

ADULT CORONARY ARTERY BYPASS  
GRAFT SURGERY IN THE  
COMMONWEALTH OF MASSACHUSETTS

FISCAL YEAR 2010 REPORT

HOSPITAL RISK-STANDARDIZED 30-DAY MORTALITY RATES  
(OCTOBER 1, 2009 THROUGH SEPTEMBER 30, 2010)

SURGEON RISK-STANDARDIZED 30-DAY MORTALITY RATES  
(OCTOBER 1, 2007 THROUGH SEPTEMBER 30, 2010)

Massachusetts Data Analysis Center  
Department of Health Care Policy  
Harvard Medical School  
180 Longwood Avenue  
Boston, MA 02115  
[www.massdac.org](http://www.massdac.org)

February 2012

CONTRACTED BY THE MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH

---



---

**Massachusetts Data Analysis Center**

**Director**

Sharon-Lise Normand, Ph.D.

Professor of Health Care Policy (Biostatistics), Harvard Medical School

Professor, Department of Biostatistics, Harvard School of Public Health

---

**Program Staff**

---

Ann Lovett, R.N., M.A.  
Program Manager  
Harvard Medical School

Treacy Silverstein Silbaugh, B.S.  
Programmer/Analyst  
Harvard Medical School

Robert Wolf, M.S.  
Biostatistician  
Programmer/Analyst  
Harvard Medical School

Matthew Cioffi, M.S.  
Senior Data Manager/Programmer  
Harvard Medical School

Katya Zelevinsky, B.A.  
Programmer/Analyst  
Harvard Medical School

Caroline Wood, B.A.  
Project Assistant  
Harvard Medical School

Kayo Walsh, M.S.  
Mass-COMM Data Manager  
Harvard Medical School

---

**Senior Medical Advisors**

**Cardiac Surgery**

---

David Shahian, M.D.  
Research Director  
Center for Quality and Safety  
Department of Surgery  
Massachusetts General Hospital

**Interventional Cardiology**

---

Frederic Resnic, M.D.  
Director, Cardiac Catheterization Laboratory  
Brigham and Women's Hospital

Kalon Ho, M.D.  
Director of Quality Assurance  
Cardiovascular Division  
Beth Israel Deaconess Medical Center

---

---

**Massachusetts Cardiac Surgery Centers**

---

Baystate Medical Center  
759 Chestnut Street  
Springfield, MA 01199

Boston Medical Center  
1 Boston Medical Center Place  
Boston, MA 02118

Cape Cod Hospital  
27 Park Street  
Hyannis, MA 02601

Lahey Clinic  
41 Mall Road  
Burlington, MA 01805

Mount Auburn Hospital  
330 Mount Auburn Street  
Cambridge, MA 02138

Southcoast Hospital Group  
Charlton Memorial Hospital  
363 Highland Avenue  
Fall River, MA 02720

Tufts Medical Center  
800 Washington Street  
Boston, MA 02111

Beth Israel Deaconess Medical Center  
330 Brookline Avenue  
Boston, MA 02215

Brigham and Women's Hospital  
75 Francis Street  
Boston, MA 02115

Saint Elizabeth's Medical Center  
736 Cambridge Street  
Boston, MA 02135

Massachusetts General Hospital  
55 Fruit Street  
Boston, MA 02114

North Shore Medical Center  
Salem Hospital  
81 Highland Avenue  
Salem, MA 01970

Saint Vincent Hospital  
at Worcester Medical Center  
123 Summer Street  
Worcester, MA 01608

UMass Memorial Medical Center  
55 Lake Avenue North  
Worcester, MA 01655

---

## Contents

<b>1</b>	<b>Director’s Message—Massachusetts Bureau of Health Care Safety and Quality</b>	<b>1</b>
<b>2</b>	<b>Key Findings: Hospitals</b>	<b>3</b>
<b>3</b>	<b>Introduction</b>	<b>4</b>
3.1	What is in this Report? . . . . .	4
3.2	What is Coronary Artery Bypass Surgery? . . . . .	5
3.3	Definition of Study Population . . . . .	5
3.4	Why Report on CABG Surgery? . . . . .	6
3.5	What is Mass-DAC? . . . . .	7
3.6	Software Utilized in Analysis . . . . .	8
<b>4</b>	<b>Summary of Data Collection and Verification Procedures</b>	<b>9</b>
4.1	Definition of Patient Outcome . . . . .	9
4.2	Massachusetts Cardiac Surgery Programs . . . . .	9
4.3	Data Sources . . . . .	9
4.3.1	Mass-DAC STS Data . . . . .	10
4.3.2	Massachusetts Inpatient Acute Hospital Case Mix and Charge Database . . . . .	10
4.3.3	Massachusetts Mortality Index Database . . . . .	10
4.4	Mass-DAC Data Collection Procedures . . . . .	11
4.5	Cleaning and Validation Procedures . . . . .	12
4.5.1	Hospital-Specific Data Quality Reports . . . . .	12
4.5.2	Massachusetts Administrative Datasets . . . . .	13
4.5.3	Meetings and Communication . . . . .	13
4.5.4	Audit Data . . . . .	13
<b>5</b>	<b>Risk Adjustment</b>	<b>17</b>
5.1	Who Receives Isolated CABG Surgery in Massachusetts? . . . . .	17
5.2	Risk Adjustment for Assessing Hospital Mortality . . . . .	17
5.3	How are Hospital Differences in Patient Outcomes Measured? . . . . .	19
<b>6</b>	<b>Identifying Outlying Cardiac Surgery Programs</b>	<b>20</b>
6.1	Standardized Mortality Incidence Rates (SMIR) . . . . .	21
6.2	Cross-Validated P-Values . . . . .	24
6.3	Sensitivity Analyses . . . . .	25
<b>7</b>	<b>Hospital Quality Following Isolated CABG Surgery: Fiscal Year 2010</b>	<b>26</b>
<b>8</b>	<b>Annual Hospital 30-Day Mortality Trends Following Isolated CABG Surgery in Massachusetts: January 1, 2002 through September 30, 2010</b>	<b>31</b>
8.1	Key Changes in Reporting . . . . .	31
<b>9</b>	<b>Surgeon-Specific Standardized 30-Day Mortality Incidence Rates: October 1, 2007</b>	

<b>through September 30, 2010</b>	<b>34</b>
9.1 Key Findings: Surgeons . . . . .	34
9.2 What Data are Used for the Surgeon Analysis? . . . . .	36
9.3 Results . . . . .	37
<b>10 Important Definitions</b>	<b>48</b>
<b>11 Advisory Committees</b>	<b>55</b>
<b>A Appendix: Procedure Identification Guidelines for Adult Cardiac Surgery</b>	<b>61</b>
<b>B Appendix: STS Data Abstraction Tool – Version 2.61</b>	<b>62</b>
<b>Bibliography</b>	<b>72</b>

## List of Tables

3.1	Surgical Procedure Type Classification of Adult Cardiac Surgeries: Oct 1, 2009–Sep 30, 2010 . . . . .	7
4.1	Cardiac Surgery Data Harvest Schedule for Surgeries Performed: Oct 1, 2009–Sep 30, 2010 . . . . .	12
4.2	Summary of Census Variable and Procedure Adjudication . . . . .	16
5.1	Demographic Distribution for All Adult Isolated CABG Surgery Admissions ( $N = 3,171$ ) in Massachusetts Hospitals: Oct 1, 2009–Sep 30, 2010. . . . .	18
7.1	Prevalences and Relative Risks of 30-Day Mortality Following Isolated CABG Surgery in Adults: Oct 1, 2009–Sep 30, 2010. Based on 3,169 surgeries with 39 deaths (1.23%). . . . .	27
8.1	Summary of Isolated CABG Admissions and 30-Day Crude Mortality Percentages CY 2002 through FY 2010 . . . . .	33
9.1	Surgeon-Specific Demographic Distribution for All Adult Isolated CABG Surgery Admissions ( $N = 9,792$ ) in Massachusetts Hospitals: Oct 1, 2007–Sep 30, 2010. Entries represent numbers of isolated CABG surgery admissions and include all patients, including those with shock, emergent status, and emergent salvage status. . . . .	39
9.2	Surgeon-Specific Prevalences and Adjusted Relative Risks of 30-Day Mortality Following Isolated CABG Surgery in Adults: Oct 1, 2007–Sep 30, 2010 . . . . .	40
9.3	Surgeon-Specific Standardized 30-Day All Cause Mortality Incidence Rates (SMIRs): Oct 1, 2007–Sep 30, 2010 . . . . .	44

## List of Figures

7.1	Ninety-Five Percent Posterior Intervals for Standardized 30-Day Mortality Incidence Rates (SMIRs): Oct 1, 2009–Sep 30, 2010 . . . . .	28
7.2	Cross-Validated P-Values: Isolated Cardiac Surgery Admissions: Oct 1, 2009–Sep 30, 2010. . . . .	29
7.3	ROC Curve-Hierarchical: Isolated CABG Cohort . . . . .	30
9.1	Surgeon-Specific Isolated CABG Surgery Analysis: Oct 1, 2007–Sep 30, 2010 . . . . .	38
9.2	Surgeon-Specific 95% Posterior Intervals for Standardized 30-Day Mortality Incidence Rates (SMIRs): Oct 1, 2007–Sep 30, 2010 (Part 1 of 2) . . . . .	41
9.3	Surgeon-Specific 95% Posterior Intervals for Standardized 30-Day Mortality Incidence Rates (SMIRs): Oct 1, 2007–Sep 30, 2010 (Part 2 of 2) . . . . .	42
9.4	Surgeon-Specific ROC Curve-Hierarchical: Isolated CABG Cohort . . . . .	43

# **1 A Message from the Director of the Massachusetts Bureau of Health Care Safety and Quality**

This is the ninth in a series of reports summarizing the quality of care provided by the 14 state licensed cardiac surgery programs in the Commonwealth. The report is contracted by the Bureau of Health Care Safety and Quality in the Massachusetts Department of Public Health. The provision of these data is part of a broad, statewide initiative to increase accessibility of health care data to consumers, policy makers, and providers. This report is meant to give residents information about the relative performance of cardiac surgery programs as an aid to decision making, and to provide hospitals in the Commonwealth with key information to help drive quality improvement.

This report contains analysis of data on 3,171 hospital admissions in which an isolated coronary artery bypass graft (CABG) surgery was performed during the period October 1, 2009 through September 30, 2010, as well as an analysis of 9,792 hospital CABG admissions by 62 surgeons for the period October 1, 2007 through September 30, 2010. After issuance of this report, Mass-DAC and the Department of Public Health will no longer publicly report on surgeon-specific mortality rates, to reduce duplication of effort and to be consistent with the Massachusetts reporting for interventional cardiologists performing percutaneous coronary interventions (PCI). Similar information is available from the Society of Thoracic Surgeons' national database. Data on individual cardiac surgeons and PCI operators will continue to be collected and analyzed. After review by a committee of content experts, information about providers who have higher than expected mortality rates *and for whom there are serious concerns about the quality of care that is provided* will be shared with the leadership of the hospital department in which that provider operates, as well as the Board of Registration in Medicine, the licensing body for physicians. The Department will continue to collect, monitor, and validate patient-specific outcome data from all hospitals that perform cardiac surgery or PCI.



The data collection, verification, audit, and analytical procedures implemented in this report constitute the most comprehensive, reliable, and rigorous used in the United States. This is due in no small part to the dedicated work of the hospital data managers and cardiac surgeons, many of whom volunteered their efforts to participate in many late night meetings to review and adjudicate data. I would also like to thank staff from the Board of Registration in Medicine and the Massachusetts Chapter of the Society of Thoracic Surgeons for their ongoing support, and of course, all the staff at Massachusetts Data Analysis Center (Mass-DAC) for their hard work and dedication.

Madeleine Biondolillo, M.D.  
Director  
Bureau of Health Care Safety and Quality  
Massachusetts Department of Public Health

## 2 Key Findings: Hospitals

- In the period October 1, 2009 through September 30, 2010 (Fiscal Year 2010), there were 6,828 hospital admissions in Massachusetts in which at least one cardiac surgery was performed. Almost one half (46.4%) of the admissions involved isolated coronary artery bypass graft (CABG) surgery.
- In the 14 hospitals that performed cardiac surgery during Fiscal Year 2010, the number of isolated CABG surgery admissions ranged from 98 to 394.
- The unadjusted 30-day all-cause mortality rate (defined as the number of patients dying within 30 days of surgery from any cause divided by the number of isolated CABG surgery admissions) in Massachusetts during Fiscal Year 2010 was 1.23%. This corresponded to 39 deaths out of 3,169<sup>1</sup> isolated CABG admissions.
- After adjusting for patient risk, the risk of 30-day mortality in a hospital one standard deviation above the state average was 1.68 times that of a hospital one standard deviation below the state average.
- **In Fiscal Year 2010, no hospital was identified as a statistical outlier for isolated coronary artery bypass surgery.**

---

<sup>1</sup>Two patients had a second isolated CABG surgery within 30 days of the first isolated CABG surgery. Analysis was done on the first isolated CABG surgery and as a result, each of the second surgeries were removed from the cohort.

## 3 Introduction

### 3.1 What is in this Report?

This report describes procedures for calculating (1) hospital-specific risk-standardized 30-day mortality rates following isolated CABG surgery performed in Massachusetts hospitals in the period October 1, 2009 through September 30, 2010 (Fiscal Year 2010) and (2) surgeon-specific risk-standardized mortality rates for isolated CABG surgeries performed from October 1, 2007 through September 30, 2010. Surgeries performed in federal hospitals (e.g., VA Boston Health-care System–Jamaica Plain Campus) are not included in this report. Information pertains to patients who were 18 years of age or older at the time of surgery.

Not all hospitals in Massachusetts are permitted to perform cardiac surgery. Hospitals wishing to establish a new cardiac surgery program must submit an application to the Determination of Need Program in the Massachusetts Department of Public Health. In Fiscal Year 2010, there were 14 cardiac surgery programs in Massachusetts, each of which submitted data to Mass-DAC.

This document is the ninth report ([www.massdac.org/reports/surgery.html](http://www.massdac.org/reports/surgery.html)) describing hospital-specific risk-standardized mortality rates following isolated CABG surgery in Massachusetts. It describes risk-standardized mortality rates for the 14 cardiac surgery programs in Massachusetts that performed at least one isolated CABG surgery during October 1, 2009 through September 30, 2010. This document also includes the seventh report of surgeon-specific risk-standardized 30-day mortality rates. The surgeon specific rates are based on isolated CABG surgery admissions performed in the period October 1, 2007 through September 30, 2010.

### **3.2 What is Coronary Artery Bypass Surgery?**

For a heart to function properly, it needs an oxygen-rich blood supply. Coronary arteries send oxygen-rich blood to the heart. When the coronary arteries are healthy, blood flows easily so that the heart muscle gets the oxygen it needs. Coronary artery disease begins when blood flow to the heart is reduced due to a build-up of plaque. Plaque may build up because of high cholesterol, high blood pressure, smoking, diabetes, genetic predisposition, or other factors. As the plaque build-up increases, the coronary arteries narrow and blood flow to the heart is reduced, often leading to angina (chest pain, arm pain, or jaw tightness that occurs with exertion, or in more serious cases, at rest). If blood flow is completely blocked by the sudden development of a clot within a coronary artery, the presence of the clot usually results in a heart attack or myocardial infarction (MI), which may irreversibly damage the heart muscle.

Coronary artery disease is usually treated by one of three methods: medication, coronary intervention, or cardiac surgery. The choice of treatment depends on the degree of blockage, patient symptoms, and the number of coronary arteries involved. CABG surgery is a type of cardiac surgery that creates a new route or bypass around the blocked part of the artery, allowing the blood flow to reach the heart muscle again. During CABG surgery, the blocked coronary arteries are bypassed using some of the patient's own blood vessels. The internal mammary arteries are commonly used for the bypass, but the saphenous vein in the leg or the radial artery in the arm can also be used. Surgical procedures in which CABG surgery is the only major heart surgery performed are referred to as isolated CABG procedures.

### **3.3 Definition of Study Population**

The patient population includes all patients aged 18 years or older undergoing isolated CABG surgery in Massachusetts adult acute care non-federal hospitals in the period October 1, 2009

through September 30, 2010. If multiple cardiac surgeries occur during an admission, admissions are categorized by the primary (initial) surgery. Isolated CABG surgery includes CABG alone as well as CABG undertaken in combination with the following procedures: maze (closed epicardial approach and radio frequency), pacemaker lead insertions, ventricular lead insertion for automatic implantable cardioverter defibrillator, patent foramen ovale closure, and femoral artery procedures. If CABG is performed in combination with maze (open heart approach), implantation of a cardioverter defibrillator, transmyocardial revascularization, or opening of the right atrium for tumor resection, then these surgeries are classified as “Other Cardiac Surgery.” Lung biopsies performed in conjunction with a CABG are considered on a case by case basis (see Appendix A, pg. 61). Table 3.1 lists the distribution of the 6,828 cardiac surgery admissions stratified by surgical procedure type in Massachusetts hospitals during Fiscal Year 2010. Two patients among the 3,171 admissions had a second isolated CABG surgery within 30 days of the first isolated CABG surgery. Analysis was done on the first isolated CABG surgery and as a result, each of the second surgeries were removed from the cohort.

### **3.4 Why Report on CABG Surgery?**

CABG surgeries are costly procedures that account for the majority of cardiac surgeries performed nationally. In Fiscal Year 2010, isolated CABG surgeries accounted for almost half (46.4%) of all cardiac surgery hospital admissions in Massachusetts. Only data on patients who have undergone isolated CABG surgery are used to determine the mortality rates in this report.

### 3.5 What is Mass-DAC?

Mass-DAC is a data-coordinating center responsible to the Massachusetts Department of Public Health for the collection, storage, cleaning, and analysis of the cardiac data submitted by Massachusetts hospitals. Mass-DAC is located in the Department of Health Care Policy within Harvard Medical School in Boston ([www.massdac.org](http://www.massdac.org)). Mass-DAC is advised by several committees on an ongoing basis, including the Massachusetts Cardiac Care Hospital Outlier Committee, the Cardiac Surgery Physician Reporting Committee, and the Cardiac Surgery Data Adjudication Committee. In addition, the National Society of Thoracic Surgeons (STS) and the Massachusetts STS serve as resources.

**Table 3.1:** *Surgical Procedure Type Classification of Adult Cardiac Surgeries:  
Oct 1, 2009–Sep 30, 2010*

<b>Surgical Procedure Type</b>	<b>No. of Cardiac Surgery Admissions</b>	<b>% of Cardiac Surgery Admissions</b>
<b>Isolated CABG</b>	<b>3,171</b>	<b>46.44</b>
Mitral Valve Replacement (MVR)	142	2.08
Aortic Valve Replacement (AVR)	862	12.62
MVR and CABG	54	0.79
AVR and CABG	579	8.48
AVR and MVR	40	0.59
Other Cardiac Surgery	1,949	28.54
Non–Cardiac (Thoracic) Procedures	31	0.45
<b>All Cardiac Surgery Admissions</b>	<b>6,828</b>	<b>100.00</b>

### 3.6 Software Utilized in Analysis

The data collection and analysis for this report utilized three different statistical software applications;

- SAS<sup>®</sup>, version 9.2 Unix/Windows [6],
- WinBUGS version 1.4 [11],
- R version 2.6.1 [5].

The data collection process utilized Base SAS to aggregate the core data elements for the analytic data sets. The statistical analysis used a combination of SAS/Stat, WinBugs, and R, to generate the results in this report. SAS Institute Inc. and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA.

## 4 Summary of Data Collection and Verification Procedures

### 4.1 Definition of Patient Outcome

Mortality, regardless of cause and measured within 30 days of the date of CABG surgery, is the primary patient outcome. Mortality was selected as the primary measure of quality because it is serious and unambiguous.

### 4.2 Massachusetts Cardiac Surgery Programs

Fourteen cardiac surgery centers treated patients in Massachusetts in the period October 1, 2009 through September 30, 2010.

### 4.3 Data Sources

Four different data sources were used to create this report:

- The Mass-DAC cardiac surgery patient-specific data collected using the Society of Thoracic Surgeons (STS) National Cardiac Surgery data collection tool [8, 9];
- hospital administrative discharge billing data [2];
- vital statistics information provided by the Massachusetts Department of Public Health [3];  
and
- the Mass-DAC PCI procedures database with data collected using the American College of Cardiology – National Cardiovascular Data Registry (ACC-NCDR<sup>®</sup>) (CathPCI Registry<sup>®</sup>) data collection tool [1].



### **4.3.1 Mass-DAC STS Data**

Patient-specific risk factor and outcome data were collected by hospital personnel using the STS National Cardiac Surgery data collection tool. Version 2.61 of the STS collection tool (see Appendix B), containing 349 variables, was used for all data submissions for surgeries performed in Fiscal Year 2010.

### **4.3.2 Massachusetts Inpatient Acute Hospital Case Mix and Charge Database**

Hospital discharge data for Fiscal Years 2002 through 2010 (October 1, 2001 through September 30, 2010) were obtained from the Massachusetts Division of Health Care Finance and Policy. Data elements include hospital identifier, sex, race, age, patient's zip code, up to 15 diagnoses and up to 15 procedure codes, discharge status, dates of admission and discharge, date of surgery, and patient medical record number. Social Security numbers were removed from this database. Data were used for validation of surgery volume.

### **4.3.3 Massachusetts Mortality Index Database**

Death date information obtained from Massachusetts Registry of Vital Records and Statistics was available for deaths occurring in Massachusetts between January 1, 2002, and October 30, 2010. While the primary source of 30-day mortality was the hospital-reported information, the mortality index database was employed as a verification tool. Using a confidential and secure transmission procedure, Mass-DAC submitted to the Registry patient names, dates of birth, and Social Security numbers for all Mass-DAC patients, regardless of hospital-reported survival status. Registry personnel subsequently linked the data submitted by Mass-DAC to the Registry mortality index database using these variables and supplied Mass-DAC with the date of death for all applicable patients.

Some hospitals reported 30-day mortalities that could not be verified using the Massachusetts Mortality Index Database. For these unverified mortalities, an individual search process was utilized to verify deaths using the Social Security Administration's Death Master File [7] available through GenealogyBank.com [4].

#### **4.4 Mass-DAC Data Collection Procedures**

The majority of Massachusetts hospitals used clinical staff, such as physicians, nurses, and perfusionists, to collect information. Data were entered directly into the STS vendor software database by the clinical staff or by a data manager. Alternatively, the data manager collected the STS information under the direction of clinical staff and then entered the data following a retrospective chart review. Data managers were also responsible for maintaining their hospital database, ensuring the accuracy of the data, and transmitting data to both the STS and Mass-DAC.

Data were regularly transmitted by hospitals and harvested by Mass-DAC (Table 4.1). This process involved submitting protected data during specific harvest periods. Hospitals encrypted and password-protected the data, and transmitted it electronically using a secure repository on a secure website. Hospitals submitted subsequent corrected data as often as desired during the three months following a harvest, and they could sign off on its accuracy and completeness at any time during that period. However, all Fiscal Year 2010 cardiac surgery data were required to be complete by April 1, 2011, after which no changes were accepted without written permission from Mass-DAC.

**Table 4.1:** *Cardiac Surgery Data Harvest Schedule for Surgeries Performed:  
Oct 1, 2009–Sep 30, 2010*

Harvest Month	Corresponding Dates of Cardiac Surgery
March 2010	October 1, 2009 through December 31, 2009
June 2010	January 1, 2010 through March 31, 2010
September 2010	April 1, 2010 through June 30, 2010
December 2010	July 1, 2010 through September 30, 2010
April 2011	Final close out date for Fiscal Year 2010 data

## 4.5 Cleaning and Validation Procedures

Hospital data submissions were cleaned and verified using a variety of procedures, including continuous feedback via ongoing data quality reports, meetings and communication, and reviews of concordance with administrative datasets and medical chart audits.

### 4.5.1 Hospital-Specific Data Quality Reports

For each data submission, Mass-DAC provided a data quality report to each hospital describing the distribution of all STS variables and identifying cases with missing, out of usual range, or inconsistent coding. The hospitals were given 30 days to correct the data deficiencies identified by Mass-DAC following receipt of each data quality report. There were a total of 134 data submissions sent by 14 hospitals during Fiscal Year 2010 with a mean of 2.4 submissions per hospital per collection period. Data submissions for Fiscal Year 2010 ranged from 1 to 5 per hospital per collection period.

#### **4.5.2 Massachusetts Administrative Datasets**

Mass-DAC found high agreement between the hospital report of 30-day mortality and information linked to vital records. After verifying the mortality status of these patients, three cases were changed to 30-day mortalities, one of which was an isolated CABG patient. The Massachusetts Inpatient Case Mix Dataset was used as an additional method in determining whether all appropriate cases of cardiac surgery from each institution were submitted to Mass-DAC. Three cases were found in the case mix data that had not been submitted to the Mass-DAC database. The three cases were confirmed with each hospital, the data submitted, and included in the Mass-DAC database. Only one case of the three was an isolated CABG.

#### **4.5.3 Meetings and Communication**

Mass-DAC communicated regularly via email and telephone with the data managers to clarify definitions or procedural issues, resolve data submission concerns, and to serve as a facilitator to the national STS. Data managers were given the opportunity to ask and discuss questions at data manager meetings or through an email network. Preliminary results were shared at the Massachusetts STS meeting and at Mass-DAC Data Manager meetings. This process helped identify areas where data may be inconsistent, incorrectly coded, or outlying.

#### **4.5.4 Audit Data**

In the spring and again in the fall of 2011, a sample of the Fiscal Year 2010 isolated CABG data was audited. Fourteen cardiac surgeons and four data managers, representing 10 of the 14 cardiac surgery programs, volunteered for the Adjudication Committee to perform audits. All participants underwent mandatory human subjects training prior to participating and were

approved by the Harvard Medical School Institutional Review Board. Records requested from the hospitals included those for:

1. All Coronary Artery Bypass Graft (CABG), Aortic Valve Replacement (AVR), or Mitral Valve Replacement (MVR) patients coded as a death within 30 days of surgery;
2. Those admissions coded as having an “other” cardiac procedure in combination with one of the following: CABG, AVR, or MVR (to determine if those should have been coded as a CABG, AVR, or MVR) that resulted in death within 30 days of surgery;
3. All CABG, AVR, or MVR patients coded as having shock prior to surgery;
4. All CABG, AVR, or MVR patients coded with emergent or emergent salvage status;
5. All CABG, AVR, or MVR patients coded as having a myocardial infarction (MI) less than 24 hours prior to surgery;
6. A sample of CABG, AVR, or MVR patients coded as having dialysis prior to surgery; and
7. A sample of CABG, AVR, or MVR patients coded as having peripheral vascular disease (PVD) prior to surgery.

For the variable audit, **354** records were requested from the 14 hospitals. The records were reviewed to determine data consistency and accuracy of coding.

An additional **302** records were requested for a subset of surgery admissions having *CABG + other* or *valve + other* surgery (see Appendix A, pg. 61, Procedure Identification Guidelines for Adult Cardiac Surgery, which outlines the rules used by Mass-DAC for classifying surgeries as isolated CABG versus *CABG + other*). These records were reviewed to determine if some might be considered isolated CABG surgery or isolated valve surgery. Documentation requested from the hospitals included discharge summaries, operative reports, anesthesia records, admission and history summaries, and catheterization reports. Records that were reviewed and identified by

the auditors to be isolated CABG procedures were then also reviewed for the variables of shock, emergent or emergent salvage status, MI within 24 hours of surgery, dialysis, and PVD.

In all, **656** records were reviewed by the Adjudication Committee to determine agreement with the information submitted by the hospitals. If the Adjudication Committee did not agree with the coding of the presence of shock, emergent status, emergent salvage status, or MI less than 24 hours before surgery, the coding was changed. Hospitals were notified of any disagreement in coding and given an opportunity to appeal the Adjudication Committee decisions. All changes made by the Adjudication Committee for the census (100% audited) variables were then made in the Mass-DAC database. Because the Adjudication Committee did not review every case coded with PVD or dialysis, Mass-DAC did not make any changes to the submitted values for those variables in the database, regardless of the Adjudication Committee decisions.

Table 4.2 summarizes changes that were made. For example, 58% of admissions coded as having shock, 11% of admissions coded as emergent, and 36% of admissions coded as *CABG + other* were changed.

**Table 4.2:** Summary of Census Variable and Procedure Adjudication

<b>Risk Factor</b>	<b>Total Reviewed</b>	<b>Final Adjudicated Status</b>	<b>Number</b>
Shock	36	Shock (no change)	15
		No Shock	21
Emergent	87	Elective	0
		Urgent	10
		Emergent (no change)	77
		Emergent Salvage	0
Emergent Salvage	<sup>a</sup>	Elective	0
		Urgent	0
		Emergent	<sup>a</sup>
		Emergent Salvage (no change)	<sup>a</sup>
MI within 24 hours of surgery	86	No MI	<sup>a</sup>
		MI <24 hours (no change)	79
		MI ≥24 hours	<sup>a</sup>
CABG + <i>other</i>	174	Isolated CABG	62
		CABG + <i>other</i> (no change)	112
Valve + <i>other</i>	128	Isolated Valve	42
		Valve + <i>other</i> (no change)	86

<sup>a</sup>Frequencies from 1 to 7 suppressed as required by the Massachusetts Department of Public Health data security guidelines.

## 5 Risk Adjustment

### 5.1 Who Receives Isolated CABG Surgery in Massachusetts?

Table 5.1 on page 18 lists the age/sex/race distribution for 3,171 adult isolated CABG surgery patients at 14 cardiac surgery programs in Massachusetts. The STS method for collecting information on race changed on January 1, 2008 with Version 2.61 (see Appendix B). Version 2.61 allows patients to select more than one race; in addition, Hispanic is an ethnicity choice and is separate from the race designations. The majority of patients were male (77.3%). In Fiscal Year 2010, 55.8% of the admissions corresponded to patients aged 65 years of age or older at the time of surgery. Patients who resided outside of Massachusetts at the time of surgery comprised 8.5% of the 3,171 CABG admissions (data not shown).

### 5.2 Risk Adjustment for Assessing Hospital Mortality

Specific **risk** factors are known to contribute to heart disease. These risk factors include high cholesterol, smoking, high blood pressure, family history of heart disease, diabetes, age, gender, and general health status. Such factors have an impact on the risk of mortality following CABG surgery. Such factors also have an impact on the risk of mortality following surgery. Sicker patients or patients with more health-related risks may be more likely to die following a CABG surgery than healthier patients. Moreover, patients who are sicker may be more likely to be treated at particular hospitals while patients who are healthier may be more likely to be treated at other hospitals. To fairly assess hospitals and avoid penalizing hospitals that treat sicker patients, it is important to consider differences in a patient's health prior to surgery. Mass-DAC selects risk factors for the annual report based on advice obtained from its Senior Medical Advisors, Mass-DAC surgeon committees, as well as the Massachusetts STS.



**Table 5.1:** Demographic Distribution for All Adult Isolated CABG Surgery Admissions (N = 3,171) in Massachusetts Hospitals: Oct 1, 2009–Sep 30, 2010.

Age Group	Total by Age	Age 65	White	African American	Other Race	Ethnicity Hispanic
<b>Male</b>						
18–44	50	≤64	1,059	30	69	53
45–54	347					
55–64	757					
65–74	776	≥65	1,226	17	59	33
≥75	522					
<b>Total</b>	<b>2,452</b>		<b>2,285</b>	<b>47</b>	<b>128</b>	<b>86</b>
<b>Female</b>						
18–44	17	≤64	216	11	20	14
45–54	62					
55–64	167					
65–74	238	≥65	432	17	26	18
≥75	235					
<b>Total</b>	<b>719</b>		<b>648</b>	<b>28</b>	<b>46</b>	<b>32</b>
<b>Total Male and Female</b>						
18–44	67	≤64	1,275	41	89	67
45–54	409					
55–64	924					
65–74	1,014	≥65	1,658	34	85	51
≥75	757					
<b>Total</b>	<b>3,171</b>		<b>2,933</b>	<b>75</b>	<b>174</b>	<b>118</b>

Patients may select more than one race category. The Ethnicity Hispanic category is independent of the race categories and may be selected in addition to a Race.

The statistical process of accounting for differences in patient sickness prior to surgery is called risk adjustment. This statistical process aims to “level the playing field” by accounting for health risks that patients have prior to surgery. The hospital-specific 30-day mortality rates in this report have been adjusted in order to account for patient health prior to surgery. The numbers reported compare each hospital’s mortality rate to what would be expected to happen given the health of patients undergoing surgery in its program. The numbers are not designed to provide

comparisons between pairs of hospitals—such comparisons would only be valid to the extent that the pairs of hospitals treated patients with very similar health status prior to surgery.

### **5.3 How are Hospital Differences in Patient Outcomes Measured?**

If there are differences in hospital quality, due to staff, experience, or other factors, then the risks of 30-day mortality for two patients having exactly the same risk factors prior to a CABG surgery but who are treated in different hospitals should be different. The statistical model used to calculate mortality rates in this report, a hierarchical Poisson regression model, permits a difference to exist between the risks of mortality for patients with the same risk factors treated at different hospitals. This is accomplished by including a hospital-specific (random) effect. If no key risk factor that varies by hospital is missing in the statistical model, then the hospital-specific random effect represents quality for each hospital. If there are no differences in the hospital-specific effects across the hospitals, then there is no evidence of quality differences.

## 6 Identifying Outlying Cardiac Surgery Programs

One of the purposes of this report is to identify hospitals that have unusually high or unusually low mortality rates. Such hospitals are denoted as “outlying”—however, the designation of outlying depends on how large the difference is. Two methods are used to identify outlying hospitals. The first method calculates a 95% interval estimate for each hospital’s risk-standardized mortality rate. If the interval estimate excludes the Massachusetts unadjusted 30-day mortality rate, the hospital is designated as “outlying”.

Because any one hospital could influence the estimates of the risk-standardized mortality rate for other hospitals, Mass-DAC also calculates the expected number of mortalities at each hospital using the experience of all other hospitals in Massachusetts. If it is *unlikely* that the actual number of mortalities observed at a hospital and the number of mortalities predicted using the combined experience of all Massachusetts hospitals except the hospital under study is the same, then the hospital is classified as “outlying”. We refer to the measure of the likelihood of this event as a cross-validated p-value. Intuitively, this strategy provides a quantitative measure of how likely the hospital’s outcome is compared to its peers.

If the 95% interval estimate for a particular hospital excludes the Massachusetts unadjusted 30-day mortality rate or if the probability of the observed mortality predicted from all other hospitals for a particular hospital is small, then the hospital is designated as outlying. It is important to note that the classification in this report is relative to all hospitals in Massachusetts performing isolated CABG surgery. For example, a Massachusetts hospital identified as having higher (or lower) than expected mortality based on our analysis may not be classified as having higher (or lower) than expected mortality compared to hospitals outside of Massachusetts.

## 6.1 Standardized Mortality Incidence Rates (SMIR)

Mass-DAC calculated a standardized mortality incidence rate (SMIR) and a corresponding 95% posterior interval for each hospital. The SMIR is interpreted as the projected mortality rate at the hospital today if hospital quality remained the same as in Fiscal Year 2010. The SMIR consists of an estimate of the hospital's underlying (true) risk-adjusted rate divided by an estimate of the mortality rate expected at the hospital given its case mix. Each hospital's SMIR should only be interpreted in the context of its posterior interval. If the 95% interval includes the unadjusted Massachusetts mortality rate, then the hospital mortality is not different than expected. If the interval excludes the Massachusetts unadjusted rate, then the hospital is an outlier. In this case, if the upper limit of the interval is lower than the unadjusted Massachusetts rate, then fewer patients than expected died. Such a hospital would be categorized as having lower than expected mortality. If the lower limit of the interval is higher than the Massachusetts unadjusted rate, then more patients than expected died. Such a hospital would be categorized as having higher than expected mortality.

Hospital-specific 30-day mortality rates, standardized to the population of adults undergoing isolated CABG surgery in Massachusetts hospitals, were calculated using the following procedure:

1. A hierarchical Poisson regression model was estimated that assumes the log of 30-day mortality is related linearly to the set of risk factors and permits baseline risk to vary across hospitals. Let  $Y_{ij} = 1$  if the  $j^{\text{th}}$  patient treated at the  $i^{\text{th}}$  CABG hospital died within 30 days of CABG surgery and 0 otherwise, and let  $n_i$  equal the total number of CABG surgery admissions at the hospital. The model estimated had the general form:

$$\text{Log}[Probability(Y_{ij} = 1)] = \beta_{0i} + \beta(\text{Risk Factors})_{ij} \quad (1)$$

$$\text{where } \beta_{0i} \sim \text{Normal}(\mu, \tau^2) \quad (2)$$

The parameters,  $\mu$  and  $\tau^2$  represent the overall mean risk-adjusted log of mortality and between-hospital variation, respectively. If there are no mortality differences based on 30-day mortality across the 14 CABG surgery hospitals after adjusting for patient risk, then

$$\beta_{0,1} = \beta_{0,2} = \dots = \beta_{0,14} = \beta_0 \quad \text{and this happens if and only if } \tau^2 = 0 \quad (3)$$

The hierarchical regression models were estimated using WinBUGS software. The prior distributions assumed for  $\beta$ ,  $\mu$ , and  $\tau^2$  were, respectively: independent normal distributions with mean 0 and variance 1,000 for the components of  $\beta$ ;  $\mu$  from a normal distribution with mean 0 and variance 1,000. We assumed that between-hospital standard deviation,  $\tau$ , arose from a half normal distribution with mean 0 and variance 0.26. This half normal distribution has its mode at 0, permitting no differences in between-hospital log-odds of mortality, but has a median of 0.39, permitting the range in the log-odds of 30-day mortality to be as large as 5. We vary these parameters as part of a sensitivity analysis. The hierarchical Poisson regression models were estimated using the WinBUGS software. A burn-in of 100,000 draws was used and conclusions were based on an additional 5,000 draws. Convergence of the model was assessed using the Gelman-Rubin statistic via three parallel chains.

2. The risk factors are those listed in Table 7.1. The term  $\beta$  describes the association of each risk factor and log(30-day mortality). Large values of  $\beta$  indicate that patients with the particular risk factor are at higher risk of dying compared to patients without the risk factor.

3. The *expected* mortality rate at hospital  $i$ ,  $\pi_i$ , is:

$$\pi_i = \frac{\sum_{j=1}^{n_i} \exp[\mu + \beta(\text{Risk Factors})_{ij}]}{n_i} \quad (4)$$

This is the mortality rate expected at hospital  $i$  using the mortality intensity for the entire state,  $\beta$ , and the case mix reported at the hospital,  $(\text{Risk Factors})_{ij}$ . Thus, it represents the severity of cases at the institution.

4. The *observed* mortality rate at hospital  $i$ ,  $p_i$ , is:

$$p_i = \frac{\sum_{j=1}^{n_i} \exp[\beta_{0i} + \beta(\text{Risk Factors})_{ij}]}{n_i} \quad (5)$$

This is interpreted as the mortality rate at the  $i^{\text{th}}$  hospital adjusted for case mix. This mortality rate is not the actual observed rate but rather a *smoothed* rate. The estimate weights the observed mortality rate by the amount of information available at the hospital relative to the amount of information available between hospitals. Because the model assumes that the probability of dying is greater than 0, the smoothed estimate must be greater than 0.

5. The Massachusetts unadjusted 30-day mortality rate is:

$$\bar{Y} = 100 \times \frac{\sum_{ij} Y_{ij}}{\sum_i n_i} \quad (6)$$

6. The standardized mortality incidence rate (SMIR) at institution  $i$  is:

$$\text{SMIR}_i = \bar{Y} \times \frac{p_i}{\pi_i} \quad (7)$$

The SMIR is interpreted as the projected mortality rate at the hospital today if hospital quality remained the same as in Fiscal Year 2010.

7. Ninety-five percent posterior intervals were calculated for each hospital's SMIR.

## 6.2 Cross-Validated P-Values

Because data from all hospitals are used to estimate the expected number of deaths in any hospital, there is a risk that outlying hospitals may influence the estimates of  $\mu$  and, in particular,  $\tau^2$ . One method to avoid this risk involves identifying hospitals as outlying through “cross-validation”. This process involves systematically dropping each hospital from the data set and re-estimating the risk-adjusted model. Using the new model, the predicted number of deaths at the dropped hospital is calculated. This predicted number may be interpreted as the number of mortalities expected at the dropped hospital if the dropped hospital had the same level of quality as the *remaining* Massachusetts hospitals.

Mass-DAC compared the predicted number of deaths to the actual number of deaths at the dropped hospital and calculated a posterior *probability*. This probability, loosely called a posterior “p-value,” quantifies how likely the observed number of deaths would be if the dropped hospital had the same level of quality as all remaining isolated CABG hospitals. Small p-values (those  $\leq 0.01$ ) indicate that the dropped hospital is outlying. When the p-value is small and the actual number of deaths is larger than that predicted by the remaining hospitals, the dropped hospital is classified as having higher than predicted mortality. When the p-value is small and the actual number of deaths is smaller than predicted by its peers, then the hospital is classified as having lower than predicted mortality. Mass-DAC eliminated each isolated CABG hospital from the data set, re-estimated the regression parameters, predicted mortality at the eliminated hospital, and calculated a posterior probability of the comparison of the observed mortality and the predicted mortality. The eliminated hospital was replaced into the data set, and Mass-DAC eliminated another hospital from the data set, repeating the entire process.

### 6.3 Sensitivity Analyses

Several sensitivity analyses were undertaken to determine whether conclusions would change when making reasonable changes to some of the underlying assumptions. A key assumption, given the small number of hospitals in Massachusetts, is the assumed distribution for the between-hospital variance. The parameter  $\tau$  represents the standard deviation of the hospital-specific risk-adjusted log(mortality) and  $\tau^2$  represents between-hospital variance. The main analyses assumed that  $\tau$  arose from a half normal distribution with mean 0 and variance 0.26. Mass-DAC re-estimated the hierarchical model using different prior distributions for  $\tau^2$  to determine how sensitive results are to the assumed prior distribution of the variance component.

1. We assumed that the between-hospital standard deviation arose from a uniform distribution over the range 0 to 1.5. This translates to assuming that small values in between-hospital heterogeneity are just as likely as large values.
2. We assumed a vague prior distribution for the precision,  $\frac{1}{\tau^2}$ . Specifically, we assumed the precision parameter arose from a highly dispersed Gamma distribution having scale parameter 0.001 and rate parameter 0.001.



## 7 Hospital Quality Following Isolated CABG Surgery: Fiscal Year 2010

Of the 3,169<sup>2</sup> isolated CABG surgery admissions in Fiscal Year 2010 in Massachusetts, 39 patients (1.23%) died within 30 days of their surgery. Table 7.1 lists the prevalence (as a percentage) of important risk factors and the relationship of each risk factor (controlling for all other risk factors) to 30-day mortality following surgery. For example, 1.55% of the 3,169 isolated CABG surgery admissions were associated with patients who had a prior CABG surgery. Relative risks greater than 1 correspond to increased risk of mortality while those less than 1 correspond to decreased risk of mortality. The relative risk of 5.91 for those having a prior CABG surgery indicates that those with such a history are almost six times as likely as those not having a prior CABG surgery to die within 30 days of CABG surgery. Patients coded in cardiogenic shock prior to isolated CABG surgery are 8.57 times more likely to die within 30 days than patients not coded as in cardiogenic shock. Because age is measured in years, the table reports the average number of years over age 65 for the cohort.

The estimate of between-hospital variation after adjusting for patient case mix is 0.067. This may be interpreted as indicating that the risk of dying if admitted to a Massachusetts cardiac surgery program one standard deviation above the state mean is 1.68 times that of dying if admitted to a program one standard deviation below the state mean. The estimated area under the ROC curve is 0.78 (Figure 7.3).

---

<sup>2</sup>Two patients had a second isolated CABG surgery within 30 days of the first isolated CABG surgery. Analysis was done on the first isolated CABG surgery and as a result, each of the second surgeries were removed from the cohort.

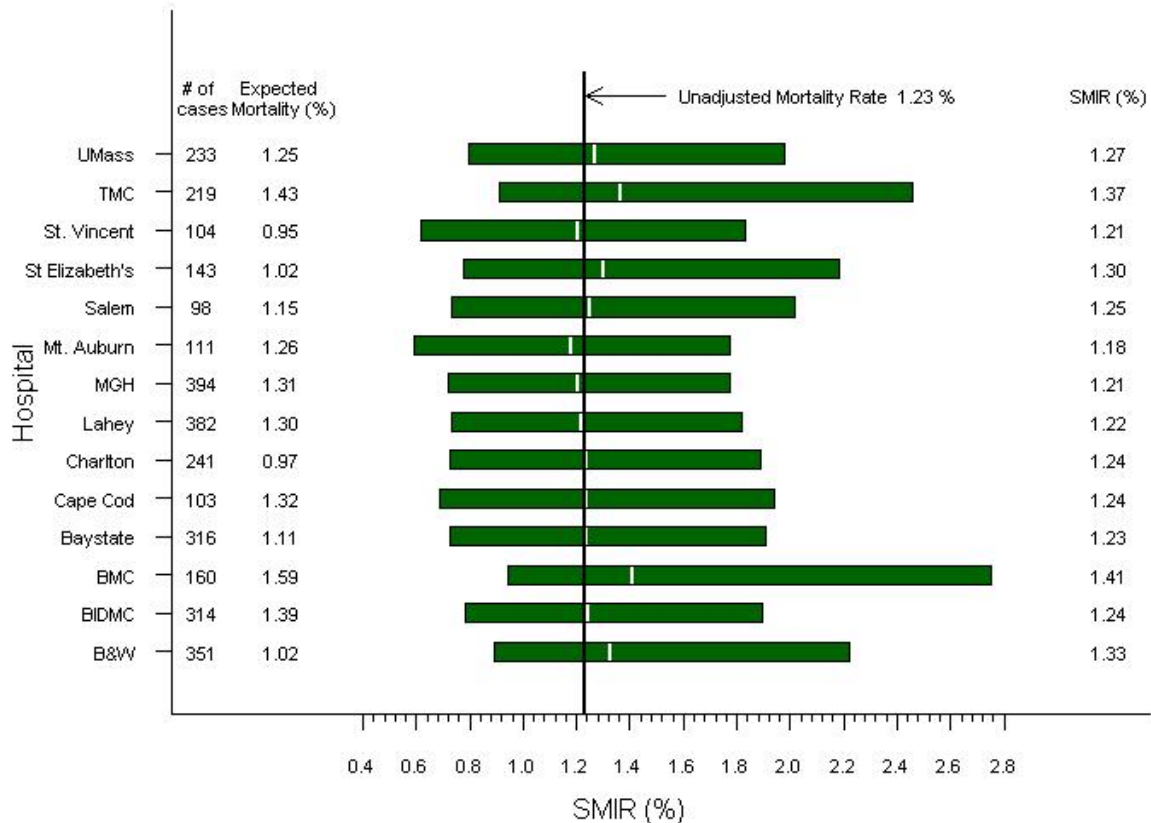
**Table 7.1:** Prevalences and Relative Risks of 30-Day Mortality Following Isolated CABG Surgery in Adults: Oct 1, 2009–Sep 30, 2010. Based on 3,169 surgeries with 39 deaths (1.23%).

Risk Factor	Prevalence (%)	Relative Risk	95% Interval for Relative Risk
Years over 65 <sup>a</sup>	0.96	1.05	(1.02, 1.08)
Renal Failure–Dialysis	2.52	3.11	(0.73, 7.43)
Diabetes	40.36	0.93	(0.46, 1.73)
Peripheral Vascular Disease	15.49	3.69	(1.76, 6.77)
Prior CABG Surgery	1.55	5.91	(1.47, 14.14)
Cardiogenic Shock	0.35	8.57	(0.62, 34.15)
Ejection Fraction <30%	6.12	1.11	(0.26, 2.77)
Myocardial Infarction (MI) <24 Hours	2.46	0.90	(0.07, 3.23)
Status of CABG (Ref = Elective)			
Urgent	61.94	1.71	(0.78, 3.49)
Emergent or Emergent Salvage	2.24	6.49	(0.79, 21.71)
<b>Between-Hospital Parameters</b>		<b>Mean</b>	<b>95% Interval</b>
Between-Hospital Average log, $\mu$		-5.52	(-6.37, -4.78)
Between-Hospital Variance in logs, $\tau^2$		0.06694	( $9.808 \times 10^{-7}$ , 0.4074)

<sup>a</sup>Average age of patients undergoing isolated CABG surgery is  $65 + 0.96 = 65.96$  years of age.

**Figure 7.1:** *Ninety-Five Percent Posterior Intervals for Standardized 30-Day Mortality Incidence Rates (SMIRs) Following Isolated CABG Surgery in Massachusetts: Oct 1, 2009–Sep 30, 2010*

# of cases refers to the number of isolated CABG surgery admissions; expected mortality is the percentage of cases expected to die given the case mix of the patients treated in the hospital. The white vertical line in each box is the hospital’s SMIR while the black vertical line denotes the unadjusted Massachusetts 30-day mortality rate of 1.23%.



**HOSPITAL KEY:**

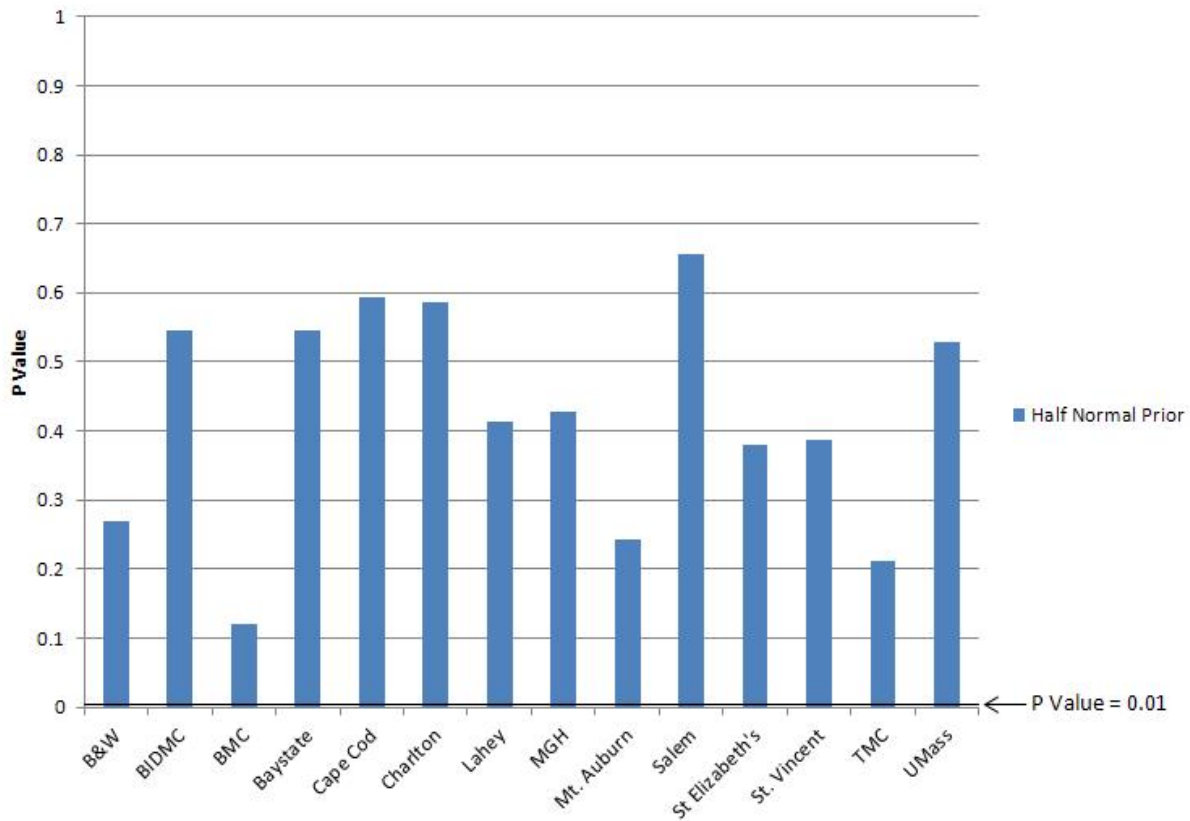
**B&W** = Brigham and Women’s Hospital; **BIDMC** = Beth Israel Deaconess Medical Center; **BMC** = Boston Medical Center; **Baystate** = Baystate Medical Center; **Cape Cod** = Cape Cod Hospital; **Charlton** = Southcoast Hospital Group–Charlton Memorial Hospital; **Lahey** = Lahey Clinic; **MGH** = Massachusetts General Hospital ; **Mt. Auburn** = Mount Auburn Hospital; **Salem** = North Shore Medical Center–Salem Hospital; **St. Elizabeth’s** = Saint Elizabeth’s Medical Center; **St. Vincent** = Saint Vincent Hospital; **TMC** = Tufts Medical Center; **UMass** = UMass Memorial Medical Center.

Figure 7.1 displays the SMIRs and corresponding 95% posterior intervals. The solid black vertical line in the figure is the unadjusted state 30-day mortality rate of 1.23%. Listed on the left-hand side of the figure are the total number of isolated CABG surgery admissions and the expected 30-day mortality rates for each hospital. The expected mortality rate provides an overall assessment of case mix severity at each program. Increasing values of the expected 30-day

mortality rates correspond to increasing admission severity. Listed on the right-hand side are the estimated SMIRs. All 95% posterior intervals (horizontal boxes) include the unadjusted Massachusetts rate of 1.23%.

**Figure 7.2:** *Cross-Validated P-Values: Isolated Cardiac Surgery Admissions: Oct 1, 2009–Sep 30, 2010.*

Posterior probabilities (p-values) of observed with predicted mortality for each of the 14 cardiac surgery programs are listed on the y-axis; the x-axis identifies the hospital. Results present the half-normal prior for fitting the hierarchical regression model.

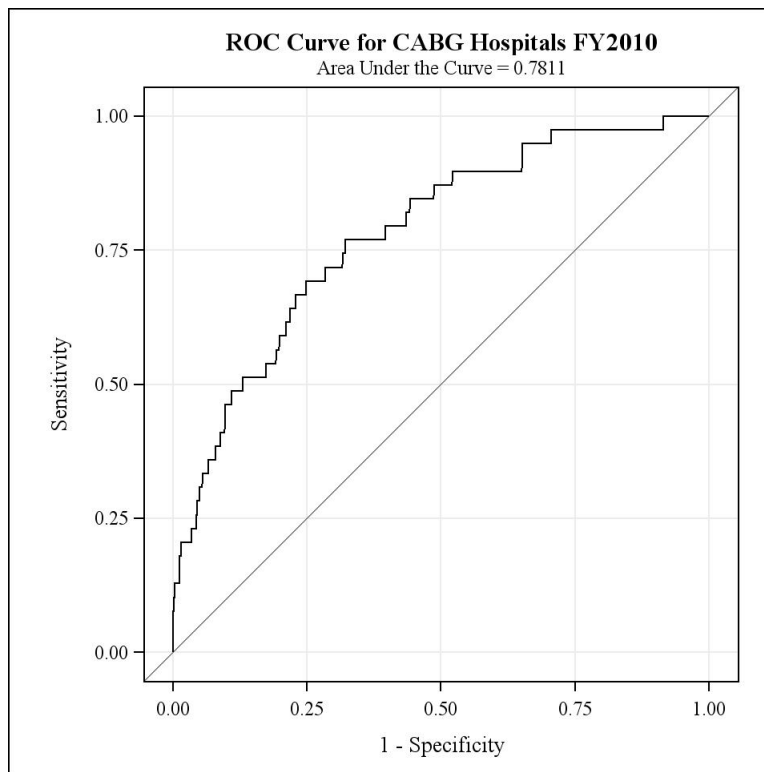


**HOSPITAL KEY:**

**B&W** = Brigham and Women’s Hospital; **BIDMC** = Beth Israel Deaconess Medical Center; **BMC** = Boston Medical Center; **Baystate** = Baystate Medical Center; **Cape Cod** = Cape Cod Hospital; **Charlton** = Southcoast Hospital Group–Charlton Memorial Hospital; **Lahey** = Lahey Clinic; **MGH** = Massachusetts General Hospital ; **Mt. Auburn** = Mount Auburn Hospital; **Salem** = North Shore Medical Center–Salem Hospital; **St. Elizabeth’s** = Saint Elizabeth’s Medical Center; **St. Vincent** = Saint Vincent Hospital; **TMC** = Tufts Medical Center; **UMass** = UMass Memorial Medical Center.

Figure 7.2 presents the cross-validated posterior probabilities (p-values) where the reference line on the graph at 0.01 indicates the cutoff for outliers based on the p-value. Any hospital with a bar entirely under this line is considered to be different than predicted. The cross validated p-values indicate that there were **no cardiac surgery program outliers** in Fiscal Year 2010.

**Figure 7.3:** ROC Curve-Hierarchical: Isolated CABG Cohort



## **8 Annual Hospital 30-Day Mortality Trends Following Isolated CABG Surgery in Massachusetts: January 1, 2002 through September 30, 2010**

### **8.1 Key Changes in Reporting**

- FY2006:
  1. Cohorts analyzed over a fiscal year October–September instead of a calendar year.
  2. The number of categories for the MI variable was reduced from five to three in the hospital model.
- FY2007:
  1. Admissions coded with shock, emergent status, or emergent salvage status were removed from the surgeon cohort.
- FY2008:
  1. Renal failure was replaced with dialysis as a risk factor.
  2. Patients for whom ejection fraction was not done or its value missing were included with the reference group in the model, while the model variable  $EF < 30$  or missing or not done was changed to  $EF < 30$ .
  3. Intra-aortic balloon pump was removed from the model.
- FY2009:
  1. The number of categories for the MI variables was reduced from three to two in the surgeon model.

- FY2010:

1. The number of covariates in both the hospital and surgeon models were reduced by eliminating the following:
  - ◇ Male
  - ◇ Hypertension
  - ◇ Prior PCI
  - ◇ Ejection Fraction 30 – 39%
  - ◇ Myocardial Infarction (MI) > 24 hours
2. The categories describing timing of Myocardial Infarction were combined < 6 hours and 7 – 24 hours
3. The model changed from a hierarchical logistic–normal regression to a hierarchical Poisson–normal regression.

**Table 8.1:** *Summary of Isolated CABG Admissions and 30-Day Crude Mortality Percentages CY 2002 through FY 2010*

<b>Year of Surgery</b>	<b>CY 2002</b>	<b>CY 2003</b>	<b>CY 2004</b>	<b>CY 2005</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>
Number of Hospitals	13	14	14	14	14	14	14	14	14
Number of Admissions	4,603	4,393	3,986	3,883	3,684	3,396	3,336	3,284	3,169
30-Day Crude Mortality, %	2.19	2.25	2.01	1.65	1.41	1.47	1.38	1.19	1.23
Between-Hospital Variance in Log-Odds of Mortality	0.042	0.094	0.349	0.130	0.035	0.389	0.049	0.049	0.067
Between-Hospital Standard Deviation in SMIRS, %	0.13	0.29	0.72	0.31	0.045	0.58	0.069	0.054	0.066

CY denotes calendar year; FY denotes fiscal year (Oct-Sep).



## **9 Surgeon-Specific Standardized 30-Day Mortality Incidence**

### **Rates: October 1, 2007 through September 30, 2010**

#### **9.1 Key Findings: Surgeons**

- 62 surgeons were identified with 9,792 isolated CABG surgery admissions in Massachusetts over the period October 1, 2007 through September 30, 2010.
- Before exclusions, the isolated CABG surgery volumes ranged from 9 to 398 across the 62 surgeons.
- Surgeon analyses were based on 61 surgeons who had 11 or more isolated CABG admissions.
- While this report contains summaries based on all isolated CABG surgery admissions, the primary analyses exclude admissions for patients with shock prior to surgery, emergent status, or emergent salvage status. The primary analyses are based on 9,500 admissions.
- 95.1% of the 61 surgeons performed isolated CABG surgery at exactly one hospital in Massachusetts over the three-year period.
- The unadjusted 30-day all-cause mortality rate following isolated CABG surgery in Massachusetts during the period October 1, 2007 through September 30, 2010 was:
  - ◇ 1.25% when admissions with shock, emergent, or emergent salvage status are included.
  - ◇ 1.09% when admissions with shock, emergent, or emergent salvage status are excluded.

- After adjusting for patient risk, the risk of 30-day mortality associated with a surgeon one standard deviation above the state average was 1.65 times that for a surgeon one standard deviation below the state average. The risk is the same whether shock and emergent status admissions are included or excluded.
- **No surgeon was identified as a statistical outlier for the period October 1, 2007 through September 30, 2010.**

## 9.2 What Data are Used for the Surgeon Analysis?

All patients undergoing isolated coronary artery bypass graft (CABG) surgery in the period October 1, 2007 through September 30, 2010 were identified. The Massachusetts Cardiac Surgery STS Quality and Outcomes Committee made recommendations regarding surgeon inclusion and exclusion criteria for the purpose of public reporting. The Department of Public Health agreed with the recommendations and Mass-DAC used the exclusions when computing surgeon-specific estimates. These recommendations included:

1. Excluding surgeons with less than 11 isolated CABG surgeries;
2. Excluding patients who were coded in shock or had emergent status or emergent salvage status prior to the surgery.

We note that for those surgeons with fewer than 175 admissions, the power to detect a higher than expected mortality may be less than 77% when assuming a one-sided one-group  $\chi^2$ -test that the surgeon rate is larger than the state rate by at least 3.0% (absolute increase). The Type I error rate was assumed to be 0.05 and an *effective sample size* for each surgeon that was larger than the observed number of admissions due to shrinkage was used. The number of admissions is approximate because the surgeon-specific expected mortality rates depend on the surgeon's case mix distribution. For surgeons with fewer than 175 isolated CABG surgery admissions over the three year period, a pound symbol # is included in figures and tables to indicate that small sample size may have reduced power to detect higher than expected mortality. Surgeon outlier status is based on the SMIR alone and not posterior predictive p-values.

The surgeon-specific 30-day mortality rates in this report have been adjusted in order to account for differences in patient health prior to surgery using methods similar to those for hospitals. The risk factors included in the model are the same (with the exception of cardiogenic shock, and emergent or emergent salvage status) as those risk factors that are used in the hospital

model. Methodology similar to the hospital analysis is utilized to identify surgeons who have unusually high or unusually low risk-standardized mortality rates. Patients are assigned to the surgeon that performed their isolated CABG surgery. Currently, there is no separation of surgeon and hospital effects in this report.

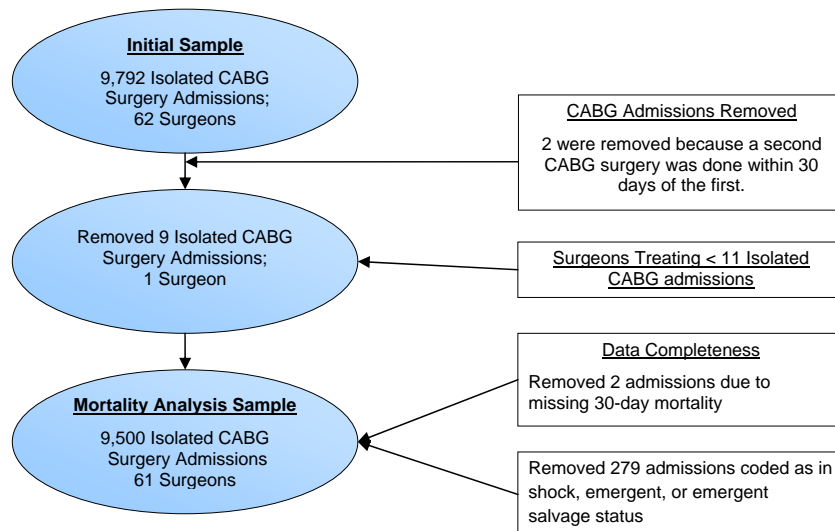
### 9.3 Results

A total of 9,792 isolated CABG surgery admissions corresponding to 62 surgeons were initially identified. One surgeon, who performed fewer than 11 isolated CABG surgeries during the three years for a total of 9 admissions, was eliminated from the analyses. Two isolated CABG admissions were eliminated from analyses because 30-day mortality status could not be verified and two isolated CABG admissions were removed because a second CABG surgery was performed on the same patient within 30 days of the first. For Fiscal Years 2008 through 2010, all patients with shock prior to surgery, emergent status, or emergent-salvage status (279 patients) were excluded from the analysis. Consequently, the surgeon analysis sample consists of 9,500 adults treated by 61 surgeons in Massachusetts (Figure 9.1).

Of the 61 surgeons, 58 (95.1%) treated patients at exactly one hospital in Massachusetts, and three (4.9%) treated patients at more than one hospital. Table 9.1 provides descriptive age-sex-race/ethnicity statistics for the sample of 9,792 patients.

Table 9.2, page 40, lists the frequencies of the risk factors used to account for patient differences across surgeons as well as the association of each risk factor with mortality for the primary analysis cohort having 30-day mortality rates of 1.09%.

The area under the ROC curve using predictions from the hierarchical regression model was 0.76 (Figure 9.4). The risk of dying 30-days post CABG surgery when treated by a Massachusetts surgeon one standard deviation above the Massachusetts average was 1.65 times that when treated by a Massachusetts surgeon one standard deviation below the Massachusetts average.

**Figure 9.1:** *Surgeon-Specific Isolated CABG Surgery Analysis: Oct 1, 2007–Sep 30, 2010*

Figures 9.2 and 9.3, starting on page 41, display the surgeon-specific SMIRs and corresponding 95% posterior intervals. The solid black vertical line in each figure is the unadjusted state 30-day mortality rate of 1.09%. Listed on the left-hand side of the figures are the total number of isolated CABG surgery admissions and the expected 30-day mortality rates for each surgeon. The expected mortality rate provides an overall assessment of case mix severity for each surgeon. Listed on the right-hand side of the figures are the estimated SMIRs.

Table 9.3, starting on page 44, identifies each surgeon, the hospital(s) where the surgeon treated cases in the period October 1, 2007 through September 30, 2010, and summary statistics. Nine surgeons who did not have any isolated CABG surgery admissions during Fiscal Year 2010 are denoted by an asterisk (\*); those having fewer than 175 isolated CABG surgery admissions across the three years are denoted by a pound sign (#). We note that 34 (56%) out of 61 surgeons had fewer than 175 admissions. No surgeon outliers were detected during this time period.

**Table 9.1:** Surgeon-Specific Demographic Distribution for All Adult Isolated CABG Surgery Admissions ( $N = 9,792$ ) in Massachusetts Hospitals: Oct 1, 2007–Sep 30, 2010. Entries represent numbers of isolated CABG surgery admissions and include all patients, including those with shock, emergent status, and emergent salvage status.

Age Group	Total by Age	Age 65	White	African American	Other Race	Ethnicity Hispanic
<b>Male</b>						
18–44	177					
45–54	1,032	≤64	3,232	109	196	157
55–64	2,371					
65–74	2,394	≥65	3,710	59	164	94
≥75	1,576					
<b>Total</b>	<b>7,550</b>		<b>6,942</b>	<b>168</b>	<b>360</b>	<b>251</b>
<b>Female</b>						
18–44	50					
45–54	211	≤64	622	41	44	52
55–64	463					
65–74	760	≥65	1,381	54	108	98
≥75	758					
<b>Total</b>	<b>2,242</b>		<b>2,003</b>	<b>95</b>	<b>108</b>	<b>98</b>
<b>Total Male and Female</b>						
18–44	227					
45–54	1,243	≤64	3,854	150	240	209
55–64	2,834					
65–74	3,154	≥65	5,091	113	228	140
≥75	2,334					
<b>Total</b>	<b>9,792</b>		<b>8,945</b>	<b>263</b>	<b>468</b>	<b>349</b>

Patients may select more than one race category. The Ethnicity Hispanic category is independent of the race categories and may be selected in addition to a Race.

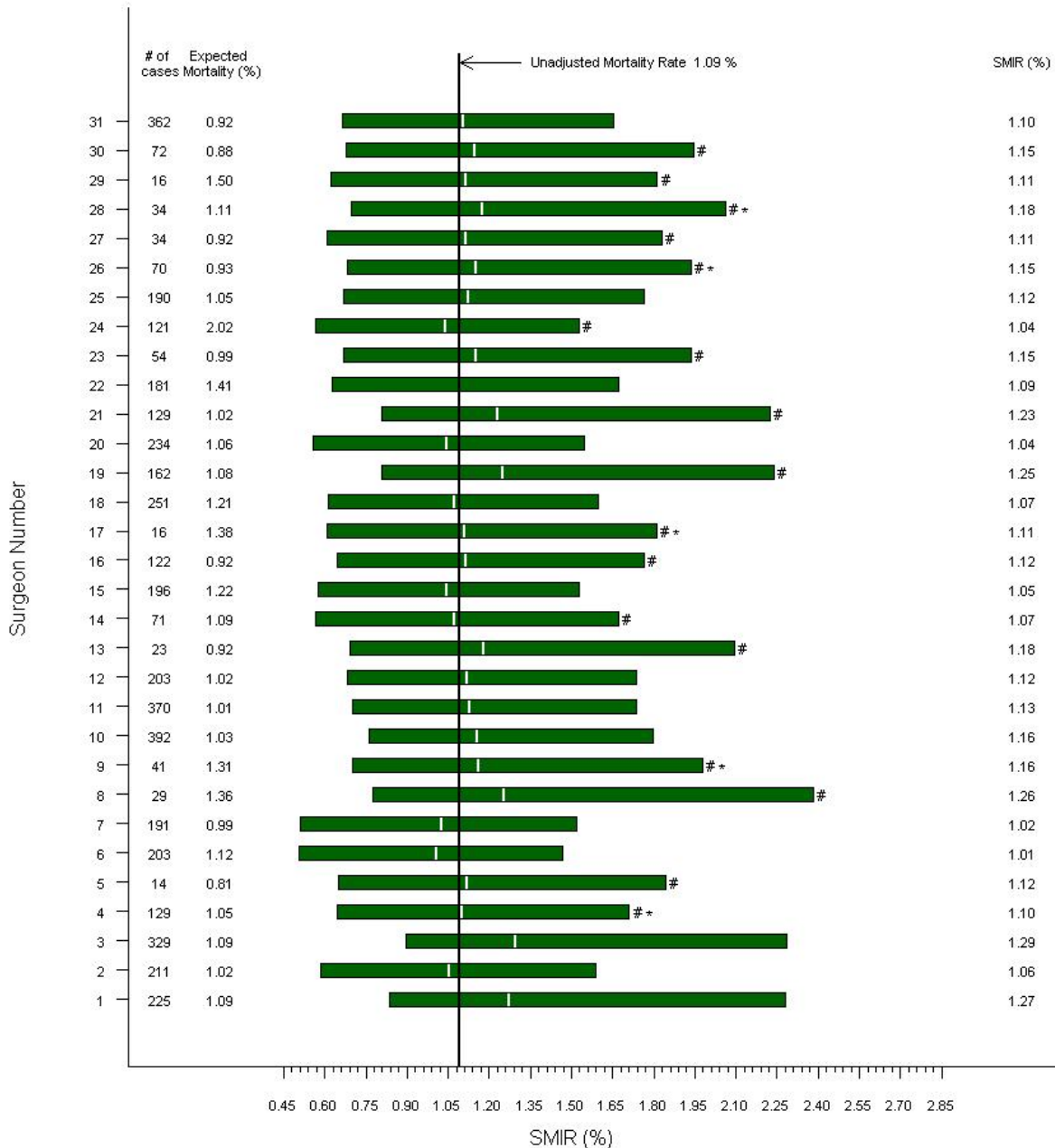
**Table 9.2:** Surgeon-Specific Prevalences and Adjusted Relative Risks of 30-Day Mortality Following Isolated CABG Surgery in Adults: Oct 1, 2007–Sep 30, 2010

Excludes Shock, Emergent Status, and Emergent Salvage Status $N = 9,500$ , $Deaths = 104$ (1.09%)			
Risk Factor	Prevalence (%)	Adjusted Relative Risk	95% Interval for Relative Risk
Years over 65 <sup>a</sup>	0.96	1.05	(1.03, 1.08)
Renal Failure–Dialysis	2.21	3.07	(1.25, 5.72)
Diabetes	38.82	1.06	(0.70, 1.55)
Peripheral Vascular Disease	15.11	1.82	(1.15, 2.73)
Prior CABG Surgery	1.77	4.98	(2.41, 8.78)
Ejection Fraction <30%	5.58	2.53	(1.36, 4.14)
Myocardial Infarction (MI) <24 Hours	1.37	3.04	(0.80, 6.89)
Status of CABG–Urgent	63.63	1.30	(0.83, 2.02)
<b>Between-Surgeon Estimates</b>		<b>Mean</b>	<b>95% Interval</b>
Between-Surgeon Average $\log, \mu$		-5.30	(-5.79, -4.89)
Between-Surgeon Variance in $\log S, \tau^2$		0.06278	(0.000942, 0.2754)

<sup>a</sup> Average age of patients undergoing isolated CABG surgery is  $65 + 0.96 = 65.96$  years of age.

**Figure 9.2:** Surgeon-Specific 95% Posterior Intervals for Standardized 30-Day Mortality Incidence Rates (SMIRs): Oct 1, 2007–Sep 30, 2010 (Part 1 of 2)

Rates based on 9,500 isolated CABG surgeries performed by 61 surgeons. See Table 9.3 starting on page 44 for surgeon details.

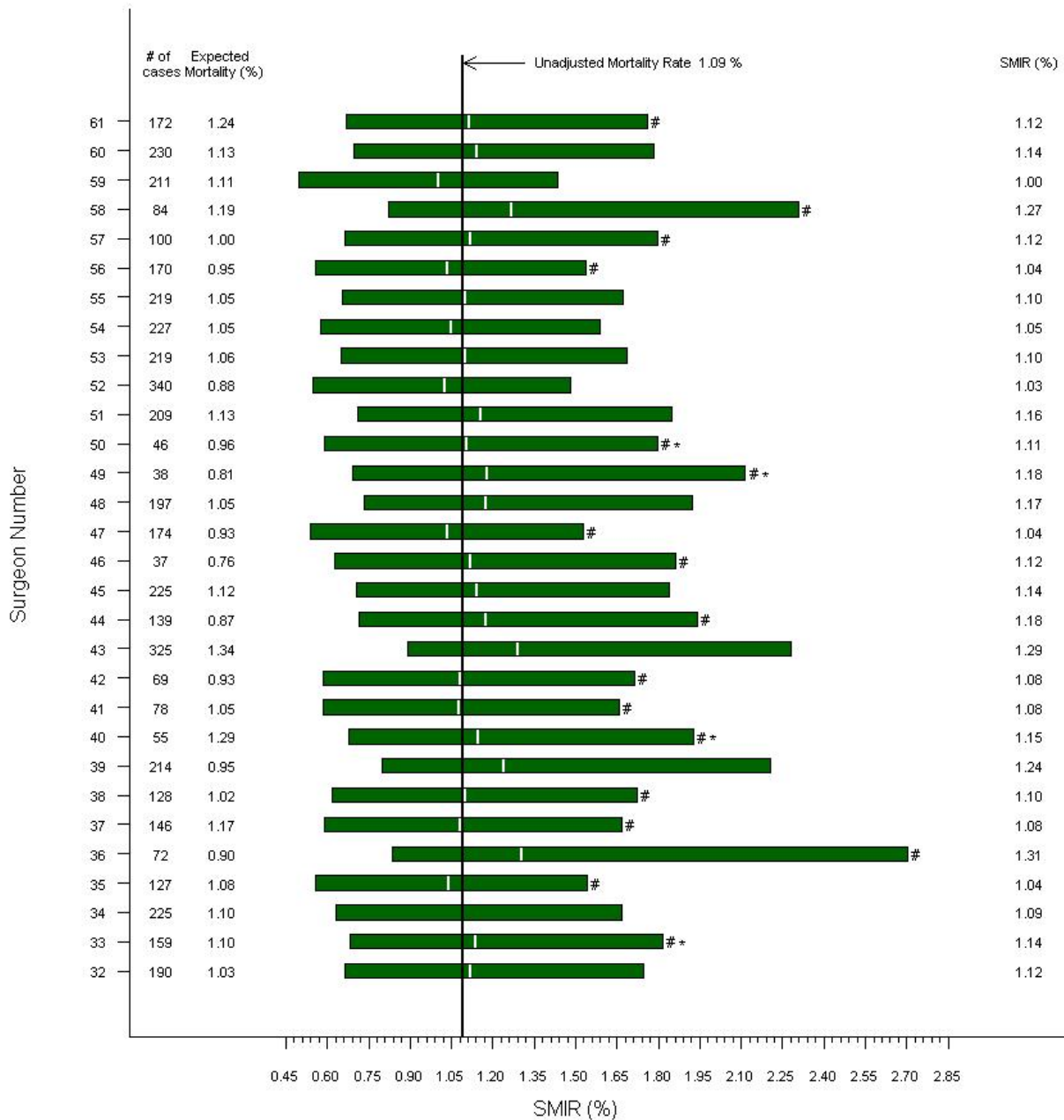


\*-No isolated CABG surgery admissions during Fiscal Year 2010.  
 #-Surgeon had volume smaller than or equal to 175.



**Figure 9.3:** Surgeon-Specific 95% Posterior Intervals for Standardized 30-Day Mortality Incidence Rates (SMIRs): Oct 1, 2007–Sep 30, 2010 (Part 2 of 2)

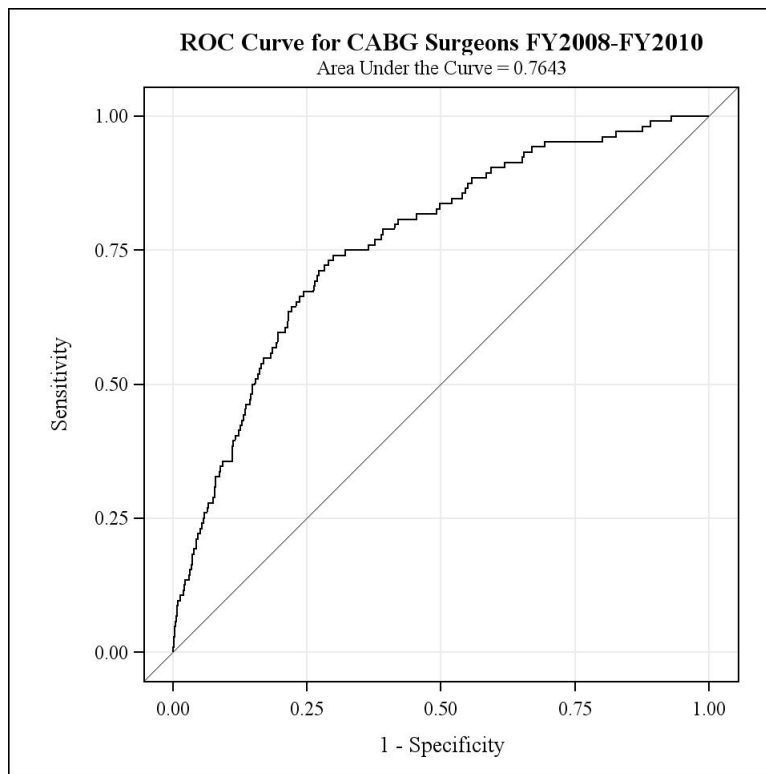
Rates based on 9,500 isolated CABG surgeries performed by 61 surgeons. See Table 9.3 starting on page 44 for surgeon details.



\*-No isolated CABG surgery admissions during Fiscal Year 2010.

#-Surgeon had volume smaller than or equal to 175.

**Figure 9.4:** Surgeon-Specific ROC Curve-Hierarchical: Isolated CABG Cohort



**Table 9.3: Surgeon-Specific Standardized 30-Day All Cause Mortality Incidence Rates (SMIRs) Following Isolated CABG Surgery (percentage): Oct 1, 2007–Sep 30, 2010**

Surgeon Num	Surgeon Name	Hospital(s)	Lower Limit of 95% Interval	SMIR (%)	Upper Limit of 95% Interval
1	Agnihotri, Arvind	Massachusetts General Hospital	0.836	1.273	2.282
2	Akins, Cary	Massachusetts General Hospital	0.587	1.055	1.588
3	Aranki, Sary	Brigham and Women's Hospital	0.896	1.294	2.287
4 # *	Arcidi, Joseph	UMass Memorial Medical Center	0.644	1.102	1.711
5 #	Baker, Joshua	Massachusetts General Hospital	0.650	1.120	1.842
6	Birjiniuk, Vladimir	Mount Auburn Hospital	0.508	1.006	1.469
7	Bojar, Robert	Saint Vincent Hospital	0.511	1.024	1.520
8 #	Bolman, Ralph	Brigham and Women's Hospital	0.776	1.255	2.383
9 # *	Bowen, Frank	Lahey Clinic	0.699	1.161	1.977
10	Campos, Christian	Charlton Memorial Hospital	0.760	1.158	1.799
11	Carr, Thomas	Charlton Memorial Hospital	0.703	1.127	1.737
12	Chen, Frederick	Brigham and Women's Hospital	0.685	1.117	1.737
13 #	Cohn, Lawrence	Brigham and Women's Hospital	0.694	1.180	2.095
14 #	Couper, Gregory	Brigham and Women's Hospital	0.568	1.071	1.670
15	D'Agostino, Richard	Lahey Clinic	0.577	1.047	1.529

# Small sample size may diminish accuracy of estimates. Indicates that the surgeon had volume smaller than or equal to 175

\* Known not to have any isolated CABG admissions during Fiscal Year 2010

Continued on next page

Continued from previous page

Surgeon			Lower Limit of	Upper Limit of		
Num	Surgeon Name	Hospital(s)	95% Interval	SMIR (%)	95% Interval	
16	#	Davidson, Michael	Brigham and Women's Hospital	0.648	1.115	1.764
17	# *	De la Torre, Ralph	Beth Israel Deaconess Medical Center	0.607	1.111	1.810
18		Deaton, David	Baystate Medical Center	0.613	1.072	1.597
19	#	Ehsan, Afshin	Tufts Medical Center	0.810	1.250	2.238
20		Engelman, Daniel	Baystate Medical Center	0.559	1.043	1.545
21	#	Fitton, Torin	Lahey Clinic	0.808	1.231	2.225
22		Flack, Joseph	Baystate Medical Center	0.628	1.091	1.671
23	#	Gallegos, Robert	Brigham and Women's Hospital	0.669	1.152	1.935
24	#	Geroyannis, Heracles	Saint Elizabeth's Medical Center	0.568	1.042	1.528
25		Hagberg, Robert	Beth Israel Deaconess Medical Center	0.670	1.123	1.767
26	# *	Harrison, Lynn	UMass Memorial Medical Center	0.682	1.154	1.935
27	#	Hedeshian, Mohir	Saint Vincent Hospital	0.610	1.113	1.830
28	# *	Hilgenberg, Alan	Massachusetts General Hospital	0.697	1.176	2.062
29	#	Kadri, Adebambo	Cape Cod Hospital	0.623	1.113	1.813
30	#	Ketchedjian, Ara	Boston Medical Center	0.680	1.149	1.947
31		Khabbaz, Kamal	Beth Israel Deaconess Medical Center	0.666	1.103	1.655
32		Lazar, Harold	Boston Medical Center	0.662	1.121	1.747

# Small sample size may diminish accuracy of estimates. Indicates that the surgeon had volume smaller than or equal to 175

Continued on next page

\* Known not to have any isolated CABG admissions during Fiscal Year 2010

Continued from previous page

Surgeon			Lower Limit of	Upper Limit of		
Num	Surgeon Name	Hospital(s)	95% Interval	SMIR (%)	95% Interval	
33	# *	Lee, Richard	Lahey Clinic	0.682	1.139	1.814
34		Liu, David	Beth Israel Deaconess Medical Center Saint Vincent Hospital	0.633	1.092	1.667
35	#	Macgillivray, Thomas	Massachusetts General Hospital	0.560	1.041	1.541
36	#	Madsen, Joren	Massachusetts General Hospital	0.834	1.305	2.703
37	#	Maggs, Peter	Mount Auburn Hospital	0.592	1.083	1.666
38	#	Mandapati, Divakar	UMass Memorial Medical Center	0.616	1.099	1.724
39		Okike, Okike Nsidinanya	UMass Memorial Medical Center	0.798	1.240	2.207
40	# *	Olenchock, Stephen	Saint Elizabeth's Medical Center	0.676	1.146	1.928
41	#	Pham, Duc	Tufts Medical Center	0.586	1.076	1.659
42	#	Pirundini, Paul	Cape Cod Hospital	0.586	1.083	1.714
43		Poston, Robert	Boston Medical Center	0.890	1.293	2.280
44	#	Rastegar, Hassan	Tufts Medical Center	0.714	1.176	1.941
45		Rizzo, Robert	Brigham and Women's Hospital Cape Cod Hospital	0.707	1.144	1.841
46	#	Rodriguez, Roberto	Saint Elizabeth's Medical Center	0.628	1.119	1.862
47	#	Rosengard, Bruce	Massachusetts General Hospital	0.540	1.036	1.529

# Small sample size may diminish accuracy of estimates. Indicates that the surgeon had volume smaller than or equal to **175**

Continued on next page

\* Known not to have any isolated CABG admissions during Fiscal Year 2010

Continued from previous page

Surgeon			Lower Limit of		Upper Limit of
Num	Surgeon Name	Hospital(s)	95% Interval	SMIR (%)	95% Interval
48	Rousou, John	Baystate Medical Center	0.731	1.174	1.921
49	# * Samy, Sanjay	Lahey Clinic	0.694	1.181	2.115
50	# * Sellke, Frank	Beth Israel Deaconess Medical Center	0.591	1.106	1.797
51	Senthilnathan, Venkatachalam	Beth Israel Deaconess Medical Center	0.709	1.155	1.850
52	Shekar, Prem	Brigham and Women's Hospital	0.548	1.025	1.483
53	Smaroff, Gregory	Lahey Clinic	0.648	1.101	1.687
54	Tam, Stanley	UMass Memorial Medical Center	0.574	1.051	1.587
55	Tolis, George	Saint Elizabeth's Medical Center	0.656	1.101	1.672
56	# Toran, Ann	North Shore Medical Center–Salem Hospital	0.560	1.035	1.538
57	# Vander-Salm, Thomas	North Shore Medical Center–Salem Hospital	0.665	1.120	1.795
58	# Vlahakes, Gus	Massachusetts General Hospital	0.821	1.266	2.306
59	Walker, Jennifer	Massachusetts General Hospital	0.497	1.001	1.434
60	Warner, Kenneth	Tufts Medical Center	0.698	1.141	1.784
61	# Williamson, Christina	Lahey Clinic	0.671	1.115	1.758

# Small sample size may diminish accuracy of estimates. Indicates that the surgeon had volume smaller than or equal to 175

\* Known not to have any isolated CABG admissions during Fiscal Year 2010

## 10 Important Definitions

STS Version 2.61 refers to the STS data collection variable definitions used by the Massachusetts hospitals for data collection in Fiscal Year 2010.

**Admissions:** Refers to a single episode of care at one facility from the date of admission to the date of discharge.

**Aortic Valve Repair:** Surgical repair of the aortic valve of the heart. The aortic valve is responsible for facilitating the flow of blood into the aorta.

**Aortic Valve Replacement (AVR):** A surgical procedure involving replacement of the aortic valve of the heart.

**Cardiac Catheterization:** A procedure that determines the extent and the location of the coronary artery obstruction or blockage.

**Cardiac Surgery:** (Massachusetts Cardiac Study definition) Surgery on the heart and the thoracic great vessels. Examples of cardiac surgery include coronary artery bypass grafts, heart valve repair or replacement, heart transplantation, surgery of the thoracic aorta, repair of congenital heart defects, and minimally invasive heart surgery.

**Cardiogenic Shock: (STS Version 2.61)** Indicate whether the patient was, at the time of procedure, in a clinical state of hypoperfusion sustained for greater than 30 minutes, according to either of the following criteria:

- a. Systolic BP <80 and/or Cardiac Index <1.8 despite maximal treatment;
- b. IV inotropes and/or IABP necessary to maintain Systolic BP >80 and/or Cardiac Index >1.8.

**Cardiovascular Disease:** Includes diseases of the heart or vessels that supply the body and the heart muscle with blood and oxygen.

**Coronary Artery Disease:** A disease affecting the coronary arteries in which the flow of oxygen-containing blood to the heart muscle is partially or completely blocked, resulting in angina or a heart attack.

**Coronary Artery Bypass Graft (CABG) Surgery:** An operation in which the blocked coronary vessels are bypassed with the patient's own vessels to improve flow to the heart muscle. Coronary vessels are those vessels that supply the heart muscle with blood and oxygen.

**Cross-Validation:** Model validation is done to ascertain whether predicted values from a statistical model are likely to accurately predict responses on future subjects or on subjects not used to develop the analytical model. Cross-validation involves dropping a set of observations from the analytical process and the outcomes for the dropped set are predicted. This process is repeated many times in order to characterize the accuracy of the predictions.

**Diabetes: (STS Version 2.61)** Indicates the patient has a history of diabetes, regardless of duration of disease or need for anti-diabetic agents. Includes on admission or preoperative diagnosis. Does not include gestational diabetes.

**Dialysis: (STS Version 2.61)** Indicates whether the patient is currently undergoing dialysis.

**Ejection Fraction: (STS Version 2.61)** Indicates the percentage of the blood emptied from the ventricle at the end of the contraction.

**Hypertension: (STS Version 2.61)** Indicate whether the patient has a diagnosis of hypertension, documented by one of the following:

- a. Documented history of hypertension diagnosed and treated with medication, diet and/or exercise;
- b. Prior documentation of blood pressure  $>140$  mmHg systolic or 90 mmHg diastolic for patients without diabetes or chronic kidney disease, or prior docu-



mentation of blood pressure >130 mmHg systolic or 80 mmHg diastolic on at least two occasions for patients with diabetes or chronic kidney disease;

- c. Currently on pharmacologic therapy to control hypertension.

**Mitral Valve Repair:** Surgical repair of the mitral valve of the heart. The mitral valve is responsible for facilitating the flow of blood from the left atrium into the left ventricle.

**Mitral Valve Replacement (MVR):** A surgical procedure which involves the replacement of the mitral valve of the heart.

**Myocardial Infarction (MI): (STS Version 2.61)** Indicates the patient has a history of an MI.

**For MI occurrence prior** to current hospitalization, one of the following is necessary:

- a. MI documented in the medical record; or
- b. EKG Documented Q wave. Q waves to be 0.03 seconds in width and/or greater than or equal to one third of the total QRS complex in two or more contiguous leads.

**For MI occurrence during** current hospitalization, two of the following three criteria are necessary:

- a. Ischemic symptoms in the presence or absence of chest discomfort. Ischemic symptoms may include:
  1. Chest, epigastric, arm, wrist, or jaw discomfort with exertion or at rest; or
  2. Unexplained nausea and vomiting; or
  3. Persistent shortness of breath secondary to left ventricular failure; or
  4. Unexplained weakness, dizziness, lightheadedness, diaphoresis, or syncope.

- b. Enzyme level elevation. One of the following four are necessary:
  - 1. CK-MB: Maximal value of CK-MB more than two times the upper limit of normal on one occasion during the first hours after the index clinical event or maximal value of CK-MB, preferable CK-MB mass, greater than upper limit of normal on two successive samples; or
  - 2. CK greater than two times the upper limit of normal; or
  - 3. LDH subtype 1 greater than LDH subtype 2; or
  - 4. Maximal concentration of troponin T or I greater than the MI decision limit on at least one occasion during the first 24 hours after the index clinical event.
- c. Serial ECG (at least two) showing changes from baseline or serially in ST-T.

**Percutaneous Coronary Intervention (PCI):** A non-surgical procedure designed to open and maintain the patency of obstructed coronary vessels. This treatment is an invasive procedure performed in the cardiac catheterization lab (e.g., outside of an operating room) by an interventional cardiologist in which a balloon, stent, or other device is delivered to the affected vessel to open and maintain its patency.

**Peripheral Arterial Disease: (STS Version 2.61)** Indicate whether the patient has a history of peripheral arterial disease (includes upper and lower extremity, renal, mesenteric, and abdominal aortic systems). This can include the following. (Peripheral arterial disease excludes disease in the carotid or cerebrovascular arteries.)

- a. Claudication, either with exertion or at rest;
- b. Amputation for arterial vascular insufficiency;
- c. Vascular reconstruction, bypass surgery, or percutaneous intervention to the extremities (excluding dialysis fistulas and vein stripping);

- d. Documented aortic aneurysm with or without repair;
- e. Positive noninvasive test (e.g., ankle brachial index  $\leq 0.9$ , ultrasound, magnetic resonance or computed tomography imaging of  $>50\%$  diameter stenosis in any peripheral artery, i.e., renal, subclavian, femoral, iliac).

**Prior CABG Surgery:** Indicates the patient had a previous coronary bypass graft prior to the current admission.

**Prior Percutaneous Coronary Intervention: (STS Version 2.61)** Indicates a previous percutaneous cardiac intervention (PCI) was performed any time prior to the surgical procedure. PCI refers to those treatment procedures that unblock narrowed coronary arteries without performing surgery. PCI may include, but is not limited to:

- a. Balloon Catheter Angioplasty, Percutaneous Transluminal Coronary Angioplasty (PTCA);
- b. Rotational Atherectomy;
- c. Directional Atherectomy;
- d. Extraction Atherectomy;
- e. Laser Atherectomy;
- f. Intracoronary Stent Placement.

**Renal Failure–Dialysis: (STS Version 2.61)** Indicates whether the patient is currently undergoing dialysis.

**Risk Factors:** Factors that contribute to an individual's risk of coronary artery disease or of death. These factors are classified as those that can be modified or changed by an individual, and those that cannot be changed. Examples of risk factors that cannot be modified include age, gender, family history of coronary artery disease, and ethnicity. Risk fac-

tors that can be controlled include diet, cholesterol levels, obesity, smoking, hypertension, inactive lifestyle, stress, and diabetes.

**Standardized Mortality Incidence Rate (SMIR):** The ratio of smoothed number of deaths (the number of deaths adjusted for the number of admissions treated at the hospital and the hospital case mix) to expected number of deaths (the expected number of deaths calculated on the basis of the mortality experience of all cardiac surgery programs) multiplied by the state unadjusted rate. SMIRs are interpreted in terms of their corresponding probability intervals. If the probability interval includes the state rate, then the SMIR is no different from what was expected. If the interval excludes the state rate, then the SMIR is “significantly different” from what was expected. In this case, if the upper limit of the interval is lower than the state rate, then fewer patients than expected died; if the lower limit of the 95% interval is higher than the state rate, then more patients than expected died.

**Status of CABG: (STS Version 2.61)** Indicate the clinical status of the patient prior to entering the operating room:

**Elective:** The patient’s cardiac function has been stable in the days or weeks prior to the operation. The procedure could be deferred without increased risk of compromised cardiac outcome.

**Urgent:** Procedure required during same hospitalization in order to minimize chance of further clinical deterioration. Examples include but are not limited to: Worsening, sudden chest pain, congestive heart failure, acute myocardial infarction, anatomy, IABP, unstable angina with intravenous nitroglycerin or rest angina.

**Emergent:** Patients requiring emergency operations will have ongoing, refractory (difficult, complicated, and/or unmanageable) unrelenting cardiac compromise, with or without hemodynamic instability, and not responsive to any form of therapy except

cardiac surgery. An emergency operation is one in which there should be no delay in providing operative intervention. The patient's clinical status includes any of the following:

- a. Ischemic dysfunction (any of the following):
  - 1. Ongoing ischemia including rest angina despite maximal medical therapy (medical and/or IABP);
  - 2. Acute Evolving Myocardial Infarction within 24 hours before surgery;  
or
  - 3. Pulmonary edema requiring intubation
- b. Mechanical dysfunction (either of the following):
  - 1. Shock with circulatory support; or
  - 2. Shock without circulatory support.

**Emergent Salvage:** The patient is undergoing CPR en route to the operating room or prior to anesthesia induction.

## 11 Advisory Committees

Mass-DAC gratefully acknowledges the support from the members of the Mass-DAC Committees who have donated their time to improve the database and the quality of cardiac care in the Commonwealth of Massachusetts.

### FY 2010 Massachusetts Cardiac Care Hospital Outlier Committee

A Massachusetts Department of Public Health Committee charged with reviewing hospital outlier findings.

Madeleine Biondolillo, M.D.  
Director  
Bureau of Health Care Safety and Quality  
Massachusetts Department of Public Health

Sharon-Lise Normand, Ph.D.  
Professor of Health Care Policy  
Department of Health Care Policy  
Harvard Medical School

Ann Lovett, R.N., M.A.  
Project Manager, Mass-DAC  
Department of Health Care Policy  
Harvard Medical School

Stanley Lewis, M.D.  
Associate Professor of Medicine  
Harvard Medical School  
Beth Israel Deaconess Medical Center

Nancy Murphy, B.A.  
Policy Analyst  
Massachusetts Department of Public Health

John Pastore, M.D.  
Clinical Cardiologist  
Saint Elizabeth's Medical Center

Iyah K. Romm, B.S.  
Special Assistant to the Director  
Bureau of Health Care Safety and Quality  
Massachusetts Department of Public Health

Kurt Barringhaus, M.D.  
Cardiac Interventionalist  
UMass Memorial Medical Center

Thomas Piemonte, M.D.  
Director, Cardiac Catheterization Laboratory  
Lahey Clinic

David Torchiana, M.D.  
Chairman and Chief Executive Officer  
Mass. General Physicians Organization

Continued on next page ...

**FY 2010 Massachusetts Cardiac Care Hospital Outlier Committee**

A Massachusetts Department of Public Health Committee charged with reviewing hospital outlier findings.

... Continued from prior page

Thomas Carr, M.D.  
Chief of Cardiac Surgery  
Charlton Memorial Hospital

Ralph M. Bolman, III, M.D.  
Chief of Cardiac Surgery  
Brigham and Women's Hospital  
President of Mass. Chapter of STS

Frederic Resnic, M.D.  
Director, Cardiac Catheterization Laboratory  
Brigham and Women's Hospital  
President of the Mass. Chapter of the ACC

Daniel Engelman, M.D.  
Cardiac Surgeon  
Baystate Medical Center

David Shahian, M.D.  
Research Director  
Center for Quality and Safety  
Department of Surgery  
Massachusetts General Hospital

Cliff Berger, M.D.  
Interventionalist  
Good Samaritan Medical Center

### FY 2010 Mass-DAC Oversight Committee for Cardiac Surgery

The members of this committee are charged with the task of reviewing blinded summary data for all cardiac surgeons in Massachusetts in the review year. Such data include risk-standardized 30-day all-cause mortality rates (SMIR), surgeon volume, surgeon complication rates, and other STS recommended process measures. For surgeons identified as having statistically significant higher than expected mortality, unblinded case fatality reports are also reviewed. Selection of Committee members is the responsibility of the current President of the Massachusetts chapter of STS.

Robert Rizzo, M.D.  
Chief of Cardiac Surgery  
Cape Cod Hospital

Samuel J. Shubrooks, Jr., M.D.  
Interventionalist  
Beth Israel Deaconess Medical Center

Sharon-Lise Normand, Ph.D.  
Professor of Health Care Policy  
Department of Health Care Policy  
Harvard Medical School

Ralph M. Bolman, III, M.D.  
Chief of Cardiac Surgery  
Brigham and Women's Hospital  
President of the Mass. Chapter of STS

Kenneth Warner, M.D.  
Chief of Cardiac Surgery  
Tufts Medical Center

Vladimir Birjiniuk, M.D.  
Chief of Cardiac Surgery  
Mount Auburn Hospital

David Shahian, M.D.  
Research Director  
Center for Quality and Safety  
Department of Surgery  
Massachusetts General Hospital

Thomas Vander-Salm, M.D.  
Chief, Department of Cardiac Surgery  
North Shore Medical Center–Salem Hospital



### The FY 2010 Mass-DAC Cardiac Surgery Data Adjudication Committee

This committee reviewed patient-specific data elements and corresponding data documentation submitted by hospitals to Mass-DAC in order to determine validity of coding.

Thoralf M. Sundt, III, M.D.  
Chief of Cardiac Surgery  
Massachusetts General Hospital

Sary F. Aranki, M.D.  
Cardiac Surgeon  
Brigham and Women's Hospital

Thomas Carr, M.D.  
Chief of Cardiac Surgery  
Charlton Memorial Hospital

Robert C. Hagberg, M.D.  
Cardiac Surgeon  
Beth Israel Deaconess Medical Center

George Tolis, Jr., M.D.  
Chief of Cardiothoracic Surgery  
Saint Elizabeth's Medical Center

Prem S. Shekar, M.D.  
Cardiac Surgeon  
Brigham and Women's Hospital

Lawrence H. Cohn, M.D.  
Cardiac Surgeon  
Brigham and Women's Hospital

Michael J. Davidson, M.D.  
Director, Endovascular Cardiac Surgery  
Brigham and Women's Hospital

Vladimir Birjiniuk, M.D.  
Chief of Cardiac Surgery  
Mount Auburn Hospital

Daniel T. Engelman, M.D.  
Cardiac Surgeon  
Baystate Medical Center

Heracles Geroyannis, M.D.  
Cardiac Surgeon  
Saint Elizabeth's Medical Center

James D. Rawn, M.D.  
Director, Cardiac Surgery Intensive Care Unit  
Brigham and Women's Hospital

Richard D'Agostino, M.D.  
Chief of Cardiac Surgery  
Lahey Clinic

Ralph M. Bolman, III, M.D.  
Chief of Cardiac Surgery  
Brigham and Women's Hospital  
President of the Mass. Chapter of STS

Continued on next page ...

**The FY 2010 Mass-DAC Cardiac Surgery Data Adjudication Committee**

This committee reviewed patient-specific data elements and corresponding data documentation submitted by hospitals to Mass-DAC in order to determine validity of coding.

---

... Continued from prior page

Susan April, R.N.  
Data Manager  
North Shore Medical Center–Salem Hospital

Michelle Doherty, R.N.  
Data Manager  
Beth Israel Deaconess Medical Center

Pauline Philie, R.N.  
Data Manager  
Cape Cod Hospital

Tamar Yehoshua  
Data Manager  
Saint Elizabeth's Medical Center

---

---

**FY 2010 Publications Committee for Cardiac Surgery**

The charge of this committee is to facilitate utilization of shared data from the Massachusetts Cardiac Surgery Data Registry for purposes of reporting observations that are of interest to the medical community and are based on sound scientific principles of study design and analysis. This committee will approve or deny the request before sending the proposal to the Massachusetts Department of Public Health for final approval. The selection of committee members is done by the current president of the Massachusetts STS.

Kamal Khabbaz, M.D.  
Cardiac Surgeon  
Beth Israel Deaconess Medical Center

Frederick Chen, M.D.  
Cardiac Surgeon  
Brigham and Women's Hospital

Joren Madsen, M.D.  
Cardiac Surgeon  
Massachusetts General Hospital

Ralph M. Bolman, III, M.D.  
Chief of Cardiac Surgery  
Brigham and Women's Hospital  
President of the Mass. Chapter of STS

Gus Vlahakes, M.D.  
Cardiac Surgeon  
Massachusetts General Hospital

## A Appendix

### Procedure Identification Guidelines for Adult Cardiac Surgery

A comparison of rules used by Mass-DAC, New York State, and the National Society of Thoracic Surgeons for classifying surgeries as *isolated CABG* versus *CABG + other*.

Procedure	Mass-DAC	New York State	STS v2.61
Maze: <b>Open</b> heart approach	Other	Excluded	Other
Maze: <b>Closed</b> epicardial approach and radio frequency	CABG	Excluded	Other
Implantable Cardioverter Defibrillator (ICD)	Other	CABG	Other
Ventricular Lead Insertion for ICD	CABG	CABG	Other
Pacemaker Lead Insertions	CABG	CABG	CABG
Lung Biopsy	Case Specific	CABG	Other
Patent Foramen Ovale Closure	CABG	CABG	Other
Femoral Artery Procedures	CABG	CABG	Other
Transmyocardial Revascularization	Other	CABG	Other
Opening of the right atrium for tumor resection	Other	Other	Other
Atrial Appendage	CABG	CABG	CABG
Myxoma	Other	Other	Other
Unplanned Ventricular Assist Device (VAD) Placement	CABG	CABG	Other
Planned Ventricular Assist Device Placement	Other	Other	Other
Carotid Surgery	Other	CABG	Other
Lead and Device Explants	Other	CABG	<sup>a</sup>

<sup>a</sup>No information available regarding how this procedure is categorized by STS.

## **B Appendix**

STS DATA ABSTRACTION TOOL <sup>[8, 9]</sup>  
VERSION 2.61

Mass-DAC harvests all optional and not harvested STS variables

This tool is the property of The Society of Thoracic Surgeons and is protected by copyright and other intellectual property laws.



The Society of Thoracic Surgeons  
Adult Cardiac Surgery Database  
Data Collection Form  
Version 2.61

**A. Administrative**

Participant ID: | | | | | | | |

Cost Link: \_\_\_\_\_

STS Trial Link Number: \_\_\_\_\_

**B. Demographics**

Patient Last Name: \_\_\_\_\_ Patient First Name: \_\_\_\_\_ Patient M.I.: \_\_\_\_\_ [Name Fields Optional Harvest](#)

Date of Birth (mm/dd/yyyy): \_\_\_/\_\_\_/\_\_\_ Patient Age: \_\_\_\_\_ [System Calculation](#) Sex: Male Female

Social Security #: \_\_\_\_\_ [Optional Harvest](#) Medical Record Number: \_\_\_\_\_ [Optional Harvest](#)

Health Insurance Claim Number: \_\_\_\_\_ [Optional Harvest](#) Patient ZIP Code: \_\_\_\_\_ [Optional Harvest](#)

Race: ([Select all that apply](#)) White Black / African American Asian  
American Indian / Alaskan Native Native Hawaiian / Pacific Islander Other

Hispanic or Latino Ethnicity: Yes No

Referring Cardiologist: \_\_\_\_\_ [Not Harvested](#) Referring Physician: \_\_\_\_\_ [Not Harvested](#)

**C. Hospitalization**

Hospital Name: \_\_\_\_\_ Hospital ZIP Code: | | | | | Hospital State: | | |

Hospital National Provider Identifier: \_\_\_\_\_

Payor – ([Select all that apply](#))

Government Health Insurance: Yes No [If Yes, select all that apply](#): → Medicare Medicaid  
Military Health Care State-Specific Plan Indian Health Service

Commercial Health Insurance: Yes No

Health Maintenance Organization: Yes No

Non-U.S. Insurance: Yes No

None / Self: Yes No

Date of Admission: \_\_\_/\_\_\_/\_\_\_ Date of Surgery: \_\_\_/\_\_\_/\_\_\_ Date of Discharge: \_\_\_/\_\_\_/\_\_\_

ICU Visit: Yes No [If Yes](#) → Initial ICU Hours: \_\_\_\_\_

Readmission to ICU: Yes No [If Yes](#) → Additional ICU Hours: \_\_\_\_\_ Total Hrs ICU: \_\_\_\_\_

**D. Risk Factors**

Weight (kg): \_\_\_\_\_ Height (cm): \_\_\_\_\_

Current Or Recent Cigarette Smoker: Yes No

Family History of Coronary Artery Disease: Yes No

Last Hematocrit: \_\_\_\_\_

Last White Blood Cell Count: \_\_\_\_\_

Diabetes: Yes No [If Yes](#) → Diabetes Control: ([select one](#)) None Diet Oral Insulin Other

Last A1c Level: \_\_\_\_\_

Dyslipidemia: Yes No

Last Creatinine Level: \_\_\_\_\_

Renal Failure – Dialysis: Yes No

Hypertension: Yes No

Infectious Endocarditis: Yes No [If Yes](#) → Infectious Endocarditis Type: Treated Active

Chronic Lung Disease: No Mild Moderate Severe

Immunosuppressive Therapy: Yes No

Peripheral Arterial Disease: Yes No

Cerebrovascular Disease: Yes No  
If Yes → Coma: Yes No  
CVA: Yes No If Yes → CVA-When: Recent (<=2 weeks) Remote (>2 weeks)  
CVD RIND: Yes No  
CVD TIA: Yes No  
CVD NonInvasive >75%: Yes No  
CVD Prior Carotid Surgery: Yes No

#### E. Previous CV Interventions

Previous CV Interventions: Yes No If Yes, complete the remainder of this section ↓  
Previous Coronary Artery Bypass: Yes No  
Previous Valve: Yes No  
Previous Other Cardiac Yes No  
Congenital Yes No  
AICD (Automatic Implanted Cardioverter / Defibrillator): Yes No  
Pacemaker: Yes No  
PCI (Percutaneous Cardiac Intervention): Yes No If Yes ↓  
PCI Stent: Yes No If Yes → Stent Type: Bare Metal Drug-eluting Unknown  
PCI Interval: <= 6 Hours > 6 Hours  
Other: Yes No

#### F. Preoperative Cardiac Status

Previous Myocardial Infarction: Yes No If Yes → When: <= 6 hours > 6 hours but <24 hours 1 - 7 days 8 - 21 days > 21 days  
Heart Failure: Yes No  
Classification - NYHA: Class I Class II Class III Class IV  
Cardiac Presentation on Admission: No Symptoms or Angina  
Symptoms Unlikely to be Ischemia  
Stable Angina  
Unstable Angina  
Non-ST Elevation MI (Non-STEMI)  
ST-Elevation MI (STEMI)  
STS Cardiogenic Shock: Yes No  
Resuscitation: Yes No  
Arrhythmia: Yes No If Yes → Arrhythmia Type: Vtach / Vfib Yes No  
3<sup>rd</sup> degree HB Yes No  
Afib / Aflutter Yes No

**G. Preoperative Medications**

Beta Blockers: Yes No Contraindicated / Not Indicated

ACE or ARB Inhibitors: Yes No Contraindicated / Not Indicated

Nitrates I.V.: Yes No Contraindicated / Not Indicated

Anticoagulants: Yes No Contraindicated / Not Indicated

If Yes → Medication Name: Heparin (Unfractionated) Heparin (Low Molecular) Thrombin Inhibitors Other

Coumadin: Yes No Contraindicated / Not Indicated

Inotropes: Yes No Contraindicated / Not Indicated

Steroids: Yes No Contraindicated / Not Indicated

Aspirin: Yes No Contraindicated / Not Indicated

Lipid-Lowering: Yes No Contraindicated / Not Indicated If Yes → Medication Name: Statin Non-statin Both

ADP Inhibitors Within Five Days: Yes No Contraindicated / Not Indicated If Yes → Discontinuation: \_\_\_\_\_ (# Days)

Antiplatelets Within 5 Days: Yes No Contraindicated / Not Indicated

Glycoprotein IIb/IIIa Inhibitor: Yes No Contraindicated / Not Indicated

If Yes → Medication Name: Abciximab (ReoPro) Eptifibatid (Integrilin) Tirofiban (Aggrastat)

**H. Hemodynamics and Cath**

Number of Diseased Coronary Vessels: None One Two Three

Left Main Disease >= 50%: Yes No

Ejection Fraction Done: Yes No If Yes → Ejection Fraction: \_\_\_\_\_ (%)

Ejection Fraction Method: LV gram Radionucleotide Estimate ECHO MRI/CT Other

Pulmonary Artery Mean Pressure Done: Yes No If Yes → Mean Pressure: \_\_\_\_\_ (mm Hg)

Aortic Stenosis: Yes No N/A If Yes → Gradient: \_\_\_\_\_

Mitral Stenosis: Yes No N/A

Tricuspid Stenosis: Yes No N/A

Pulmonic Stenosis: Yes No N/A

Aortic Insufficiency: 0=None 1=Trivial 2=Mild 3= Moderate 4= Severe 5= N/A

Mitral Insufficiency: 0=None 1=Trivial 2=Mild 3= Moderate 4= Severe 5= N/A

Tricuspid Insufficiency: 0=None 1=Trivial 2=Mild 3= Moderate 4= Severe 5= N/A

Pulmonic Insufficiency: 0=None 1=Trivial 2=Mild 3= Moderate 4= Severe 5= N/A

**I. Operative**

Surgeon: \_\_\_\_\_ Surgeon's National Provider Identifier: \_\_\_\_\_

Taxpayer Identification Number: \_\_\_\_\_

- Incidence: First cardiovascular surgery
- First re-op cardiovascular surgery
- Second re-op cardiovascular surgery
- Third re-op cardiovascular surgery
- Fourth or more re-op cardiovascular surgery

Status: ↓

Elective

Urgent → Reason: AMI IABP Worsening CP CHF Anatomy USA Rest Angina  
Valve Dysfunction Aortic Dissection Angiographic Accident Cardiac Trauma

Emergent → Reason: Shock Circ Support Shock No Circ Support Pulmonary Edema AEMI  
Ongoing Ischemia Valve Dysfunction Aortic Dissection Angiographic Accident Cardiac Trauma

Emergent Salvage

Robotic Technology Assisted: Yes No

Coronary Artery Bypass: Yes No → If Yes, also complete Section J

Valve Surgery : Yes No → If Yes, also complete Section K



Ventricular Assist Device: Yes No → If Yes, also complete Section L

Other Cardiac Procedure: Yes No → If Yes, also complete Section M

Other Non-Cardiac Procedure: Yes No → If yes, also complete Section N

Enter up to 10 CPT-I Codes pertaining to the surgery for which the data collection form was initiated:

#1. \_\_\_\_\_, #2. \_\_\_\_\_, #3. \_\_\_\_\_, #4. \_\_\_\_\_, #5. \_\_\_\_\_, #6. \_\_\_\_\_, #7. \_\_\_\_\_, #8. \_\_\_\_\_, #9. \_\_\_\_\_, #10. \_\_\_\_\_

OR Entry Date And Time: \_\_\_/\_\_\_/\_\_\_ : \_\_\_ (mm/dd/yyyy, 24 hr clk)

OR Exit Date And Time: \_\_\_/\_\_\_/\_\_\_ : \_\_\_ (mm/dd/yyyy, 24 hr clk)

Initial Intubation Date And Time: \_\_\_/\_\_\_/\_\_\_ : \_\_\_ (mm/dd/yyyy, 24 hr clk)

Initial Extubation Date And Time: \_\_\_/\_\_\_/\_\_\_ : \_\_\_ (mm/dd/yyyy, 24 hr clk)

Skin Incision Start Date And Time: \_\_\_/\_\_\_/\_\_\_ : \_\_\_ (mm/dd/yyyy, 24 hr clk)

Skin Incision Stop Date And Time: \_\_\_/\_\_\_/\_\_\_ : \_\_\_ (mm/dd/yyyy, 24 hr clk)

Antibiotic Selection: Yes No

Antibiotic Timing: Yes No

Antibiotics Discontinued: Yes No

CPB Utilization: None Combination Full

If Combination → CPB Utilization - Combination Plan: Planned Unplanned

If Unplanned → Unplanned Combination Reason: Exposure/visualization

Bleeding

Inadequate size and/or diffuse disease of distal vessel

Hemodynamic instability

Conduit quality and/or trauma

Other

If Combination or Full → Perfusion Time (minutes): \_\_\_\_\_

Cannulation Method: Aorta and Femoral/Jugular Vein: Yes No

Femoral Artery and Femoral/Jugular Vein: Yes No

Aorta and Atrial/Caval: Yes No

Femoral Artery and Atrial/Caval: Yes No

Other: Yes No

Circulatory Arrest: Yes No If Yes → Circulatory Arrest Time: \_\_\_\_\_ (minutes)

Aortic Occlusion None

Aortic Crossclamp → If Aortic Crossclamp or Balloon Occlusion → Cross Clamp Time (minutes): \_\_\_\_\_

Balloon Occlusion ↗

Partial Crossclamp

Cardioplegia: Yes No

Cerebral Oximetry: [Optional Harvest](#)

Pre-Induction Baseline Regional Oxygen Saturation: Left: \_\_\_\_\_ (%) Right \_\_\_\_\_ (%)

Cumulative Saturation Below Threshold: Left: \_\_\_\_\_ (minute-%) Right \_\_\_\_\_ (minute-%)

Cerebral Oximeter Provided The First Indication: Yes No

Skin Closure Regional Oxygen Saturation: Left: \_\_\_\_\_ (%) Right \_\_\_\_\_ (%)

IABP: Yes No If Yes → When Inserted: Preoperatively Intraoperatively Postoperatively

Indication: Hemodynamic Instab PTCA Support Unstable Angina CPB Wean Prophylactic

Intraop Blood Products: Yes No

If No → Intraop Blood Products Refused: Yes No

If Yes → Red Blood Cell Units: \_\_\_\_\_

Fresh Frozen Plasma Units: \_\_\_\_\_

Cryoprecipitate Units: \_\_\_\_\_

Platelet Units: \_\_\_\_\_

Intraop Medications: Aprotinin: Yes No If Yes → Aprotinin – Dose: Full Dose Half Dose

Epsilon Amino-Caproic Acid: Yes No

Desmopressin: Yes No  
 Tranexamic Acid: Yes No

**J. Coronary Bypass**

Number of Distal Anastomoses with Arterial Conduits: \_\_\_\_\_  
 Number of Distal Anastomoses with Venous Conduits: \_\_\_\_\_  
 Distal Anastomoses - Vein Harvest Technique: Endovascular Direct Vision Both  
 Saphenous Vein Harvest Time: \_\_\_\_\_ (minutes)  
 Anastomotic Device Used: Yes No **If Yes →** Anastomotic Device: Glue Magnets Clips Staples Other  
 Internal Mammary Arteries Used as Grafts: Left IMA Right IMA Both IMAs No IMA **If Left, Right, or Both ↓**  
 IMA Harvest Technique: Direct Vision Thoracoscopy Combination Robotic Assisted  
 Number of IMA Distal Anastomoses: \_\_\_\_\_  
 Radial Artery Used: No Radial Left Radial Right Radial Both Radials **If Left, Right, or Both ↓**  
 Number of Radial Artery Distal Anastomoses: \_\_\_\_\_  
 Radial Distal Anastomoses Harvest Technique: Endovascular Direct Vision Both  
 Radial Artery Harvest Time: \_\_\_\_\_ (minutes)  
 Number of Gastro-Epiploic Artery Distal Anastomoses: \_\_\_\_\_  
 Number of Other Arterial Distal Anastomoses: \_\_\_\_\_

**K. Valve Surgery**

<u>Aortic Procedure:</u>	<u>Mitral Procedure:</u>	<u>Tricuspid Procedure:</u>	<u>Pulmonic Procedure</u>
No	No	No	No
Replacement	Annuloplasty Only	Annuloplasty Only	Replacement
Repair/Reconstruction	Replacement	Replacement	Reconstruction
Root Reconstruction w/ Valve Conduit	Reconstruction w/ Annuloplasty	Reconstruction w/ Annuloplasty	
Replacement + Aortic Graft Conduit	Reconstruction w/o Annuloplasty	Reconstruction w/o Annuloplasty	
Root Reconstruction w/ Valve Sparing	↓	Valvectomy	
Resuspension Aortic Valve w/	(If Replacement)		
Replacement Ascending Aorta	<u>Mitral Repair Attempt:</u> Yes No		
Resuspension Aortic Valve w/o			
Replacement Ascending Aorta			
Resection Sub-Aortic Stenosis			

Aortic Annular Enlargement: Yes No  
 ↓ **Key** M = Mechanical B = Bioprosthesis H = Homograft A = Autograft (Ross) R = Ring/Annuloplasty BA = Band/Annuloplasty

Aortic Prosthesis -	Implant Type:	None M B H A R BA	Implant: _____	Size: _____
Mitral Prosthesis -	Implant Type:	None M B H A R BA	Implant: _____	Size: _____
Tricuspid Prosthesis -	Implant Type:	None M B H A R BA	Implant: _____	Size: _____
Pulmonic Prosthesis -	Implant Type:	None M B H A R BA	Implant: _____	Size: _____

**Valve Key** (check STS web site for periodic updates to this list).

**Mechanical**

ATS Mechanical Prosthesis = 2  
 Björk-Shiley Convex-Concave Mechanical Prosthesis = 3  
 Björk-Shiley Monostrut Mechanical Prosthesis = 4  
 CarboMedics Mechanical Prosthesis = 6  
 CarboMedics Carbo-Seal Ascending Aortic Valved Conduit Prosthesis = 57  
 CarboMedics Carbo-Seal Valsalva Ascending Aortic Valved Conduit Prosthesis = 58  
 CarboMedics Reduced Cuff Aortic Valve = 59  
 CarboMedics Standard Aortic Valve = 60  
 CarboMedics Top-Hat Supra-annular Aortic Valve = 61  
 CarboMedics OptiForm Mitral Valve = 62  
 CarboMedics Standard Mitral Valve = 63  
 CarboMedics Orbis Universal Valve = 64  
 CarboMedics Small Adult Aortic and Mitral Valves = 65  
 Edwards Tekna Mechanical Prosthesis = 7  
 Lillehei-Kaster Mechanical Prosthesis = 53  
 MCRI On-X Mechanical Prosthesis = 10  
 Medtronic-Hall/Hall Easy-Fit Mechanical Prosthesis = 8  
 Medtronic ADVANTAGE Mechanical Prosthesis = 66  
 OmniCarbon Mechanical Prosthesis = 9  
 OmniScience Mechanical Prosthesis = 54  
 Sorin Bicarbon (Baxter Mira) Mechanical Prosthesis = 11  
 Sorin Monoleaflet Allcarbon Mechanical Prosthesis = 12  
 St. Jude Medical Mechanical Prosthesis or St. Jude Medical® Mechanical Heart Valve = 13  
 SJM® Masters Series Mechanical Heart Valve = 67

Medtronic Freestyle Stentless Porcine Bioprosthesis – Subcoronary = 83  
 Medtronic Freestyle Stentless Porcine Bioprosthesis – Root = 84  
 Medtronic Intact Porcine Bioprosthesis = 35  
 Medtronic Mosaic Porcine Bioprosthesis = 36  
 Medtronic Contegra Bovine Jugular Bioprosthesis = 85  
 Mitroflow Pericardial Bioprosthesis = 37  
 St. Jude Medical - Toronto SPV Stentless Porcine Bioprosthesis or SJM  
 Toronto SPV® Valve = 39  
 St. Jude Medical-Bioimplant Porcine Bioprosthesis = 40  
 SJM Biacor™ Valve = 86  
 SJM Epic™ Valve = 87  
 SJM Toronto Root™ Bioprosthesis = 88  
 Sorin Pericarbon Stentless Pericardial Bioprosthesis = 38

**Homograft**

CryoLife Aortic Homograft = 89  
 CryoLife Pulmonary Homograft = 90  
 CryoLife CryoValve SG(Decellularized) Aortic Homograft = 91  
 CryoLife CryoValve SG Pulmonary Homograft = 92  
 Homograft Aortic – Subcoronary = 41  
 Homograft Aortic Root = 42  
 Homograft Mitral = 43  
 Homograft Pulmonic Root = 44  
 LifeNet CV Allografts = 93

**Autograft**

Pulmonary Autograft to aortic root (Ross Procedure) = 45

SJM® Masters Series Aortic Valve Graft Prosthesis = 68  
 St. Jude Medical® Mechanical Heart Valve Hemodynamic Plus (HP) Series = 69  
 SJM® Masters Series Hemodynamic Plus Valve with FlexCuff™ Sewing Ring = 70  
 SJM Regent™ Valve = 71  
 Starr-Edwards Caged-Ball Prosthesis = 14  
 Ultracor Mechanical Prosthesis = 15

**Bioprosthesis**

ATS 3f Aortic Bioprosthesis = 108  
 Baxter Prima Stentless Porcine Bioprosthesis – Subcoronary = 72  
 Baxter Prima Stentless Porcine Bioprosthesis – Root = 73  
 Biocor Porcine Bioprosthesis = 19  
 Biocor Stentless Porcine Bioprosthesis – Subcoronary = 74  
 Biocor Stentless Porcine Bioprosthesis – Root = 75  
 CarboMedics PhotoFix Pericardial Bioprosthesis = 21  
 Carpentier-Edwards Duraflex Porcine Bioprosthesis = 76  
 Carpentier-Edwards Prima Plus Stentless Porcine Bioprosthesis – Subcoronary = 77  
 Carpentier-Edwards Prima Plus Stentless Porcine Bioprosthesis – Root = 78  
 Carpentier-Edwards PERIMOUNT Pericardial Bioprosthesis = 22  
 Carpentier-Edwards PERIMOUNT Pericardial Magna Bioprosthesis = 103  
 Carpentier-Edwards Standard Porcine Bioprosthesis = 23  
 Carpentier-Edwards Supra-Annular Aortic Porcine Bioprosthesis = 25  
 Cryolife O'Brien Stentless Porcine Bioprosthesis – Subcoronary = 79  
 Cryolife O'Brien Stentless Porcine Bioprosthesis – Root = 80  
 Hancock Standard Porcine Bioprosthesis = 55  
 Hancock II Porcine Bioprosthesis = 28  
 Hancock Modified Orifice Porcine Bioprosthesis = 29  
 Ionescu-Shiley Pericardial Bioprosthesis = 30  
 Labcor Stented Porcine Bioprosthesis = 31  
 Labcor Stentless Porcine Bioprosthesis – Subcoronary = 81  
 Labcor Stentless Porcine Bioprosthesis – Root = 82

**Ring / Annuloplasty**

ATS Simulus Flex-O Ring = 109  
 ATS Simulus Flex-C Band = 110  
 CarboMedics AnnuloFlo Ring = 94  
 CarboMedics AnnuloFlex Ring = 95  
 CarboMedics CardioFix Bovine Pericardium with PhotoFix Technology = 96  
 Carpentier-Edwards Classic Annuloplasty Ring = 46  
 Carpentier-Edwards Geoflex Ring = 104  
 Carpentier-Edwards IMR Etlogix Ring = 105  
 Carpentier-Edwards Physio Annuloplasty System Ring = 47  
 Cosgrove-Edwards Annuloplasty System Ring = 48  
 Edwards MC³ Tricuspid Annuloplasty System G Future Band = 97  
 Genesee Sculptor Annuloplasty Ring = 98  
 Medtronic Sculptor Ring = 49  
 Medtronic-Duran AnCore Ring = 50  
 Sorin-Puig-Messana Ring = 51  
 St. Jude Medical Sequin Ring or SJM® Séguin Annuloplasty Ring = 52  
 St. Jude RSR (Rigid Saddle Ring) = 106  
 SJM Tailor™ Annuloplasty Ring = 99

**Band / Annuloplasty**

Medtronic Colvin Galloway Future Band = 100  
 Medtronic Duran Band = 101  
 Medtronic Duran – Ancore Band = 102  
 St. Jude Tailor Band = 107

**Other**

Other = 777

**L. VAD**

Previous VAD: Yes No **If Yes →** Implanted at another facility: Yes No

**References to "Initial VAD" refer to the initial VAD for this hospitalization, not a VAD placed during a previous hospitalization.**

**Current Circulatory Support: For Initial VAD Only**

Indication for VAD: Bridge to Transplantation Bridge to Recovery Destination  
 Postcardiotomy Ventricular Failure (Separation from CPB) Device Malfunction End of Life

Intubated Pre VAD: Yes No

Hemodynamics Pre VAD:

PCWP: \_\_\_\_mm/Hg CVP: \_\_\_\_mm/Hg CI: \_\_\_\_L/ (min x m2)  
 RV Function: Normal Mildly Impaired Moderately Impaired Severely Impaired

**VAD Device Data:**

Implant Type: **Fill in below:** Right VAD (RVAD) Left VAD (LVAD) BiVentricular BiVAD (BiVAD) Total Artificial Heart (TAH)  
 Product Type: **Fill in below:** 1. HeartQuest VAD 2. Lion Heart 3. Novacor LVAS 4. Heartsaver VAD 5. Jarvik 2000 6. DeBakey VAD  
 7. TandemHeart pVAD 8. AB-180 iVAD 9. CardioWest TAH 10. Thoratec iVAD 11. HeartMate VE 12. HeartMate IP LVAS  
 13. HeartMate SNAP-VE 14. HeartMate XVE 15. HeartMate II 16. HeartMate III 17. BVS5000i 18. AbioCor 19. Incor  
 20. Excor 21. Other

Explant Reason: **Fill in below:** 1. Cardiac Transplant 2. Recovery 3. Device Transfer 4. Device Related Infection 5. Device Malfunction 6. End of Life

**Initial Implant Data**

Implant Type	Product Type	Implant Date	Explant	Explant Date	Explant Reason	Transplant Date
_____	_____	___/___/_____ mm dd yyyy	Yes No	___/___/_____ mm dd yyyy	_____	___/___/_____ mm dd yyyy

Initial VAD Cannulation/Attach Site:

LVAD Inflow: Left Atrium Left Ventricle  
 RVAD Inflow: Right Atrium Right Ventricle

**Additional Implant(s) Data**

Second Device Implanted: Yes No **If Yes ↓**

Implant Type #2	Product Type #2	Implant Date #2	Explant #2	Explant Date #2	Explant Reason #2	Transplant Date #2
_____	_____	___/___/_____ mm dd yyyy	Yes No	___/___/_____ mm dd yyyy	_____	___/___/_____ mm dd yyyy

Implant #2 VAD Cannulation/Attach Site:

LVAD Inflow: Left Atrium Left Ventricle

RVAD Inflow: Right Atrium Right Ventricle

Third Device Implanted: Yes No [If Yes ↓](#)

Implant Type #3	Product Type #3	Implant Date #3	Explant #3	Explant Date #3	Explant Reason #3	Transplant Date #3
_____	_____	___/___/___	Yes No	___/___/___	_____	___/___/___
		mm dd yyyy		mm dd yyyy		mm dd yyyy

Implant #3 VAD Cannulation/Attach Site:

LVAD Inflow: Left Atrium Left Ventricle

RVAD Inflow: Right Atrium Right Ventricle

**Primary VAD Complications Data:**

Intracranial Bleed:	Yes	No
Embolic Stroke:	Yes	No
Driveline and/or Cannula Infection:	Yes	No
Pump Pocket Infection:	Yes	No
VAD Endocarditis:	Yes	No
Device Malfunction:	Yes	No
Bowel Obstruction:	Yes	No

**Additional Complications (not specific to initial VAD as above) to be collected in section "P", Complications.**

VAD Discharge Status: With VAD  
 Without VAD  
 Expired in hospital (where initial VAD was implanted)

**M. Other Cardiac Procedures**

Left Ventricular Aneurysm Repair	Yes	No	Ventricular Septal Defect Repair	Yes	No	Atrial Septal Defect Repair	Yes	No
Batista	Yes	No	Surgical Ventricular Restoration	Yes	No	Congenital Defect Repair	Yes	No

Transmyocardial Laser Revascularization	Yes	No	Cardiac Trauma	Yes	No	Cardiac Transplant	Yes	No
-----------------------------------------	-----	----	----------------	-----	----	--------------------	-----	----

Arrhythmia Correction Surgery: None  
 Permanent Pacemaker  
 Permanent Pacemaker with Cardiac Resynchronization Therapy (CRT)  
 Automatic Implanted Cardioverter Defibrillator (AICD)  
 AICD with CRT  
[If "Permanent Pacemaker with CRT" or "AICD with CRT" ↓](#)  
 Lead Placement: Epicardial Endocardial

Atrial Fibrillation Correction Surgery: None  
 Standard Surgical Maze Procedure  
 Other Surgical Ablative Procedure  
 Combination of Standard and Other

Aortic Aneurysm	Yes	No	<a href="#">If Yes →</a>	Ascending Aorta	Yes	No
				Aortic Arch	Yes	No
				Descending Aorta	Yes	No
				Thoracoabdominal Aneurysm	Yes	No
Other	Yes	No				

**N. Other Non Cardiac Procedures**

Carotid Endarterectomy	Yes	No	Other Vascular	Yes	No	Other Thoracic	Yes	No	Other	Yes	No
------------------------	-----	----	----------------	-----	----	----------------	-----	----	-------	-----	----

**O. Post Operative**

Postoperative Creatinine Level \_\_\_\_\_

Blood Products Used Postoperatively: Yes No **If Yes →** Red Blood Cell Units \_\_\_\_\_  
Fresh Frozen Plasma Units \_\_\_\_\_  
Cryoprecipitate Units \_\_\_\_\_  
Platelet Units \_\_\_\_\_

Extubated in OR: Yes No

Re-intubated During Hospital Stay: Yes No **If Yes →** Additional Hours Ventilated: \_\_\_\_\_

**P. Complications** In Hospital Postoperative Complications: Yes No **If Yes ↓**

**Operative:**

ReOp for Bleeding/Tamponade Yes No  
ReOp for Valvular Dysfunction Yes No  
ReOp for Graft Occlusion Yes No  
ReOp for Other Cardiac Reason Yes No  
ReOp for Other Non-Cardiac Reason Yes No  
Perioperative MI Yes No

**Infection**

Sternum – Deep Yes No  
Thoracotomy Yes No  
Leg Yes No  
Arm Yes No  
Septicemia Yes No

**Neurologic**

Postoperative Stroke (Perm > 24 hours) Yes No  
Transient Ischemic Attack (TIA) Yes No  
RIND Yes No  
Continuous Coma >=24Hrs Yes No  
Paralysis Yes No **If Yes ↓**

**Pulmonary**

Prolonged Ventilation Yes No  
Pulmonary Embolism Yes No  
Pneumonia Yes No

Paralysis Type: Transient Permanent

**Renal**

Renal Failure Yes No **If Yes ↓**  
Dialysis (Newly Required): Yes No

**Vascular**

Iliac/Femoral Dissection Yes No  
Acute Limb Ischemia Yes No

**Other:**

Heart Block Yes No  
Cardiac Arrest Yes No  
Anticoagulant Event Yes No  
Tamponade Yes No  
Gastro-Intestinal Event Yes No  
Multi-System Failure Yes No  
Atrial Fibrillation Yes No  
Aortic Dissection Yes No  
Other Yes No

**Q. Mortality**

Mortality: Yes No Discharge Status: Alive Dead Status at 30 days After Surgery: Alive Dead Unknown

**If Mortality = Yes ↓**

Operative Death: Yes No

Mortality - Date \_\_\_/\_\_\_/\_\_\_ (mm/dd/yyyy)

Location of Death: OR during Initial Surgery Hospital Home Other Care Facility OR during Reoperation Unknown

**Primary Cause of Death (select only one) ↓**

Cardiac Neurologic Renal Vascular Infection Pulmonary Valvular Unknown Other

R. **Discharge** (Note: This section is only answered if Discharge Status is Alive)

ADP Inhibitors: Yes No Contraindicated / Not Indicated

Antiarrhythmics: Yes No Contraindicated / Not Indicated If Yes → Medication Name: Amiodarone Other

Aspirin: Yes No Contraindicated / Not indicated

Ace or ARB Inhibitors: Yes No Contraindicated / Not Indicated

Beta Blockers: Yes No Contraindicated / Not Indicated

Lipid Lowering: Yes No Contraindicated / Not Indicated If Yes → Medication Type: Statin Non-statin Both

Coumadin: Yes No Contraindicated / Not Indicated

Discharge Location: Home Extended Care / Transitional Care Unit/Rehab Other Hospital Nursing Home Hospice Other

Cardiac Rehabilitation Referral: Yes No Not Applicable

Smoking Cessation Counseling: Yes No Not Applicable

S. **Readmission** (Note: This section is only answered if Discharge Status is Alive)

Readmit <=30 Days from Date of Procedure: Yes No If Yes ↓

Readmit Primary Reason:

Anticoagulation Complication – Valvular

Anticoagulation Complication - Pharmacological

Arrhythmia/Heart Block

Congestive Heart Failure

Myocardial Infarction and/or Recurrent Angina

Pericardial Effusion and/or Tamponade

Pneumonia or other Respiratory Complication

Coronary Artery Dysfunction

Valve Dysfunction

Infection - Deep Sternum

Infection – Conduit Harvest Site

Renal Failure

TIA

Permanent CVA

Acute Vascular Complication

Subacute Endocarditis

VAD Complication

Transplant Rejection

Other – Related Readmission

Other – Nonrelated Readmission

Readmit Primary Procedure

OR for Bleeding

Pacemaker Insertion/AICD

PCI

Pericardiotomy / Pericardiocentesis

OR for Coronary Arteries

OR for Valve

OR for Sternal Debridement / Muscle Flap

Dialysis

OR for Vascular

No Procedure Performed

Other Procedure

Unknown

## Bibliography

- [1] American College of Cardiology, *NCDR CathPCI registry*, December 2011, Accessed December 16, 2011, at <https://www.ncdr.com/webncdr/DefaultCathPCI.aspx>.
- [2] Massachusetts Division of Health Care Finance and Policy, *Acute hospital case mix databases*, December 2011, Accessed December 20, 2011, at <http://www.mass.gov/eohhs/researcher/physical-health/health-care-delivery/hcf-data-resources/acute-hospital-case-mix-databases.html>.
- [3] Massachusetts Registry of Vital Records and Statistics, *Vital records database*, Accessed September 8, 2011, at <http://www.mass.gov/eohhs/gov/departments/dph/programs/vital-records.html>, October 2011.
- [4] NewsBank, inc, *Genealogybank.com social security death index 1937–current*, December 2011, Accessed December 1, 2011, at <http://www.genealogybank.com/gbnk/ssdi/>.
- [5] R Development Core Team, *R: A language and environment for statistical computing*, R Foundation for Statistical Computing, Vienna, Austria, November 2011, ISBN 3-900051-07-0; Accessed December 16, 2011, at <http://www.r-project.org/>.
- [6] SAS Institute Inc, *Sas system for unix/windows – version 9.2*, SAS Institute Inc, Cary, North Carolina, 2011, © 2011; Accessed December 16, 2011, at <http://www.sas.com/>.
- [7] Social Security Administration, *Social security administration’s death master file*, December 2011, Available through NTIS, U.S. Department of Commerce; Accessed December 20, 2011, at <http://www.ntis.gov/products/ssa-dmf.aspx>.
- [8] Society of Thoracic Surgeons, *The society of thoracic surgeons adult cardiac data collection form – version 2.61*, August 2007, Accessed December 16, 2011, at [http://www.sts.org/sites/default/files/documents/pdf/AdultCV2.61DCF\\_Annotated.pdf](http://www.sts.org/sites/default/files/documents/pdf/AdultCV2.61DCF_Annotated.pdf).

- [9] \_\_\_\_\_, *Sts adult cardiac data specifications – version 2.61*, August 2007, © 2007; Accessed December 16, 2011, at <http://www.sts.org/sites/default/files/documents/pdf/AdultCVDDataSpecifications2.61.pdf>.
- [10] \_\_\_\_\_, *Adult cardiac surgery database*, 2011, Accessed December 16, 2011, at <http://www.sts.org/sts-national-database/database-managers/adult-cardiac-surgery-database>.
- [11] David Spiegelhalter, Andrew Thomas, Nicky Best, and Dave Lunn, *Winbugs user manual – version 1.4*, January 2003, © 2003; Accessed December 16, 2011, at <http://www.mrc-bsu.cam.ac.uk/bugs/winbugs/manual14.pdf>.