ADULT CORONARY ARTERY BYPASS GRAFT SURGERY IN THE COMMONWEALTH OF MASSACHUSETTS

Fiscal Year 2007 Report

(October 1, 2006 – September 30, 2007)

HOSPITAL AND SURGEON STANDARDIZED 30-DAY MORTALITY RATES

Mass-DAC

Department of Health Care Policy

Harvard Medical School

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CONTRACTED 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

October 1, 2006 – September 30, 2007

Baystate Medical Center 759 Chestnut Street Springfield, MA 01199	Massachusetts General Hospital (MGH) 55 Fruit Street Boston, MA 02114
Beth Israel Deaconess Medical Center (BIDMC) 330 Brookline Avenue Boston, MA 02215	Mount Auburn Hospital 330 Mount Auburn Street Cambridge, MA 02138
Boston Medical Center (BMC) One Boston Medical Center Place 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 Medical Center (TMC) (previously New England Medical Center) 800 Washington Street Boston, MA 02111
Lahey Clinic 41 Mall Road Burlington, MA 01805	UMass Memorial Medical Center 55 Lake Avenue North Worcester, MA 01655

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1 - A MESSAGE FROM THE DIRECTOR OF THE MASSACHUSETTS BUREAU OF HEALTH CARE SAFETY AND QUALITY

This is the sixth in a series of reports summarizing the quality of care provided by the 14 state licensed cardiac surgery programs in the Commonwealth. The report – contracted by the Division of Health Care Quality in the Massachusetts Department of Public Health -- is meant to provide residents with information about the relative performance of cardiac surgery programs as an aid to elective decision making, and health care providers in the Commonwealth with information for quality improvement. Persons experiencing chest pain or other emergency conditions should call '911' immediately.

This report contains analysis of data on 3396 hospital admissions in which an isolated coronary artery bypass graft (CABG) surgery was performed during the period October 1, 2006 through September 30, 2007. This report also includes an analysis of 11,033 hospital CABG admissions by 60 surgeons during the period of October 1, 2004 to September 30, 2007.

The data collection, verification, audit, and analytical procedures implemented in this report constitute the most comprehensive, reliable, and rigorous used in the U.S. 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 at Harvard Medical School. 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 Mass-DAC for their hard work and dedication.

Paul Dreyer, Ph.D., Director
Bureau of Health Care Safety and Quality
Massachusetts Department of Public Health

2 - KEY FINDINGS - HOSPITALS

- Between October 1, 2006 and September 30, 2007 (fiscal year 2007), there were **6820** hospital admissions in which at least one cardiac surgery was performed in Massachusetts. Approximately one half of the admissions involved isolated coronary artery bypass graft (CABG) surgery.

- In the **fourteen** hospitals that performed cardiac surgery in fiscal year 2007, the number of isolated CABG surgery admissions ranged from **75 to 467**.

- 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 2007 was **1.47%**. This corresponded to 50 deaths out of 3396 isolated CABG admissions.

- After adjusting for patient risk, the odds of 30-day mortality in a hospital one standard deviation above the state average was three and one half (odds = 3.48) that of a hospital one standard deviation below the state average.

- In fiscal year 2007, **no** hospital was identified as a statistical outlier for Isolated Coronary Artery Bypass Surgery.

3 - INTRODUCTION

3.1 - What is in this Report?

This report describes procedures for calculating both hospital-specific risk standardized 30-day mortality rates following isolated coronary artery bypass graft (**CABG**) surgery performed in Massachusetts hospitals between October 1, 2006 and September 30, 2007 (fiscal year 2007), and surgeon-specific standardized mortality rates for CABG surgeries performed from October 1, 2004 through September 30, 2007. In 2006, Mass-DAC began reporting on a fiscal year (October 1 through September 30) rather than a calendar year at the request of the Massachusetts Department of Health. 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 fiscal year 2007, there were fourteen cardiac surgery programs in Massachusetts, each of which submitted data to Mass-DAC.

This document is the sixth report (http://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 fourteen cardiac surgery programs in Massachusetts that performed at least one isolated CABG surgery between October 1, 2006 and September 30, 2007. This report also includes the fourth report of surgeon-specific risk-standardized 30-day mortality rates. These rates are based on CABG surgery admissions performed from October 1, 2004 through September 30, 2007.

3.2 - 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.

3.3 - 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 non-federal hospitals between October 1, 2006 and September 30, 2007. 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 1)**. **Table 3.1** lists the distribution of the 6820 cardiac surgery admissions stratified by surgical procedure type in Massachusetts' hospitals during fiscal year 2007.

Table 3.1: Surgical Procedure Type Classification of Adult Cardiac Surgeries During October 1, 2006 – September 30, 2007, Commonwealth of Massachusetts.

Surgical Procedure Type	No. of Cardiac Surgery Admissions	% of Cardiac Surgery Admissions
Isolated CABG	**3396**	**49.79**
Mitral Valve Replacement (MVR)	142	2.08
Aortic Valve Replacement (AVR)	729	10.69
MVR + CABG	66	0.97
AVR + CABG	540	7.92
AVR + MVR	33	0.48
Other Cardiac Surgery	1870	27.42
Non-Cardiac (Thoracic) Procedures	44	0.65
All Cardiac Surgery Admissions	**6820**	**100.00**

3.4 - Why Report on CABG Surgery?

CABG surgeries account for the majority of cardiac surgeries performed nationally and are costly procedures. In fiscal year 2007, isolated CABG surgeries accounted for half of all 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.

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, 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.

4 - SUMMARY OF DATA COLLECTION & VERIFICATION PROCEDURES

4.1 - 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.

4.2 - Massachusetts Cardiac Surgery Programs

Fourteen cardiac surgery centers treated patients in Massachusetts during October 1, 2006 through September 30, 2007.

4.3 - 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 2**), containing 293 variables, was used for all data submissions for surgeries performed during fiscal year 2007.

Massachusetts Inpatient Acute Hospital Case Mix and Charge Database. Hospital discharge data for fiscal years 2002 through 2007, (October 1, 2002 through September 30, 2007) 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 was available for all deaths occurring in Massachusetts between January 1, 2002 and October 30, 2007 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 employed as 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.

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 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 encrypt and password-protect the data, and transmit it electronically using a secure repository on a secure website. Hospitals submitted subsequent corrected data as often as desired during the 3 months following a harvest, and could sign off on its accuracy and completeness at any time during that period. However, all fiscal year 2007 cardiac surgery data were required to be complete by April 1, 2008, after which no changes were accepted without written permission from Mass-DAC.

Table 4.1: Cardiac Surgery Data Harvest Schedule for Surgeries Performed Between October 1, 2006 and September 30, 2007.	
Month of Data Harvest	**Corresponding Dates of Cardiac Surgery**
June 2007	October 1, 2006 through March 31, 2007
December 2007	April 1, 2007 through September 30, 2007
April 2008	**Final Data Close-Out for Fiscal Year 2007 Data**
June 2008: hospitals received their unadjusted 30-day mortality rates for fiscal year 2007 surgery admissions as well as the state rate.	

4.5 - 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 coding. 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 80 data submissions sent in by 14 hospitals during fiscal year 2007 with a mean of 2.9 submissions per hospital per collection period. Data submissions for fiscal year 2007, ranged from 1 to 5 per hospital per collection period. Each hospital data submission generated a Mass-DAC quality report returned to the hospital.

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 three 30-day mortalities for all cardiac surgeries, including an increase of two 30-day mortalities 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. Data managers have the opportunity to ask and discuss questions 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 and again in the fall of 2008, a sample of the fiscal year 2007 isolated CABG data was audited. Ten cardiac surgeons and two data managers, representing eight of the fourteen cardiac surgery programs, volunteered for the Adjudication Committee performing the audits. All participants underwent 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 coded as having an isolated CABG, isolated Aortic Valve Replacement (AVR) or an isolated Mitral Valve Replacement (MVR), that died within 30 days; or those patients who were coded as having an "other" cardiac procedure in combination with CABG, AVR or MVR (to determine if those should have been coded as an CABG, AVR or MVR) that died within 30 days of surgery; (2) **all** CABG, AVR or MVR patients coded as having shock prior to surgery; (3) **all** CABG, AVR or MVR patients coded with emergent or emergent salvage status; (4) **all** CABG, AVR or MVR patients coded as having a myocardial infarction (MI) less than 24 hours prior to surgery; and (5) **a sample** of those CABG, AVR or MVR patients coded as having an ejection fraction of less than 30. The total number of records requested amounted to **364** from the 14 hospitals. The records were reviewed to determine data consistency and accuracy of coding.

An additional **282** records were also requested for a subset of surgery admissions that were coded as having "CABG + other" and "valve + other" surgery and alive within 30-days of surgery. 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, 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 emergent salvage status, MI within 24 hours of surgery and ejection fraction.

In all, **646** records were reviewed by the Adjudication Committee to determine agreement with the information submitted by the hospitals. The subset of records where procedures were coded as "CABG + other" and "valve + other" were reviewed by the committee to determine whether the "other" procedures were appropriate to move the entire surgery into the isolated CABG or isolated valve category **(see Appendix 1),** while the additional records were audited to determine justification of shock, emergent or emergent salvage status, ejection fraction, myocardial infarction and timing. If the Adjudication Committee did not agree with the coding 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 variable were then made in the Mass-DAC database. Because the Adjudication Committee did not review every case coded with ejection fraction of less than 30, Mass-DAC did not make any changes to ejection fraction coding in the database, regardless of the Adjudication Committee decisions. **Table 4.2** summarizes changes that were made.

Table 4.2: Summary of Adjudication.

Risk Factor	Total Reviewed	Final Adjudicated Status	Number
Shock	75	Shock (no change)	39
		No Shock	36
Emergent	161	Elective	1
		Urgent	31
		Emergent (no change)	129
		Emergent Salvage	0
Emergent Salvage	4	Elective	0
		Urgent	0
		Emergent	0
		Emergent Salvage (no change)	4
MI within 24 hours of surgery	147	No MI	11
		MI ≤ 24 hours (no change)	116
		MI > 24 hours	20
CABG + Other	149	Isolated CABG	93
		CABG + Other (no change)	56
Valve + Other	133	Isolated Valve	74
		Valve + Other (no change)	59

5 - RISK ADJUSTMENT

5.1 - Who Receives Isolated CABG Surgery in Massachusetts?

Table 5.1 lists the age/sex/race distribution for 3396 adult CABG surgery patients at 14 cardiac surgery programs in Massachusetts. The majority of patients were male (76%) and white (90%). In fiscal year 2007, 56% 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 8.9% of the 3396 CABG admissions (data not shown).

Table 5.1: Age-Sex-Race distribution for all adult Isolated CABG surgery admissions (N = 3396) in MA hospitals during October 1, 2006 – September 30, 2007. Entries represent numbers of patients.

Age Group	Males					Females				
	White	African American	Hispanic	Other§	Total	White	African American	Hispanic	Other§	Total
18 – 44	55	3	3	6	67	19	2	3	1	25
45 – 54	325	13	20	20	378	57	4	3	3	67
55 – 64	733	17	23	38	811	134	9	5	11	159
65 – 74	711	7	15	40	773	227	4	11	13	255
≥ 75	517	6	8	16	547	289	8	5	12	314
Total	2341	46	69	120	**2576**	726	27	27	40	**820**

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 prior to the CABG surgery. Such factors also have an impact on the risk of mortality following surgery. Sicker patients or patients

§ Includes some patients with unknown or missing race information.

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 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 patient health prior to surgery. The numbers reported compare **each hospital's outcome** to what would be expected to happen **given the types of patients undergoing surgery in its program**; the numbers are not designed to provide comparisons between pairs of hospitals and would only be valid to the extent the pairs of hospitals treated patients with very similar health 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 may not be the same. The statistical model used to calculate mortality rates in this report, a ***hierarchical logistic 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 through the inclusion of 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 classified as "outlying" – 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 Massachusetts, Mass-DAC also calculates the predicted number of mortalities at each hospital using the experience of all **other** hospitals in Massachusetts. We first calculated the probability that the actual number of mortalities in a particular hospital is **no different** from the predicted number of mortalities. If this probability is **small**, then the hospital is classified as "outlying." 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 state unadjusted 30-day hospital mortality rate **or** if the probability of the observed mortality is no different from that predicted from all other hospitals for a particular hospital is 0.01 or less, then the hospital is designated as outlying. It is important to note that the classification of hospitals as outliers in this report is relative to all hospitals in Massachusetts performing CABG surgery.

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 2007. 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 fiscal year 2007. 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 7.1** (for surgeries performed between October 1, 2006 and September 30, 2007). The term β describes the association of each risk factor and the log-odds of dying within 30-days of surgery. Large values of β indicate 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 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 "smoothed" 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. This mortality rate is termed "smoothed" because it 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, then the smoothed 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:

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

   The SMIR is interpreted as the mortality rate at the hospital expected today if hospital quality remained the same as in fiscal year 2007.
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 mortality differences 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 logistic 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.

[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.

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 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 of deaths to the observed number of deaths at the dropped hospital and calculated a "probability." This probability, loosely called a "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 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.

6.3 - Sensitivity Analyses

Several sensitivity analyses were undertaken to determine whether conclusions would be altered 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. Because the parameter τ represents the standard deviation of the hospital –specific risk-adjusted log-odds of mortality and the parameter τ^2 represents between-hospital variance. The primary analyses assumed the *precision* (defined as $1/\tau^2$)) 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. We first changed our assumptions regarding the likely values of the standard deviation. For example, a value of $\tau = 0.75$ implies that between-hospital mortality log-odds could range anywhere from 1 to 15. We thus assumed that the between-hospital *standard deviation* arose from a uniform distribution over the range 0 to 1.5. This amounts to assuming that small values of between-hospital variation are just as likely as large values. Second, we assumed that τ arose from a half normal distribution with mean 0 and variance 0.26. The half normal distribution has its mode at 0, thereby permitting no differences in between-hospital log-odds of mortality after adjusting for patient sickness, and its median at 0.39, permitting the range in hospital log-odds of mortality of about 5.

7 - HOSPITAL QUALITY FOLLOWING ISOLATED CABG SURGERY: FISCAL YEAR 2007

Of the 3396 isolated CABG surgery admissions in fiscal year 2007 in Massachusetts, 50 patients (1.47%) died within 30 days of their surgery. **Table 7.1** 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, 75.9% of the 3396 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 0.51 for males indicates that males are half as likely as females to die within 30 days of CABG surgery. In contrast, patients coded in cardiogenic shock prior to isolated CABG surgery are 3.84 times more likely to die within 30 days than patients coded as not 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 0.389. This may be interpreted as indicating that the odds of dying if admitted to a Massachusetts cardiac surgery program one standard deviation above the state mean is three and one half (3.45) that of dying if admitted to a program one standard deviation below the state mean.

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 1.47%. 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 1.47%.

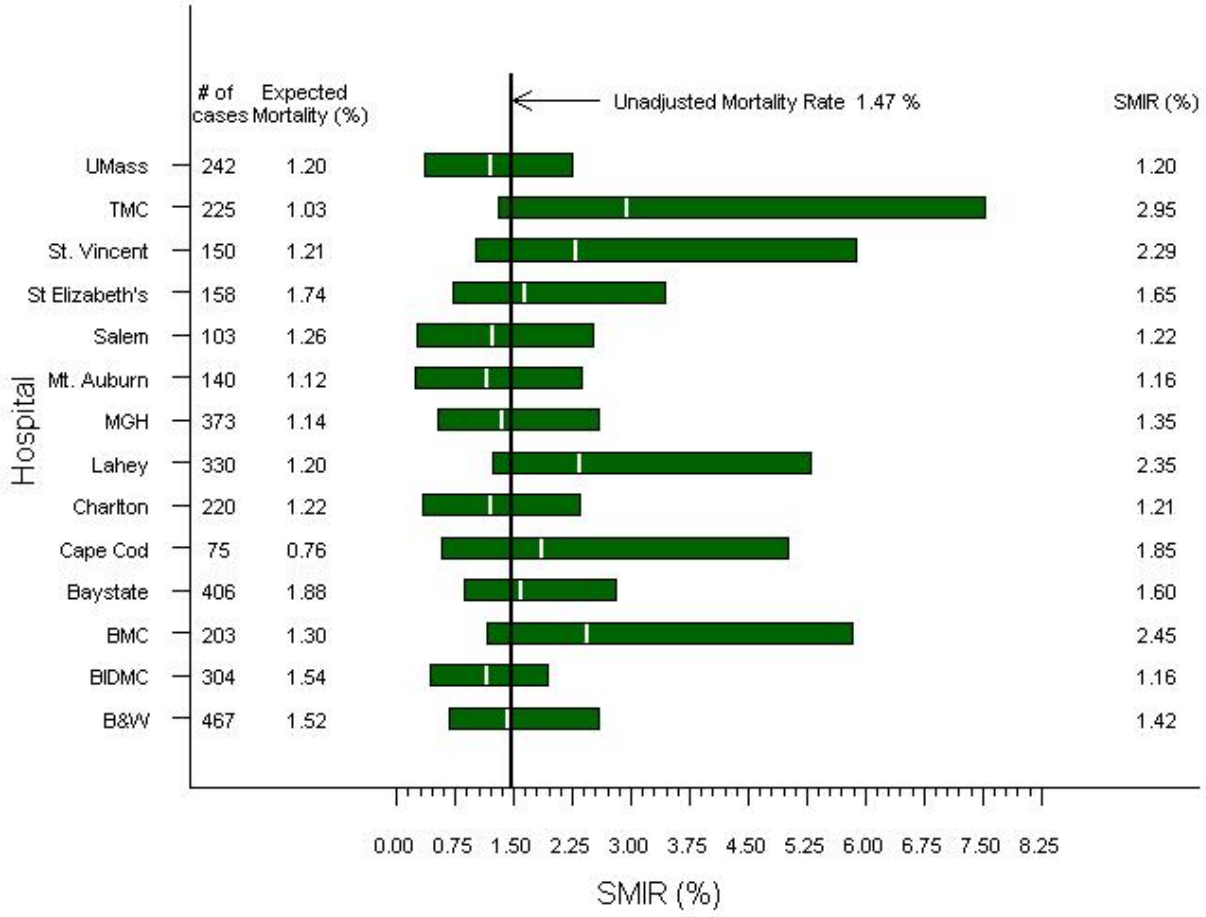
[3] Fit using a non-hierarchical logistic regression model indicated area under the ROC curve of 0.79. The Hosmer-Lemeshow Goodness-of-Fit test did not indicate a lack of fit ($\chi 2$ (8 dof) = 3.01, p = 0.93). Model discrimination ranged form 0.3% (1 death in 340 admissions) in the lowest risk decile to 7.1% (23 deaths in 326 admissions) in the highest risk decile.

Figure 7.2 presents the cross-validated p-values under the different assumed prior distributions for the between-hospital variation parameter. The reference line on the graph at 0.01 indicates the cutoff for outliers based on p value. Any hospital with a bar under this line is considered to be different than expected. The cross validated p-values indicate that there were no cardiac surgery program outliers in fiscal year 2007.

Table 7.1: Prevalences and Adjusted Odds Ratios of 30-Day Mortality Following Isolated CABG Surgery in Adults: 10/1/2006 – 9/30/2007. Based on 3396 surgeries with 50 deaths (1.47%). *Average age of patients undergoing isolated CABG surgery is 65 + 0.96= 65.96 years of age.

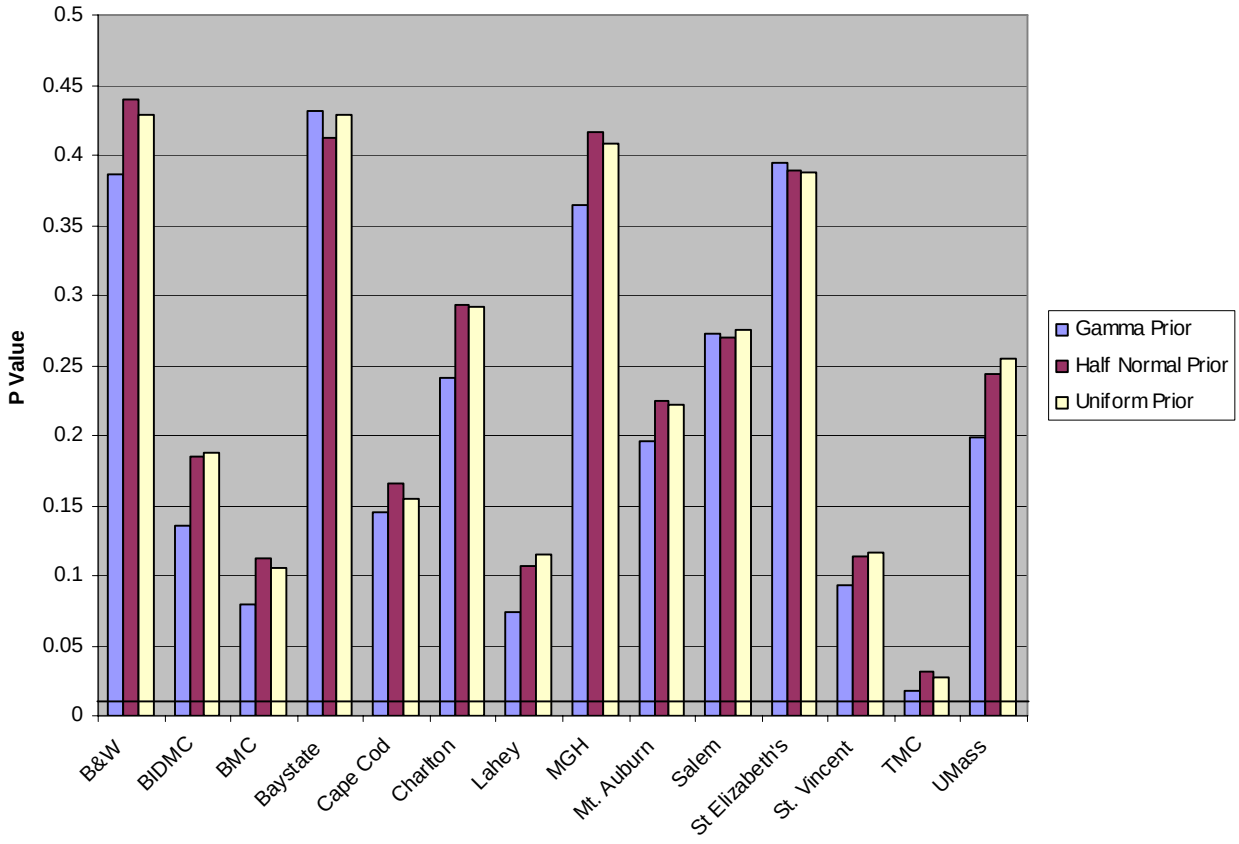
Risk Factor	Prevalence (%)	Adjusted Odds Ratio	95% Interval for the Adjusted Odds Ratio
Years over 65*	0.96	1.05	(1.02,1.09)
Male	75.85	0.51	(0.29,0.99)
Renal Failure	7.48	1.71	(0.59,3.68)
Diabetes	42.58	1.25	(0.66,2.21)
Hypertension	83.54	2.11	(0.68,5.59)
Peripheral Vascular Disease	17.37	1.90	(0.93,3.43)
Prior CABG surgery	2.06	3.36	(0.57,9.67)
Prior Percutaneous Coronary Intervention (PCI)	21.55	1.70	(0.81,3.08)
Cardiogenic Shock	0.77	3.84	(0.53,13.00)
Ejection Fraction (Ref = ≥ 40%)			
< 30% or missing	10.45	3.05	(1.33,5.77)
30 – 39 %	10.51	0.82	(0.20,2.02)
Myocardial Infarction (MI) (Ref = None)			
< 6 hours	1.24	1.33	(0.07,5.99)
7 – 24 hours	2.09	5.67	(1.06,17.09)
≥ 1 day	50.53	1.36	(0.66,2.61)
Status of CABG (Ref = Elective)			
Urgent	62.34	2.13	(0.92,4.39)
Emergent/Emergent Salvage	3.27	7.51	(1.28,25.17)
Pre-Op Intra-Aortic Balloon Pump	11.28	0.79	(0.27,1.73)
Between-Hospital Parameters		**Mean**	**95% Interval**
Between-Hospital Average logit, μ		-6.822	(-8.232, -5.568)
Between-Hospital Variance in logits, τ^2		0.3888	(0.0012, 1.698)

Figure 7.1. Ninety-Five Percent Posterior Intervals for Standardized Mortality Incidence Rates (SMIRs) Following Isolated CABG Surgery in Massachusetts, 10/1/2006 – 9/30/2007. # 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 state 30-day mortality rate of 1.47%.



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** = South coast Hospital Group – Charlton Memorial Hospital; **Lahey** = Lahey Clinic; **MGH** = Massachusetts General Hospital ; **Mt. Auburn** = Mount Auburn Hospital; **TMC** = Tufts 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; **UMass** = UMass Memorial Medical Center.

Figure 7.2: Cross-Validated P-Values: Isolated Cardiac Surgery Admissions between 10/1/2006 – 9/30/2007. 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** = South coast Hospital Group – Charlton Memorial Hospital; **Lahey** = Lahey Clinic; **MGH** = Massachusetts General Hospital ; **Mt. Auburn** = Mount Auburn Hospital; **TMC** = Tufts 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; **UMass** = UMass Memorial Medical Center**.**

8 – TRENDS IN MORTALITY FOLLOWING ISOLATED CABG SURGERY IN MASSACHUSETTS CY 2002 – FY 2007

Table 8.1: Summary of Admissions and 30-Day Crude Mortality Percentages CY 2002 – FY 2007

Year of Isolated CABG Surgery	CY2002	CY2003	CY2004	CY2005	FY2006	FY 2007
Number of Hospitals	13	14	14	14	14	14
Number of Admissions	4603	4393	3986	3883	3684	3396
30-Day Crude Mortality, %	2.19	2.25	2.01	1.65	1.41	1.47
Between-Hospital Variance in Log-Odds of Mortality	0.042	.094	0.349	0.130	0.035	0.389
Between-Hospital Stand. Dev. in SMIRs, %	0.13	0.29	0.72	0.31	0.05	0.58

9A--KEY FINDINGS - SURGEONS

- **66** surgeons were identified with **11,061** Isolated CABG surgery admissions in Massachusetts over the period October 1, 2004 through September 30, 2007.
- Isolated CABG surgery volumes ranged from **1 to 541** across the 66 surgeons.
- Surgeon analyses were based on **60** surgeons who had 11 or more CABG admissions. This year, all patients with shock prior to surgery, emergent status, or emergent salvage status were eliminated from the surgeons' profiles. This resulted in **10,701** admissions.
- **83.3% of the 60** surgeons performed isolated CABG surgery at exactly one hospital in the Commonwealth over the 3-year period.
- The unadjusted 30-day all-cause mortality rate in Massachusetts during the period October 1, 2004 through September 30, 2007 was **1.26%**.
- After adjusting for patient risk, the odds of 30-day mortality associated with a surgeon one standard deviation above the state average was **one and one-half** (1.49) that for a surgeon one standard deviation below the state average. While this is **a reduction in between-surgeon variation** from fiscal year 2006, the patient sample in FY2006 did not exclude patients on the basis of shock or surgery status.
- No surgeon was identified as a statistical outlier.

9B –SURGEON-SPECIFIC STANDARDIZED 30-DAY MORTALITY INCIDENCE RATES: OCTOBER 1, 2004 – SEPTEMBER 30, 2007

9.1 -What Data are used for this Analysis?

All patients undergoing isolated coronary artery bypass grafting (CABG) surgery between October 1, 2004 and September 30, 2007 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 2008); and excluding surgeons associated with 10 or fewer isolated CABG surgeries. For those surgeons with fewer than 223[4] Isolated CABG surgery admissions over the three year period, a pound symbol (#) is included to indicate that "small sample size may diminish the accuracy of these estimates."

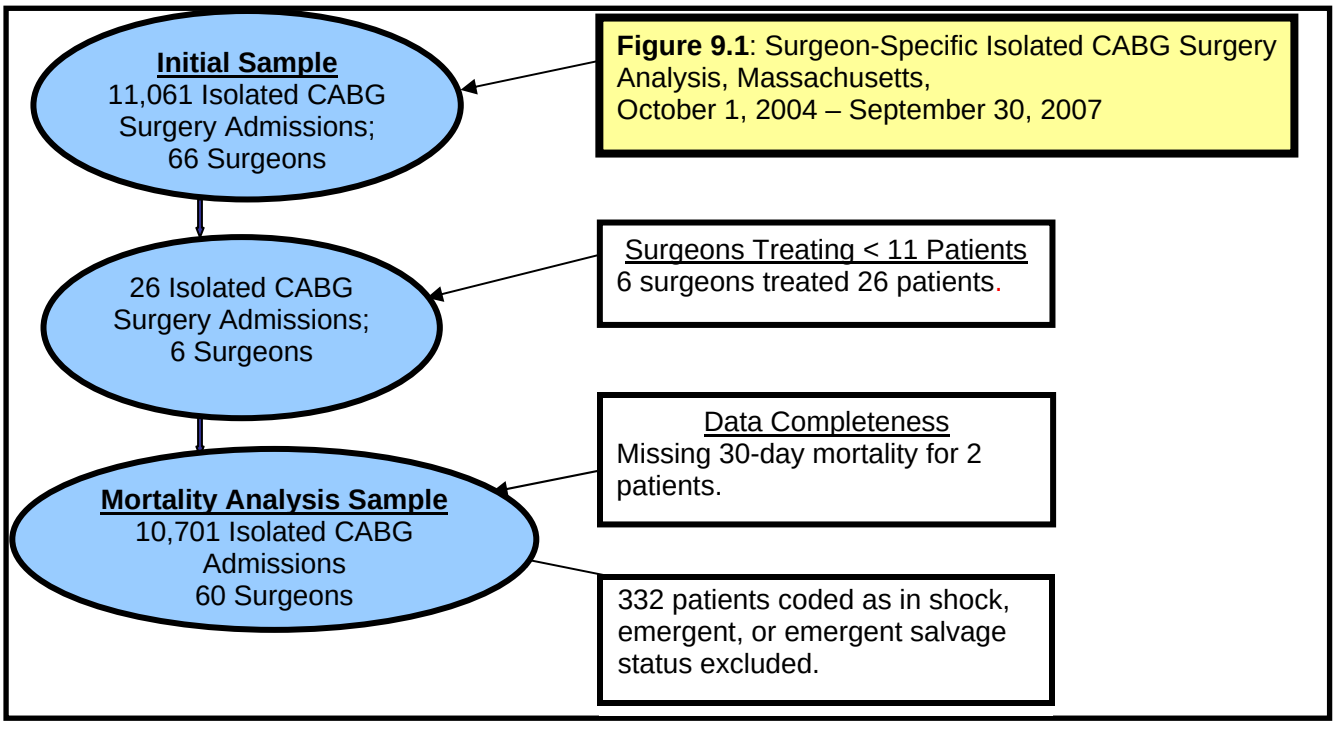
The committee also made recommendations regarding patient inclusion criteria for assessing surgeon quality. They recommended that patients who were coded as in shock, emergent status, or emergent salvage status prior to the surgery be excluded from the analysis because their expected mortality was very high. The Department of Public Health agreed to these recommendations. Mass-DAC eliminated these patients when computing surgeon-specific estimates. Surgeon outlier status is based on the SMIR alone and not posterior predictive p-values.

[4]The number 223 comes from a "power" calculation. The overall 30-day mortality rate between fy2005 and fy2007 is 1.28%. Using a 2 sided-test with alpha = 0.05 and 80% power, minimum sample size was calculated assuming a true hospital performance rate about three times the expected. Approximately 223 cases are needed to detect an absolute increase of 2.5 percentage points (1.28% versus 3.8%). This calculation is approximate because the surgeon-specific expected mortality rates depend on the surgeon's case-mix distribution. This implies that for some surgeons, the expected mortality rate is < 1.28 because they treated healthier patients and for other surgeons the expected rate would be more than 1.28% because they treated sicker patients.

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 model. 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 all patients treated by a surgeon are assigned to each surgeon, regardless of which hospital the surgery was performed. Thus patients are assigned to the surgeon that performed their Isolated CABG surgery. There is no separation of surgeon and hospital "effects."

9.2 - Results.

A total of 11,061 Isolated CABG surgery admissions corresponding to 66 surgeons were initially identified. Six surgeons who treated a total of 26 patients were eliminated from the analyses because they each treated less than 11 patients during the 3 years. Two Isolated CABG patients were also eliminated from analyses because 30-day mortality status was missing and their survival status could not be verified. Consequently, the surgeon analysis sample consists of **11,033** adults treated by 60 surgeons in the Commonwealth.



Of the 60 surgeons**, 50 (83.3%) treated patients at exactly one hospital** in the Commonwealth, 9 (15%) at **exactly two** hospitals, and 1 (1.7%) treated patients at **exactly three** hospitals. **Table 9.1** provides descriptive age-sex-race/ethnicity statistics for the sample of 11,033 patients.

Table 9.1: Age-Sex-Race distribution for all adult Isolated CABG surgery admissions (N = 11,033) in MA hospitals during October 1, 2004 – September 30, 2007. Entries represent numbers of patients and includes all patients, even those with shock, emergent status, and emergent salvage status.

Age Group	Females					Males				
	White	African American	Hispanic	Other[5]	Total	White	African American	Hispanic	Other[2]	Total
18 – 44	62	3	8	2	75	150	11	10	17	188
45 – 54	175	15	14	8	212	988	34	62	56	1140
55 – 64	433	25	27	27	512	2352	47	74	117	2590
65 – 74	747	25	41	49	862	2366	36	71	113	2586
≥ 75	949	20	19	26	1014	1762	19	26	47	1854
Total	2366	88	109	112	**2675**	7618	147	243	350	**8358**

Table 9.1a: Age-Sex-Race distribution for all adult Isolated CABG surgery admissions (N = 10,701) in MA hospitals during October 1, 2004 – September 30, 2007. Entries represent numbers of patients. (patients excluded with shock, emergent, or emergent salvage status).

Age Group	Females					Males				
	White	African American	Hispanic	Other[2]	Total	White	African American	Hispanic	Other[2]	Total
18 – 44	59	2	7	2	70	146	11	10	17	184
45 – 54	168	15	14	8	205	944	33	62	53	1092
55 – 64	420	24	26	24	494	2279	45	72	116	2512
65 – 74	728	25	40	48	841	2304	35	70	112	2521
≥ 75	906	19	19	25	969	1724	18	25	46	1813
Total	2281	85	106	107	**2579**	7397	142	239	344	**8122**

Table 9.2 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 for

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

all patients and for the subset with 30-day mortality rates of 1.49% and 1.28% respectively. For the subset of 10,701 patients, a non-hierarchical logistic regression model indicated area under the ROC curve of 0.72. The Hosmer-Lemeshow Goodness-of-Fit test did not indicate a lack of fit ($\chi 2$ (8 dof) = 6.05, p = 0.64). Model discrimination ranged from 0.5% (5 deaths in 1070 admissions) in lowest risk decile to 4.6% (49 deaths in 1071 admissions) in the highest risk decile.

Figure 9.1 displays the surgeon-specific SMIRs and corresponding 95% posterior intervals. The solid black vertical line in the figure is the unadjusted state 30-day mortality rate of 1.28%. 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.

Table 9.3 identifies each surgeon, the hospital(s) where the surgeon treated cases between October 1, 2004 and September 30, 2007, and summary statistics. Ten surgeons who did not have any Isolated CABG surgery admissions during fiscal year 2008 are denoted by a * symbol; those having fewer than 223 Isolated CABG surgery admissions across the 3 years are denoted by a **#.** We note that 41 (68**%**) out of 60 surgeons had fewer than 223 admissions. No surgeon outliers were detected during this time period.

Table 9.2	Prevalences and Adjusted Odds Ratios of 30-Day Mortality Following Isolated CABG Surgery in Adults, Massachusetts: 10/1/04- 9/30/07.					
	All patients included. Based on 11,033 surgeries by 60 surgeons with 164 deaths (1.49%). *Average age of patients undergoing isolated CABG surgery is 65 + 1.35 = 66.35 years of age.			Excludes shock and emergent/salvage patients. Based on 10,701 surgeries by 60 surgeons with 137 deaths (1.28%). *Average age of patients undergoing isolated CABG surgery is 65 + 1.38 = 66.38 years of age.		
Risk Factor	**Prevalence (%)**	**Adjusted Odds Ratio**	**95% Interval for Adjusted Odds Ratio**	**Prevalence (%)**	**Adjusted Odds Ratio**	**95% Interval for Adjusted Odds Ratio**
Years over 65*	1.35	1.05	(1.03,1.07)	1.38	1.05	(1.03,1.07)
Male	75.75	0.68	(0.49,0.96)	75.90	0.63	(0.45,0.93)
Renal Failure	6.75	2.07	(1.26,3.12)	6.74	2.03	(1.20,3.22)
Diabetes	40.27	1.08	(0.77,1.48)	40.44	1.10	(0.76,1.57)
Hypertension	83.63	1.20	(0.76,1.91)	83.76	1.42	(0.75,2.59)
Peripheral Vascular Disease	17.56	1.77	(1.23,2.47)	17.47	1.75	(1.16,2.51)
Prior CABG surgery	2.16	2.68	(1.08,5.10)	2.16	3.11	(1.23,5.94)
Prior Percutaneous Coronary Intervention (PCI)	20.51	1.12	(0.75,1.60)	20.21	1.16	(0.72,1.74)
Cardiogenic Shock	0.92	4.00	(1.84,7.63)	**Not applicable**		
Ejection Fraction (Ref = ≥ 40%)						
< 30% or missing	10.87	1.95	(1.26,2.87)	10.03	1.76	(1.02,2.71)
30 – 39	10.68	1.17	(0.70,1.79)	10.55	1.46	(0.85,2.28)
Myocardial Infarction(MI)(Ref = None)						
< 6 hours	1.11	1.18	(0.38,2.70)	0.21	0.07	(0.00,0.70)
7 – 24 hours	2.21	1.86	(0.77,3.59)	1.60	2.79	(0.87,6.22)
≥ 1 day	49.27	1.17	(0.81,1.63)	49.84	1.15	(0.77,1.69)
Status of CABG (Ref = Elective)						
Urgent	61.24	2.00	(1.28,3.04)	62.9	1.93	(1.22,2.90)
Emergent/Emergent Salvage	2.77	5.80	(2.49,11.21)	**Not applicable**		
Pre-Op Intra-Aortic Balloon Pump	11.02	1.38	(0.85,2.09)	9.03	1.35	(0.77,2.11)
Between-Surgeon Estimates						
Between-Surgeon Average logit, μ	-5.854	(-6.562, -5.309)		-5.975	(-6.753, -5.288)	
Between-Surgeon Variance in logits, τ^2	0.07294	(0.001114, 0.02892)		0.03989	(0.000534, 0.216)	

Figure 9.1: FY2005 - FY2007 Risk-Standardized 30-Day Surgeon-Specific Mortality Rates.
Rates based on 10,701 Isolated CABG surgeries performed by 60 surgeons.

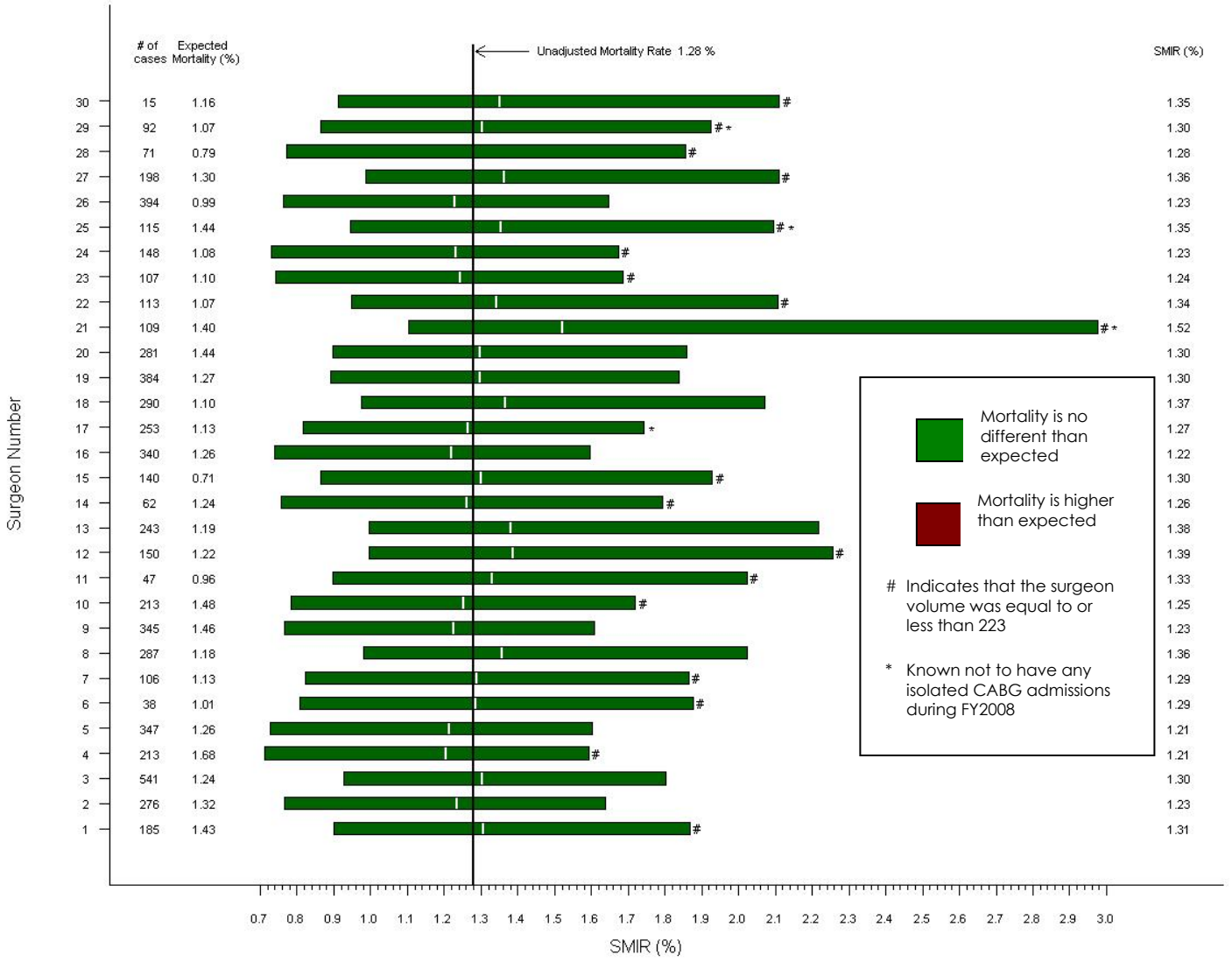


Figure 9.1 Continued

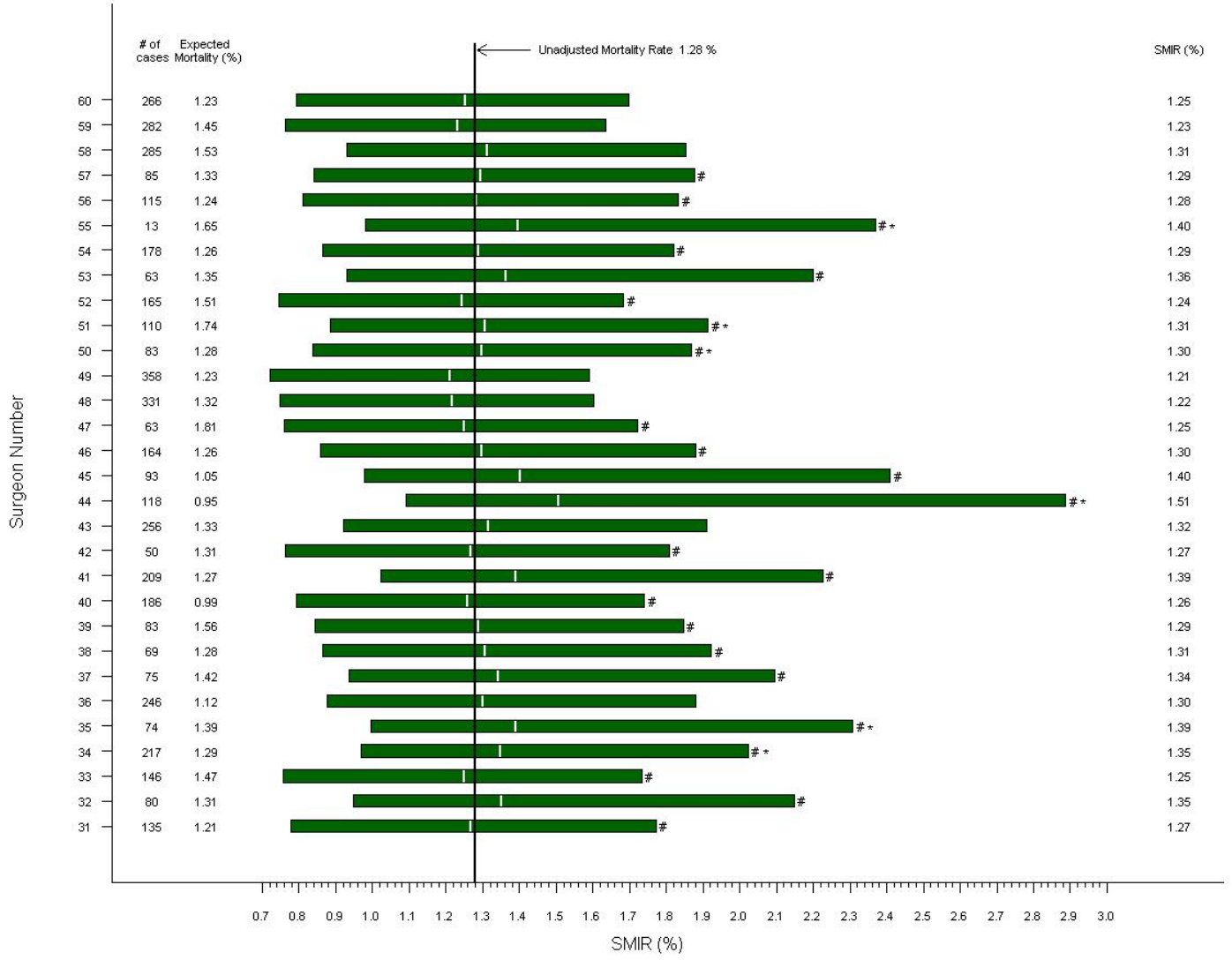


Table 9.3 - Surgeon Standardized 30-Day All Cause Mortality Incidence Rates (SMIRS) Following Isolated CABG Surgery (%), MA., October 1, 2004 – September 30, 2007. Surgeons ordered alphabetically by surname. Excludes patients with shock, emergent, or emergent salvage status prior to surgery.

Surgeon No. & Name	Hospital(s)	Lower Limit of 95% Interval	SMIR (%)	Upper Limit of 95% Interval	Interpretation ¶
1 - Agnihotri, Arvind #	Massachusetts General Hospital	0.8997	1.306	1.868	As-expected
2 - Akins, Cary	Massachusetts General Hospital	0.7657	1.234	1.637	As-expected
3 - Aranki, Sary	Brigham & Women's Hospital	0.9261	1.302	1.803	As-expected
4 - Birjiniuk, Vladimir #	Mount Auburn Hospital	0.711	1.206	1.592	As-expected
5 - Bojar, Robert	Saint Vincent Hospital at Worcester Medical Center; Tufts Medical Center	0.7278	1.213	1.602	As-expected
6 - Bolman, Ralph #	Brigham & Women's Hospital	0.8077	1.285	1.876	As-expected
7 - Bowen, Frank #	Lahey Clinic	0.8233	1.289	1.865	As-expected
8 - Campos, Christian	Southcoast Hospital Group-Charlton Memorial Hospital; UMass Memorial Medical Center	0.9803	1.356	2.022	As-expected
9 - Carr, Thomas	Southcoast Hospital Group-Charlton Memorial Hospital	0.7642	1.227	1.608	As-expected
10 - Chen, Frederick #	Brigham & Women's Hospital	0.7825	1.254	1.719	As-expected
11 - Cohn, Lawrence #	Brigham & Women's Hospital	0.8985	1.33	2.023	As-expected
12 - Couper, Gregory #	Brigham & Women's Hospital	0.995	1.388	2.255	As-expected
13 - D'Agostino, Richard	Lahey Clinic	0.9961	1.382	2.217	As-expected
14 - Davidson, Michael #	Brigham & Women's Hospital	0.7573	1.263	1.794	As-expected
15 - De La Torre, Ralph #	Beth Israel Deaconess Medical Center	0.864	1.301	1.928	As-expected
16 - Deaton, David	Baystate Medical Center	0.7376	1.219	1.596	As-expected
17 - DeGuzman, Brian *	Lahey Clinic	0.8155	1.265	1.743	As-expected
18 - Ehsan, Afshin	Saint Vincent Hospital at Worcester Medical Center; Tufts Medical Center	0.9755	1.366	2.07	As-expected
19 - Engelman, Daniel	Baystate Medical Center	0.8908	1.298	1.839	As-expected
20 - Flack, Joseph	Baystate Medical Center	0.8977	1.296	1.858	As-expected
21 - Francalancia, Nicola # *	UMass Memorial Medical Center	1.103	1.521	2.975	As-expected
22 - Hagberg, Robert #	Beth Israel Deaconess Medical Center; Saint Vincent Hospital at Worcester Medical Center	0.9485	1.343	2.107	As-expected
23 - Harrison, Lynn #	UMass Memorial Medical Center	0.7432	1.243	1.687	As-expected
24 - Hilgenberg, Alan #	Massachusetts General Hospital	0.7288	1.233	1.673	As-expected
25 - Hunter, Curtis # *	Boston Medical Center	0.9436	1.354	2.095	As-expected
26 - Khabbaz, Kamal	Beth Israel Deaconess Medical Center	0.7614	1.23	1.648	As-expected
27 - Lazar, Harold #	Boston Medical Center	0.987	1.363	2.109	As-expected
28 - Lee, Richard #	Lahey Clinic	0.7727	1.279	1.856	As-expected
29 - Liddicoat, John # *	Beth Israel Deaconess Medical Center	0.8631	1.303	1.925	As-expected
30 - Liu, David #	Saint Vincent Hospital at Worcester Medical Center	0.9128	1.35	2.111	As-expected
31 - MacGillivray, Thomas #	Massachusetts General Hospital	0.777	1.268	1.771	As-expected

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Surgeon No. & Name	Hospital(s)	Lower Limit of 95% Interval	SMIR (%)	Upper Limit of 95% Interval	Interpretation ¶
32 - Madsen, Joren #	Massachusetts General Hospital	0.9484	1.352	2.148	As-expected
33 - Maggs, Peter #	Mount Auburn Hospital	0.7556	1.251	1.733	As-expected
34 - Moon, Richard # *	Caritas Saint Elizabeth's Medical Center	0.9679	1.349	2.023	As-expected
35 - Moses, Robert # *	Caritas Saint Elizabeth's Medical Center	0.9943	1.39	2.308	As-expected
36 - Okike, Okike Nsidinanya	UMass Memorial Medical Center	0.8762	1.301	1.88	As-expected
37 - Olenchock,Stephen #	Caritas Saint Elizabeth's Medical Center	0.9346	1.342	2.095	As-expected
38 - Pham, Duc #	Saint Vincent Hospital at Worcester Medical Center; Tufts Medical Center	0.8632	1.305	1.922	As-expected
39 - Pirundini, Paul #	Cape Cod Hospital	0.843	1.289	1.847	As-expected
40 - Rastegar, Hassan #	Caritas Saint Elizabeth's Medical Center; Saint Vincent Hospital at Worcester Medical Center; Tufts Medical Center	0.793	1.26	1.74	As-expected
41 - Rizzo, Robert #	Brigham & Women's Hospital; Cape Cod Hospital	1.023	1.391	2.226	As-expected
42 - Rosengard, Bruce #	Massachusetts General Hospital	0.7624	1.269	1.808	As-expected
43 - Rousou, John	Baystate Medical Center	0.9205	1.315	1.911	As-expected
44 - Saltman, Adam # *	UMass Memorial Medical Center	1.092	1.506	2.887	As-expected
45 - Samy, Sanjay #	Lahey Clinic	0.977	1.402	2.409	As-expected
46 - Sellke, Frank #	Beth Israel Deaconess Medical Center	0.8596	1.298	1.879	As-expected
47 - Senthilnathan,V #	Beth Israel Deaconess Medical Center	0.7601	1.251	1.722	As-expected
48 - Shapira, Oz	Boston Medical Center	0.748	1.217	1.602	As-expected
49 - Shekar, Prem	Brigham & Women's Hospital	0.7199	1.21	1.591	As-expected
50 - Shemin, Richard # *	Boston Medical Center	0.8386	1.298	1.869	As-expected
51 - Symes, James # *	Caritas Saint Elizabeth's Medical Center	0.8837	1.306	1.913	As-expected
52 - Tam, Stanley #	Mount Auburn Hospital; UMass Memorial Medical Center	0.7437	1.243	1.684	As-expected
53 - Tolis,George #	Caritas Saint Elizabeth's Medical Center	0.9309	1.362	2.199	As-expected
54 - Toran, Ann #	North Shore Medical Center-Salem Hospital	0.8641	1.287	1.819	As-expected
55 - Torchiana, David # *	Massachusetts General Hospital	0.9812	1.397	2.369	As--expected
56 - Vandersalm, Thomas #	North Shore Medical Center-Salem Hospital	0.8115	1.281	1.833	As-expected
57 - Vlahakes, Gus #	Massachusetts General Hospital	0.8402	1.294	1.876	As-expected
58 - Walker, Jennifer	Massachusetts General Hospital; North Shore Medical Center-Salem Hospital	0.9291	1.312	1.854	As-expected
59 - Warner, Kenneth	Saint Vincent Hospital at Worcester Medical Center Tufts Medical Center	0.7632	1.233	1.636	As-expected
60 - Williamson, Christina	Lahey Clinic	0.7929	1.253	1.699	As-expected

¶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 223
*Known not to have any Isolated CABG admissions during Fiscal Year 2008.

10 - 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.

Cardiogenic Shock: (STS variable definition): Indicates the patient was, at the time of surgery, in a clinical state of hypoperfusion according to either of the following criteria:

1. Systolic BP < 80 and/or Cardiac Index < 1.8 despite maximal treatment;
2. IV inotropes and/or IABP necessary to maintain Systolic BP > 80 and/or CI > 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 variable definition) 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.

Ejection Fraction: (STS variable definition) Indicates the percentage of the blood emptied from the ventricle at the end of the contraction.

Hypertension: (STS variable definition) Indicates 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. Blood pressure >140 systolic or >90 diastolic on at least 2 occasions.

c. Currently on antihypertensive medication.

Pre-Operative Intra-Aortic Balloon Pump: (STS variable definition) Indicates the patient was placed on Intra-Aortic Balloon Pump (IABP).

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.

Myocardial Infarction: (STS variable definition) Indicates the patient has a history of an MI. For MI occurrence prior to current hospitalization, one of the following is necessary:

1. MI documented in the medical record. OR
2. EKG Documented Q wave. Q waves to be 0.03 seconds in width and/or > or = 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:

1. Ischemic symptoms in the presence or absence of chest discomfort.
   Ischemic symptoms may include: a) chest, epigastric, arm, wrist or jaw discomfort with exertion or at rest; b) unexplained nausea and vomiting; c) Persistent shortness of breath secondary to left ventricular failure; d) Unexplained weakness, dizziness, lightheadedness, diaphoresis or syncope.
2. Enzyme level elevation. One of the following four are necessary:
   a) CK-MB: -Maximal value of CK-MB > 2 x 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, > upper limit of normal on two successive samples; b) CK > 2x the upper limit of normal; c) LDH subtype 1 > LDH subtype 2; d) Maximal concentration of troponin T or I > the MI decision limit on at least one occasion during the first 24 hours after the index clinical event.
3. Serial ECG (at least two) showing changes from baseline or serially in ST-T.

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.

Peripheral Vascular Disease: (STS variable definition) Indicates the patient has Peripheral Vascular Disease, as indicated by claudication either with exertion or rest; amputation for arterial insufficiency; aorto-iliac occlusive disease reconstruction; peripheral vascular

bypass surgery, angioplasty, or stent; documented Aortic Abdominal Aneurysm, Aortic Abdominal Aneurysm repair, or stent; positive non-invasive testing documented. Does not include procedures such as vein stripping, carotid disease, or procedures originating above the diaphragm.

Prior CABG Surgery: (STS variable definition) Indicates the patient had a previous Coronary Bypass Graft prior to the current admission.

Prior Percutaneous Coronary Intervention (PCI): (STS variable definition) 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: 1. Balloon Catheter Angioplasty, Percutaneous Transluminal Coronary Angioplasty (PTCA); 2. Rotational Atherectomy; 3. Directional Atherectomy; 4. Extraction Atherectomy; 5. Laser Atherectomy; 6. Intracoronary Stent Placement

Renal Failure: (STS variable definition) Indicates the patient has 1) a documented history of renal failure and/or 2) a history of creatinine > 2.0. Prior renal transplant patients are not included as pre-op renal failure unless since transplantation their creatinine has been or currently is > 2.0.

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 smoothed number of deaths (the number of deaths adjusted for the number of cases 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 variable definition) Indicates the status that best describes the clinical status of the patient at the time of surgery:

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

Emergent: 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.

Urgent: ALL of the following conditions are met: a. Not elective status. and b. Not emergent status and c. Procedure required during same hospitalization in order to minimize chance of further clinical deterioration and Worsening, sudden chest pain, CHF, acute myocardial infarction, anatomy, IABP, unstable angina with intravenous nitroglycerin or rest angina may be included.

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.

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.

Massachusetts Cardiac Care Hospital Outlier Committee. A MA Department of Public Health Committee charged with reviewing hospital outlier findings. *Members excluded from reviewing FY2007 findings due to potential conflicts. Dr. Fred Resnic from Brigham and Women's hospital participated.	
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 FY 2007 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	Robert Hagberg, M.D. Beth Israel Deaconess Medical Center
Vladimir Birjiniuk, M.D. Mount Auburn Hospital	James Rawn, M.D. Brigham and Women's Hospital
Thomas Carr, M.D. Charlton Hospital	Bruce Rosengard, M.D. Brigham and Women's Hospital
Richard D'Agostino, M.D. Lahey Clinic	David Shahian, M.D. Massachusetts General Hospital
Daniel Engleman, M.D. Baystate Medical Center	Prem Shekar, M.D. Brigham and Women's Hospital
Jennifer Rautine Data Manager Beth Israel Deaconess Medical Center	Tamar Yehoshua Data Manager St. Elizabeth's Medical Center

Mass-DAC Physician Reporting Oversight Committee for Cardiac Surgery: The charge of this Committee is to 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. (Immediate past Governor, MA ACC) 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	Other	All Maze procedures are excluded	Other
Maze: **Closed** epicardial approach and radio frequency	CABG		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 considered optional and 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

