-value and test statistic < 0, then fewer deaths than expected (denoted as "○")
Otherwise, the number of deaths were within the expected range (denoted as "⊙")

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

Post-surgical Length of Stay

Risk-Adjustment Methodology

Risk Adjustment Model

While *logistic* regression was used to construct the models for in-hospital mortality, 30-day post-surgical mortality, 7-day and 30-day readmission, a general <u>linear</u> 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.

Data Preparation

The first task in constructing the post-surgical length of stay model involved randomly splitting the data set into two, equal-size samples (after cases to be excluded were removed). One set was used as the development sample (Sample I), and the other set was used as the cross-validation sample (Sample II).

Case counts and average length of stay in days

	Sample I	*Sample II*	*Total*
Number of Cases	9,294	9,293	18,587
Average Length of Stay *(arithmetic)*	6.4	6.4	6.4
Average Length of Stay *(geometric)*	5.8	5.8	5.8

Model Selection

The model was constructed using Sample I, after a natural log transformation was done to adjust for skewness in the distribution. All tests of significance were based on general linear model F-tests. A $p < 0.10$ model was built for more liberal identification of risk factors.

Variables Evaluated as Potential Predictors of Post-surgical Length of Stay

Candidate Variables	Length of Stay
Acute Myocardial Infarction (AMI)	ns
Age	✓
Age Squared	ns
CABG Severity†	✓
Cancer	✓
Cardiogenic Shock	✓
Cardiomyopathy	ns
Complicated Hypertension	✓
COPD	✓
Diabetes	✓
Dialysis	✓
Gender	✓
Heart Failure	✓
Obesity	✓
Peripheral Vascular Disease	ns
Prior CABG and/or Valve Surgery	ns
PTCA/Stent (same day as CABG)	ns
Race/Ethnicity	✓
Renal Failure	✓

✓ = Significant predictor

ns = not significant

† = CABG severity represents a patient's probability of dying during the hospital admission in which the CABG surgery was performed. It is calculated using MediQual's® Atlas Outcomes® taking into account the patient's risk upon admission based on clinical data found in the medical record.

For this report, the candidate variable reflects the patient's condition during the hospital admission in which the CABG surgery was performed. For example, this table shows that a patient with an acute myocardial infarction (heart attack) as the principal diagnosis during the hospital admission in which the CABG surgery was performed was not a significant predictor of post-surgical length of stay.

Cross Validation – Length of Stay

The steps in the model cross validation were similar to those used for in-hospital mortality, 30-day post-surgical mortality, 7-day and 30-day readmission. The first step in the cross validation was to re-estimate the model, using only the variables that were significant in Sample I, to determine which factors remain significant in Sample II.

Probability Values for Each Significant Variable

Significant Predictors	Length of Stay	
	Sample	
	I	II
Age	< 0.0001	< 0.0001
CABG Severity..................................	< 0.0001	< 0.0001
Cancer	0.0082	0.0001
Cardiogenic Shock...........................	< 0.0001	< 0.0001
Complicated Hypertension	0.0001	0.0022
COPD	< 0.0001	< 0.0001
Diabetes	< 0.0001	0.0067
Dialysis	0.0003	< 0.0001
Gender	0.0057	0.0768
Heart Failure	< 0.0001	< 0.0001
Obesity..	0.0928	0.0455
Race/Ethnicity.................................	<0.0001	< 0.0001
Renal Failure	0.0221	0.0611

Note: A p-value of 0.10 was used to determine the significant risk factors for this report.

Measure of Model Adequacy

For the second step in the cross validation process, the estimated coefficients from Sample I were applied to both Sample I and Sample II. The objective was to evaluate the model's performance in both Sample I and Sample II. R-squared was the measure considered in evaluating the model's performance. (See earlier discussion on R-squared).

R-squared values by sample

Development	Cross Validation	All Cases
16.9%	17.0%	17.0%

Coefficients

Each category for each statistically significant clinical or demographic factor is assigned a weight or coefficient. These coefficients are used to compute each individual patient's expected post-surgical length of stay given the risk factors of the patient.

Coefficients (or "weights") for Post-surgical Length of Stay Model

Significant Predictors	Coefficient	p-value
Constant	2.674690232	< 0.0001
Age	0.005001057	< 0.0001
CABG Severity	0.094215564	< 0.0001
Cancer		< 0.0001
none	0.059608717	
malignant neoplasm/cancer in situ	0.071596667	
history of cancer	0.000000000	
Cardiogenic Shock	0.255847241	< 0.0001
Complicated Hypertension	0.093474343	< 0.0001
COPD	0.109154451	< 0.0001
Diabetes		< 0.0001
none	- 0.063021005	
without complication	- 0.065934188	
with complication	0.000000000	
Dialysis	0.171184621	< 0.0001
Gender	0.020892248	0.0015
Heart Failure	0.154641704	< 0.0001
Obesity		0.0051
none	- 0.049362478	
unspecified obesity	- 0.068712150	
morbid obesity	0.000000000	
Race/Ethnicity		< 0.0001
Hispanic	0.186492063	
white/non-Hispanic	0.024652230	
black/non-Hispanic	0.131681529	
other/unknown	0.000000000	
Renal Failure		0.0015
none	- 0.087491679	
chronic	- 0.039736636	
acute	0.000000000	

Calculation of Outcome Measures

Once the significant risk factors are determined, the average expected post-surgical length of stay is calculated. The calculation of the expected length of stay is discussed below (following the discussion on the actual length of stay).

Actual Length of Stay

The actual post-surgical length of stay can be derived by subtracting the CABG procedure date from the discharge date. The average post-surgical length of stay is reported as a *geometric* mean not an arithmetic mean.

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**, *not* 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. Using hospitals as an example, a hospital's expected average was determined by averaging the expected post-surgical lengths of stay for each CABG patient. The expected average was then compared to the actual average (both are geometric averages) to determine whether the actual is significantly higher or lower than expected. Post-surgical length of stay outcomes for hospitals and surgeons were evaluated in the same way.

Expected Length of Stay

Calculating the expected length of stay. Each category for each statistically significant clinical or demographic factor is assigned a weight or coefficient. Coefficients are listed in the table on the previous page. These coefficients are summed to compute each individual patient's expected length of stay given the risk factors of the patient. The coefficient for a category represents the estimated difference in mean (log) length of stay for this category versus the base category of that factor. Thus, the coefficient for the base category of a factor is always "0" (zero). When dealing with categorical variables in the length of stay model there is 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 is required at the base level for any factor because it is already accounted for in the constant. For example, a patient with acute renal failure has a "0" or "baseline" coefficient; while a patient without acute renal failure would be adjusted *downward* by 0.087491679. *(See table on previous page)*. The order is 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 no renal failure and acute renal failure would always be - 0.087491679 independent of what the specific coefficients were for each). For quantitative factors (e.g., age, age-squared and CABG severity), there is always an adjustment since the "baseline" is 0.

Risk-adjusted Length of Stay

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".

Calculations used in post-surgical length of stay analysis

Total Cases: Number of hospitalizations *after exclusions*

Actual Mean LOS: Geometric mean of the length of stay across all cases

Calculate geometric mean length of stay (GMLOS):

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

$$\textbf{ln}(GMLOS) = (1/n)(\textbf{ln}LOS_{case\ 1} + \textbf{ln}LOS_{case\ 2} + \ldots + \textbf{ln}LOS_{case\ n})$$

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

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

Expected Mean LOS: Geometric mean of the *expected* length of stay for all cases

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

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

$$E\textbf{ln}LOS = (\text{constant}) + (0.00500157)(\text{patient's age}) +$$
$$(\text{risk factor category coefficients relevant to each patient})$$

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

$$\textbf{ln}(GM E LOS) = (1/n)(E\textbf{ln}LOS_{case\ 1} + E\textbf{ln}LOS_{case\ 2} + \ldots + \textbf{ln}LOS_{case\ n})$$

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

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

Note: The following calculation can be used in determining a *patient's* expected length of stay; it is not necessary, however, in determining a hospital's geometric mean of the expected length of stay.

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

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

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

Risk-adjusted Length of Stay: Average length of stay / expected average length of stay x state average length of stay (5.8%)

ln = natural logarithm (base e)

Hospital Charge Analysis

Trimmed and case-mix adjusted average charge was reported for hospitals only.

Exclusions from Analysis

Exclusions from the charge analysis are outlined in Attachment A.

Construction of Reference Database

The patients included in the charge analysis fall into four DRGs. It is important to note that the study population was not identified by DRG (see study population discussion below); however, these patients are included in the four DRGs listed below.

- Group 1: DRG 106 **–** coronary bypass with PTCA
- Group 2: DRG 107 – coronary bypass with cardiac catheterization
- Group 3: DRG 108 – other cardiothoracic procedures
- Group 4: DRG 109 – coronary bypass without cardiac catheterization

Trim Methodology

Trimming methodology was used to remove outlier charge values from the study population. Identification of outliers is imperative for the elimination of extreme values that have a significant and unrepresentative impact on the mean (average).

The trimming (that is, deleting) of individual records from the analysis was performed after all other exclusions were satisfied. If the charge on a particular record was less than the lower trim point or in excess of the upper trim point, that record was removed from the charge analyses.

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

Since charges vary dramatically among regions, upper and lower trim points were calculated for each of the four groups of patients at the regional level (The Council uses nine regional designations). For two of the groups (DRGs 106 and 108), these nine regions were regrouped into larger areas because of the small numbers of cases in several regions.

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)

Total Charges Trim Points			
	Upper Trim Point*	**Median**	**Percentage Outliers**
DRG 106			
Regions 1, 2, 3	$ 230,722	$ 69,518	1.6 %
Regions 4, 5, 6	$173,730	$ 63,569	2.4%
Regions 7, 8, 9	$431,514	$ 91,216	0.6%
DRG 107			
Region 1	$190,806	$ 55,471	1.3%
Region 2	$107,875	$ 48,104	2.9%
Region 3	$ 90,657	$ 43,805	1.0%
Region 4	$ 83,945	$ 37,532	3.7%
Region 5	$114,233	$ 40,918	1.7%
Region 6	$110,628	$ 42,161	1.5%
Region 7	$102,303	$ 41,534	2.2%
Region 8	$226,000	$ 73,774	1.8%
Region 9	$275,829	$ 108,821	1.9%
DRG 108			
Regions 1, 2, 3	$240,834	$ 77,496	0.5%
Regions 4, 5, 6	$104,244	$ 41,084	3.7%
Regions 7, 8, 9	$341,951	$ 84,640	1.7%
DRG 109			
Region 1	$169,628	$ 47,414	1.2%
Region 2	$ 70,159	$ 32,842	3.1%
Region 3	$ 65,752	$ 34,805	3.4%
Region 4	$ 52,247	$ 24,348	3.9%
Region 5	$ 78,039	$ 31,039	2.9%
Region 6	$ 83,887	$ 33,943	1.2%
Region 7	$ 75,412	$ 32,769	2.3%
Region 8	$169,792	$ 53,993	2.7%
Region 9	$231,008	$ 80,191	2.7%

* Charges of less than $10,000 were considered invalid so no lower trim point is displayed.

Case-Mix Adjustment of Average Charge

Using case-mix adjustment, a composite average charge was developed for each of the four groups of patients. The charges associated with each group are adjusted according to the number of patients and the relative cost associated with treating patients in each of the four groups.

First, regional relative weights for each of the four groups were determined. After all exclusions were satisfied and outlier trimming was performed, the relative weight for each of the four groups within each of the nine regions (or the three larger areas) was calculated using the formula:

Relative Weight **=** Average Charge for each Group (either Group 1, 2, 3, or 4)
Average Charge for Groups 1, 2, 3, and 4 (combined)

Next, each hospital's case-mix index was calculated.

A Hospital's Case-mix Index $= \dfrac{\Sigma(n_i \times RW_i)}{\Sigma n_i}$

where, for a hospital located in a particular region
RW_i = the regional relative weights (corresponding to each of the four groups)
n_i = the number of cases (corresponding to each of the four groups)
and Σn_i = the total number of cases for the hospital (for all of the four groups)

Finally, for each hospital the trimmed and case-mix adjusted average charge is calculated.

Trimmed and Adjusted Charge = <u>Avg Charge for the four Groups (combined)</u>
Case-Mix Index

Average Total Charges (by DRG and Region) and Associated Relative Weights		
	Average Charge	**Relative Weight**
DRG 106		
Regions 1, 2, 3	$ 77,451	1.30281604
Regions 4, 5, 6	$ 67,312	1.78155945
Regions 7, 8, 9	$117,152	2.43200434
DRG 107		
Region 1	$ 60,745	1.02181222
Region 2	$ 51,788	1.17728599
Region 3	$ 45,595	1.07195394
Region 4	$ 39,251	1.03884536
Region 5	$ 44,489	1.13106268
Region 6	$ 44,405	1.05113629
Region 7	$ 44,005	0.91349015
Region 8	$ 84,327	1.09635565
Region 9	$116,232	1.09241669
DRG 108		
Regions 1, 2, 3	$ 86,027	1.44708193
Regions 4, 5, 6	$ 42,859	1.13434181
Regions 7, 8, 9	$ 94,803	1.96798510
DRG 109		
Region 1	$ 51,537	0.86692336
Region 2	$ 34,426	0.78260559
Region 3	$ 34,200	0.80405400
Region 4	$ 25,681	0.67970061
Region 5	$ 33,066	0.84064130
Region 6	$ 34,818	0.82420009
Region 7	$ 34,206	0.71006743
Region 8	$ 61,708	0.80227171
Region 9	$ 87,470	0.82209247

ATTACHMENT A

Cases Included / Excluded

Exclusion Criteria

Specific cases were excluded from the analysis. Standard exclusions were identified first for the in-hospital mortality analysis. Additional cases were then excluded from the analyses for the other measures in this report (30-day post-surgical mortality, 7-day readmissions, 30-day readmissions, post-surgical length of stay, and average hospital charge).

In-hospital mortality analysis	*Statewide*		
	Cases		Mortality
	#	%	%
Total cases *before* exclusions	22,856	100.0	3.3
Exclusions:			
Patients designated as "clinically complex" *	3,436	15.0	8.4
Patients who left against medical advice	8	<0.1	0.0
Patients under age 30	3	<0.1	33.3
Hospitals closed during CY 2000	128	0.6	Not reported
Total exclusions	3,575	15.6	8.3
Total cases to be *included* in the analysis	19,281	84.4	2.4

*cases not in DRG 106-109 or DRG 483, cases excluded during individual case review, and cases undergoing certain procedures during the same admission (as defined by one of the following procedures — ICD.9.CM codes are in parentheses):

> *heart transplant (33.6, 37.5)*
> *lung transplant (33.5)*
> *kidney transplant (55.61, 55.69)*
> *concurrent valve surgery (35.10 - 35.14, 35.20 - 35.28, 35.99)*
> *operations on structures adjacent to heart valves (35.31 - 35.35, 35.39)*
> *creation of septal defect in heart (35.42)*
> *repair of atrial and ventricular septa (35.50 - 35.54, 35.60 - 35.63, 35.70 - 35.73)*
> *total repair of certain congenital cardiac anomalies (35.81 - 35.84)*
> *other operations on valves and septa of heart (35.91 - 35.95, 35.98)*
> *repair of aneurysm of coronary vessel (36.91)*
> *other operations on vessels of heart (36.99)*
> *excision of aneurysm of heart or other lesion of heart (37.32, 37.33)*
> *implantation/replacement of automatic cardioverter/defibrillator (37.94 - 37.98)*
> *resection of abdominal aorta, thoracic vessel, abdominal arteries (38.44 - 38.46)*
> *clipping of aneurysm/other aneurysm repair (39.51, 39.52)*
> *diagnosis of constrictive pericarditis & undergoing pericardiectomy (423.2 in combination with 37.31)*

30-day post-surgical mortality analysis | | | ***Statewide*** | |

	Cases		30 day post-surgical mortality
	#	%	%
Total cases before post-surgical mortality exclusions	19,281	100.0	–
Exclusions:			
Cases with invalid/inconsistent data*	60	0.3	–
Out-of-state residents**	2,029	10.5	–
Total cases excluded from 30-day post-surgical mortality analysis	2,089	10.8	–
Total cases included in 30-day post surgical mortality analysis	17,192	89.2	2.7

*Prohibited linkage of cases with death certificate information.

**Out-of-state residents were excluded because such patients could undergo CABG surgery in a Pennsylvania hospital, return to their home state and die there. We would have no death certificate data for these patients.

7-day and 30-day Readmission analysis | | | **Statewide** | |

	Cases		7-day Readmis-sion	30-day Readmis-sion
	#	%	%	%
Total cases *before* readmission exclusions	19,281	100.0	–	–
Exclusions:				
Patients who died during hospitalization where CABG was performed	460	2.4	–	–
Cases with invalid/inconsistent data*	155	0.8	–	–
Out-of-state residents**	1,963	10.2	–	–
Total cases *excluded* from readmission analysis	2,578	13.4	–	–
Total cases *included* in readmission analysis	16,703	86.6	6.2	14.5

*Prohibited linkage of cases to other subsequent hospital admissions

**Out-of-state residents were excluded because such patients could under CABG surgery in a Pennsylvania hospital and be readmitted to an out-of-state hospital. We would have no readmission information for these patients.

NOTE: A readmission was counted as such if the patient was hospitalized between 1 and 7 days or between 1 and 30 days after being discharged from the hospital where the CABG surgery was performed.

Post-surgical length of stay analysis

Statewide

	Cases		Average Post-surgical LOS
	#	%	days
Total cases *before* post-surgical LOS exclusions	19,281	100.0	7.0
Exclusions:			
Patients who died	460	2.4	13.9
Patients with post-surgical LOS > 30 days	218	1.1	48.4
Patients with post-surgical LOS same day or one day	16	0.1	0.7
Total *exclusions* from post-surgical LOS analysis	694	3.6	24.4
Total cases *included* in post-surgical LOS analysis	18,587	96.4	6.4

Charge analysis

Statewide

	Cases		Avg. Total Charge
	#	%	$
Total cases *before* charge exclusions	19,281	100.0	$66,645
Exclusions:			
Patients with invalid/missing charges	27	0.1	---
Tracheostomy cases (DRG 483)	269	1.4	$345,684
Charge outliers*	369	1.9	$204,671
Total cases *excluded* from charge analysis	665	3.5	---
Total cases *included* in charge analysis	18,616	96.6	$59,939

*Charge outliers were determined using the same "± 3.0 interquartile range" method used for other Council reports – after accounting for differences in charges by DRG and by region.

ATTACHMENT B

Readmission Categories

Definition - Readmissions

Readmissions were counted only if the patient was readmitted for particular reasons (as indicated by a principal diagnosis of the patient during the readmission; examples include infections, other heart-related conditions, complications from the surgery, etc). The list follows:

Diagnosis	ICD.9.CM Code	7-Days N = 1,033 (6.2%)		30-Days N = 2,426 (14.5%)	
		#	%	#	%
Cardiac Diagnoses					
Cardiac dysrhythmias post cardiac surgery		**102**	**9.9**	**214**	**8.8**
conduction disorders (i.e., av block)	426	6	0.6	12	0.5
paroxysmal tachycardias	427.0, 427.1, 427.2	5	0.5	12	0.5
atrial fibrillation/flutter	427.31, 427.32	67	6.5	145	6.0
ventricular fibrillation/flutter	427.41, 427.42	0	–	0	–
premature beats	427.60, 427.61, 427.69	2	0.2	3	0.1
other rhythm disorders (i.e., ectopic, nodal)	427.89	14	1.4	25	1.0
miscellaneous dysrhythmias	427.5, 427.81, 427.9	8	0.8	17	0.7
Heart Failure		**212**	**20.5**	**476**	**19.6**
rheumatic heart failure	398.91	1	0.1	4	0.2
benign hypertensive heart disease with CHF	402.11	1	0.1	2	0.1
malignant hypertensive heart & renal disease with CHF	404.03	0	–	1	<0.1
unspecified hypertensive heart disease with CHF	402.91	4	0.4	11	0.5
unspecified hypertensive heart & renal disease with CHF	404.91	0	–	0	–
unspecified hypertensive heart & renal disease with CHF & renal failure	404.93	2	0.2	4	0.2
congestive heart failure	428.0	147	14.2	335	13.8
functional disturbances post heart valve surgery	429.4	56	5.4	118	4.9
cardiogenic shock	785.51	1	0.1	1	<0.1
Coronary atherosclerosis / myocardial ischemia and infarction		**37**	**3.6**	**92**	**3.8**
AMI	410	28	2.7	67	2.8
postmyocardial infarction syndrome	411.0	7	0.7	20	0.8
intermediate coronary syndrome	411.1	0	–	0	–
coronary occlusion without MI	411.81	0	–	0	–
acute ischemic heart disease	411.89	2	0.2	2	0.1
angina pectoris	413	0	–	3	0.1
coronary atherosclerosis	414.0x	0	–	0	–
aneurysm of the heart	414.10, 414.11, 414.19	0	–	0	–
other forms of chronic ischemic heart disease	414.8, 414.9	0	–	0	–
Hypertension / hypotension / syncope / dizziness	**401, 458.x, 780.2, 780.4**	**22**	**2.1**	**66**	**2.7**
Artery and vein disease/embolism/thrombosis		**12**	**1.2**	**49**	**2.0**
atherosclerosis of artery, vein graft	440	6	0.6	23	0.9
aortic aneurysm and dissection	441	0	–	0	–
other aneurysm	442	0	–	0	–
other peripheral vascular disease (i.e. intermittent claudication, vessel spasm)	443	0	–	0	–
arterial embolism and thrombosis	444	3	0.3	6	0.2

Diagnosis	ICD.9.CM Code	7-Days N = 1,033 (6.2%)		30-Days N = 2,426 (14.5%)	
		#	%	#	%
phlebitis and thrombophlebitis..451		1	0.1	5	0.2
other venous embolism and thrombosis 453		0	–	0	–
peripheral vascular complications..997.2		2	0.2	15	0.6
Other forms of heart disease		**13**	**1.3**	**30**	**1.2**
acute pericarditis 420		3	0.3	13	0.5
acute myocarditis 422.90, 422.91, 422.92		0	–	0	–
other diseases of pericardium 423		10	1.0	17	0.7
Neurologic Diagnoses					
Stroke / transient cerebral ischemia / anoxic brain damage		**49**	**4.7**	**98**	**4.0**
anoxic brain damage 348.1, 997.01		3	0.3	5	0.2
retinal/visual disorders .... 362.30 - 362.34, 368.12		0	–	0	–
intracerebral hemorrhage..431		1	0.1	3	0.1
occlusion and stenosis of precerebral arteries..433		6	0.6	16	0.7
cerebral thrombosis..434		23	2.2	41	1.7
transient cerebral ischemia..435		6	0.6	19	0.8
acute, but ill-defined cerebrovascular disease (CVA) 436		4	0.4	6	0.2
iatrogenic cerebrovascular infarction or hemorrhage..997.02		6	0.6	8	0.3
Respiratory Diagnoses					
Pleurisy		**47**	**4.5**	**108**	**4.5**
pleurisy 511.0		0	–	1	<0.1
pleural effusion / atelectasis 511.9, 518.0		33	3.2	78	3.2
hemothorax / hemopneumothorax 511.8		6	0.6	17	0.7
pneumothorax 512		8	0.8	12	0.5
Pulmonary edema / insufficiency		**12**	**1.2**	**24**	**1.0**
pulmonary eosinophilia 518.3		0	–	0	–
acute pulmonary edema 518.4		0	–	1	<0.1
pulmonary insufficiency post trauma or surgery 518.5		3	0.3	3	0.1
acute respiratory failure 518.81		9	0.9	18	0.7
other pulmonary insufficiency (i.e. acute respiratory distress) 518.82		0	–	2	0.1
acute and chronic respiratory failure 518.84		0	–	0	–
other diseases of the lung (i.e. broncholithiasis) 518.89		0	–	0	–
Respiratory and other chest symptoms		**55**	**5.3**	**135**	**5.6**
Tietze's disease (i.e. costochondritis)..733.6		0	–	4	0.2
respiratory and other chest symptoms (i.e.shortness of breath, chest pain) 786		55	5.3	131	5.4
subcutaneous emphysema resulting from a procedure 998.81		0	–	0	–
Pulmonary embolism / infarction 415		**50**	**4.8**	**100**	**4.1**
Aspiration pneumonia 507.0, 997.3		**48**	**4.6**	**101**	**4.2**

Diagnosis	ICD.9.CM Code	7-Days N = 1,033 (6.2%)		30-Days N = 2,426 (14.5%)	
		#	%	#	%
Other Diagnoses					
Infections		**186**	**18.0**	**567**	**23.4**
intestinal infection due to Clostridium difficile	008.45	1	0.1	5	0.2
septicemia	038	16	1.5	28	1.2
bacteremia	790.7	0	–	1	<0.1
acute/subacute bacterial endocarditis	421.0, 421.9	1	0.1	2	0.1
bronchitis	466.0, 490	7	0.7	9	0.4
pneumonia	481, 482, 485, 486	44	4.3	92	3.8
empyema	510.0, 510.9	2	0.2	2	0.1
urinary tract infection	599.0	5	0.5	21	0.9
cellulitis	681.10, 682	5	0.5	16	0.7
fever	780.6	3	0.3	10	0.4
infection, due to heart device	996.61	3	0.3	5	0.2
infected post-surgical seroma	998.51	2	0.2	6	0.2
infection due to vascular device	996.62	0	–	2	0.1
infection due to other device	996.69	0	–	0	–
mediastinitis	519.2	1	0.1	2	0.1
non-healing surgical wound	998.83	0	–	6	0.2
other post-surgical infection	998.59	96	9.3	360	14.8
Device, Implant, or Graft Complications		**3**	**0.3**	**12**	**0.5**
mechanical complication of cardiac device, implant, graft	996.0X	0	–	1	<0.1
other complication of cardiac device, implant, graft	996.71, 996.72, 996.74	3	0.3	11	0.5
GI hemorrhage / complications		**38**	**3.7**	**77**	**3.2**
acute gastric ulcer	531.00, 531.01, 531.20, 531.21	1	0.1	2	0.1
chronic/unspecified gastric ulcer	531.40. 531.41, 531.60, 531.61	3	0.3	6	0.2
acute duodenal ulcer	532.00, 532.01, 532.20, 532.21	7	0.7	13	0.5
chronic/unspecified duodenal ulcer	532.40, 532.41, 532.60, 532.61	12	1.2	34	1.4
acute peptic ulcer	533.00, 533.01, 533.20, 533.21	0	–	0	–
chronic/unspecified peptic ulcer	533.40. 533.41, 533.60, 533.61	0	–	0	–
acute gastritis without mention of hemorrhage	535.01	1	0.1	1	<0.1
other specified gastritis with hemorrhage	535.41	0	–	0	–
hemorrhage of rectum and anus	569.3	2	0.2	2	0.1
blood in stool	578.1	1	0.1	1	<0.1
hemorrhage of gastrointestinal tract, unspecified	578.9	5	0.5	11	0.5
digestive system complications due to procedure	997.4	6	0.6	7	0.3
Genitourinary complications		**6**	**0.6**	**22**	**0.9**
acute renal failure	584	5	0.5	20	0.8
urinary retention	788.2X	0	–	1	<0.1
urinary complications due to procedure	997.5	1	0.1	1	<0.1

Diagnosis	ICD.9.CM Code	7-Days N = 1,033 (6.2%)		30-Days N = 2,426 (14.5%)	
		#	%	#	%
Anemia / thrombocytopenia		**5**	**0.5**	**14**	**0.6**
iron deficiency anemias 280		1	0.1	2	0.1
acquired hemolytic anemias 283		0	–	0	–
other and unspecified anemias (i.e. post hemorrhagic anemia) 285		2	0.2	7	0.3
purpura and other hemorrhagic conditions (i.e. thrombocytopenia) 287		0	–	2	0.1
hemorrhage, unspecified (i.e. rupture of blood vessel) 459.0		1	0.1	1	<0.1
hemoperitoneum (i.e. resulting from pseudoaneurysm due to IABP) 568.81		1	0.1	2	0.1
Fluid and electrolyte imbalance..276		**17**	**1.6**	**42**	**1.7**
Other surgical complications		**119**	**11.5**	**199**	**8.2**
disturbance of skin sensation (i.e. paresthesia, hyperesthesia)................................782.0		0	–	1	<0.1
cardiac complications resulting from procedure 997.1		80	7.7	127	5.2
Hemorrhage or hematoma complicating a procedure..998.1X		14	1.4	21	0.9
dehiscence or rupture of operation wound..998.3		21	2.0	42	1.7
foreign body left during procedure resulting in obstruction, perforation....................998.4		0	–	1	<0.1
other procedure complications not listed elsewhere 998.89		4	0.4	7	0.3

ATTACHMENT C

Candidate Variables

In-hospital Mortality — Candidate Variable Frequency and Percent Mortality

Variable and ICD.9.CM Codes	Number of Cases (statewide)			Percent In-hospital Mortality		
	sample I	sample II	total	sample I	sample II	total
	9,641	9,640	19,281	2.5%	2.2%	2.4%
Acute Myocardial Infarction (AMI)						
no	7,477	7,482	14,959	2.2	1.8	2.0
yes (initial episode as principal diagnosis) 410.x1	2,164	2,158	4,322	3.7	3.6	3.6
CABG Admission Severity Group (ASG)						
(tested as probability of death – a continuous variable)						
0.000 – 0.001	0	0	0	–	–	–
0.002 – 0.011	3,352	3,372	6,724	0.4	0.4	0.4
0.012 – 0.057	5,542	5,528	11,070	2.7	2.4	2.6
0.058 – 0.499	747	738	1,485	10.8	9.2	10.0
0.500 – 1.000	0	2	2	–	50.0	50.0
Age & Age-Squared (tested as continuous variables)						
30-39 years	71	74	145	1.4	0.0	0.7
40-49 years	588	630	1,218	0.7	0.2	0.4
50-59 years	1,896	1,941	3,837	0.9	1.3	1.1
60-69 years	2,920	2,854	5,774	1.8	1.3	1.6
70-79 years	3,329	3,218	6,547	3.7	3.4	3.6
80-89 years	821	913	1,734	5.5	4.4	4.9
90-99 years	16	10	26	6.3	10.0	7.7
Average age: 66.3 (males 65.1; females 69.0)						
Cancer						
none	8,980	9,002	17,982	2.6	2.3	2.4
Malig. neoplasm/cancer in situ . 140.0 - 208.9, 230.0 - 234.99	168	157	325	2.4	1.3	1.8
history of cancer ....V10.00 - V10.9	493	481	974	1.4	2.1	1.7
Cardiogenic Shock						
no	9,562	9,564	19,126	2.3	2.0	2.2
yes (before surgery–using clinical info. in the medical record).	79	76	155	26.6	26.3	26.5
Cardiomyopathy						
no	9,463	9,472	18,935	2.5	2.2	2.3
yes 425.3, 425.4, 425.8, 425.9	178	168	346	5.6	6.0	5.8
Complicated Hypertension						
no	9,345	9,359	18,704	2.4	2.0	2.2
yes.................402.x1, 403.x1, 404.x1, 404.x2, 404.x3, 405.xx	296	281	577	8.1	8.5	8.3
COPD						
no	8,240	8,221	16,461	2.3	2.0	2.2
yes 491.20, 491.21, 492.0, 492.8, 496, 506.4, 518.2	1,401	1,419	2,820	3.8	3.5	3.6
Diabetes						
none	6,515	6,498	13,013	2.6	2.2	2.4
diabetes without complication 250.0x	2,625	2,598	5,223	2.0	2.0	2.0
diabetes with complication ....250.1x - 250.9x	501	544	1,045	4.8	3.7	4.2

In-hospital Mortality — Candidate Variable Frequency and Percent Mortality

Variable and ICD.9.CM Codes	Number of Cases (statewide)			Percent In-hospital Mortality		
	sample I	*sample II*	*total*	*sample I*	*sample II*	*total*
	9,641	9,640	19,281	2.5%	2.2%	2.4%
Dialysis						
no	9,515	9,523	19,038	2.3	2.0	2.1
yes 39.95, 54.98, V45.1, V56.0, V56.8	126	117	243	19.8	22.2	21.0
Gender						
male	6,686	6,722	13,408	2.1	1.6	1.9
female	2,955	2,918	5,873	3.6	3.6	3.6
Heart Failure						
no	8,008	7,960	15,968	1.6	1.5	1.5
yes 398.91, 428.0, 428.1, 428.9	1,633	1,680	3,313	7.0	5.8	6.4
Note: For those cases having one of the above heart failure codes <u>and</u> a hypertension with congestive heart failure code (402.x1, 404.x1, 404.x3) in the same record, only the hypertension code was used.						
Obesity						
none	8,746	8,721	17,467	2.7	2.4	2.6
unspecified obesity 278.00	693	715	1,408	1.2	0.4	0.8
morbid obesity 278.01	202	204	406	0.5	0.5	0.5
Peripheral Vascular Disease						
no	8,996	8,990	17,986	2.5	2.2	2.3
yes 443.0, 443.1, 443.81, 443.89, 443.9	645	650	1,295	3.6	2.9	3.2
Prior CABG and/or Valve Surgery						
no	9,101	9,064	18,165	2.4	2.1	2.3
yes V42.2, V43.3, V45.81, 414.02, 414.03, 414.04, 414.05, 996.02, 996.03..	540	576	1,116	5.4	3.6	4.5
PTCA/Stent (same day as CABG)						
no	9,549	9,568	19,117	2.5	2.2	2.3
yes 36.01, 36.02, 36.05, 36.06, 36.09	92	72	164	4.3	11.1	7.3
Race/Ethnicity						
Hispanic	67	76	143	4.5	3.9	4.2
white/non-Hispanic	8,133	8,067	16,200	2.4	2.2	2.3
black/non-Hispanic	274	314	588	5.8	4.1	4.9
other/unknown	1,167	1,183	2,350	2.7	1.9	2.3
Renal Failure						
none	9,481	9,480	18,961	2.4	2.0	2.2
chronic 585	68	72	140	8.8	13.9	11.4
acute (before surgery – as indicated by the hospital)..............	92	88	180	16.3	12.5	14.4

30-day Post-surgical Mortality - Candidate Variable Frequency and Percent Mortality

Variable and ICD.9.CM Codes	Number of Cases (statewide)			Percent 30-day Post-surgical Mortality		
	sample I	*sample II*	*total*	*sample I*	*sample II*	*total*
	8,596	8,596	17,192	2.9%	2.6%	2.7%
Acute Myocardial Infarction (AMI)						
no	6,677	6,687	13,364	2.5	2.1	2.3
yes (initial episode as principal diagnosis) 410.x1	1,919	1,909	3,828	4.0	4.3	4.2
***CABG* Admission Severity Group (ASG)**						
(*tested as probability of death – a continuous variable*)						
0.000 – 0.001	0	0	0	–	–	–
0.002 – 0.011	2,975	2,989	5,964	0.5	0.7	0.6
0.012 – 0.057	4,949	4,967	9,916	3.2	2.8	3.0
0.058 – 0.499	671	639	1,310	10.6	9.7	10.2
0.500 – 1.000	1	1	2	0.0	0.0	0.0
Age & Age-Squared (*tested as continuous variables*)						
30-39 years	59	64	123	1.7	0.0	0.8
40-49 years	534	541	1,075	1.1	0.7	0.9
50-59 years	1,642	1,737	3,379	1.0	1.7	1.4
60-69 years	2,590	2,561	5,151	2.0	1.9	1.9
70-79 years	2,962	2,915	5,877	4.1	3.4	3.8
80-89 years	798	766	1,564	6.0	5.6	5.8
90-99 years	11	12	23	9.1	0.0	4.3
Average age: 66.4 (males 65.1; females 69.1)						
Cancer						
none	7,993	8,044	16,037	3.0	2.7	2.8
Malig. neoplasm/cancer in situ . 140.0 - 208.9, 230.0 - 234.99	157	133	290	1.3	0.8	1.0
history of cancer ....V10.00 - V10.9	446	419	865	1.6	2.1	1.8
Cardiogenic Shock						
no	8,520	8,544	17,064	2.7	2.4	2.5
yes (before surgery–using clinical info. in the medical record).	76	52	128	25.0	34.6	28.9
Cardiomyopathy						
no	8,454	8,465	16,919	2.8	2.6	2.7
yes 425.3, 425.4, 425.8, 425.9	142	131	273	5.6	3.8	4.8
Complicated Hypertension						
no	8,344	8,335	16,679	2.7	2.4	2.6
yes 402.x1, 403.x1, 404.x1, 404.x2, 404.x3, 405.xx	252	261	513	8.3	8.4	8.4
COPD						
no	7,296	7,382	14,678	2.7	2.4	2.5
yes 491.20, 491.21, 492.0, 492.8, 496, 506.4, 518.2	1,300	1,214	2,514	3.9	4.0	4.0
Diabetes						
none	5,759	5,816	11,575	3.0	2.7	2.8
diabetes without complication 250.0x	2,374	2,302	4,676	2.5	2.1	2.3
diabetes with complication ....250.1x - 250.9x	463	478	941	3.5	4.0	3.7

30-day Post-surgical Mortality - Candidate Variable Frequency and Percent Mortality

Variable and ICD.9.CM Codes	Number of Cases (statewide)			Percent 30-day Post-surgical Mortality		
	sample I	sample II	total	sample I	sample II	total
	8,596	8,596	17,192	2.9%	2.6%	2.7%
Dialysis						
no	8,483	8,497	16,980	2.7	2.4	2.5
yes 39.95, 54.98, V45.1, V56.0, V56.8	113	99	212	17.7	20.2	18.9
Gender						
male	5,892	6,004	11,896	2.3	2.0	2.2
female	2,704	2,592	5,296	4.1	3.9	4.0
Heart Failure						
no	7,130	7,151	14,281	2.0	1.8	1.9
yes 398.91, 428.0, 428.1, 428.9	1,466	1,445	2,911	7.1	6.6	6.9
Note: For those cases having one of the above heart failure codes <u>and</u> a hypertension with congestive heart failure code (402.x1, 404.x1, 404.x3) in the same record, only the hypertension code was used.						
Obesity						
none	7,817	7,751	15,568	3.0	2.7	2.9
unspecified obesity 278.00	592	660	1,252	1.4	2.0	1.7
morbid obesity 278.01	187	185	372	1.1	1.1	1.1
Peripheral Vascular Disease						
no	8,019	8,027	16,046	2.8	2.5	2.6
yes 443.0, 443.1, 443.81, 443.89, 443.9	577	569	1,146	3.3	4.6	3.9
Prior CABG and/or Valve Surgery						
no	8,105	8,097	16,202	2.7	2.4	2.6
yes V42.2, V43.3, V45.81, 414.02, 414.03, 414.04, 414.05, 996.02, 996.03...	491	499	990	5.5	5.8	5.7
PTCA/Stent (same day as CABG)						
no	8,529	8,511	17,040	2.8	2.6	2.7
yes 36.01, 36.02, 36.05, 36.06, 36.09	67	85	152	9.0	7.1	7.9
Race/Ethnicity						
Hispanic	55	65	120	5.5	3.1	4.2
white/non-Hispanic	7,304	7,271	14,575	2.7	2.7	2.7
black/non-Hispanic	280	263	543	5.0	4.2	4.6
other/unknown	957	997	1,954	3.0	1.9	2.5
Renal Failure						
none	8,436	8,463	16,899	2.7	2.5	2.6
chronic 585	73	53	126	12.3	5.7	9.5
acute (before surgery – as indicated by the hospital)	87	80	167	12.6	16.3	14.4

7-day Readmission - Candidate Variable Frequency and Percent Readmission

Variable and ICD.9.CM Codes	Number of Cases (statewide)			Percent 7-day Readmission		
	sample I	sample II	total	sample I	sample II	total
	8,352	8,351	16,703	6.0%	6.4%	6.2%
Acute Myocardial Infarction (AMI)						
no	6,522	6,515	13,037	5.6	6.0	5.8
yes (initial episode as principal diagnosis) 410.x1	1,830	1,836	3,666	7.4	7.7	7.6
CABG Admission Severity Group (ASG)						
(tested as probability of death – a continuous variable)						
0.000 – 0.001	0	0	0	–	–	–
0.002 – 0.011	2,908	3,004	5,912	4.4	3.6	4.0
0.012 – 0.057	4,858	4,760	9,618	6.6	7.6	7.1
0.058 – 0.499	586	586	1,172	8.7	10.2	9.5
0.500 – 1.000	0	1	1	–	0.0	0.0
Age & Age-Squared (tested as continuous variables)						
30-39 years	61	61	122	6.6	6.6	6.6
40-49 years	515	552	1,067	4.9	4.0	4.4
50-59 years	1,642	1,680	3,322	4.3	4.8	4.5
60-69 years	2,496	2,554	5,050	5.7	6.2	6.0
70-79 years	2,875	2,772	5,647	7.1	7.0	7.0
80-89 years	749	725	1,474	7.2	10.1	8.6
90-99 years	14	7	21	7.1	14.3	9.5
Average age: 66.2 (males 65.0; females 69.0)						
Cancer						
none	7,792	7,781	15,573	6.0	6.5	6.2
Malig. neoplasm/cancer in situ . 140.0 - 208.9, 230.0 - 234.99	148	137	285	7.4	3.6	5.6
history of cancer ....V10.00 - V10.9	412	433	845	4.9	5.5	5.2
Cardiogenic Shock						
no	8,301	8,306	16,607	6.0	6.4	6.2
yes (before surgery–using clinical info. in the medical record)	51	45	96	11.8	8.9	10.4
Cardiomyopathy						
no	8,237	8,209	16,446	6.0	6.3	6.2
yes 425.3, 425.4, 425.8, 425.9	115	142	257	7.0	9.2	8.2
Complicated Hypertension						
no	8,125	8,108	16,233	5.9	6.2	6.1
yes 402.x1, 403.x1, 404.x1, 404.x2, 404.x3, 405.xx	227	243	470	8.4	12.3	10.4
COPD						
no	7,153	7,136	14,289	5.8	6.1	6.0
yes 491.20, 491.21, 492.0, 492.8, 496, 506.4, 518.2	1,199	1,215	2,414	6.9	7.7	7.3
Diabetes						
none	5,636	5,612	11,248	5.3	5.8	5.6
diabetes without complication 250.0x	2,281	2,279	4,560	6.9	7.0	7.0
diabetes with complication ....250.1x - 250.9x	435	460	895	9.7	10.4	10.1

43

7-day Readmission - Candidate Variable Frequency and Percent Readmission

Variable and ICD.9.CM Codes	Number of Cases (statewide)			Percent 7-day Readmission		
	sample I	sample II	total	sample I	sample II	total
	8,352	8,351	16,703	6.0%	6.4%	6.2%
Dialysis						
no	8,274	8,265	16,539	6.0	6.3	6.1
yes 39.95, 54.98, V45.1, V56.0, V56.8	78	86	164	9.0	17.4	13.4
Gender						
male	5,853	5,773	11,626	5.6	5.6	5.6
female	2,499	2,578	5,077	7.0	8.1	7.5
Heart Failure						
no	6,972	7,025	13,997	5.7	5.8	5.8
yes 398.91, 428.0, 428.1, 428.9	1,380	1,326	2,706	7.3	9.6	8.4
Note: For those cases having one of the above heart failure codes <u>and</u> a hypertension with congestive heart failure code (402.x1, 404.x1, 404.x3) in the same record, only the hypertension code was used.						
Obesity						
none	7,568	7,530	15,098	6.0	6.3	6.2
unspecified obesity 278.00	613	624	1,237	5.5	6.3	5.9
morbid obesity 278.01	171	197	368	7.6	8.1	7.9
Peripheral Vascular Disease						
no	7,803	7,794	15,597	5.9	6.2	6.0
yes 443.0, 443.1, 443.81, 443.89, 443.9	549	557	1,106	6.9	9.3	8.1
Prior CABG and/or Valve Surgery						
no	7,897	7,863	15,760	5.9	6.3	6.1
yes V42.2, V43.3, V45.81, 414.02, 414.03, 414.04, 414.05, 996.02, 996.03...	455	488	943	7.9	7.6	7.7
PTCA/Stent (same day as CABG)						
no	8,292	8,270	16,562	6.0	6.4	6.2
yes 36.01, 36.02, 36.05, 36.06, 36.09	60	81	141	5.0	7.4	6.4
Race/Ethnicity						
Hispanic	58	54	112	6.9	11.1	8.9
white/non-Hispanic	7,052	7,132	14,184	6.1	6.3	6.2
black/non-Hispanic	272	242	514	8.8	7.0	8.0
other/unknown	970	923	1,893	4.2	6.5	5.3
Renal Failure						
none	8,221	8,233	16,454	6.0	6.3	6.1
chronic 585	67	43	110	9.0	14.0	10.9
acute (before surgery – as indicated by the hospital)..............	64	75	139	6.3	13.3	10.1

30-day Readmission - Candidate Variable Frequency and Percent Readmission

Variable and ICD.9.CM Codes	Number of Cases (statewide)			Percent 30-day Readmission		
	sample I	*sample II*	*total*	*sample I*	*sample II*	*total*
	8,352	8,351	16,703	14.4%	14.7%	14.5%
Acute Myocardial Infarction (AMI)						
no	6,522	6,515	13,037	13.5	13.9	13.7
yes (initial episode as principal diagnosis) 410.x1	1,830	1,836	3,666	17.3	17.5	17.4
***CABG* Admission Severity Group (ASG)**						
(*tested as probability of death – a continuous variable*)						
0.000 – 0.001	0	0	0	–	–	–
0.002 – 0.011	2,908	3,004	5,912	9.7	9.1	9.4
0.012 – 0.057	4,858	4,760	9,618	16.0	16.8	16.4
0.058 – 0.499	586	586	1,172	23.7	26.1	24.9
0.500 – 1.000	0	1	1	–	0.0	0.0
Age & Age-Squared (*tested as continuous variables*)						
30-39 years	61	61	122	19.7	16.4	18.0
40-49 years	515	552	1,067	8.2	11.8	10.0
50-59 years	1,642	1,680	3,322	11.3	11.3	11.3
60-69 years	2,496	2,554	5,050	12.9	13.7	13.3
70-79 years	2,875	2,772	5,647	17.2	16.7	17.0
80-89 years	749	725	1,474	18.7	20.7	19.7
90-99 years	14	7	21	21.4	14.3	19.0
Average age: 66.2 (males 65.0; females 69.0)						
Cancer						
none	7,792	7,781	15,573	14.3	14.7	14.5
Malig. neoplasm/cancer in situ . 140.0 - 208.9, 230.0 - 234.99	148	137	285	15.5	12.4	14.0
history of cancer ....V10.00 - V10.9	412	433	845	15.5	15.0	15.3
Cardiogenic Shock						
no	8,301	8,306	16,607	14.3	14.7	14.5
yes (before surgery–using clinical info. in the medical record).	51	45	96	27.5	17.8	22.9
Cardiomyopathy						
no	8,237	8,209	16,446	14.3	14.6	14.4
yes 425.3, 425.4, 425.8, 425.9	115	142	257	17.4	21.8	19.8
Complicated Hypertension						
no	8,125	8,108	16,233	14.1	14.3	14.2
yes 402.x1, 403.x1, 404.x1, 404.x2, 404.x3, 405.xx	227	243	470	22.9	28.4	25.7
COPD						
no	7,153	7,136	14,289	13.8	14.1	13.9
yes 491.20, 491.21, 492.0, 492.8, 496, 506.4, 518.2	1,199	1,215	2,414	17.9	18.1	18.0
Diabetes						
none	5,636	5,612	11,248	12.7	12.8	12.8
diabetes without complication 250.0x	2,281	2,279	4,560	16.8	17.2	17.0
diabetes with complication .... 250.1x - 250.9x	435	460	895	22.8	24.6	23.7

30-day Readmission - Candidate Variable Frequency and Percent Readmission

Variable and ICD.9.CM Codes	Number of Cases (statewide)			Percent 30-day Readmission		
	sample I	sample II	total	sample I	sample II	total
	8,352	8,351	16,703	14.4%	14.7%	14.5%
Dialysis						
no	8,274	8,265	16,539	14.2	14.5	14.4
yes 39.95, 54.98, V45.1, V56.0, V56.8	78	86	164	29.5	31.4	30.5
Gender						
male	5,853	5,773	11,626	12.7	12.7	12.7
female	2,499	2,578	5,077	18.1	19.0	18.6
Heart Failure						
no	6,972	7,025	13,997	13.2	13.3	13.2
yes 398.91, 428.0, 428.1, 428.9	1,380	1,326	2,706	20.4	22.2	21.3
Note: For those cases having one of the above heart failure codes <u>and</u> a hypertension with congestive heart failure code (402.x1, 404.x1, 404.x3) in the same record, only the hypertension code was used.						
Obesity						
none	7,568	7,530	15,098	14.3	14.5	14.4
unspecified obesity 278.00	613	624	1,237	14.2	15.1	14.6
morbid obesity 278.01	171	197	368	19.3	20.8	20.1
Peripheral Vascular Disease						
no	7,803	7,794	15,597	14.1	14.4	14.2
yes 443.0, 443.1, 443.81, 443.89, 443.9	549	557	1,106	18.0	19.4	18.7
Prior CABG and/or Valve Surgery						
no	7,897	7,863	15,760	14.3	14.6	14.4
yes V42.2, V43.3, V45.81, 414.02, 414.03, 414.04, 414.05, 996.02, 996.03..	455	488	943	14.9	16.8	15.9
PTCA/Stent (same day as CABG)						
no	8,292	8,270	16,562	14.4	14.6	14.5
yes 36.01, 36.02, 36.05, 36.06, 36.09	60	81	141	8.3	19.8	14.9
Race/Ethnicity						
Hispanic	58	54	112	13.8	16.7	15.2
white/non-Hispanic	7,052	7,132	14,184	14.4	14.6	14.5
black/non-Hispanic	272	242	514	16.9	18.2	17.5
other/unknown	970	923	1,893	13.0	14.2	13.6
Renal Failure						
none	8,221	8,233	16,454	14.2	14.6	14.4
chronic 585	67	43	110	26.9	23.3	25.5
acute (before surgery – as indicated by the hospital).............	64	75	139	18.8	25.3	22.3

Post-surgical Length of Stay - Candidate Variable Frequency and Average Length of Stay

Variable and ICD.9.CM Codes	Number of Cases (statewide)			Post-surgical Length of Stay (Arithmetic average)		
	sample I	*sample II*	*total*	*sample I*	*sample II*	*total*
	9,294	9,293	18,587	6.4	6.4	6.4
Acute Myocardial Infarction (AMI)						
no	7,238	7,270	14,508	6.2	6.3	6.3
yes (initial episode as principal diagnosis) 410.x1	2,056	2,023	4,079	6.8	6.8	6.8
***CABG* **Admission Severity Group (ASG)**						
(*tested as probability of death – a continuous variable*)						
0.000 – 0.001	0	0	0	–	–	–
0.002 – 0.011	3,362	3,312	6,674	5.3	5.3	5.3
0.012 – 0.057	5,289	5,341	10,630	6.8	6.7	6.7
0.058 – 0.499	643	640	1,283	8.7	8.9	8.8
0.500 – 1.000	0	0	0	–	–	–
Age & Age-Squared *(tested as continuous variables)*						
30-39 years	76	68	144	5.2	5.0	5.1
40-49 years	605	597	1,202	5.0	5.4	5.2
50-59 years	1,929	1,845	3,774	5.6	5.6	5.6
60-69 years	2,783	2,845	5,628	6.2	6.2	6.2
70-79 years	3,093	3,109	6,202	6.9	6.9	6.9
80-89 years	798	815	1,613	7.7	7.8	7.7
90-99 years	10	14	24	8.1	8.2	8.2
Average age: 66.1 (males 64.9; females 68.9)						
Cancer						
none	8,664	8,654	17,318	6.4	6.4	6.4
Malig. neoplasm/cancer in situ . 140.0 - 208.9, 230.0 - 234.99	153	162	315	6.3	7.0	6.7
history of cancer ....V10.00 - V10.9	477	477	954	6.1	6.0	6.0
Cardiogenic Shock						
no	9,244	9,237	18,481	6.3	6.3	6.3
yes (before surgery–using clinical info. in the medical record).	50	56	106	10.2	10.8	10.5
Cardiomyopathy						
no	9,141	9,127	18,268	6.3	6.4	6.4
yes 425.3, 425.4, 425.8, 425.9	153	166	319	7.3	7.5	7.4
Complicated Hypertension						
no	9,044	9,043	18,087	6.3	6.3	6.3
yes 402.x1, 403.x1, 404.x1, 404.x2, 404.x3, 405.xx	250	250	500	8.8	8.8	8.8
COPD						
no	7,966	7,970	15,936	6.2	6.2	6.2
yes 491.20, 491.21, 492.0, 492.8, 496, 506.4, 518.2	1,328	1,323	2,651	7.6	7.5	7.5
Diabetes						
none	6,297	6,238	12,535	6.3	6.3	6.3
diabetes without complication 250.0x	2,486	2,579	5,065	6.2	6.4	6.3
diabetes with complication ....250.1x - 250.9x	511	476	987	7.4	7.5	7.5

Post-surgical Length of Stay - Candidate Variable Frequency and Average Length of Stay

Variable and ICD.9.CM Codes	Number of Cases (statewide)			Post-surgical Length of Stay (Arithmetic average)		
	sample I	*sample II*	*total*	*sample I*	*sample II*	*total*
	9,294	9,293	18,587	6.4	6.4	6.4
Dialysis						
no	9,197	9,209	18,406	6.3	6.3	6.3
yes 39.95, 54.98, V45.1, V56.0, V56.8	97	84	181	10.1	10.4	10.2
Gender						
male	6,483	6,525	13,008	6.1	6.1	6.1
female	2,811	2,768	5,579	6.9	6.9	6.9
Heart Failure						
no	7,841	7,765	15,606	6.0	6.0	6.0
yes 398.91, 428.0, 428.1, 428.9	1,453	1,528	2,981	8.2	8.2	8.2
Note: For those cases having one of the above heart failure codes <u>and</u> a hypertension with congestive heart failure code (402.x1, 404.x1, 404.x3) in the same record, only the hypertension code was used.						
Obesity						
none	8,403	8,393	16,796	6.4	6.4	6.4
unspecified obesity 278.00	705	685	1,390	5.9	5.9	5.9
morbid obesity 278.01	186	215	401	6.7	6.6	6.6
Peripheral Vascular Disease						
no	8,695	8,649	17,344	6.4	6.3	6.4
yes 443.0, 443.1, 443.81, 443.89, 443.9	599	644	1,243	6.5	6.7	6.6
Prior CABG and/or Valve Surgery						
no	8,778	8,757	17,535	6.3	6.3	6.3
yes V42.2, V43.3, V45.81, 414.02, 414.03, 414.04, 414.05, 996.02, 996.03..	516	536	1,052	6.6	7.2	6.9
PTCA/Stent (same day as CABG)						
no	9,222	9,217	18,439	6.4	6.4	6.4
yes 36.01, 36.02, 36.05, 36.06, 36.09	72	76	148	7.7	7.1	7.4
Race/Ethnicity						
Hispanic	63	68	131	7.2	7.5	7.3
white/non-Hispanic	7,820	7,816	15,636	6.4	6.4	6.4
black/non-Hispanic	271	276	547	7.0	7.4	7.2
other/unknown	1,140	1,133	2,273	6.1	6.1	6.1
Renal Failure						
none	9,156	9,164	18,320	6.3	6.3	6.3
chronic 585	63	59	122	8.1	9.2	8.6
acute (before surgery – as indicated by the hospital).............	75	70	145	9.7	8.7	9.2

ATTACHMENT D

MediQual® Atlas Outcomes® CABG Severity Model

MediQual® Atlas Outcomes® CABG Severity Model
Definition and Description

Hospitals are required to use the MediQual® Atlas Outcomes® System to abstract patient severity information. *Atlas* Outcomes®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). It represents a summarization of patient risk based on clinical data found in the medical record. The information used covers the first two days of the hospital stay. Some pre-admission data are also captured (e.g., cardiac catheterization findings) as are some history findings. The admission severity group (ASG scores) is submitted to the Council for acute care inpatient records.

For this project, MediQual, in consultation with their Clinical Advisory Panel, designed a mortality model focusing specifically on the CABG population. This model has many similarities to other disease group models used to calculate Admission Severity Groups (ASGs) in the Atlas system, though some differences were introduced to account for the unique characteristics of this population.

Like other MediQual clinical models, the CABG model uses Key Clinical Findings (KCFs), history findings, and information from the Uniform Hospital Discharge Data Set to predict a probability of in-hospital mortality. Normally, KCFs would be included in the predictions if they were collected on the first or second day; but for this model, KCFs collected on the second day for patients receiving CABG on the first day were not included. Furthermore, new variables were defined from other Atlas data specifically for use in this model, as suggested and defined by their Clinical Advisory Panel.

The results of this model were predicted probabilities of in-hospital mortality for each of the reported patients receiving CABG in 2000. PHC4 used the probabilities of in-hospital mortality, along with other patient risk factors, to risk-adjust the hospital- and physician-specific outcomes printed in the 2000 CABG Report.

The following is a list of the risk factors used in MediQual's CABG specific model.

CABG Model Variables - Final Model

The MediQual CABG Model

Step	Var Description	Parameter Estimate	Std Error	C Stat	pValue	Odds Ratio	Lower 95% CI	Upper 95% CI
Core	Intercept	-4.334	1.397	.	0.0019			
Core	Age	-0.054	0.041	.	0.1900	0.947	0.874	1.027
Core	Age Squared	0.721	0.302	.	0.0170	2.056	1.138	3.715
Core	Female	0.439	0.079	.	<.0001	1.551	1.328	1.812
Core	PTCA/Tear Not Same Day	0.380	0.232	.	0.1013	1.462	0.928	2.303
Core	EF >50%	-0.044	0.114	.	0.7029	0.957	0.766	1.197
Core	EF <=25%	0.368	0.143	.	0.0103	1.444	1.091	1.913
Core	EF >25 <=50%	-0.097	0.104	.	0.3488	0.907	0.741	1.112
Core	0-4 CAD Vessels	-0.203	0.099	.	0.0405	0.816	0.672	0.991
Core	5-7 CAD Vessels	-0.038	0.202	.	0.8517	0.963	0.649	1.429
Core	Previous CABG	0.441	0.119	.	0.0002	1.554	1.231	1.961
Core	Left Main	0.004	0.001	.	0.0018	1.004	1.002	1.007
Core	WBC<13,000	-0.018	0.107	.	0.8691	0.983	0.797	1.211
Core	WBC>=13,000	0.311	0.140	.	0.0270	1.364	1.036	1.797
1	Valve/Septa Ops	0.957	0.087	0.7448	<.0001	2.604	2.198	3.086
2	Renal Group	0.681	0.096	0.7638	<.0001	1.976	1.637	2.386
3	PTCA/Tear Same Day	1.497	0.203	0.7706	<.0001	4.468	3.002	6.648
4	Pre-Op Mech Vent	0.041	0.009	0.7744	<.0001	1.042	1.024	1.060
5	CHF Group	0.423	0.093	0.7791	<.0001	1.526	1.272	1.831
6	AMI Other Inf Wall	0.700	0.155	0.7797	<.0001	2.014	1.487	2.728
7	Other CV Procs	0.591	0.154	0.7819	0.0001	1.806	1.335	2.443
8	MI/Oth Ant Wall	0.691	0.187	0.7829	0.0002	1.996	1.383	2.881
9	Creatinine mg/dL	0.086	0.026	0.7843	0.0009	1.089	1.035	1.146
10	COPD Group	0.278	0.094	0.7869	0.0032	1.320	1.097	1.587
11	Immunocompromised Grp	0.456	0.155	0.7882	0.0032	1.577	1.165	2.136
12	Malnutrition Group	0.413	0.143	0.7884	0.0038	1.512	1.143	2.000

Description of the model

Definition of variables contained in the model

0-4 Occluded Vessels (dichotomous variable) (KCF Codes 1301,1302,1305,1306,1308,1310, 1311)
1 =   the sum of the number of arteries with recorded occlusions > 70% is between 0 and 4
0 =   the sum of the number of arteries with recorded occlusions > 70% is not between 0 and 4 or not collected

5-7 Occluded Vessels (dichotomous variable) (KCF Codes 1301,1302,1305,1306,1308,1310, 1311)
1 =   the sum of the number of arteries with recorded occlusions > 70% is between 5 and 7
0 =   the sum of the number of arteries with recorded occlusions > 70% is not between 5 and 7

Age is a continuous (integer valued) variable that takes on the patient's age in years.

Age squared is also a continuous variable and is simply the product of age times age, divided by 1000.

AMI Other Inf Wall (dichotomous variable)
1 =   Presence of ICD9-CM code 410.41 inferoseptal MI initial episode
0 =   Absence of ICD9-CM code 410.41

Note: Other AMI sites were tested but only two were significant ("other inferior wall" and "other anterior wall").

CHF Group (group variable)
1 =   if any one of the following is found:
          KCF Effusion Respiratory (KCF Code 1321 with modifier 9441) or
          KCF Wedge Pressure >14 (KCF Code 5330) or
          KCF Ejection Fraction <41% (KCF Code 5532) or
          History of CHF (History Code 832)
          KCF Edema (KCF Code 1399)
          KCF CHF (KCF Code 1500)
          KCF Gallop (KCF Code 5524)
0 =   none of the above criteria are satisfied

COPD Group (group variable)
1 =   if any one of the following is found:
          KCF FEV1 < 66% of predicted (KCF Code 5305) or
          History of chronic lung disease (History 840)
0 =   none of the above criteria are satisfied

Creatinine is a continuous variable that takes on the value of the serum creatinine level in mg/dL. (KCF Code 3080, 3083)

EF <=25% (dichotomous variable) (KCF Code 5532)
1 =   the recorded ejection fraction is less than or equal to 25%
0 =   the recorded ejection fraction is greater than 25% or is not recorded

EF >25% <=50% (dichotomous variable) (KCF Code 5532)
1 =   the recorded ejection fraction is greater than 25% but less than or equal to 50%
0 =   the recorded ejection fraction is less than or equal to 25% or greater than 50% or is not recorded

EF >50% (dichotomous variable) (KCF Code 5532)
1 =   If the recorded ejection fraction is strictly greater than 50%
0 =   If the recorded ejection fraction is less than or equal to 50% or not recorded

Female gender (dichotomous variable)
1 =   the patient is female
0 =   the patient is male

Immunocompromised Group (group variable)
1 =   if any one of the following is found:
         HIV positive or (History Code 807)
         Immunocompromised (History Code 819) or
         Current Med Immunosuppressive (History Code 892) or
         KCF Transplant rejection (KCF Code 1554)
0 =   none of the above criteria are satisfied

Left Main is a continuous variable that takes on a value representing the percent occlusion of the left main coronary artery. (KCF Code 1308)

Malnutrition Group (group variable)
1 =   if any one of the following is found:
         KCF Serum Albumin < 3 gm/dL (KCF Code 3030,3033) or
         KCF of Severe Malnutrition (KCF Code 1043)
0 =   none of the above criteria are satisfied

MI/Oth Ant Wall (paired variable)
1 =   if both of the following are found:
         KCF MI group (CPK MB - KCF Code 3070 or MI – KCF Code 1501) is true and
         Diagnosis AMI Oth Ant Wall is true
0 =   at least one of the above criteria are satisfied

Note: Other AMI sites were tested but only two were significant ("other inferior wall" and "other anterior wall").

Other CVProcs (dichotomous variable)
1 =   36.91, 39.99 Other Operation heart vessels
         37.10 Incision Heart NOS
         37.11 Cardiotomy
         37.31 Pericardiectomy
         37.32 Excision Heart Aneurysm
         37.33 Excision Other Heart Lesion
         38.44 Resection Abd Aorta with Rep
         38.45 Resect Thor Vess w Rep
         38.46 Resect Abd Art w Rep
         39.51 Clipping of Aneurysm
         39.52 Oth Repair Aneurysm
         37.94, 37.95, 37.96, 37.97, 37.98 Implantable defibrillator
0 =   None of the above codes are present. (i.e. no other concomitant CV surgery)

Pre-op Mech Vent is a continuous variable for any patient who was placed on a mechanical ventilator pre-operatively and represents the number of hospital days that the patient remained on mechanical ventilation. (Treatment Code 9010)

Previous CABG (dichotomous variable) (History Code 831)
1 =   the patient has had prior CABG surgery
0 =   the patient has never had prior CABG surgery

PTCA/Tear SameDay (dichotomous variable)
1 =   patients who had PTCA on the same day as CABG or who had evidence of Vessel Tear (KCF Code 1390 with modifier 9455) on the same day as CABG (whether or not PTCA was coded)
0 =   absence of either of the above criteria

PTCA/Tear NotSameDay (dichotomous variable)
1 =   patients with either PTCA and/or Tear Vessel (KCF Code 1390 with modifier 9455) neither of which occurs on the day of CABG surgery
0 =   absence of the above criteria

Renal Group (group variable)
1 =   if any one of the following is found:
        BUN > 30 mg/dL or (KCF Code 3260,3263)
        Creatinine > 1.7 mg/dL or (KCF Code 3080, 3083)
        History of chronic renal failure or (History Code 833)
        Urine protein > 1 gm/24 hr (KCF Code 3800,3803)
0 =   none of the above criteria are satisfied

Valve/Septal Ops (dichotomous variable)
1 =   ICD9-CM code of 35.* (all codes in this group) includes Closed heart valvulectomy, Open heart valvuloplasty, Replacement of heart valve, Operations on structures adjacent to heart valves, ASD and VSD repair, Congenital heart defects
0 =   none of the above codes are present (i.e. no valvular or septal surgery)

WBC <13,000 (dichotomous variable) (KCF Codes 3660,3663)
1 =   the WBC is less than 13,000
0 =   the WBC is not present or greater than or equal to 13,000

WBC >= 13,000 (dichotomous variable) (KCF Codes 3660,3663)
1 =   the WBC is greater than or equal to13,000
0 =   the WBC is not present or less than 13,000