**Introduction**

This is a quality monitoring (QM) report for the Veterans Affair’s Hospitals. This report summarizes period 39’s observed death rate and data quality control for all valve and CABG heart surgeries for 44 hospitals. Prior to procedure initiation, the patient’s condition (ASA), height, weight, BMI, and albumin level is recorded. The primary aim is to compare the observed 30-day death rate of heart surgeries to an adjusted expected 30-day death rate per hospital to identify hospitals with higher or lower than expected death rates. The secondary aims are to provide data control and feedback on variables collected prior to surgery. The scientific hypothesis for this QM report is that there is a difference between observed death rates and expected death rates for hospitals. The statistical null hypothesis is that the comparison rate ratio between observed and expected rates is less than 1.2 for all hospitals. The statistical alternative hypothesis is that the comparison rate ratio is greater than 1.20 between the observed and expected rates at one or more of the hospitals.

**Methods**

Quality monitoring included a thorough data investigation of all variables entered by each hospital. Univariate statistics were performed to examine the means, minimum and maximum values, and number missing. BMI had extreme outliers and was recalculated using the CDC’s equation to correct BMI values greater than 50. A BMI difference variable was used to identify hospitals that had a BMI change greater than one with the new variable. Weight, height, and BMI variables were compared across hospitals to examine these BMI differences. ASA was re-categorized as good health (1, 2, 3) or bad health (4, 5) because of small values and assist in logistic regression analysis.

Bivariate analyses of means and frequencies were performed to examine descriptive statistics for the covariates that would be added to create the adjusted death rate. These covariates included the recalculated BMI, ASA, procedure, and albumin. Percentages for categorical variables (ASA, procedure) were calculated using a chi-squared test. The median, 25th percentile, and 75th percentile were calculated for continuous variables (BMI, albumin) by hospital and overall for period 39. This was done to determine if any hospitals saw a population different than the overall median.

Missing data analyses were performed for each covariate due to the amount of missing data in period 39. For each covariate the percent of missing-ness was determined as an overall percentage for period 39 and then examined by the percentage from each hospital. If the covariate was missing more than 5-10% in either situation, descriptive statistics and plots were used to compare missing data to those with a 30-day death and those who survived. This was done to determine if a covariate needed to be assessed for removal from the adjustment because a high percentage of missing data could skew the expected death rate. Hospitals with a high percentage of missing-ness were recorded. To determine if albumin is a useful predictor for 30-day death, t-tests and logistic regression analyses were performed to compare albumin levels and significance for procedures with a 30-day death compared to survival.

Logistic regression was performed to calculate an adjusted predicted probability of death per 100 surgeries for each individual hospital. Adjustment variables were added to the model based on investigator’s clinical knowledge and previous use in other QM reports. Three models were compared to select the best fitting model using ROC sensitivity curve, correlations between covariates, change in estimates, and percentage of missing-ness in a covariate. The expected death rate used only periods 34-38 and did not include period 39. The observed death rate was calculated using the number of 30-day deaths divided by the total procedures in the period 39. A comparison rate ratio was calculated by dividing the observed rate by the expected rate. This was done to compare the two rates and determine a clinically relevant difference between observed and expected rates. The investigator decided a comparison rate ratio greater than 1.20 was determined to be a clinically significant. Analysis was completed using SAS University Edition with virtual box and Microsoft Excel.

**Results**

There were 4424 procedures performed in period 39. CABG surgeries accounted for 3507 (81.16%) and valve surgeries accounted for 814 (18.84%). The majority (75.12%) of patient conditions were recorded as a level 4 prior to start of surgery. Table 1 in the appendix summarizes the BMI and albumin population for each hospital. Overall, the median BMI was 28.64 (25th[26.17]; 75th [31.17]). Hospital 35 saw a lower BMI population with a median of 27.40 [25.67; 30.76]. Hospital 31 saw a larger BMI population 29.55 [26.82; 31.41]. Hospital 42 saw the widest variability in BMI 29.06 [25.64; 31.44]. Albumin levels across hospitals were 3.99 [3.63;4.36]. Hospital 22 had the most variability in albumin levels 4.17 [3.36, 4.56] with the lowest 25th percentile and highest 75th percentile.

Data Quality Monitoring

Hospital 18 and 23 entered two BMI values that were greater than 70. Hospitals 1-16 entered significantly smaller numbers for weight than other hospitals. BMI was missing 4.79% of the time, with 2.56% from hospital 30 and was determined to be missing at random. Hospital 30 did not enter any weight, height, or BMI values; therefore their adjusted expected death rate is missing 117 procedures. ASA was the highest recorded variable and was entered for 97.4% of the procedures. Procedure type was missing 2.3% of the time and had no significant differences between hospitals. Albumin was missing from 49.73% of surgeries. Separate investigation per hospital found mirroring percentages per hospital and determined to be missing completely at random. Albumin is missing equally from those who survived (49.01 vs. 47.72) and missing equally from those with death (1.63 vs. 1.65). Excluding albumin, hospital 19 had the highest percentage (100%) of non-missing variables.

Expected versus Observed Death Rates

Table 2 in the appendix summarizes all hospitals expected death rates, observed death rates, and comparison rate ratio. Rate ratios greater than 1.2 are highlighted in red. There were 18 hospitals that had a higher than expected death rate. Hospital 34 had the highest observed rate with 14.14 deaths per 100 procedures (Comparison Rate Ratio: 4.70). Hospital 17 had the second highest observed rate with 13.98 deaths per 100 procedures (CRR: 4.48). Comparison rate ratios higher than 2.0 included hospitals 7, 23, 30, and 31 and higher than the clinically significant 1.20 were hospitals 3, 4, 12, 13, 21, 24, 26, 28, 35, 37, 39, and 41. Hospitals 9, 19, 32, 33, 42, and 44 had the lowest comparison rate ratios with zero deaths per 100 procedures (CRR: 0).

The final predicted probability was adjusted for the new calculated BMI, re-categorized ASA, and procedure type. Re-categorized ASA had a stronger, significant association with 30-day death (p=<0.0001). The expected death rate did not include adjustment for albumin. Albumin was removed from the logistic regression model because nearly 50% of the covariate was missing. Albumin was not significantly related to the outcome (-0.0487 [0.172]; p=0.6495) and only slightly increased the area under the ROC curve (0.5883 vs. 0.5922). The intercept did decrease approximately 20%, but was still significant (p=<0.0001). The AIC test was better with albumin in the model (3251 vs. 6687). Correlations found re-categorized ASA and albumin to be moderately, negatively correlated (r= -0.4; p= <0.0001).

**Conclusion**

Period 39 observed 3.28 deaths per 100 surgeries and performed below the comparison rate ratio at 1.08. Hospitals 34 and 17 had much higher observed death rates than expected. Hospitals 9,19,32, 33, 42, and 44 had zero 30-day deaths this six-month period and therefore, the lowest observed rates. There were 18 hospitals that had higher than expected observed death rates, suggesting that a clinically significant cut off 1.2 comparison rate ratio may be to low. Site visits for high death rates could include 7, 23, 30, and 31 in addition to hospitals 34 and 17. Hospitals that could have site visits to observe best methods could include 9, 19, 32, 33, 42, and 44. Hospital 19 had zero deaths per 100 surgeries and 100% of patient information entered.

Hospitals that require data specific quality monitoring follow up include hospitals 1-16 for entering kilograms instead of pounds. Hospital 30 is missing all BMI, height, and weight information, which may have artificially decreased their expected death rate as the logistic regression removes missing values. Ensuring all hospitals are using the same measurements for BMI will ensure expected death rate accuracy. There was a large percentage of missing data from albumin, but missing data analyses found that the data was missing completely at random. Albumin was still removed from the model to keep the additional 50% of procedures in adjusting for the expected death rate. Models with and without albumin were similar and correlations found albumin and ASA to be moderately correlated. It may be that albumin and ASA are reflecting a similar aspect of patient health prior to the procedure. Albumin may not be a useful predictor of procedure outcome as ASA was more significantly related to the outcome and could be a less expensive means of capturing patient health prior to procedure. However, if ASA is decided subjectively albumin could provide an objective measure of patient health prior to surgery.

**Appendix**

**Table 1: Median, 25th, and 75th percentiles of BMI and Albumin**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | BMI | | | Albumin | | |
| Hospital Code | Number Procedures | Median | 25th Quartile | 75th Quartile | Median | 25th Quartile | 75th Quartile |
| 1 | 87 | 28.43 | 25.88 | 30.27 | 3.88 | 3.56 | 4.34 |
| 2 | 106 | 28.05 | 25.88 | 31.08 | 3.99 | 3.66 | 4.42 |
| 3 | 100 | 29.40 | 26.93 | 31.40 | 3.87 | 3.60 | 4.18 |
| 4 | 94 | 28.93 | 26.69 | 30.94 | 3.90 | 3.63 | 4.42 |
| 5 | 115 | 28.11 | 26.17 | 30.29 | 3.98 | 3.58 | 4.44 |
| 6 | 104 | 28.90 | 26.44 | 31.23 | 3.91 | 3.58 | 4.26 |
| 7 | 105 | 28.26 | 26.34 | 30.61 | 4.06 | 3.72 | 4.40 |
| 8 | 120 | 28.65 | 26.77 | 31.34 | 4.07 | 3.76 | 4.34 |
| 9 | 105 | 28.23 | 26.72 | 31.23 | 3.90 | 3.50 | 4.21 |
| 10 | 100 | 28.81 | 26.53 | 31.49 | 3.95 | 3.57 | 4.38 |
| 11 | 90 | 28.13 | 26.14 | 30.55 | 4.14 | 3.74 | 4.49 |
| 12 | 98 | 28.73 | 26.51 | 31.01 | 4.08 | 3.65 | 4.42 |
| 13 | 84 | 27.78 | 25.48 | 31.86 | 3.77 | 3.58 | 4.25 |
| 14 | 103 | 28.76 | 26.38 | 31.28 | 3.91 | 3.59 | 4.31 |
| 15 | 105 | 28.93 | 26.09 | 30.56 | 4.01 | 3.75 | 4.33 |
| 16 | 111 | 28.01 | 25.98 | 30.25 | 3.99 | 3.55 | 4.36 |
| 17 | 93 | 28.45 | 25.75 | 31.32 | 3.86 | 3.45 | 4.15 |
| 18 | 95 | 28.68 | 26.46 | 30.73 | 4.00 | 3.49 | 4.35 |
| 19 | 113 | 28.62 | 25.74 | 31.39 | 3.94 | 3.63 | 4.26 |
| 20 | 98 | 28.68 | 26.05 | 31.43 | 4.11 | 3.71 | 4.40 |
| 21 | 92 | 29.18 | 26.64 | 31.10 | 3.83 | 3.58 | 4.26 |
| 22 | 86 | 28.84 | 27.02 | 31.21 | 3.82 | 3.62 | 4.29 |
| 23 | 97 | 28.45 | 25.27 | 31.32 | 4.13 | 3.77 | 4.50 |
| 24 | 104 | 28.40 | 26.57 | 30.67 | 3.97 | 3.59 | 4.22 |
| 25 | 95 | 28.27 | 25.93 | 30.78 | 4.00 | 3.55 | 4.27 |
| 26 | 99 | 29.14 | 25.03 | 30.92 | 4.12 | 3.81 | 4.49 |
| 27 | 99 | 28.48 | 25.83 | 30.83 | 4.17 | 3.36 | 4.56 |
| 28 | 101 | 29.05 | 26.80 | 31.23 | 3.88 | 3.52 | 4.27 |
| 29 | 105 | 28.82 | 26.88 | 31.11 | 4.10 | 3.82 | 4.43 |
| 30 | 117 | . | . | . | 4.10 | 3.66 | 4.57 |
| 31 | 104 | 29.58 | 26.82 | 31.41 | 4.12 | 3.76 | 4.29 |
| 32 | 93 | 29.30 | 26.30 | 31.21 | 3.91 | 3.59 | 4.26 |
| 33 | 113 | 28.78 | 26.38 | 31.68 | 4.08 | 3.61 | 4.36 |
| 34 | 99 | 28.64 | 26.13 | 31.37 | 4.02 | 3.61 | 4.32 |
| 35 | 84 | 27.40 | 25.67 | 30.76 | 4.07 | 3.70 | 4.34 |
| 36 | 99 | 28.98 | 26.93 | 31.33 | 4.16 | 3.63 | 4.67 |
| 37 | 107 | 28.12 | 25.05 | 30.93 | 3.85 | 3.58 | 4.29 |
| 38 | 113 | 28.23 | 26.35 | 30.96 | 3.97 | 3.71 | 4.27 |
| 39 | 101 | 28.77 | 26.18 | 31.26 | 4.04 | 3.71 | 4.32 |
| 40 | 86 | 28.12 | 25.54 | 30.84 | 3.84 | 3.55 | 4.33 |
| 41 | 116 | 28.27 | 25.27 | 30.93 | 4.03 | 3.62 | 4.37 |
| 42 | 107 | 29.06 | 25.64 | 31.44 | 4.11 | 3.69 | 4.45 |
| 43 | 83 | 28.76 | 26.59 | 30.76 | 4.18 | 3.79 | 4.44 |
| 44 | 98 | 28.91 | 25.71 | 31.25 | 3.90 | 3.59 | 4.29 |
| Total |  | 28.64 | 26.17 | 31.17 |  |  |  |

**Table 2: Expected Compared to Observed Death Rate**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| VA Hospital 30day Death Rate  Expected compared to Observed Death Rate  (Rate per 100 people) | | | | |
| Hospital Code | Number Procedures | Expected Mortality Rate | Observed Mortality Rate | Comparison Rate Ratio |
| 1 | 87 | 3.04 | 1.15 | 0.38 |
| 2 | 106 | 3.12 | 0.94 | 0.30 |
| 3 | 100 | 3.07 | 4 | 1.30 |
| 4 | 94 | 3.05 | 4.26 | 1.40 |
| 5 | 115 | 3.07 | 0.87 | 0.28 |
| 6 | 104 | 3.02 | 1.92 | 0.64 |
| 7 | 105 | 2.95 | 6.67 | 2.26 |
| 8 | 120 | 2.98 | 3.33 | 1.12 |
| 9 | 105 | 3.05 | 0 | 0.00 |
| 10 | 100 | 3.04 | 2 | 0.66 |
| 11 | 90 | 2.99 | 1.11 | 0.37 |
| 12 | 98 | 3.06 | 4.08 | 1.33 |
| 13 | 84 | 3.06 | 4.76 | 1.56 |
| 14 | 103 | 3 | 0.97 | 0.32 |
| 15 | 105 | 3.07 | 2.86 | 0.93 |
| 16 | 111 | 3.07 | 0.9 | 0.29 |
| 17 | 93 | 3.12 | 13.98 | 4.48 |
| 18 | 95 | 3.05 | 2.11 | 0.69 |
| 19 | 113 | 3.01 | 0 | 0.00 |
| 20 | 98 | 3.04 | 2.04 | 0.67 |
| 21 | 92 | 3.1 | 5.43 | 1.75 |
| 22 | 86 | 3 | 2.33 | 0.78 |
| 23 | 97 | 2.97 | 6.19 | 2.08 |
| 24 | 104 | 3.04 | 3.85 | 1.27 |
| 25 | 95 | 3.06 | 3.16 | 1.03 |
| 26 | 99 | 3.03 | 4.04 | 1.33 |
| 27 | 99 | 3.07 | 2.02 | 0.66 |
| 28 | 101 | 3.02 | 4.95 | 1.64 |
| 29 | 105 | 2.98 | 1.9 | 0.64 |
| 30 | 117 | 3.11 | 8.55 | 2.75 |
| 31 | 104 | 3.07 | 6.73 | 2.19 |
| 32 | 93 | 2.94 | 0 | 0.00 |
| 33 | 113 | 3.02 | 0 | 0.00 |
| 34 | 99 | 3.01 | 14.14 | 4.70 |
| 35 | 84 | 3 | 5.95 | 1.98 |
| 36 | 99 | 3 | 1.01 | 0.34 |
| 37 | 107 | 3 | 3.74 | 1.25 |
| 38 | 113 | 2.97 | 0.88 | 0.30 |
| 39 | 101 | 3.03 | 3.96 | 1.31 |
| 40 | 86 | 2.99 | 2.33 | 0.78 |
| 41 | 116 | 3.01 | 4.31 | 1.43 |
| 42 | 107 | 3.02 | 0 | 0.00 |
| 43 | 83 | 3.09 | 2.41 | 0.78 |
| 44 | 98 | 2.95 | 0 | 0.00 |
| Total | 4424 | 3.03 | 3.28 | 1.08 |