Cardiac Surgery in New Jersey
2021-2022

Technical Report

Health Care Quality Assessment
Health Care Quality and Informatics

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Background

This report assesses the performance records of the 18 hospitals in New Jersey that are licensed to offer cardiac surgeries (also referred to as open heart surgeries in this report) in 2021 and 2022. New Jersey is one of five states that has issued reports on isolated Coronary Artery Bypass Graft (CABG or bypass) surgery outcomes for hospitals and surgeons and began reporting on patient mortality for bypass surgery hospitals and surgeons in 1997, using 1994 and 1995 data combined.

An important goal of this report is to give hospitals information they can use in assessing and improving quality of care and patient outcomes related to CABG surgery.

Cardiovascular Health Advisory Panel

This report was a collaborative effort between the New Jersey Department of Health (Department) and a select committee of experts known as the Cardiovascular Health Advisory Panel (CHAP), which includes cardiac surgeons, cardiologists, nurses and professional associations and consumer representatives (Appendix A). The Cardiovascular Health Advisory Panel (CHAP) was established by the Commissioner of Health by Executive Order (No. 187 (2001) and amended by Executive Order 207) to provide the Commissioner with expert advice on sound cardiovascular health policy. CHAP provides advice on cardiovascular health promotion, disease prevention, standards of care, emerging technologies, and their applications to cardiac services in the State, and review of the State's cardiac data for quality assessment, performance evaluation, and research.

Data

For this report, the Department collected data on 18,658 patients undergoing open heart surgery at 18 hospitals in the period 2021-2022 (Appendix C). Of these patients, 7,627 had CABG surgery with no other major surgery during the same admission, i.e., isolated CABG surgery (or simply referred to as bypass surgery in this report) (Appendix C and Table 2).

Before analyzing the data, the Department performed extensive error checks on the entire cardiac surgery data. In addition, sample medical records from each hospital were selected for independent medical audit.

Method

Definition of Operative Mortality for Isolated CABG (Bypass) Surgery

Isolated CABG surgery (or simply called **bypass surgery**) refers to heart bypass surgery with no other major heart procedure being performed at the same time[1]. Beginning with the 2000 report[2],and

[1] The Department, in consultation with CHAP, reviewed the way operative procedures are coded and issued an operative procedure coding guide to be followed by all hospitals starting with 2005 data.

[2] Prior to 2000, the Department defined patient death for this report as in-hospital death before discharge from the hospital after bypass surgery. As a result, patients who died after being discharged home or to post-acute care

upon consultation with the CHAP, the Department included in its definition of "**operative mortality**": 1) all deaths that occurred during the hospitalization after the procedure, regardless of days; or 2) all deaths that occurred after discharge up to 30 days post-surgery. Deaths occurring within 30 days after surgery, but post-discharge, were identified by matching patient records in the Department's Cardiac Surgery database with the State's official death records.

Risk-Adjustment

The observed bypass surgery mortality rate for a hospital is estimated as the number of bypass surgery patients who died in the hospital during or after surgery, or patients who died after discharge but within 30 days of post-surgery, divided by the total number of patients who underwent the bypass surgery.

This observed mortality rate does not account for how sick the patients were before surgery. To make fair comparisons, the Department uses logistical regression to adjust mortality rates for each hospital by pre-surgery risk factors of each patient. Additionally, extremely high-risk patients, where the probability of death is very high, may, with the concurrence of the CHAP expert clinical panel, be excluded from the calculation.

A logistic regression model which included all the before-surgery health and demographic factors was fitted to the data for the period covered by this report to identify those risk factors that were important in predicting whether a patient would die after a bypass surgery. The general form of a logistic regression model for estimating the "logit" of the probability of dying (p), denoted by Y_i, is presented as follows:

$$Y_i = \sum_{k}^{K} \beta_k X_{ki} + \varepsilon_i \text{ , } Where X_{0i} = 1;$$

$$Y_i = \log_e \left(\frac{p_i}{1 - p_i} \right) = \text{ the "logit" of } p_i$$

i = 1,2,…,n; k = 0,1,2,...,K,
β_k= Logistic regression coefficient for risk factor X_k,
K = Number of risk factors in the model,
n = Number of patients,
ε_i = Random error term i.

The risk factors for this report (X_k) identified by using the Bayesian Information Criterion (BIC). BIC measures the efficiency of the model in terms of predicting the data, while it penalizes the complexity of the model where complexity refers to the number of parameters in the model. The finalized model not only includes statistically significant risk factors but also include risk factors that increase the efficiency of the model. Table 1 includes estimates of coefficients for all risk factors that selected using BIC, an indication of the level of statistical significance (p-values), and odds ratios.

The odds ratios are derived from the coefficients and are used to compare the relative importance of the risk factors in predicting mortality from bypass surgery. For each of the risk factors identified in

facilities were not counted for purposes of calculating bypass surgery mortality rates. This caused concerns about "gaming" of outcomes through discharge practices.

Table 1, the odds ratio represents how much more likely a patient is at risk of mortality when compared to a patient who is in the reference group. So, for example, Table 1 shows that the odds of mortality for a patient who had renal failure that required dialysis was three and half times (odds ratio = 3.47) as high as a patient who did not have renal failure. This assumes that both patients have the same set of other risk factors presented in the Table 1.

Estimation of Risk-Adjusted Mortality Rates

The risk factors presented in Table 1 were used in the fitted logistic regression model to predict the probability of mortality from bypass surgery for each patient. The sum of predicted probabilities of mortality for patients operated on in each hospital divided by the number of patients operated on in that hospital provides the predicted (or expected) mortality rate associated with the hospital. Terms such as "expected" and "predicted" are used interchangeably in this report to signify that the estimates are derived from predicted probabilities after accounting for risk factors.

The predicted probability of dying for patient i ($\hat{p}_i$) is given as follows:

$$\hat{p}_i = \frac{e^{(\hat{Y}_i)}}{1+e^{(\hat{Y}_i)}}, \text{Where } i = 1,2,3,...,n \text{ ; and}$$

$$\hat{Y}_i = \hat{\beta}_0 + \hat{\beta}_1 X_{1i} + \hat{\beta}_2 X_{2i} + \hat{\beta}_3 X_{3i} + ... + \hat{\beta}_k X_{ki}$$

To assess the performance of each hospital, the observed patient mortality was compared with the expected or predicted patient mortality based on the existing risk factors for the hospital's patients. The observed patient mortality is divided by the expected mortality. If the resulting ratio is higher than one, the hospital has a higher patient mortality than expected based on their patient mix. If the ratio is lower than one, the hospital has a lower mortality rate than expected, based on their patient mix. The ratio is then multiplied by the statewide mortality rate to produce the risk-adjusted patient mortality rate for the hospital.

The risk-adjusted patient mortality rate represents what a hospital's patient mortality rate would have been if they had a mix of patients identical to the statewide mix. Thus, the risk-adjusted patient mortality has, to the extent possible, adjusted for differences among hospitals as it applies to variations in the severity of illness of their patients before surgery.

The statistical methods described above are tested to determine if they are sufficiently accurate in predicting the risk of death for all patients – for those who are severely ill prior to undergoing bypass surgery as well as those who are relatively healthy.

In the analysis of data for this report, the tests confirmed that the model is reasonably accurate in predicting how patients of different risk levels will fare when undergoing bypass surgery. The area under the Receiver Operating Characteristic (ROC) curve, denoted by C-statistic in Table 1, was used to evaluate model performance. The C-statistic may be interpreted as the degree to which the risk factors in the model predicted the probability of death for bypass surgery patients. Specifically, the C-statistic measures the tendency of the predicted mortality for patients in the sample that died to be higher than that for patients who were discharged alive and were also alive 30 days after bypass surgery. The 2021-2022 model C-statistic is 81.1 percent, suggesting that the model has strong predictive power (Table 1).

Table 1. Risk Factors Identified for Isolated CABG Surgery Operative Mortality*, 2021 – 2022

Patient Risk Factors Identified	Proportion of patients (%)	Logistic Regression Results		
		Coefficient	P-Value	Odds Ratio
Demographic factors				
Age-squared	-	0.0004	<.0001	1.000
Non-hispanic White	66.17	*ref*		
Non-hispanic Black	7.36	0.4401	0.0191	2.134
Non-hispanic Other	13.79	-0.1038	0.5797	1.239
Hispanic	12.67	-0.0186	0.9172	1.349
PPO and Commercial Insurance	28.24	*ref*		
Medicaid	7.37	0.4419	0.0711	1.396
Medicare	49.88	-0.2855	0.1095	0.674
HMO	11.41	-0.4920	0.1009	0.549
Other (Self-pay, Uninsured and Other)	3.11	0.2273	0.5269	1.126
Health factors				
No Renal Failure	93.09	*ref*		
Renal Failure without Dialysis	3.47	0.3745	0.0404	3.269
Renal Failure with Dialysis	3.44	0.4352	0.0230	3.473
No Lung Disease	78.42	*ref*		
Lung Disease -Mild	9.36	-0.3654	0.1339	1.076
Lung Disease -Moderate	4.17	0.4436	0.0527	2.417
Lung Disease -Severe	2.50	0.4133	0.1113	2.345
Lung Disease -Unknow	5.55	-0.0527	0.8320	1.471
No Peripheral Vascular Disease	85.68	*ref*		
Peripheral Vascular Disease	14.32	0.6497	0.0005	1.915
Factors related to functioning of the heart				
No Myocardial Infraction	49.50	*ref*		
Myocardial Infraction	50.50	0.5095	0.0071	1.664
NYHA - I	32.67	*ref*		
NYHA - II	36.63	-0.2027	0.1440	1.169
NYHA - III	23.80	-0.0190	0.8885	1.405
NYHA - IV	6.90	0.5804	0.0008	2.558
No Left Main Disease	65.08	*ref*		
Left Main Disease	34.92	0.3350	0.0442	1.398
Ejection Fraction 50%+	71.99	*ref*		
Ejection Fraction 1 - 29%	6.07	0.5420	0.0003	2.353
Ejection Fraction 30 - 49%	21.94	-0.2281	0.0782	1.090
No Cardiogenic Shock at Surgery	98.52	*ref*		
Cardiogenic Shock at Surgery	1.48	0.5326	0.0009	2.902
No Arrhythmia	86.10	*ref*		
Arrhythmia - ≤30 Days	8.39	0.4478	0.0100	1.735
Arrhythmia - >30 days	5.51	-0.3448	0.1620	0.785
Intercept	-4.3490			
C-Statistic	0.811			
Number of CABGs (N)	7,627			

SOURCE: 2021 - 2022 New Jersey Cardiac Surgery Data.

* = Operative Mortality includes: (1) all deaths occurring during the hospitalization in which the operation was performed, even after 30 days; and (2) those deaths occurring after discharge from the hospital, but within 30 days of the procedures.

Risk Factors for Post-Surgery Length of Stay

To predict a patient's post-operative length of stay, we fitted a generalized linear regression model on the log transformation of length of stay. The model was developed using demographic factors, health factors, factors related to functioning of the heart and prior cardiac intervention as predictors. Patients who experienced mortality during the bypass surgery hospitalization were excluded from analysis as were patients who stayed fewer than two days in hospital and those who stayed over 30 days.

Table 2 presents the final model used to estimate risk-adjusted length of stay by hospital and includes only those predictors found to be statistically significant at five percent or lower levels. Consistent with findings in Pennsylvania, the predictive power of the model is low (only 20.3 percent). Such low predictive power is usually common when one fits a regression model using individual level data as large as these.

Please note that the coefficients provided in Table 2 are in log form and interpretation of the values should take that into consideration.

Table 2. *Risk Factors Identified for Isolated CABG Surgery Length of Stay, 2021 – 2022

Patient Risk Factors Identified	Proportion of Patients(%)	Generalized Linear Regression Results	
		Coefficient	P-Value
Demographic factors			
Age	-	-0.01628	0.0004
Age-squared	-	0.00018	<.0001
Male	78.55	*ref*	
Female	21.45	0.07974	<.0001
Non-hispanic White	66.56	*ref*	
Non-hispanic Black	7.19	0.11516	<.0001
Non-hispanic Other	13.65	0.04596	0.0007
Hispanic	12.60	0.05218	0.0002
PPO and Commercial Insurance	28.51	*ref*	
Medicaid	7.28	0.08832	0.0096
Medicare	49.69	-0.00963	<.0001
HMO	11.46	-0.03229	0.4422
Other (Self-pay, Uninsured and Other)	3.06	0.06938	0.0379
Health factors			
No Obesity	60.30	*ref*	
Obesity	39.70	0.04212	<.0001
No Diabetes	54.53	*ref*	
Diabetes - Diet or Oral or Other/Other Subcutaneous	26.86	0.00297	0.7780
Diabetes - Insulin	17.01	0.03287	0.0103
Diabetes - Other Method	1.60	0.04656	0.1869
No Renal Failure	93.59	*ref*	
Renal Failure without Dialysis	3.19	0.20281	<.0001
Renal Failure with Dialysis	3.22	0.23673	<.0001
No CVD	81.56	*ref*	
CVD Without CVA	10.89	0.03574	0.0130
CVD and CVA	7.55	0.10292	<.0001
No Lung Disease	78.73	*ref*	
Lung Disease - Mild	9.38	0.04803	0.0017
Lung Disease - Moderate	4.01	0.10838	<.0001
Lung Disease - Severe	2.37	0.15545	<.0001
Lung Disease - Unknow	5.52	0.03697	0.0581
No Peripheral Vascular Disease	86.01	*ref*	
Peripheral Vascular Disease	13.99	0.08520	<.0001

(To be continued)

Table 2. *Risk Factors Identified for Isolated CABG Surgery Length of Stay, 2021 – 2022 (continued)

Patient Risk Factors Identified	Proportion of Patients(%)	Generalized Linear Regression Results	
		Coefficient	P-Value
Factors related to functioning of the heart			
No MI	50.05	*ref*	
MI - Less than 7 Days	27.73	0.03322	0.0027
MI - 8 to 21 Days	5.47	0.04246	0.0381
MI - More than 21 Days	16.75	0.01806	0.1501
No Congestive Heart Failure	77.35	*ref*	
Congestive Heart Failure	22.65	0.09219	<.0001
No Cardiogenic Shock	98.81	*ref*	
Cardiogenic Shock	1.19	0.20971	<.0001
No Resuscitation	99.77	*ref*	
Resuscitation	0.23	0.18108	0.0032
No Arrhythmia	92.06	*ref*	
Arrhythmia - Sustained VT/VF	1.61	-0.04453	0.2216
Arrhythmia - Heart Block	0.54	0.06070	0.3114
Arrhythmia - Afib/Flutter	5.66	0.15595	<.0001
Arrhythmia - Sick Sinus Syndrome	0.14	0.48705	<.0001
NYHA - I	33.02	*ref*	
NYHA - II	36.96	0.06963	<.0001
NYHA - III	23.56	0.07321	<.0001
NYHA - IV	6.47	0.06243	0.0015
Ejection Fraction 50 - 100%	72.61	*ref*	
Ejection Fraction 1 - 29%	5.62	0.22020	<.0001
Ejection Fraction 30 - 49%	21.77	0.04397	0.0001
No Diseased Vessels	0.11	*ref*	
Number of Diseased Vessels - One	3.25	-0.29098	0.0318
Number of Diseased Vessels - Two	17.50	-0.20684	0.1218
Number of Diseased Vessels - Three	79.15	-0.18112	0.1745
Intercept	2.0243		
R-Square	20.28		
Number of CABGs (N)*	7,390		

SOURCE: 2021-2022 New Jersey Cardiac Surgery Data.

* Excluded are patients who died during hospitalization where CABG was performed; patients with post-surgical LOS > 30 days; and patients with post-surgical LOS < 2 days.

Results

Bypass Surgery Mortality Rate by Hospital Compared with the Statewide Rate in 2021-2022

Table 3 presents the bypass volume, observed mortality rate, expected mortality rate, risk-adjusted mortality rate and its confidence interval following bypass surgery for each of the 18 hospitals.

The observed operative mortality rate statewide in 2021-2022 for bypass patients was 2.18 %, based on 166 deaths out of 7,627 bypass operations performed.

After adjusting for severity of illness of the patients before surgery at each hospital, the estimates of risk-adjusted patient mortality rate for each hospital and related confidence interval are calculated and presented in columns 6 and 7 of Table 3. Please note that the confidence interval is shorter for hospitals performing more surgeries, and longer for those with lower volumes. This reflects the fact that larger numbers -- in this case, more surgeries -- increase the precision of a statistic.

If a hospital's 95 percent confidence interval contains the statewide rate, it means that the difference between the hospital's risk-adjusted mortality rate and the statewide rate was not statistically significant. If a hospital's 95 percent confidence interval is below the statewide rate, it means that the hospital's risk-adjusted patient mortality rate was statistically significantly lower than the statewide rate. If a hospital's 95 percent confidence interval is above the statewide rate, it means that the hospital's risk-adjusted mortality rate was statistically significantly higher than the statewide rate.

Despite the variations in bypass mortality rates among hospitals, the quality of care delivered by most hospitals were like the statewide performance in 2021-2022. Only one hospital, Morristown Memorial Hospital, had a statistically significantly lower risk-adjusted mortality rate than the statewide rate. The risk-adjusted mortality rate for University Hospital could not be calculated due to their low bypass volume in this two-year period.

Table 3. Risk-Adjusted Operative Mortality* and Post-Surgery Length of Stay by Hospital, 2021-2022

Hospital	Number of Isolated CABG Surgeries	Patient Operative Deaths*	Observed Patient Mortality (%)	Expected Patient Mortality (%)	Risk-Adjusted Patient Mortality (%)		95% Confidence Interval	Risk-Adjusted Patient Post-Surgery LOS** (days)
AtlantiCare Regional MC - Mainland	258	7	2.71	1.84	3.20		(1.28, 6.60)	6.22
Capital Health System at Fuld	116	3	2.59	3.40	1.65		(0.33, 4.83)	7.46
Cooperman Barnabas Medical Center	384	10	2.60	1.98	2.86		(1.37, 5.26)	7.56
Deborah Heart and Lung Center	324	4	1.23	2.91	0.92		(0.25, 2.36)	6.19
Englewood Hospital and Medical Center	391	7	1.79	1.51	2.58		(1.03, 5.32)	6.54
Hackensack University Medical Center	801	12	1.50	1.57	2.08		(1.07, 3.63)	6.00
Jersey City Medical Center	251	7	2.79	3.50	1.73		(0.69, 3.57)	6.32
Jersey Shore University Medical Center	892	8	0.90	1.76	1.11		(0.48, 2.18)	5.41
(-)Morristown Memorial Hospital	1194	16	1.34	2.24	1.30	**LO**	(0.74, 2.11)	6.69
Newark Beth Israel Medical Center	171	8	4.68	3.65	2.79		(1.20, 5.50)	6.83
Robert Wood Johnson University Hospital	1001	21	2.10	1.73	2.64		(1.64, 4.04)	5.55
Saint Michael's Medical Center	67	1	1.49	1.86	1.75		(0.02, 9.74)	7.83
St. Joseph's Regional Medical Center	236	12	5.08	4.65	2.38		(1.23, 4.16)	5.75
St. Mary's Hospital (Passaic)	109	7	6.42	3.01	4.65		(1.86, 9.58)	5.92
The Cooper Health System	635	16	2.52	1.92	2.86		(1.63, 4.64)	6.52
University Hospital***	16	0	N/A	N/A	N/A		N/A	N/A
Valley Hospital	204	5	2.45	1.45	3.68		(1.19, 8.59)	6.00
Virtua Our Lady of Lourdes Hospital	577	22	3.81	2.77	2.99		(1.88, 4.53)	5.41
Statewide	7,627	166	2.18	2.18	2.18			6.16

SOURCE: 2021-2022 New Jersey Cardiac Surgery Data.

* = Operative Mortality includes: (1) all deaths occurring during the hospitalization in which the operation was performed, even after 30 days; and (2) those deaths occurring after discharge from the hospital, but within 30 days of the procedures.

** = Excluded are patients who died during hospitalization where CABG was performed; patients with post-surgical LOS > 30 days; and patients with post-surgical LOS < 2 days.

*** = Risk-adjusted mortality rate and length of stay cannot be reliably calculated for the hospital due to low volume.

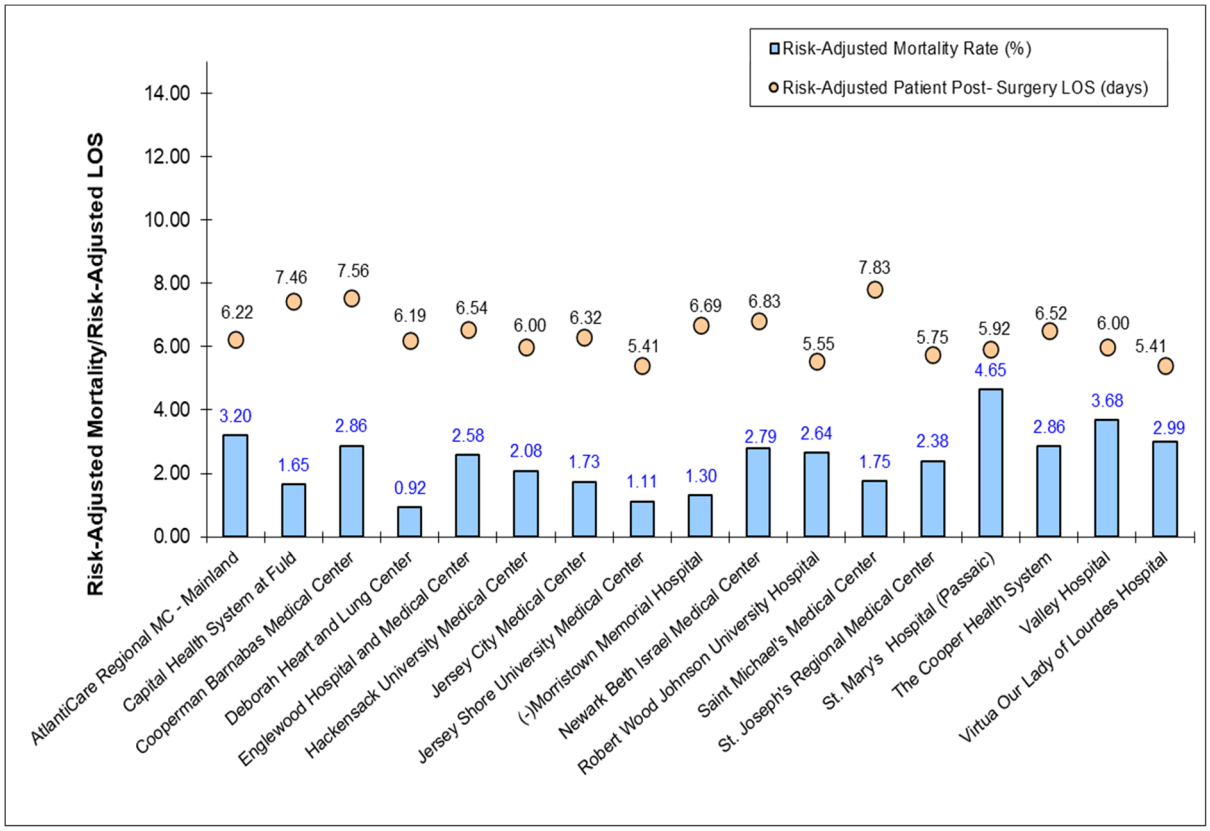
LO = Risk-adjusted mortality rate significantly lower than the New Jersey statewide mortality rate based on 95 percent confidence interval.

Length of Stay by Hospital

Post-surgery length of stay is an additional tool to measure hospital performance on bypass surgery. The statewide post-surgery length of stay is 7.34 days in the period 2021-2022 (7.15 days in 2021 and 7.53 days in 2022).

The risk-adjusted length of stay by hospital are displayed in the last column of Table 3 and in Figure 1. There is a marked variation in risk-adjusted length of stay by hospital as shown in Figure 1. The risk-adjusted length of stay by hospital ranged from 5.41 days (at Jersey Shore University Medical Center and Virtua Our Lady of Lourdes Hospital) to 7.83 days (at Saint Michael's Medical Center) in this two-year period. This report did not find a correlation (that was statistically significant) between mortality rate and length of stay.

Figure 1. Risk-Adjusted Operative Mortality* and Length of Stay (LOS) by Hospital***, 2021 – 2022**



SOURCE: 2021 - 2022 New Jersey Cardiac Surgery Data.

* = Operative Mortality includes: (1) all deaths occurring during the hospitalization in which the operation was performed, even after 30 days; and (2) those deaths occurring after discharge from the hospital, but within 30 days of the procedures.

** = Excluded are patients who died during hospitalization where CABG was performed; patients with post-surgical LOS > 30 days; and patients with post-surgical LOS < 2 days.

*** = Risk-adjusted mortality rate and length of stay could not be reliably calculated for University Hospital due to low volume.

(-) = Risk-adjusted mortality rate significantly lower than the New Jersey statewide mortality rate based on 95 percent confidence interval.

Annual Risk-Adjusted Mortality Rate Compared to the Combined 2013-2022 Mortality Rate

Table 4 presents trends in the statewide mortality rate of patients who had bypass surgery using a statistical model based on the pooled data collected over the period 2013-2022. For each of the years, the table presents statewide observed patient mortality rate, expected patient mortality rate, and risk-adjusted patient mortality rate estimate. Note that the numbers differ from those shown in reports produced in previous years, due to the revised definition of mortality and the use of pooled data for the analysis. The table further exhibits whether the risk-adjusted mortality rate for the year is statistically different from the pooled mortality rate for the 2013-2022 period.

Table 4 shows that risk-adjusted mortality rate (RAMR) from bypass surgery rose by 60.5percent from 1.57% in 2013 to 2.52% in 2021, averaging 0.14 percentage points in absolute terms per year according to a fitted regression line (data not shown).

Between 2021 and 2022, RAMR fell by 20.6 percent from 2.52% to 2.00%.

Table 4. Annual Risk-Adjusted Operative Mortality* Rate Derived from the Pooled Data, 2013-2022

Year	Number of Isolated CABG Operations	Operative Patient Mortality*	Observed Patient Mortality Rate (%)	Predicted Patient Mortality Rate (%)	Risk-Adjusted Patient Mortality Rate (%)		Yearly Change in Risk-Adjusted Mortality Rate (%)	Percent Change from 2013 Risk-Adjusted Mortality Rate (%)
2013	3,881	61	1.57	1.92	1.57	**SA**	----	----
2014	3,790	51	1.35	1.98	1.30	**LO**	-0.27	-17.2
2015	3,945	79	2.00	2.12	1.80	**SA**	0.50	14.6
2016	4,121	63	1.53	1.98	1.47	**LO**	-0.33	-6.4
2017	4,059	81	2.00	1.84	2.07	**SA**	0.60	31.8
2018	3,947	64	1.62	1.83	1.69	**SA**	-0.38	7.6
2019	4,094	99	2.42	1.85	2.49	**HI**	0.80	58.6
2020	3,305	76	2.30	1.88	2.34	**SA**	-0.15	49.0
2021	3,831	94	2.45	1.86	2.52	**HI**	0.18	60.5
2022	3,796	72	1.90	1.81	2.00	**SA**	-0.52	27.4
2013-2022	**38,769**	**740**	**1.91**	**1.91**	**1.91**			

SOURCE: New Jersey 1994 – 2022 Cardiac Surgery Data.
*Operative Mortality includes: (1) all deaths occurring during the hospitalization in which the operation was performed, even after 30 days; and (2) those deaths occurring after discharge from the hospital, but within 30 days of the procedures.
LO - The risk-adjusted patient mortality is significantly lower than the mortality for the 1994-2022 combined when evaluated with a 95 percent confidence interval.
SA - The risk-adjusted patient mortality is same as the mortality for the 1994-2022 combined when evaluated with a 95 percent confidence interval.
HI - The risk-adjusted patient mortality is significantly higher than the mortality for the 1994-2022 combined when evaluated with a 95 percent confidence interval.

Statewide Bypass Surgery Related Infections

Table 5 presents statewide infection rates that includes sternal-deep infection (involving muscle, bone and/or mediastinum requiring operative intervention), thoracotomy, leg infections, septicemia (presence of bacteria in the blood stream) and urinary tract infections (UTI), as well as post-operative pneumonia.

Statewide, 4.97 % of patients who had bypass surgery had some type of infection. The highest percentage of infections were due to pneumonia (2.64 %), followed by UTI (1.67%), septicemia (0.85%), leg infection (0.51%), and sternal-deep infection (0.38%).

Observed bypass surgery mortality for those who had infections (15.57%) was more than ten times as high as those who had no infection (1.48%). In addition, patients who developed post-surgery infections stayed in the hospital almost three times as long (19.92 days) as those who had no infection (6.68 days).

Septicemia had the highest mortality rate of 38.46% among all infections reported, followed by pneumonia (23.38%), sternal-deep (20.69%), leg infection (12.82%), and UTI (6.3%).

Overall infection rate increased by 9.47 percent from 4.54% in 2019-2020 to 4.97% in 2021-2022. Mortality rate for overall infections increased by 16.28 percent from 13.39% in 2019-2020 to 15.57% in 2021-2022 (data not shown).

Table 5. Statewide In-Hospital Infection Rate, Operative Mortality Rate and Post-Surgery Length of Stay by Infection Type, 2021-2022

	Number of Cases	Infection Rate	Operative Mortality*		Average Length of Stay (in Days)
		(%)	Number	Rate (%) (Observed)	
Cases with Infections	**379**	4.97	**59**	**15.57**	**19.92**
Sternal-Deep	29	0.38	6	20.69	24.90
Thoracotomy	2	0.03	0	0.00	10.50
Leg	39	0.51	5	12.82	16.85
Septicemia	65	0.85	25	38.46	33.83
UTI	127	1.67	8	6.30	16.25
Pneumonia	201	2.64	47	23.38	23.98
Cases without Infections	**7,248**		**107**	**1.48**	**6.68**
Total CABG cases	**7,627**		**166**	**2.18**	**7.34**

SOURCE: 2021 - 2022 New Jersey Cardiac Surgery Data.

* = Operative Mortality includes: (1) all deaths occurring during the hospitalization in which the operation was performed, even after 30 days; and (2) those deaths occurring after discharge from the hospital, but within 30 days of the procedures.

Notes on Data:

The data used in this study were reported by hospitals according to criteria established by the Department, with assistance from clinical experts from CHAP. Additionally, the Department has made a good faith effort to ensure that the data elements and definitions are consistent with those issued by the Society for Thoracic Surgeons (STS). The data were audited by an independent reviewer under contract to the Department.

Throughout the process of developing this report, the Department has taken steps to make sure that all hospitals were informed about data reporting and auditing requirements, as well as the statistical methods being used to the reported mortality data.

The Department considers it a vital function of hospitals to be able to collect and report complete, accurate medical information on patients. This function is critical not only to the success of the cardiac surgery report, but to the hospitals' own ongoing efforts to improve the quality of care for all patients. The Department and hospitals will continue working to improve data collection procedures so that this report contains the best possible information.

Appendix A

New Jersey's Cardiovascular Health Advisory Panel (CHAP) Members

Perry Weinstock, MD, - Chairperson of the CHAP
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Appendix B

Statewide Observed In-Hospital and Operative Mortality Rates, 1994-2022

Year of Operation	Mortality Rates	
	In-Hospital	Operative Mortality *
1994-1995	3.75	4.14
1996-1997	3.37	3.75
1998	2.60	3.01
1999	2.89	3.31
2000	2.22	2.68
2001	2.01	2.51
2002	1.80	2.15
2003	1.91	2.33
2004	1.54	1.98
2005	1.83	2.10
2006	1.73	2.00
2007	1.66	2.00
2008	1.19	1.47
2009	1.00	1.31
2010	1.58	1.95
2011	1.13	1.35
2012	1.63	2.01
2013	1.13	1.57
2014	1.32	1.96
2015-2016	1.44	1.76
2017-2018	1.40	1.80
2019-2020	1.81	2.37
2021-2022	1.72	2.18

SOURCE: 1994 - 2022 New Jersey Cardiac Surgery Data.

* = Operative Mortality includes: (1) all deaths occurring during the hospitalization in which the operation was performed, even after 30 days; and (2) those deaths occurring after discharge from the hospital, but within 30 days of the procedures.

Appendix C

Cardiac Surgery Volume by Hospital and Type* of Surgery, 2021-2022

Hospital	CABG	Valve	CABG + Valve	Valve + Other	CABG + Valve + Other	CABG + Other	Other	Total
AtlantiCare Regional MC - Mainland	258	242	34	43	6	4	11	598
	43%	40%	6%	7%	1%	1%	2%	100%
Capital Health System at Fuld	116	5	7	0	0	2	0	130
	89%	4%	5%	0%	0%	2%	0%	100%
Cooperman Barnabas Medical Center	384	432	79	25	7	1	14	942
	41%	46%	8%	3%	1%	0%	1%	100%
Deborah Heart and Lung Center	324	489	117	23	9	6	70	1,038
	31%	47%	11%	2%	1%	1%	7%	100%
Englewood Hospital and Medical Center	391	47	55	0	0	1	440	934
	42%	5%	6%	0%	0%	0%	47%	100%
Hackensack University Medical Center	801	679	104	64	25	21	199	1,893
	42%	36%	5%	3%	1%	1%	11%	100%
Jersey City Medical Center	251	120	27	15	2	3	13	431
	58%	28%	6%	3%	0%	1%	3%	100%
Jersey Shore University Medical Center	892	893	101	43	14	13	102	2,058
	43%	43%	5%	2%	1%	1%	5%	100%
Morristown Memorial Hospital	1,194	1,772	211	221	44	25	144	3,611
	33%	49%	6%	6%	1%	1%	4%	100%
Newark Beth Israel Medical Center	171	299	43	69	15	5	86	688
	25%	43%	6%	10%	2%	1%	13%	100%
Robert Wood Johnson University Hospital	1,001	288	90	126	53	16	218	1,792
	56%	16%	5%	7%	3%	1%	12%	100%
Saint Michael's Medical Center	67	55	8	1	0	0	1	132
	51%	42%	6%	1%	0%	0%	1%	100%
St. Joseph's Regional Medical Center	236	169	51	40	10	4	29	539
	44%	31%	9%	7%	2%	1%	5%	100%
St. Mary's Hospital (Passaic)	109	38	19	0	0	1	2	169
	64%	22%	11%	0%	0%	1%	1%	100%
The Cooper Health System	635	559	94	93	11	7	172	1,571
	40%	36%	6%	6%	1%	0%	11%	100%
University Hospital	16	40	3	2	3	1	10	75
	21%	53%	4%	3%	4%	1%	13%	100%
Valley Hospital	204	403	31	66	18	14	47	783
	26%	51%	4%	8%	2%	2%	6%	100%
Virtua Our Lady of Lourdes Hospital	577	549	60	24	6	3	53	1,272
	45%	43%	5%	2%	0%	0%	4%	100%
Statewide	7,627	7,079	1,134	855	223	127	1,611	18,656
	41%	38%	6%	5%	1%	1%	9%	100%

SOURCE: 2021 - 2022 New Jersey Cardiac Surgery Data.

* CABG = Coronary Artery Bypass Graft Surgery without any other major cardiac surgery performed at the same time.

Valve = Valve surgery without any other major cardiac surgery performed at the same time.

Other = Including Left Vent. Aneurysm Repair, Vent. Septal Defect Repair, Surgical Ventricular Restoration, Cardiac Trauma Repair, Cardiac Transplant, Aortic Aneurysm Repair, Carotid Endarterectomy, and others.

References

The Massachusetts Department of Public Health, Adult Coronary Artery Bypass Graft Surgery FY14 Annual Report. Massachusetts Data Analysis Center, Department of Health Care Policy, Harvard Medical School, November 2016. https://www.mass.gov/files/documents/2019/12/14/cabg-fy2014.pdf

New Jersey Department of Health, Cardiac Surgery in New Jersey, 2019-2020, Health Care Quality Assessment, Office of Population Health, August 2022. https://www.nj.gov/health/healthcarequality/documents/Cardiac%20Surgery%20Report%202019t2020_08162022%20(1).pdf

New York State Department of Health, Adult Cardiac Surgery in New York State: 2017-2019, January 2023. https://www.health.ny.gov/statistics/diseases/cardiovascular/heart_disease/docs/2017-2019_adult_cardiac_surgery.pdf

California Office of Statewide Health Planning and Development, 2021 California Hospital Performance Ratings for Coronary Artery Bypass Graft (CABG) Surgery, Sacramento, CA, September 2023. https://data.chhs.ca.gov/dataset/california-hospital-performance-ratings-for-coronary-artery-bypass-graft-cabg-surgery/resource/889abc39-43dc-4d15-bd44-e8ae0dc7d2a3?inner_span=True

Pennsylvania Health Care Cost Containment Council, Cardiac Procedures Report: 2019- 2020 Data. August 2022. https://www.phc4.org/reports/cardiac-procedures-report-2019-2020/