ADULT CORONARY ARTERY BYPASS GRAFT SURGERY IN THE COMMONWEALTH OF MASSACHUSETTS

January 1 – December 31, 2005

HOSPITAL AND SURGEON STANDARDIZED 30-DAY MORTALITY RATES

Mass-DAC

Department of Health Care Policy

Harvard Medical School

October 2007

FUNDED BY THE MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH

MASSACHUSETTS DATA ANALYSIS CENTER (MASS-DAC)

Department of Health Care Policy
Harvard Medical School
180 Longwood Avenue
Boston, MA 02115
(www.massdac.org)

MASSACHUSETTS CARDIAC SURGERY CENTERS 2005

Baystate Medical Center 759 Chestnut Street Springfield, MA 01199	Massachusetts General Hospital (MGH) 12 Fruit Street Boston, MA 02114
Beth Israel Deaconess Medical Center (BIDMC) 330 Brookline Avenue Boston, MA 02115	Mount Auburn Hospital 330 Mount Auburn Street Cambridge, MA 02138
Boston Medical Center (BMC) 88 East Newton Street Boston, MA 02118	North Shore Medical Center - Salem Hospital 81 Highland Avenue Salem, MA 01970
Brigham & Women's Hospital (B&W) 75 Francis Street Boston, MA 02115	Southcoast Hospital Group - Charlton Memorial Hospital 363 Highland Avenue Fall River, MA 02720
Cape Cod Hospital 27 Park Street Hyannis, MA 02601	Saint Vincent Hospital at Worcester Medical Center 123 Summer Street Worcester, MA 01608
Caritas Saint Elizabeth's Medical Center 736 Cambridge Street Boston, MA 02135	Tufts-New England Medical Center (NEMC) 750 Washington Street Boston, MA 02111
Lahey Clinic 41 Mall Road Burlington, MA 01805	UMass Memorial Medical Center 55 Lake Avenue North Worcester, MA 01655

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

1 - KEY FINDINGS - HOSPITALS

- In 2005, there were **7164** hospital admissions in which at least one cardiac surgery was performed in Massachusetts. More than half **(54**%) of the admissions involved an isolated coronary artery bypass graft (CABG) surgery.

- **Fourteen** hospitals performed at least one CABG operation in Massachusetts in 2005.

- In the fourteen hospitals that performed cardiac surgery in 2005, the number of isolated CABG surgery admissions ranged from **99 to 501.**

- The unadjusted all-cause 30-day mortality rate (defined as the number of patients dying within 30 days of surgery divided by the number of patients undergoing isolated CABG surgery) in Massachusetts during 2005 was **1.65%**. This corresponded to 64 deaths out of 3883 CABG admissions.

- After adjusting for patient risk, the odds of 30-day mortality in a hospital one standard deviation above the state average was **twice** (odd = 2.06) that of a hospital one standard deviation below the state average. This represents a **reduction in between-hospital variation** from 2004 CABG surgeries (odds in 2004 = 3.3).

- **One** hospital (UMass Memorial Medical Center) was identified as a statistical outlier, having higher than expected 30-day mortality in 2005. **However**, in late 2005 UMass Memorial Medical Center implemented significant changes to improve its program. Preliminary analyses of 2006 data indicate substantial improvement consistent with these changes – the unadjusted 30-day CABG mortality rate at UMass Memorial Medical Center was about 1/3 that of the 2006 state rate.

– KEY FINDINGS - SURGEONS

- **57** surgeons performed **12,264** Isolated CABG surgeries in Massachusetts over the period January 1, 2003 through December 31, 2005.
- **80%** of surgeons performed isolated CABG surgery at only one hospital.
- Isolated CABG surgery volumes ranged from **7 to 538** across the 57 surgeons.
- Surgeon analyses were based on **56** surgeons who had 10 or more CABG admissions; this corresponded to **12, 255** admissions.
- The unadjusted all-cause 30-day mortality rate in Massachusetts during 2003 - 2005 was **1.98%**.
- After adjusting for patient risk, the odds of 30-day mortality associated with a surgeon one standard deviation above the state average was **twice** (2.11) that for a surgeon one standard deviation below the state average. There was **no reduction in between-surgeon variation** from 2004.
- There were **3** surgeons identified as statistical outliers, each having higher than expected mortality. **However,** the 3 surgeons are **no longer** performing cardiac surgery in Massachusetts after identification of outlier status in October 2005.

2 - INTRODUCTION

2.1 - What is in this Report?

This report describes procedures for calculating hospital-specific risk standardized 30-day mortality rates following isolated coronary artery bypass graft (**CABG**) surgery performed in Massachusetts hospitals during 2005 and for calculating surgeon-specific standardized rates for CABG surgeries performed from 2003 through 2005. Surgeries performed in United States Government Hospitals (e.g., VA Boston Healthcare 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 their 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 2005, there were fourteen cardiac surgery programs in Massachusetts: eleven well established and three relatively new programs. The newer hospital programs (Southcoast Hospital Group – Charlton Memorial Hospital, Cape Cod Hospital and North Shore Medical Center - Salem Hospital) all began performing cardiac surgery in 2002 - 2003. All Massachusetts hospitals with cardiac surgery programs submitted data to Mass-DAC.

This document is the 4th annual report (http://massdac.org/reports/surgery.html) describing hospital-specific risk standardized mortality rates following isolated CABG surgery in Massachusetts. It describes standardized mortality rates for the fourteen cardiac surgery programs in Massachusetts that performed at least one isolated CABG surgery between January 1, 2005 and December 31, 2005. It also contains the second annual reporting of surgeon-specific risk-standardized mortality using data covering the period from January 1, 2003 through December 31, 2005.

2.2 - What is Coronary Artery Bypass Graft 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. If 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. Coronary artery bypass graft (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 is the only major heart surgery performed are referred to as ***isolated CABG*** procedures.

2.3 - Definition of Study Population

The patient population consists of all patients aged 18 years or older undergoing isolated CABG surgery in Massachusetts' adult acute care hospitals between January 1, 2005 and December 31, 2005. Surgeries performed in United States Government hospitals (e.g., VA Boston Healthcare System) are not included. If multiple cardiac surgeries occur during an admission, admissions are categorized by the primary (initial) surgery. Isolated CABG surgery included 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 was 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 procedures were classified as "Other Cardiac Surgery." Lung biopsies performed in conjunction with a CABG were considered on a case by case basis **(see Appendix 1)**. **Table 2.1** lists the distribution of the 7164 cardiac surgery admissions stratified by surgical procedure type in Massachusetts' hospitals during 2005.

Table 2.1: Surgical Procedure Type Classification of Adult Cardiac Surgeries During January 1, 2005 - December 31, 2005, Commonwealth of Massachusetts. * Includes 4 Cardiac Surgery patients with unknown mortality status (2 Isolated CABG patients).

Surgical Procedure Type	No. of Cardiac Surgery Admissions	% of Cardiac Surgery Admissions
Isolated CABG	**3885***	**54.23**
Mitral Valve Replacement (MVR)	126	1.76
Aortic Valve Replacement (AVR)	603	8.42
MVR + CABG	65	0.91
AVR + CABG	501	6.99
AVR + MVR	34	0.47
Other Cardiac Surgery	1920	26.80
Non-Cardiac (Thoracic) Procedures	30	0.42
All Cardiac Surgery Admissions	**7164**	**100.00**

2.4 - Why Report on CABG Surgery?

CABG surgeries account for the majority of cardiac surgeries performed nationally and are a costly procedure. In 2005, isolated CABG surgeries accounted for 54.2 percent of the 7164 cardiac surgery hospital admissions in Massachusetts. Only data on patients who have undergone isolated CABG surgery are used to determine the hospital mortality rates in this report.

2.5 - What is Mass-DAC?

Mass-DAC is a data-coordinating center responsible to the Massachusetts Department of Public Health for the collection, storage, and analysis of the cardiac data submitted by Massachusetts hospitals. Mass-DAC is located in the Department of Health Care Policy, Harvard Medical School in Boston (www.massdac.org). Mass-DAC is advised by several committees on an ongoing basis: 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.

3 - SUMMARY OF DATA COLLECTION & VERIFICATION PROCEDURES

3.1 - Definition of Patient Outcome

Mortality, regardless of cause, measured within 30 days from 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.

3.2 - Massachusetts Cardiac Surgery Programs

Fourteen cardiac surgery centers treated patients in Massachusetts during January 1, 2005 through December 31, 2005.

3.3 - Data Sources

Three different data sources were used to create this report: patient-specific data collected by hospital personnel using the Society of Thoracic Surgeons (STS) National Cardiac Surgery Database software; hospital administrative discharge data; and vital statistics information provided by the Massachusetts Department of Public Health.

Mass-DAC STS Data. Patient-specific risk factor and outcome data were collected by hospital personnel using the STS National Cardiac Surgery Database software. Version 2.52.1 of the STS collection tool (**see Appendix 3**) containing 293 variables was used for all data submissions for surgeries performed during 2005.

Massachusetts Inpatient Acute Hospital Case Mix and Charge Database. Hospital discharge data for fiscal years 2002 through 2006, (October 1, 2002 through September 30, 2006) were obtained from the Massachusetts Division of Health Care Finance and Policy. Data elements included: hospital identifier; gender, race, age and home zip code of the patient; ICD-9 codes; discharge status; dates of admission and discharge; date of surgery; and patient medical record number. Social Security numbers were removed from this database.

Massachusetts Mortality Index Database. Date of death information obtained from Massachusetts death certificates were available for all deaths occurring in Massachusetts between January 1, 2002 and September 30, 2006 from the Massachusetts Registry of Vital Records and Statistics. While the primary source of 30-day mortality rates was the hospital-reported rates, the mortality index database was used in a verification procedure. 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.

3.4 - 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 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 3.1**). This process involved submitting protected data during specific harvest periods. Hospitals encrypt and password protect the data and transmit it electronically using a secure repository on a secure website. Because 30-day mortality information for patients undergoing cardiac surgery between January 1, 2005 and June 30, 2005 would be complete by July 30, 2005, the harvest began September 1, 2005, one month after the last 30-day follow-up. Data harvests were scheduled in September, 2005 for surgeries between January 1, 2005 and June 30, 2005; data on surgeries performed between July 1, 2005 and December 31, 2005 were collected in the March 2006 harvest. Hospitals were allowed up to one month to submit data during the harvest periods. Hospitals submitted subsequent corrected data as often as desired, and could sign off on its accuracy and completeness

at any time. However, all 2005 cardiac surgery data were required to be complete by July 1, 2006 after which no changes were accepted without written permission from Mass-DAC.

Table 3.1: Cardiac Surgery Data Harvest Schedule for Surgeries Performed in 2005.

Month of Data Harvest	Corresponding Dates of Cardiac Surgery
September, 2005	January 1, 2005– June 30, 2005
March, 2006	July 1, 2005 – December 31, 2005
July, 2006	**Data Close-Out for 2005 Data** January 1, 2005 – December 31, 2005

3.5 - Cleaning and Validation Procedures

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

Hospital-Specific Data Quality Reports. For each data submission, Mass-DAC provided a quality report to each hospital describing the distribution of all STS elements and identifying cases with missing, out of usual range, or inconsistent. The hospitals were given thirty days to correct the data deficiencies identified by Mass-DAC following receipt of each quality report.

There were a total of 91 data submissions sent in by 14 hospitals during 2005 with a mean of 3.3 submissions per hospital. Data submissions for 2005, ranged from 1 to 6 per hospital. Mass-DAC returned a total of 90 quality reports with a mean of 3.2 reports per hospital. Each submission of data generated a quality report returned to the hospital with the exception of one submission which was resubmitted almost immediately after the first was submitted.

MA 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, there was a net increase of 8 thirty-day mortalities for all cardiac surgeries and a net increase of 1 thirty-day mortality for isolated CABG patients. The Massachusetts Inpatient Case Mix Dataset was used to determine whether all appropriate cases of cardiac surgery from each institution were submitted to Mass-DAC.

Meetings and Communication. Mass-DAC communicated regularly via electronic mail and telephone with the data managers to clarify definitions or procedural issues, and to serve as a facilitator to the national STS. Recently asked and answered questions were discussed at data manager meetings or through an email network. Preliminary results were shared at the state STS meeting and at Mass-DAC Data Manager meetings. This process helped identify areas where data may be inconsistent, incorrectly coded, or outlying.

Audit Data. In the spring of 2007, a sample of the 2005 isolated CABG data was audited. Ten cardiac surgeons and two data managers volunteered to assist the Cardiac Surgery Adjudication Committee with performing the audits of the 2005 records. All participants took the Harvard Medical School Human Subjects training prior to review of records and were approved by the Harvard Medical School Internal Review Board (IRB). Records requested from the hospitals included those for (1) **all** patients who died within 30 days of surgery, (2) **all** patients reported to have shock prior to surgery, (3) **all** patients coded with emergent or emergent salvage status, (4) **all** patients coded as having a myocardial infarction (MI) less than 24 hours prior to surgery and (5) a random sample of those patients coded as having peripheral vascular disease (PVD). The total number of records requested amounted to 392 from the 14 hospitals. The records were reviewed to determine data consistency and accuracy of coding.

An additional 294 records were also requested for a subset of surgeries that were coded as "CABG + other" and "CABG plus valve" surgery. These records were reviewed to determine if some might be considered Isolated CABG surgery. Documentation requested from the hospitals included discharge summaries, operative reports, admission and history summaries, and catheterization reports. Records that were reviewed and identified by the auditors to be Isolated CABG were then also reviewed for the variables of shock, emergent or salvage status, MI within 24 hours of surgery and PVD.

In all, 642 records were reviewed by the surgeons to determine agreement with the information submitted by the hospitals. The subset of records where procedures were coded as "CABG + other" and "CABG plus valves" were reviewed by the committee to determine whether the "other" procedures were appropriate to move the entire surgery into the isolated CABG category **(see Appendix 1),** while the additional records were audited to determine justification of shock, emergent or salvage status, PVD, myocardial infarction and timing. If the Adjudication Committee did not agree with the coding of shock, emergent or 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 final decision changes were then made in the Mass-DAC database.

Of the 642 records that were identified for audit, the auditors disagreed with and changed the coding of 80 records to Isolated CABG; 27 records which were coded for MI 24 hours or less prior to surgery were changed; 37 records coded for status and 63 records coded for shock were also changed by the Adjudication Committee.

4 - RISK ADJUSTMENT

4.1 - Who Receives Isolated CABG Surgery in Massachusetts?

Table 4.1 lists the age/sex/race distribution for 3885 adult CABG surgery patients at 14 cardiac surgery programs in Massachusetts. The majority of patients were male (76%) and white (91%). In 2005, 57% of the cases were age 65 years or older at the time of their surgery. Patients who resided outside of Massachusetts at the time of their surgery comprised 12% of the 3885 CABG admissions (data not shown).

Table 4.1: Age-Sex-Race distribution for all adult Isolated CABG surgery admissions (N = 3885*) in MA hospitals during January 1, 2005 - December 31, 2005. Entries represent numbers of patients. *Includes 2 isolated CABG patients with unknown 30 day mortality status.

Age Group	Females					Males				
	White	African American	Hispanic	Other§	Total	White	African American	Hispanic	Other§	Total
18 – 44	25	1	3	1	30	49	5	5	6	65
45 – 54	52	4	6	2	64	334	12	23	21	390
55 – 64	150	8	11	4	173	854	16	28	40	938
65 – 74	257	9	15	14	295	846	11	26	34	917
≥ 75	333	8	7	7	355	632	4	10	12	658
Total	817	30	42	28	**917**	2715	48	92	113	**2968**

4.2 - 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 prior to the CABG operation. 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 operation than healthier patients. Moreover, patients who are sicker may be more likely

§ Includes some patients with unknown or missing race information.

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 not to penalize hospitals that treat sicker patients, it is important to consider differences in patient health prior to surgery.

The statistical process of accounting for differences in patient sickness prior to their 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 differences in patient health prior to surgery.

4.3 - 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 may not be the same. The statistical model used to calculate mortality rates in this report, a ***hierarchical logistic regression*** model, models the difference between the risks of mortality for patients with the same risk factors who are treated at different hospitals. This is accomplished through the inclusion of a hospital-specific (random) effect. If no key risk factor 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.

5 - IDENTIFYING OUTLYING CARDIAC SURGERY PROGRAMS

The purpose of this report is to identify hospitals that have ***unusually*** high or ***unusually*** low mortality rates. Such hospitals are classified as "outlying" – however, the designation of outlying depends on how large the difference is. Two methods were 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 does not contain the state unadjusted 30-day hospital mortality rate, the hospital is designated as outlying.

However, because any one hospital could influence the estimates of the risk-standardized mortality rate for other hospitals in the state, Mass-DAC also calculates the predicted number of mortalities at each hospital using the experience of all **other** hospitals in Massachusetts. If the probability that the actual number of mortalities is **no different** from the predicted number of mortalities is **small**, then the hospital is classified as "outlying."

If the 95% interval estimate for a particular hospital excludes the state unadjusted 30-day hospital mortality rate **or** if the probability of the observed mortality based is no different from that predicted from all other hospitals for a particular hospital is small, then Mass-DAC classified the hospital as outlying. It is important to note that the classification in this report is relative to all hospitals in Massachusetts performing CABG surgery.

5.1 - 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 2005. 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 state rate, then the hospital mortality is **not different than expected**. If the interval excludes the state unadjusted rate, then the hospital's SMIR is different from what was expected. In this case, if the upper limit of the interval is lower

than the unadjusted state 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 state 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 CABG surgery in Massachusetts hospitals were calculated using the following procedure:

1. A hierarchical logistic regression model was estimated. This model assumes that the log-odds 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^{th} patient treated at the i^{th} cardiac surgery program died within 30-days of surgery and 0 otherwise, and n_i the total number of isolated CABG cases at the institution in 2005. The model estimated was:

$$\text{Log-odds}[\text{Probability}\ (Y_{ij} = 1)] = \beta_{0i} + \beta(\text{Risk Factors})$$
$$\beta_{0i} \sim \text{Normal}(\mu, \tau^2)$$

2. The Risk Factors are those listed in **Table 6.1** (for surgeries performed between January 1, 2005, and December 31, 2005).
3. The "expected" mortality rate at institution "i" is: $1/n_i \sum_j \text{logit}^{-1}[\mu + \beta(\text{Risk Factors})]$. This is the mortality rate expected using the mortality intensity for the entire state and the case mix reported at the institute. Thus it represents the severity of cases at the institution.
4. The "true" mortality rate at institution "i" is: $1/n_i \sum_j \text{logit}^{-1}[\beta_{0i} + \beta(\text{Risk Factors})]$. This is interpreted as the mortality rate at the i^{th} hospital adjusted for case-mix, with larger values generally meaning a sicker baseline population. Note that because the model assumes that the probability of dying is greater than 0, then the true estimate must be greater than 0.
5. The Massachusetts unadjusted rate is: $Y = 100\times (\sum_{ij} Y_{ij})/\sum_i n_i$.
6. The standardized mortality incidence rate (SMIR) at institution "i" is:

$$Y \times (\text{true})/(\text{expected}).$$

The SMIR is interpreted as the projected mortality rate at the hospital today if hospital quality remained the same as in 2005.

7. Ninety-five percent posterior intervals were calculated for each cardiac program's SMIR.
8. An implicit assumption is that the SMIR must be greater than 0.

The parameters μ and τ^2 represent the overall mean risk-adjusted log-odds of mortality and between-hospital variation, respectively. If there are no quality differences (based on mortality) across cardiac surgery hospitals, then

$$\beta_{0,1} = \beta_{0,2} = \ldots = \beta_{0,14} = \beta_0 \text{ and this happens if and only if } \tau^2 = 0$$

The hierarchical model was estimated using WinBUGS software.[2] The prior distributions assumed for β, μ, and τ^2 were, respectively: independent normal distributions with mean 0 and variance 1000 for the components of β; μ from a normal distribution with mean 0 and variance 1000; and $1/\tau^2$ from a gamma distribution with shape and inverse scale 0.001.

5.2 - 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 μ and τ^2. One method to identify hospitals as outlying is 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 hospitals in the Commonwealth.

Mass-DAC compared the predicted number to the observed number of deaths at the dropped hospital and calculated a "probability." This probability, loosely called a "p-

[2] A burn-in of 5000 draws and inference based on a subsequent 5000 draws. Convergence was assessed using the Gelman-Rubin statistics via 3 parallel chains.

value" quantifies how **likely** the observed number of deaths would be if the dropped hospital had the same level of quality as all remaining cardiac surgery hospitals. Small p-values (those ≤ 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 the number of deaths predicted by its peers, then the hospital is classified as having **lower than predicted mortality**. Mass-DAC repeated this procedure, eliminating each cardiac surgery hospital, and calculating a p-value for each hospital.

5.3 - 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 main analyses assumed the *precision* (defined as one over the variance) arose from a gamma distribution. Because the prior distribution for the variance component can influence the results, Mass-DAC re-estimated the hierarchical model using different prior distributions for τ^2: (**1**) the between-hospital *standard deviation* arose from a uniform distribution over the range 0 to 1.5 and (**2**) the between-hospital *standard deviation* arose from a half normal distribution with mean 0 and variance 0.26. In the former case, we are giving equal weight to values across the range 0 to 1.5 – a value of 1.5 for the standard deviation implies a very large range in hospital odds ratios. In the latter case, the half normal distribution has its mode at 0 and its median at 0.39.

6 - HOSPITAL QUALITY FOLLOWING ISOLATED CABG SURGERY: 2005

Of the 3883 isolated CABG surgery admissions in 2005 in Massachusetts, 64 patients (1.65%) died within 30 days of their surgery. **Table 6.1** lists the prevalence (%) of important risk factors and the relationship of each risk factor (controlling for all other risk factors) with 30-day mortality following surgery[3]. For example, 76.4% of the 3883 CABG surgery admissions were male patients. Odds ratios greater than 1 correspond to increased risk of mortality while those less than 1 correspond to decreased risk of mortality. The odds ratio of 0.86 for males indicates that males are 0.86 times as likely as females to die within 30 days of CABG surgery. In contrast, patients having cardiogenic shock prior to isolated CABG surgery are 5.09 times more likely to die within 30 days than patients not having cardiogenic shock. Because age is measured in years, the table reports the average number of years over age 65 for the cohort.

Figure 6.1 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 1.65%. 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 of the cases. Listed on the right-hand side are the estimated SMIRs. All 95% probability intervals include the unadjusted state rate of 1.65%.

Figure 6.2 presents the cross-validated p-values under the different assumed prior distributions for the between-hospital variation parameter. The cross validated p-values indicated that UMass Memorial Medical Center had a small p-value (0.001). Because the mortality predicted at UMass Memorial Medical Center was lower than that observed, this evidence suggests that relative to all other Massachusetts' programs, 30-day all cause mortality at UMass Memorial Medical Center was higher than expected. **However**, in late

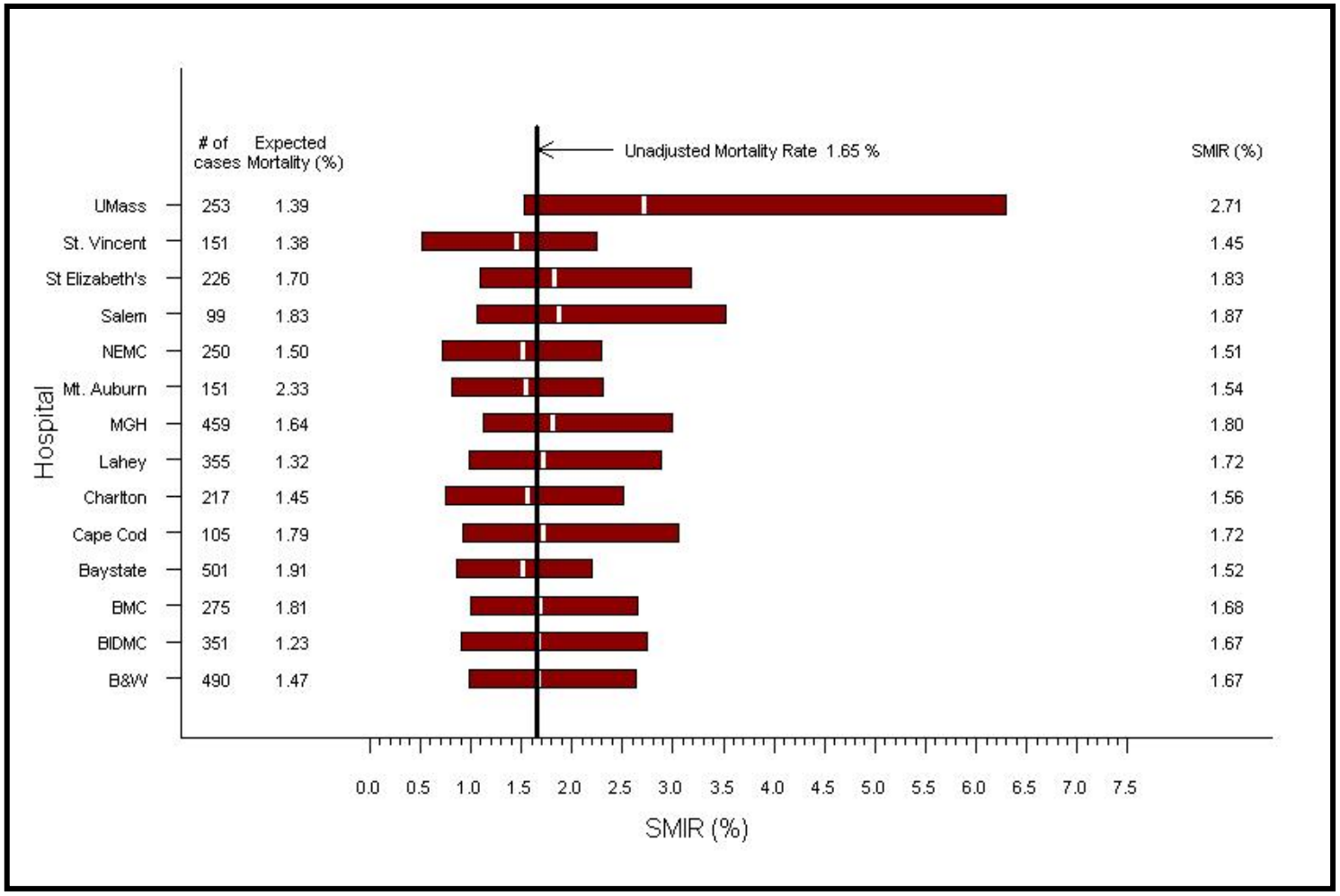
[3] Fit using a non-hierarchical logistic regression model indicated area under the ROC curve of 0.76. The Hosmer-Lemeshow Goodness-of-Fit test did not indicate a lack of fit ($\chi 2$ (8 dof) = 4.89, p = 0.77). Model discrimination ranged form 0% (0 deaths in 397 admissions) in the lowest risk decile to 7.3% (30 deaths in 410 admissions) in the highest risk decile.

2005 UMass Memorial Medical Center implemented changes to improve its program. Preliminary analyses of 2006 data indicate substantial improvement consistent with these changes – the unadjusted 30-day CABG mortality rate at UMass Memorial Medical Center was about 1/3 that of the 2006 state rate.

Table 6.1: Prevalences and Adjusted Odds Ratios of 30-Day Mortality Following Isolated CABG Surgery in Adults: 2005. Based on 3883 surgeries with 64 deaths (1.65%). *Average age of patients undergoing isolated CABG surgery is 65 + 1.5 = 66.5 years of age.

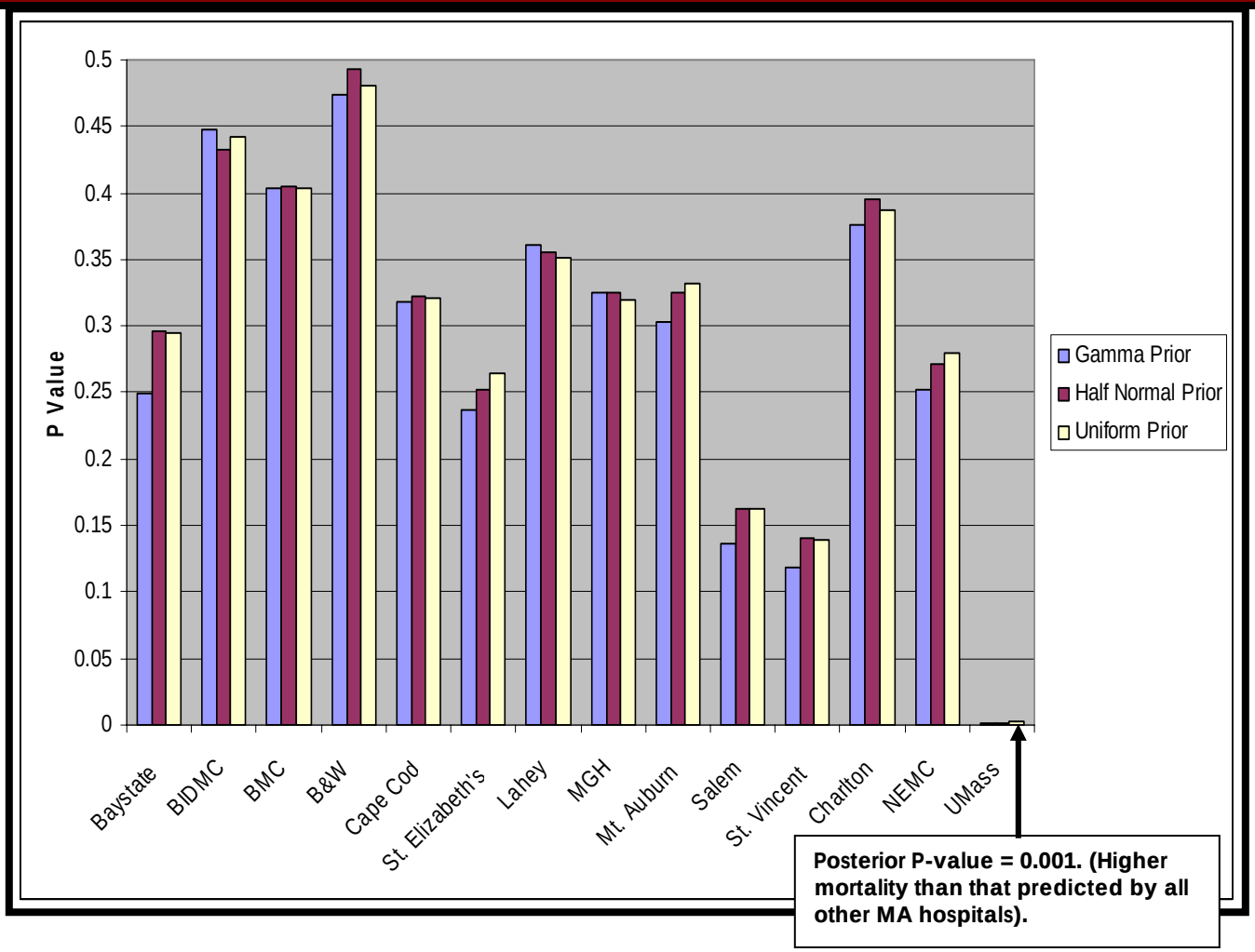
Risk Factor	Prevalence (%)	Adjusted Odds Ratio	95% Interval for the Adjusted Odds Ratio
Years over 65*	1.45	1.07	(1.04, 1.11)
Male	76.38	0.86	(0.51, 1.59)
Renal Failure	6.39	1.59	(0.58, 3.29)
Diabetes	39.25	0.76	(0.40, 1.27)
Hypertension	83.90	1.03	(0.49, 2.11)
Peripheral Vascular Disease	17.43	1.40	(0.69, 2.46)
Prior CABG surgery	2.50	1.51	(0.17, 4.61)
Prior Percutaneous Coronary Intervention (PCI)	20.24	1.04	(0.48, 1.86)
Cardiogenic Shock	1.00	5.09	(1.04, 15.6)
Ejection Fraction (Ref = ≥ 40%)			
< 30% or missing	11.61	0.95	(0.38, 1.88)
30 – 39 %	10.89	1.59	(0.71, 2.96)
Myocardial Infarction (MI) (Ref = None)			
< 6 hours	1.06	1.51	(0.23, 4.90)
7 – 24 hours	1.85	0.38	(0.01, 1.61)
1 – 7 days	23.07	1.73	(0.81, 3.22)
8 – 21 days	5.15	2.96	(1.05, 6.56)
> 21 days	20.24	0.93	(0.34, 1.97)
Status of CABG (Ref = Elective)			
Urgent	61.29	1.30	(0.60, 2.59)
Emergent/Salvage	2.47	5.48	(1.12, 16.13)
Pre-Op Intra-Aortic Balloon Pump	10.89	2.22	(0.99, 4.28)
Between-Hospital Parameters		**Mean**	**95% Interval**
Between-Hospital Average logit, μ		-5.243	(-6.122,-4.407)
Between-Hospital Variance in logits, τ^2		0.1304	(0.000979, 0.5806)

Figure 6.1. Ninety-Five Percent Posterior Intervals for Standardized Mortality Incidence Rates (SMIRs) Following Isolated CABG Surgery in Massachusetts, 2005. # 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 in the hospital. The white vertical line in each box is the hospital's SMIR while the black vertical line denotes the unadjusted state 30-day mortality rate of 1.65%.



KEY: **B&W** = Brigham & Women's Hospital; **BIDMC** = Beth Israel Deaconess Medical Center; **BMC** = Boston Medical Center; **Baystate** = Baytstate 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; **NEMC** = Tufts New England Medical Center; **Salem** = North Shore Medical Center-Salem Hospital; **St. Elizabeth's** = Caritas Saint Elizabeth's Medical Center; **St. Vincent** = Saint Vincent Hospital at Worcester Medical Center; **Mass** = UMass Memorial Medical Center.

Figure 6.2: Cross-Validated P-Values: Isolated Cardiac Surgery Admissions in 2005. P-values for each of the 14 cardiac surgery programs are listed on the y-axis; the x-axis identifies the hospital. Results are presented under a variety of assumptions for fitting the hierarchical regression model. From left to right, bars represent gamma, half normal and uniform prior distributions.



KEY: **B&W** = Brigham & 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; **NEMC** = Tufts New England Medical Center; **Salem** = North Shore Medical Center-Salem Hospital; **St. Elizabeth's** = Caritas Saint Elizabeth's Medical Center; **St. Vincent** = Saint Vincent Hospital at Worcester Medical Center; **Mass** = UMass Memorial Medical Center.

7 –SURGEON-SPECIFIC STANDARDIZED 30-DAY MORTALITY INCIDENCE RATES: JANUARY 1, 2003 – DECEMBER 31, 2005

7.1 -What Data are used for this Analysis?

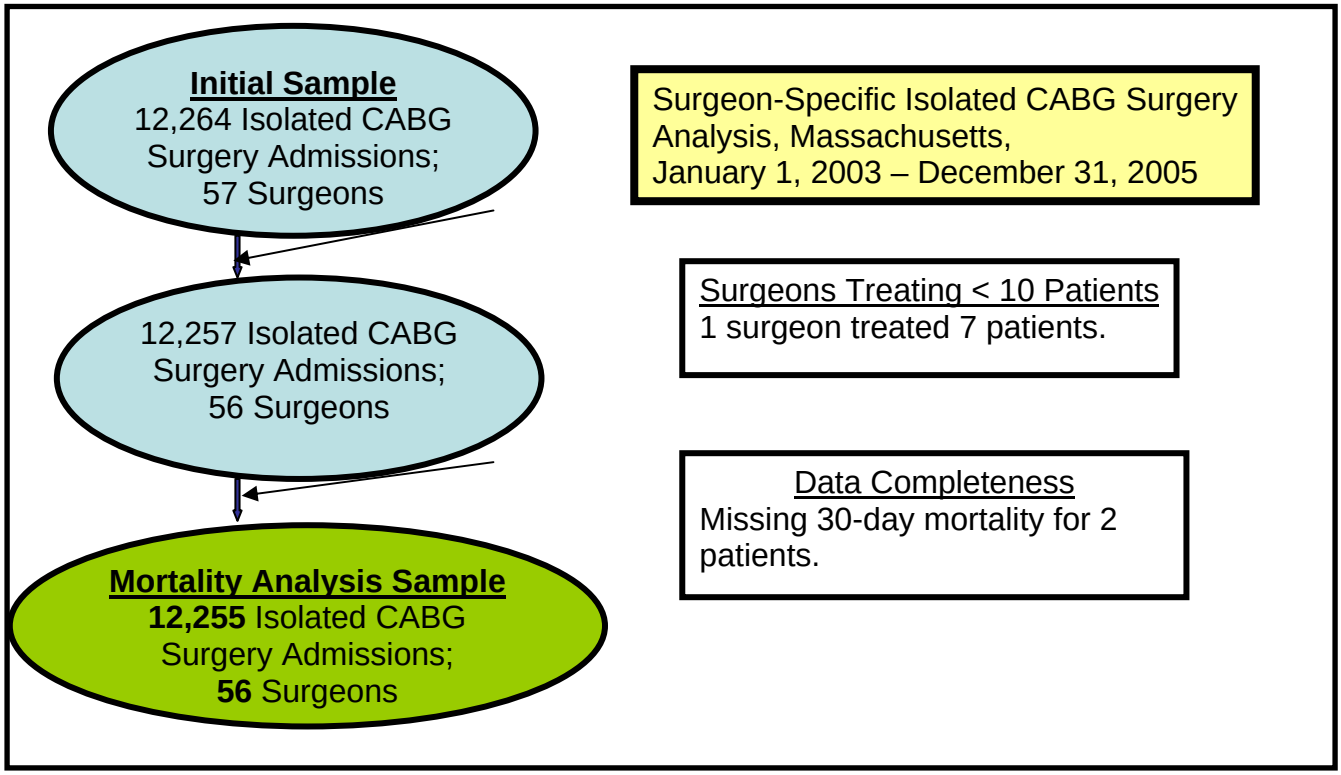
All patients undergoing isolated coronary artery bypass grafting (CABG) surgery between January 1, 2003 and December 31, 2005 were identified. The Massachusetts Cardiac Surgery STS Quality and Outcomes Committee made recommendations regarding surgeon inclusion and exclusion criteria for the purpose of public reporting. These recommendations involved having a very low surgeon volume threshold but took into consideration whether or not the surgeon was active for at least two years and still active in the year after the end of the reporting period (e.g., in 2006); and excluding surgeons associated with 10 or fewer isolated CABG surgeries. For those surgeons with fewer than **190**[4] Isolated CABG surgery admissions over the three year period, an asterisk is included to indicate that "small sample size may diminish the accuracy of these estimates."

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 as those risk factors that are used in the hospital models (see earlier sections of this report). Methodology similar to the hospital analysis is utilized to identify surgeons who have unusually high or unusually low risk-standardized mortality rates. It is important to note that that all patients treated by a surgeon are assigned to each surgeon, regardless of which hospital the surgery was performed. Thus there is no separation of surgeon and hospital "effects."

[4]The number 190 comes from a "power" calculation. The overall 30-day mortality rate between 2003 and 2005 is 1.98%. Using a 2 sided-test with alpha = 0.05 and 80% power, 190 cases are needed to detect a difference of 3 times the expected rate (1.98 versus 6.00). This calculation is approximate because the surgeon-specific mortality rates depend on the surgeon's case-mix distribution. This implies that for some surgeons, the expected mortality rate is < 1.98% because they treat healthier patients and for other surgeons the expected rate would be more than 1.98% because they treat sicker patients.

7.2 - Results.

A total of 12,264 Isolated CABG surgery admissions corresponding to 57 surgeons were initially identified. One surgeon who treated a total of 7 patients was eliminated from the analyses. Two Isolated CABG patients were also eliminated from analyses because 30-day mortality was missing and their survival status was not verified. Consequently, the surgeon analysis sample consists of **12,255** adults treated by **56** surgeons in the Commonwealth.



Of the 56 surgeons, 45 (80%) treated patients at **exactly one** hospital in the Commonwealth, 10 (18%) at **exactly two** hospitals, and 1 (2%) treated patients at **exactly three** hospitals. **Table 7.1** provides descriptive age-sex-race/ethnicity statistics for the sample of 12,255 patients.

Table 7.1: Age-Sex-Race distribution for all adult Isolated CABG surgery admissions (N = 12,255) in MA hospitals during January 1, 2003 - December 31, 2005. Entries represent numbers of patients.

Age Group	Females					Males				
	White	African American	Hispanic	Other[5]	Total	White	African American	Hispanic	Other[5]	Total
18 – 44	66	5	7	5	83	160	9	12	22	203
45 – 54	183	14	15	6	218	1020	38	68	58	1184
55 – 64	514	28	41	26	609	2517	45	97	101	2760
65 – 74	885	32	52	49	1018	2648	41	78	118	2885
≥ 75	1096	22	20	26	1164	2033	15	27	56	2131
Total	2744	101	135	112	**3092**	8378	148	282	355	**9163**

Table 7.2 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. A non-hierarchical logistic regression model indicated area under the ROC curve of 0.78. The Hosmer-Lemeshow Goodness-of-Fit test did not indicate a lack of fit ($\chi 2$ (8 dof) = 4.00, p = 0.85). Model discrimination ranged from 0.4% (5 deaths in 1218 admissions) in lowest risk decile to 8.7% (111 deaths in 1281 admissions) in the highest risk decile.

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 1.98%. 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 surgeon. The expected mortality rate provides an overall assessment of case-mix severity for each surgeon. Listed on the right-hand side are the estimated SMIRs. One surgeon's 95% probability interval lies entirely above the unadjusted state rate of 1.98%.

Figure 7.2 presents the cross-validated p-values under the different assumed prior distributions for the between-surgeon variation parameter. The cross validated p-values indicated that three surgeons are statistical outliers: surgeon numbers 21, 34, and 41. Because the mortality predicted for these surgeons was lower than that observed, each surgeon is classified as having higher than expected mortality. In the figure, there were **12** surgeons who did not have any Isolated CABG surgery admissions during 2006 (denoted

[5] Includes some patients with unknown or missing race information.

by a * symbol) including two of the surgeons having higher than predicted mortality. Surgeons having fewer than 190 Isolated CABG surgery admissions are denoted by a # in Figure 7.2 with 25 (**45%**) out of 56 surgeons fell into this group.

Table 7.3 identifies each surgeon, the hospital(s) where the surgeon treated cases during 2003 through 2005, and summary statistics. Three surgeons are identified as having higher than expected 30-day mortality and the remaining 53 surgeons are identified as having 30-day mortality no different than expected. It is important to note that the 3 surgeons are **no longer** performing cardiac surgery in the state.

Table 7.2; Prevalences and Adjusted Odds Ratios of 30-Day Mortality Following Isolated CABG Surgery in Adults, Massachusetts: 2003-2005. Based on12, 255 surgeries by 56 surgeons with 243 deaths (1.98%). *Average age of patients undergoing isolated CABG surgery is 65 + 1.67 = 66.67 years of age.

Risk Factor	Prevalence (%)	Adjusted Odds Ratio	95% Interval for Adjusted Odds Ratio
Years over 65*	Mean = 1.67 yrs	1.06	(1.04, 1.07)
Male	74.77	0.58	(0.45, 0.79)
Renal Failure	6.40	2.73	(1.87, 3.85)
Diabetes	38.08	1.20	(0.90, 1.57)
Hypertension	81.93	0.85	(0.58, 1.18)
Peripheral Vascular Disease	17.50	1.84	(1.36, 2.43)
Prior CABG surgery	2.76	2.29	(1.16, 3.81)
Prior Percutaneous Coronary Intervention (PCI)	20.14	1.09	(0.76, 1.50)
Cardiogenic Shock	1.25	4.56	(2.41, 7.81)
Ejection Fraction (Ref = ≥ 40%)			
< 30% or missing	12.03	1.70	(1.16, 2.37)
30 – 39	11.48	1.78	(1.20, 2.50)
Myocardial Infarction(MI)(Ref = None)			
< 6 hours	0.95	1.21	(0.41, 2.64)
7 – 24 hours	2.33	1.45	(0.65, 2.70)
1 – 7 days	22.70	1.21	(0.81, 1.72)
8 – 21 days	5.20	1.49	(0.85, 2.41)
> 21 days	20.29	1.24	(0.82, 1.79)
Status of CABG (Ref = Elective)			
Urgent	64.61	1.13	(0.78, 1.61)
Emergent/Salvage	2.87	2.34	(1.14, 4.38)
Pre-Op Intra-Aortic Balloon Pump	11.37	1.74	(1.16, 2.52)
Between-Surgeon Estimates			
Between-Hospital Average logit, μ		-5.25	(-5.70. -4.75)
Between-Hospital Variance in logits, τ^2		0.14	(0.0034, 0.36)

Figure 7.1: 2003 - 2005 Risk-Standardized 30-Day Surgeon-Specific Mortality Rates. Rates based on 12, 255 Isolated CABG surgeries performed by 56 surgeons.

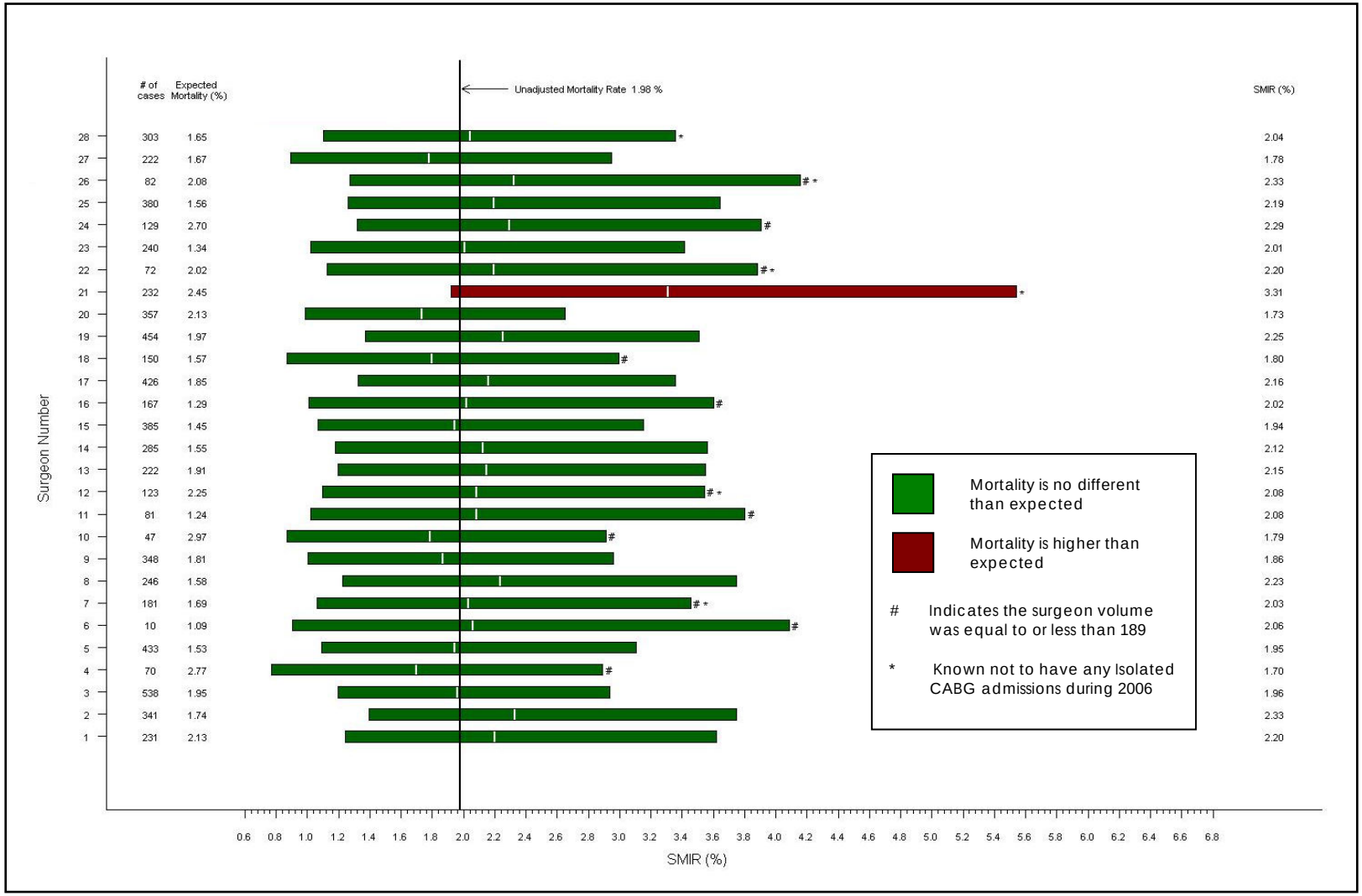


Figure 7.1 continues on the following page

Figure 7.1 Continued

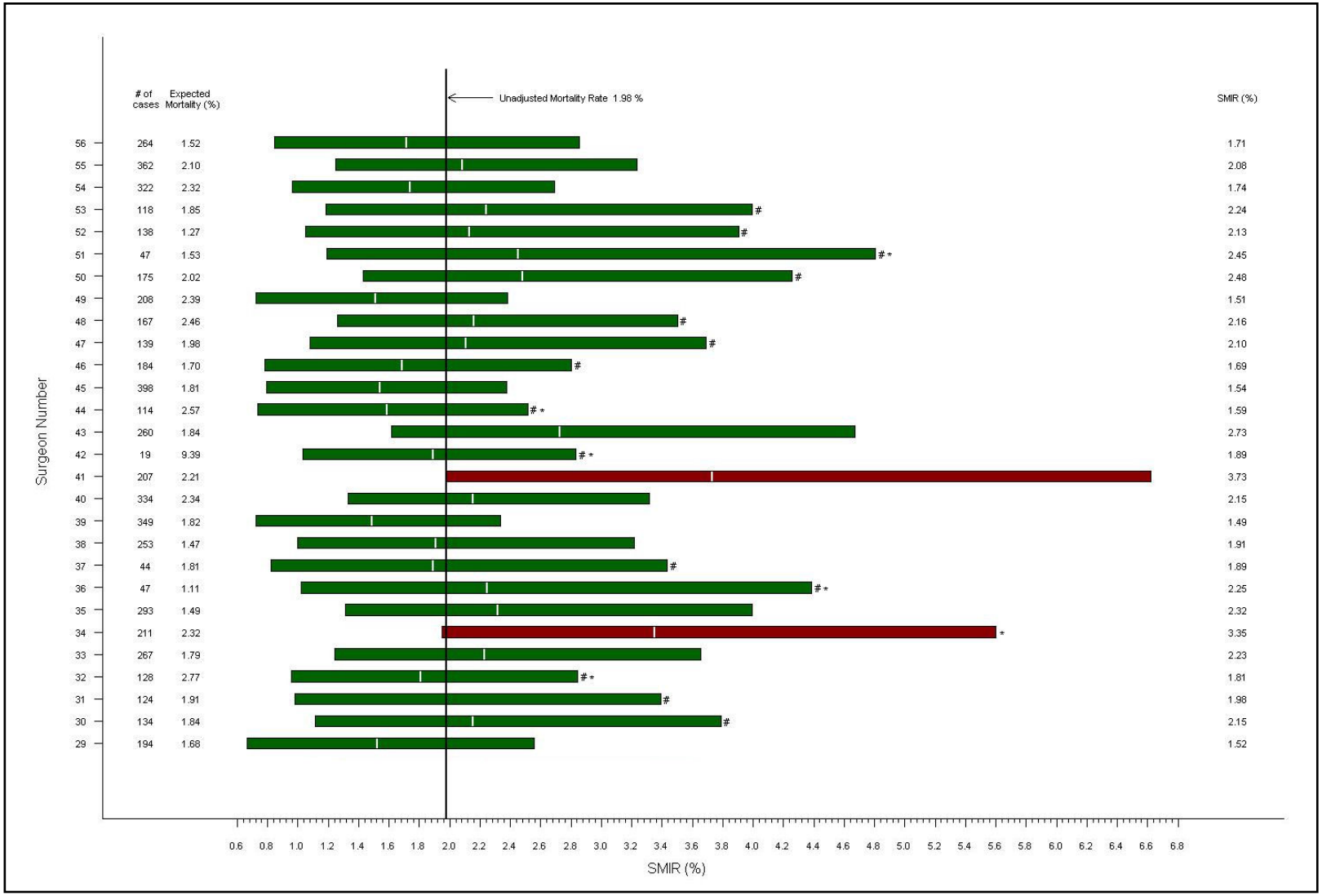


Figure 7.2 2003 - 2005 Surgeon P Values. Based on 12, 255 Isolated CABG surgeries performed by 56 surgeons.

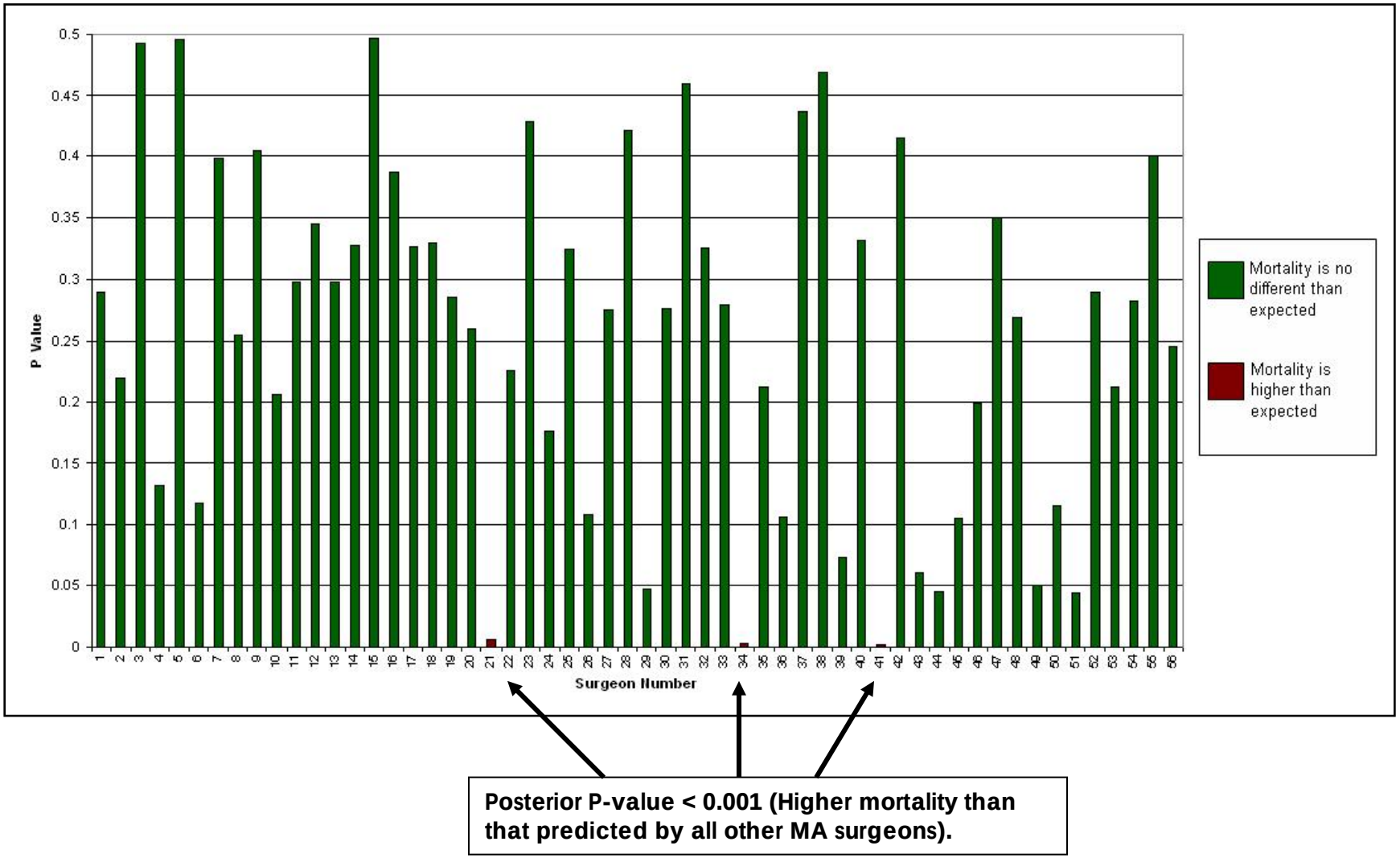


Table 7.3 - Surgeon Standardized 30-Day All Cause Mortality Incidence Rates (SMIRS) Following Isolated CABG Surgery, MA., January 1, 2003 – December 31, 2005. Surgeons ordered alphabetically by surname.

Surgeon No. & Name	Hospital(s)	Lower Limit of 95% Interval	SMIR (%)	Upper Limit of 95% Interval	P Value §	Interpretation ¶
1 - Agnihotri, Arvind	Massachusetts General Hospital; North Shore Medical Center - Salem Hospital	1.243	2.199	3.62	0.2898	As-expected
2 - Akins, Cary	Massachusetts General Hospital	1.392	2.331	3.75	0.22	As-expected
3 - Aranki, Sary	Brigham and Women's Hospital	1.195	1.961	2.937	0.4932	As-expected
4 - Birjiniuk, Vladimir #	Mount Auburn Hospital	0.7717	1.699	2.89	0.1322	As-expected
5 - Bojar, Robert	Saint Vincent Hospital; Tufts New England Medical Center	1.089	1.945	3.103	0.4958	As-expected
6 - Bolman, Ralph #	Brigham and Women's Hospital	0.9032	2.062	4.086	0.118	As-expected
7 - Byrne, John # *	Brigham and Women's Hospital	1.063	2.032	3.454	0.3986	As-expected
8 - Campos, Christian	Southcoast Hospital Group - Charlton Memorial Hospital; UMass Memorial Medical Center	1.224	2.233	3.75	0.2538	As-expected
9 - Carr, Thomas	Southcoast Hospital Group - Charlton Memorial Hospital	1.006	1.865	2.961	0.4048	As-expected
10 - Chen, Frederick #	Brigham and Women's Hospital	0.8681	1.786	2.911	0.2064	As-expected
11 - Cohn, Lawrence #	Brigham and Women's Hospital	1.02	2.085	3.803	0.2982	As-expected
12 - Cohn, William # *	Beth Israel Deaconess Medical Center	1.099	2.082	3.541	0.346	As-expected
13 - Couper, Gregory	Brigham and Women's Hospital	1.194	2.15	3.552	0.2982	As-expected
14 - D'Agostino, Richard	Lahey Clinic	1.179	2.122	3.562	0.3272	As-expected
15 - De Guzman, Brian	Lahey Clinic	1.067	1.944	3.153	0.4968	As-expected
16 - De la Torre, Ralph #	Beth Israel Deaconess Medical Center	1.011	2.021	3.6	0.387	As-expected
17 - Deaton, David	Baystate Medical Center	1.324	2.159	3.357	0.3264	As-expected
18 - Ehsan, Afshin #	Saint Vincent Hospital; Tufts New England Medical Center	0.8703	1.8	2.993	0.3292	As-expected
19 - Engelman, Daniel	Baystate Medical Center	1.373	2.255	3.506	0.2858	As-expected
20 - Flack, Joseph	Baystate Medical Center	0.9831	1.734	2.65	0.2594	As-expected
21 - Francalancia, Nicola *	Umass Memorial Medical Center	1.923	3.308	5.539	0.0064	Higher-than-expected
22 - Hatton, Paul # *	Southcoast Hospital Group - Charlton Memorial Hospital	1.127	2.196	3.883	0.2252	As-expected
23 - Hilgenberg, Alan	Massachusetts General Hospital	1.023	2.009	3.415	0.4288	As-expected
24 - Hunter, Curtis #	Boston Medical Center	1.318	2.295	3.907	0.1762	As-expected
25 - Khabbaz, Kamal	Beth Israel Deaconess Medical Center; Saint Vincent Hospital; Tufts New England Medical Center	1.261	2.194	3.641	0.3242	As-expected
26 - Lahey, Stephen # *	UMass Memorial Medical Center	1.274	2.325	4.155	0.1086	As-expected
27 - Lazar, Harold	Boston Medical Center	0.8899	1.78	2.949	0.2748	As-expected
28 - Liddicoat, John *	Beth Israel Deaconess Medical Center	1.102	2.042	3.354	0.4212	As-expected

Continued next page...

Surgeon No. & Name	Hospital(s)	Lower Limit of 95% Interval	SMIR (%)	Upper Limit of 95% Interval	P Value §	Interpretation ¶
29 - MacGillivray, Thomas	Massachusetts General Hospital	0.6637	1.522	2.557	0.0478	As-expected
30 - Madsen, Joren #	Massachusetts General Hospital	1.115	2.154	3.787	0.2762	As-expected
31 - Maggs, Peter #	Mount Auburn Hospital	0.979	1.977	3.391	0.4594	As-expected
32 - Mihaljevic, Tomislav # *	Brigham and Women's Hospital	0.9536	1.808	2.845	0.3256	As-expected
33 - Moon, Richard	St. Elizabeth's Medical Center	1.241	2.228	3.652	0.2792	As-expected
34 - Moses, Robert *	St. Elizabeth's Medical Center	1.951	3.353	5.602	0.0032	Higher-than-expected
35 - Okike, O. Nsidinanya	Umass Memorial Medical Center	1.315	2.318	3.994	0.2124	As-expected
36 - Pettiford, Brian # *	Southcoast Hospital Group - Charlton Memorial Hospital	1.023	2.246	4.386	0.1056	As-expected
37 - Pirundini, Paul #	Cape Cod Hospital	0.8222	1.889	3.433	0.4368	As-expected
38 - Rastegar, Hassan	Saint Vincent Hospital; Tufts New England Medical Center	0.9978	1.911	3.214	0.4682	As-expected
39 - Rizzo, Robert	Brigham and Women's Hospital; Cape Cod Hospital	0.7252	1.49	2.337	0.0724	As-expected
40 - Rousou, John	Baystate Medical Center	1.332	2.153	3.318	0.3318	As-expected
41 - Saltman, Adam	Umass Memorial Medical Center	1.977	3.732	6.624	0.0018	Higher-than-expected
42 - Sayeed-Shah, Umer # *	Boston Medical Center	1.034	1.892	2.834	0.4154	As-expected
43 - Sellke, Frank	Beth Israel Deaconess Medical Center	1.614	2.726	4.67	0.061	As-expected
44 - Shahian, David # *	Lahey Clinic	0.7333	1.589	2.513	0.0454	As-expected
45 - Shapira, Oz	Boston Medical Center	0.7913	1.542	2.373	0.1054	As-expected
46 - Shekar, Prem #	Brigham and Women's Hospital	0.7831	1.685	2.802	0.1986	As-expected
47 - Shemin, Richard #	Boston Medical Center	1.082	2.105	3.69	0.35	As-expected
48 - Symes, James #	St. Elizabeth's Medical Center	1.258	2.16	3.502	0.2692	As-expected
49 - Tam, Stanley	Mount Auburn Hospital; North Shore Medical Center-Salem Hospital	0.7253	1.513	2.38	0.0506	As-expected
50 - Toran, Ann #	North Shore Medical Center - Salem Hospital; St. Elizabeth's Medical Center	1.432	2.482	4.259	0.1156	As-expected
51 - Torchiana, David # *	Massachusetts General Hospital	1.193	2.453	4.807	0.0436	As-expected
52 - Vandersalm, Thomas #	North Shore Medical Center - Salem Hospital	1.052	2.129	3.904	0.2898	As-expected
53 - Vlahakes, Gus #	Massachusetts General Hospital	1.186	2.24	3.993	0.213	As-expected
54 - Walker, Jennifer	Massachusetts General Hospital; North Shore Medical Center - Salem Hospital	0.9638	1.742	2.689	0.2822	As-expected
55 - Warner, Kenneth	Saint Vincent Hospital; Tufts New England Medical Center	1.246	2.083	3.233	0.4	As-expected
56 - Williamson, Christina	Lahey Clinic	0.8451	1.714	2.857	0.245	As-expected

§P-values less than or equal to 0.01 denote statistical outliers.
¶As-expected = surgeon's mortality rate is no different from that expected among surgeons treating similar case-mix;
¶Higher-than-expected = surgeon's mortality rate is higher than expected among surgeons with similar case-mix.
¶ Lower-than-expected = surgeon's mortality rate is lower than expected among surgeons with similar case-mix.
# Small sample size may diminish accuracy of estimates. Indicates that the surgeon had volume smaller than or equal to 189
*Known not to have any Isolated CABG admissions during 2006.

8 - IMPORTANT DEFINITIONS

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: 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 (as defined by the Massachusetts legislature for the Massachusetts Cardiac Study): 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.

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.

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: A surgical procedure which involves the replacement of the mitral valve of the heart.

Percutaneous Coronary Intervention: 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.

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

Standardized Mortality Incidence Rate (SMIR): The ratio of projected deaths (the number of deaths adjusted for the number of cases treated at the hospital and the hospital case mix) to expected 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.

9 - 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.

Massachusetts Cardiac Care Hospital Outlier Committee. A MA Department of Public Health Committee charged with reviewing hospital outlier findings.	
David Shahian, M.D., Chair, Center for Quality and Safety; Department of Surgery Massachusetts General Hospital Boston, MA	Sharon-Lise Normand, Ph.D. Professor of Health Care Policy (Biostatistics) Department of Health Care Policy Harvard Medical School Boston, MA
Paul Dreyer, Ph.D. Director, Division of Health Care Quality Massachusetts Department of Public Health Boston, MA	John Pastore, M.D. Clinical Cardiologist St. Elizabeth's Medical Center Boston, MA
Stanley Lewis, M.D. Associate Professor of Medicine Harvard Medical School Beth Israel Deaconess Medical Center Boston, MA	David Torchiana, M.D. Chairman and Chief Executive Officer Massachusetts General Physicians Organization Boston, MA
Frank Sellke, M.D. Professor of Surgery Harvard Medical School Beth Israel Deaconess Medical Center Boston, MA	Thomas Piemonte, M.D. Director, Cardiac Catheterization Laboratory Lahey Clinic Burlington, MA
Gail Palmeri Massachusetts Department of Public Health Boston, MA	Nancy Murphy Massachusetts Department of Public Health Boston, MA

The 2005 Mass-DAC Cardiac Surgery Data Adjudication Committee reviewed patient-specific data elements and corresponding data documentation submitted by hospitals to Mass-DAC in order to determine validity of coding.

Sari Aranki, M.D. Brigham and Women's Hospital	Sanjay Samy, M.D. Lahey Clinic
Vladimir Birjiniuk, M.D. Mount Auburn Hospital	Frank Sellke, M.D. Beth Israel Deaconess Medical Center
Thomas Carr, M.D. Charlton Hospital	David Shahian, M.D. Massachusetts General Hospital
Richard D'Agostino, M.D. Lahey Clinic	Prem Shekar, M.D. Brigham and Women's Hospital
Daniel Engleman, M.D. Baystate Medical Center	Stanley Tam, M.D. UMass Memorial Medical Center
Harold Lazar, M.D Boston Medical Center	James Rawn, M.D. Brigham and Women's Hospital
Karen Lynch, R.N. Data Manager Massachusetts General Hospital	Tamar Yehoshua Data Manager St. Elizabeth's Medical Center

Mass-DAC Physician Reporting Oversight Committee for Cardiac Surgery: The charge of Committee is to first review blinded summary data for all cardiac surgeons in MA 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 MA STS.

Susan Edgman-Levitan Executive Director, The John D. Stoeckle Center for Primary Care Innovation Massachusetts General Hospital Boston, MA	David Shahian, M.D. Chair, Center for Quality and Safety; Department of Surgery Massachusetts General Hospital Boston, MA
Frank Sellke, M.D. Professor of Surgery Harvard Medical School Beth Israel Deaconess Medical Center Boston, MA	Samuel Shubrooks, M.D. Co-Director, Cardiac Cath Lab Beth Israel Deaconess Medical Center Boston, MA
David Torchiana, M.D. Chairman and Chief Executive Officer Massachusetts General Physicians Organization Boston, MA	Thomas Vander Salm, M.D. Chief, Department of Cardiac Surgery North Shore Medical Center –Salem Hospital Salem, MA
Sharon-Lise Normand, Ph.D. Professor of Health Care Policy (Biostatistics) Department of Health Care Policy Harvard Medical School Boston, MA	

APPENDIX 1:

PROCEDURE IDENTIFICATION GUIDELINES FOR ADULT CARDIAC SURGERY

Appendix 1: Procedure Identification Guidelines for Adult Cardiac Surgery. Comparison of classification rules used by New York State and the National STS for determining surgeries belonging in the **Isolated CABG** group versus the **CABG plus Other** group. *Refers to the National STS Procedure ID Table.

Procedure	Mass-DAC	New York State	STS*
Maze: **Open** heart approach Maze: **Closed** epicardial approach and radio frequency	Other CABG	All Maze procedures are excluded	Other 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 by case basis	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	No information available regarding how these procedures are categorized.	
Myoxoma	Other		
Unplanned Ventricular Assist Device (VAD) placement	CABG		
Planned Ventricular Assist Device (VAD) placement	Other		
Carotid Surgery	Other		
Lead and device explants	Other		

APPENDIX 2: STS DATA ABSTRACTION TOOL - VERSION 2.52.1

(Variables not harvested by STS are harvested by Mass-DAC)

The Society of Thoracic Surgeons
Adult Cardiac Surgery Database
Data Collection Form
Version 2.52.1

A. Administrative

Participant ID: |___|___|___|___|___|___| Record ID _____

Cost Link Field: _____ STS Trial Link Number: |___|___|___|___|___|___| Patient ID _____

B. Demographics

Last Name: _____ First Name: _____ Patient M.I.: ____ Name Fields Not Harvested

Date of Birth (mm/dd/yyyy): __ __/__ __/__ __ __ __ Patient Age: _____ System Calculation

Gender: Male Female

Social Security (or National Patient ID) Number: _____ Not Harvested Medical Record Number: _____ Not Harvested

Patient ZIP or Postal Code: _____ Race: Caucasian Black Hispanic Asian Native American Other

Referring Cardiologist's Name: _____ Not Harvested Referring Physician's Name: _____ Not Harvested

C. Hospitalization

Hospital Name: _____ Hospital ZIP Code |_____| Hospital State |___|___|

Payor: _____ Not Harvested

Date of Admission: __ __/__ __/__ __ __ __ Date of Surgery: __ __/__ __/__ __ __ __ Date of Discharge: __ __/__ __/__ __ __ __

ICU Visit: Yes No If Yes, → Initial ICU Hours:_____

Readmn to ICU: Yes No If Yes, → Additional ICU Hours _____

Total Hours in ICU:_____

D. Risk Factors

Weight (kg): _____ Height (cm): _____

Smoker: Yes No If Yes, → Current Smoker: Yes No

Family History of Coronary Artery Disease: Yes No

Diabetes: Yes No If Yes, select one: → Diabetes Control: None Diet Oral Insulin

Dyslipidemia: Yes No

Last Creatinine Level Preop: _____

Renal Failure: Yes No If Yes, → Dialysis: Yes No

Hypertension: Yes No

Cerebrovascular Accident: Yes No If Yes, → When: Recent <= 2 weeks Remote > 2 weeks

Infectious Endocarditis: Yes No If Yes, → Infectious Endocarditis Type: Treated Active

Chronic Lung Disease: No Mild Moderate Severe

Immunosuppressive Therapy: Yes No

Peripheral Vascular Disease: Yes No

Cerebrovascular Disease: Yes No If Yes, → CVD Type: Coma CVA RIND TIA Non Invasive > 75% Prior Carotid Surgery

E. Previous CV Interventions

Incidence: First CV Surgery First Re-op CV Surgery Second Re-op CV Surgery Third Re-op CV Surgery Fourth or More Re-op Surgery

Previous CV Interventions: Yes No If Yes, complete the rest of this section ↓

Previous Coronary Artery Bypass: Yes No

Previous Valve: Yes No

Previous Other Cardiac – Intrapericardial or Great Vessel: Yes No

Previous Other Cardiac – AICD: Yes No

Previous Other Cardiac – Pacemaker: Yes No If Yes, → Previous Other Cardiac – Pacemaker Type: Biventricular Univentricular

Previous Other Cardiac – PCI: Yes No If Yes, → Previous Other Cardiac – PCI Interval: <= 6 Hours > 6 Hours

F. Preoperative Cardiac Status

Myocardial Infarction: Yes No If Yes, → When: <= 6 hours > 6 hours but <24 hours 1 - 7 days 8 - 21 days > 21 days

Congestive Heart Failure: Yes No

Angina: Yes No If Yes, → Angina Type: Stable Unstable

Cardiogenic Shock: Yes No If Yes, → Cardiogenic Shock Type: Refractory Shock Hemodynamic Instability

Resuscitation: Yes No

Arrhythmia: Yes No If Yes, → Arrhythmia Type: Sust VT/VF Heart Block AFib/Flutter None

Classification - NYHA: I II III IV

G.. Preoperative Medications

Beta Blockers: Yes No

ACE Inhibitors: Yes No

Nitrates I.V.: Yes No

Anticoagulants: Yes No If Yes, → Anticoagulants Medication Name: Heparin (Unfractionated) Heparin (Low Molecular) Thrombin Inhibitors

Coumadin: Yes No

Inotropes: Yes No

Steroids: Yes No

Aspirin: Yes No

Lipid-Lowering: Yes No If Yes, → Lipid Lowering Medication Name: Statin Non statin

ADP Inhibitors: Yes No

Glycoprotein IIbIIIa Inhibitor: Yes No If Yes, → Glycoprotein IIbIIIa Inhibitor Medication Name: Abciximab (ReoPro)
Eptifibatied (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: _____
Method: LV gram Radionucleotide Estimate ECHO

Pulmonary Artery Mean Pressure Done? Yes No If Yes, → Pulmonary Artery Mean Pressure: _____

Aortic Stenosis: Yes No If Yes, → Gradient: _____

Mitral Stenosis: Yes No

Tricuspid Stenosis: Yes No

Pulmonic Stenosis: Yes No

Aortic Insufficiency: 0=None 1=Trivial 2=Mild 3= Moderate 4= Severe

Mitral Insufficiency: 0=None 1=Trivial 2=Mild 3= Moderate 4= Severe

Tricuspid Insufficiency: 0=None 1=Trivial 2=Mild 3= Moderate 4= Severe

Pulmonic Insufficiency: 0=None 1=Trivial 2=Mild 3= Moderate 4= Severe

I. Operative

Surgeon's Name: _____ Surgeon ID: _____

Status of the procedure: ↓

Elective

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

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

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

Skin Incision Start Time: _____ 24 hour clock Skin Incision Stop Time: _____ 24 hour clock

CPB Utilization: None Combination Full ↓

If Combination, → 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 (min): _____

Cannulation Method: → Aorta and Fem/Jug Vein
Fem Art and Fem/Jug Vein
Aorta and Atrial/Caval
Fem Art and Atrial/Caval
Other

Aortic Occlusion: → None
Aortic Crossclamp → If Aortic Crossclamp or Balloon Occlusion, → Cross Clamp Time (min): _____
Balloon Occlusion
Partial Crossclamp

Cardioplegia: Yes No

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 Yes, Red Blood Cell Units _____
Fresh Frozen Plasma Units _____
Cryoprecipitate Units _____
Platelet Units _____

J. Coronary Bypass

Number of Distal Anastomoses with Arterial Conduits: _____

Number of Distal Anastomoses with Venous Conduits: _____

Anastomotic Device Used: Yes No If Yes, → Anastomotic Device: Glue Magnets Clips Staples Other

IMAs 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: _____

Number of Gastro-Epiploic Artery Distal Anastomoses: _____

Number of Other Arterial Distal Anastomoses: _____

K. **Valve Surgery**

Aortic:	Mitral:	Tricuspid:	Pulmonic:
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/out Annuloplasty	Reconstruction w/out Annuloplasty	
Root Reconstruction w/ Valve Sparing		Valvectomy	
Resuspension Aortic Valve with replacement ascending Aorta			
Resuspension Aortic Valve without replacement ascending Aorta			
Resection Sub-Aortic Stenosis			

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

Mechanical
ATS Mechanical Prosthesis = M1
Björk-Shiley Convex-Concave Mechanical Prosthesis = M2
Björk-Shiley Monostrut Mechanical Prosthesis = M3
CarboMedics Mechanical Prosthesis = M4
CarboMedics Carbo-Seal Ascending Aortic Valved Conduit Prosthesis = M16
CarboMedics Carbo-Seal Valsalva Ascending Aortic Valved Conduit Prosthesis = M17
CarboMedics Reduced Cuff Aortic Valve = M18
CarboMedics Standard Aortic Valve = M19
CarboMedics Top-Hat Supra-annular Aortic Valve = M20
CarboMedics OptiForm Mitral Valve = M21
CarboMedics Standard Mitral Valve = M22
CarboMedics Orbis Universal Valve = M23
CarboMedics Small Adult Aortic and Mitral Valves = M24
Edwards Tekna Mechanical Prosthesis = M5
Lillehei-Kaster Mechanical Prosthesis = M6
MCRI On-X Mechanical Prosthesis = M10
Medtronic-Hall/Hall Easy-Fit Mechanical Prosthesis = M7
Medtronic ADVANTAGE Mechanical Prosthesis= M25
OmniCarbon Mechanical Prosthesis = M8
OmniScience Mechanical Prosthesis = M9
Sorin Bicarbon (Baxter Mira) Mechanical Prosthesis = M11
Sorin Monoleaflet Allcarbon Mechanical Prosthesis = M12
St. Jude Medical Mechanical Prosthesis or St. Jude Medical® Mechanical Heart Valve = M13
SJM® Masters Series Mechanical Heart Valve = M26
SJM® Masters Series Aortic Valve Graft Prosthesis = M27
St. Jude Medical® Mechanical Heart Valve Hemodynamic Plus (HP) Series = M28
SJM® Masters Series Hemodynamic Plus Valve with FlexCuff™ Sewing Ring = M29
SJM Regent™ Valve = M30
Starr-Edwards Caged-Ball Prosthesis = M14
Ultracor Mechanical Prosthesis = M15

Bioprosthetic
Baxter Prima Stentless Porcine Bioprosthesis – Subcoronary = B24
Baxter Prima Stentless Porcine Bioprosthesis – Root = B25
Biocor Porcine Bioprosthesis = B3
Biocor Stentless Porcine Bioprosthesis – Subcoronary = B26
Biocor Stentless Porcine Bioprosthesis – Root = B27
CarboMedics PhotoFix Pericardial Bioprosthesis = B5
Carpentier-Edwards Duraflex Porcine Bioprosthesis = B28
Carpentier-Edwards Prima Plus Stentless Porcine Bioprosthesis – Subcoronary = B29
Carpentier-Edwards Prima Plus Stentless Porcine Bioprosthesis – Root = B30
Carpentier-Edwards PERIMOUNT Pericardial Bioprosthesis = B6
Carpentier-Edwards Standard Porcine Bioprosthesis = B7
Carpentier-Edwards Supra-Annular Aortic Porcine Bioprosthesis = B8
Cryolife O'Brien Stentless Porcine Bioprosthesis – Subcoronary = B31
Cryolife O'Brien Stentless Porcine Bioprosthesis – Root = B32
Hancock Standard Porcine Bioprosthesis = B10
Hancock II Porcine Bioprosthesis = B11
Hancock Modified Orifice Porcine Bioprosthesis = B12
Ionescu-Shiley Pericardial Bioprosthesis = B13
Labcor Stented Porcine Bioprosthesis = B14
Labcor Stentless Porcine Bioprosthesis – Subcoronary = B33
Labcor Stentless Porcine Bioprosthesis – Root = B34
Medtronic Freestyle Stentless Porcine Bioprosthesis – Subcoronary = B35
Medtronic Freestyle Stentless Porcine Bioprosthesis – Root = B36
Medtronic Intact Porcine Bioprosthesis = B17
Medtronic Mosaic Porcine Bioprosthesis = B18
Medtronic Contegra Bovine Jugular Bioprosthesis = B37
Mitroflow Pericardial Bioprosthesis = B19
St. Jude Medical - Toronto SPV Stentless Porcine Bioprosthesis or SJM Toronto SPV® Valve = B21
St. Jude Medical-Bioimplant Porcine Bioprosthesis = B22
SJM Biocor™ Valve = B38
SJM Epic™ Valve = B39
SJM Toronto Root™ Bioprosthesis = B40
Sorin Pericarbon Stentless Pericardial Bioprosthesis = B20

Homograft
CryoLife Aortic Homograft = H6
CryoLife Pulmonary Homograft = H7
CryoLife CryoValve SG(Decellularized)Aortic Homograft = H8
CryoLife CryoValve SG Pulmonary Homograft = H9
Homograft Aortic – Subcoronary = H1
Homograft Aortic Root = H2
Homograft Mitral = H3
Homograft Pulmonic Root = H4
LifeNet CV Allografts = H10

Autograft
Pulmonary Autograft to aortic root (Ross Procedure) = A1

Ring - Annuloplasty
CarboMedics AnnuloFlo Ring = R8
CarboMedics AnnuloFlex Ring = R9
CarboMedics CardioFix Bovine Pericardium with PhotoFix Technology = R10
Carpentier-Edwards Classic Annuloplasty Ring = R1
Carpentier-Edwards Physio Annuloplasty System Ring = R2
Cosgrove-Edwards Annuloplasty System Ring = R3
Edwards MC³ Tricuspid Annuloplasty System G Future Band = R11
Genesee Sculptor Annuloplasty Ring = R12
Medtronic Sculptor Ring = R4
Medtronic-Duran AnCore Ring = R5
Sorin-Puig-Messana Ring = R6
St. Jude Medical Sequin Ring or SJM® Séguin Annuloplasty Ring = R7
SJM Tailor™ Annuloplasty Ring = R13

Band – Annuloplasty
Medtronic Colvin Galloway Future Band = Ba1
Medtronic Duran Band = Ba2
Medtronic Duran – Ancore Band = Ba3

Other = 777

L. **VAD**

Previous VAD: Yes No
Please note that future 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 Transplant) (Bridge to Recovery) (Destination) (Separation from CPB) (Device Malfunction)

Intubated Pre VAD: Yes No

Hemodynamics Pre VAD: May be obtained Prior to induction in the OR, or in an ICU immediately prior to OR

PCWP: _____mm/Hg CVP: _____mm/Hg PVR: _____woods units CI: _____L/ (min x m2)

RV Function: (Normal) (Mildly Impaired) (Moderately Impaired) (Severely Impaired)

RV Function method: _____ (Pre-op ECHO) (Intra-op pre VAD TEE)

VO2 Measured: Yes No

Peak VO2:_____ml/kg/min

VAD Device Data:

Implant Type: Fill in below: (RVAD) (LVAD) (BiVAD)
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

Initial Implant Data

Implant Type	Product Type	Implant Date	Explant	Explant Date	Explant Reason	Cardiac Tx	Tx Date
_____	_____	___ / __ / ___	Y N	___ / ___ / ___	_____	Y N	___ / ___ / ___

Initial VAD Cannulation/Attachment Sites:

LVAD Inflow: (LA) (LV)

RVAD Inflow: (RA) (RV)

Additional Implant(s) Data

Implant(s) Type	Product Type	Implant Date	Explant	Explant Date	Explant Reason	Cardiac Tx	Tx Date
_____	_____	___ / ___ / ___	Y N	___ / ___ / ___	_____	Y N	___ / ___ / ___
_____	_____	___ / ___ / ___	Y N	___ / ___ / ___	_____	Y N	___ / ___ / ___

Primary VAD Complications Data:

Intracranial Bleed: Yes No

Embolic Stroke: Yes No

Driveline/Cannula Infection: Yes No

Pump Pocket Infection: Yes No

VAD Endocarditis: Yes No

Device Malfunction: Yes No

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

VAD Status: Discharged from hospital: (with VAD) (without VAD)

M. **Other Cardiac Procedures**

Yes	No	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	Transmyocard Laser Revasc	Yes	No	Cardiac Trauma	Yes	No	Cardiac Transplant

Arrhythmia Correction Surgery → None
Permanent Pacemaker
Permanent Pacemaker with Cardiac Resynchronization Therapy (CRT)
Implanted Cardioverter Defibrillator (ICD)
ICD with CRT

If "Permanent Pacemaker with CRT" or "ICD with CRT", then answer ↓

Arrhythmia Correction Surgery – Lead Placement → Epicardial Endocardial

Atrial Fibrillation Correction Surgery → None
Standard Surgical Maze Procedure
Other Surgical Ablative Procedure
Combination of Standard and Other If Other or Combo, then answer ↓

Atrial Fibrillation Surgery – Energy Source → Unipolar Radiofrequency
Bipolar Radiofrequency
Microwave
Cryothermia
Other
Combination of above

Yes No Aortic Aneurysm If Yes, → Yes No Ascending Aorta
Yes No Aortic Arch
Yes No Descending Aorta
Yes No Thoracoabdominal Aorta

Yes No Other

N. **Other Non Cardiac Procedures**

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

O. **Post Operative**

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 If No, → Initial # Hrs Ventilated Postop: _____

Re-intubated During Hosp Stay: Yes No If Yes, → Addl Hours Ventilated Postop: _____

Total Hours Ventilated Postop: _____

P. **Complications** In Hospital Complications: Yes No

Operative:

Yes No ReOp for Bleeding Tamponade
Yes No ReOp for Valvular Dysfunction
Yes No ReOp for Graft Occlusion
Yes No ReOp for Other Cardiac Problem
Yes No ReOp for Other Non Cardiac Problem
Yes No Perioperative MI

Infection:

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

Neurologic:

Yes No Postoperative Stroke for >72 hours

Yes No Transient Neurologic Deficit

Yes No Continuous Coma >=24Hrs

Pulmonary:

Yes No Prolonged Ventilation

Yes No Pulmonary Embolism

Yes No Pneumonia

Renal:

Yes No Renal Failure If Yes, ↓

Yes No Dialysis (Newly Required)

Vascular:

Yes No Illiac/Femoral Dissection

Yes No Acute Limb Ischemia

Other:

Yes No Heart Block

Yes No Cardiac Arrest

Yes No Anticoagulant Complication

Yes No Tamponade

Yes No Gastro-Intestinal Complication

Yes No Multi-System Failure

Yes No Atrial Fibrillation

Yes No Aortic Dissection

Yes No Other

Q. **Mortality**

Mortality: Yes No Discharge Status: Alive Dead Status at 30 days after surgery: Alive Dead Unknown

Operative Death: Yes No Only answered if Mortality = Yes

Mortality - Date __ __/__ __/__ __ __ __ (mm/dd/yyyy) Only answered if Mortality = Yes

Location of Death: OR during initial surgery Hospital Home Other Care Facility OR during reoperation Only answered if Mortality = Yes

Primary Cause of Death (select only one): Only answered if Mortality = Yes

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

Antiarrhythmics: Yes No If Yes, ↓

Antiarrhythmics – Discharge – Medication Name: Amiodarone Other

Aspirin: Yes No

Ace-Inhibitors: Yes No

Beta Blockers: Yes No

Lipid Lowering: Yes No If Yes, ↓

Lipid Lowering – Discharge – Medication Type: Statin Non statin

Coumadin: Yes No

Discharge Location: Home Extended Care/TCU Other Hospital Nursing Home 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, select the primary reason and procedure

Readmit Reason:

- Anticoagulation Complication – Valvular
- Anticoagulation Complication - Pharmacological
- Arrhythmias/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
- Other – Related Readmission
- Other – Nonrelated Readmission

Readmit Reason – 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

