BIOS 6623 Project 2 Written Report

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Introduction

The goal of this analysis was to determine whether the observed 30 day mortality rate for patients undergoing heart surgery during the current six-month period is close to what they expect the mortality rate to be for each of the 44 different hospitals. The results of this analysis will be used by VA hospital executives to identify hospitals that have either higher or lower than expected mortality rates. This will inform executives as to which hospitals they should visit to learn about what makes these hospitals different. They then hope to use what they learn from these visits to potentially implement future changes in standards of practice or procedures across all hospitals, with the ultimate goal of improving patient outcomes. The hypothesis of interest is whether the observed mortality rate is significantly different from the expected mortality rate for each hospital. A clinically significant difference is defined as a 20% or larger difference from the expected rate. The investigators provided data from all 44 hospital for the current sixmont period (period 39) and also for the previous 5 sixmonth periods (34-38). I was provided VA dataset 1. Variables included in the dataset were height, weight, BMI, procedure type (CABG or valve replacement), ASA, and albumin. Albumin was a new variable they provided that hadn't been used in past models, but the investigators hoped to include this biological marker in the model.

Methods

Upon initially cleaning the data there appeared to be impossible values for weight and height. After further investigation and discussing with the investigators we identified

hospitals 1-16 during period 39 likely reported their values for weight in kilograms rather than pounds. After converting the weight values for these hospitals from kilograms to pounds and re-calculating BMI using the new weight the issue was resolved and the new weight and BMI had reasonable ranges. To avoid issues with collinearity and per the investigators request we looked only at BMI rather than height and weight. Inital cleaning of the data also revealed that there was missing data for BMI, procedure type, ASA, and albumin. We used plots and descriptive statistics to investigate the pattern of missingness for each of these variables. We also used descriptive statistics to compare the characteristics of patients who died within 30 days of the surgery with those who did not.

To calculate the observed death rate for each hospital, we simply calculated the percentage of patients who died within 30 days during period 39 for each hospital. To find the expected death rate for each hospital we fit a logistic regression model. For this model we used data available from all hospitals and all six-month periods that was provided. The outcome for this model was 30 day mortality (yes or no) and the predictors that we included in the final model were procedure type, BMI, and ASA. Using this model we were able to calculate predicted values, or predicted death rates, for each patient. We did this just for patients in period 39. We then averaged the subject specific predicted death rates across the 44 hospitals. This allowed us to obtain an average or expected death rate for each hospital during period 39.

Two methods were used to allow us to determine whether the observed death rates were significantly different from the expected death rates. First, we created a boostrap 95% confidence interval for the expected death rate for each hospital. The bootstrap was done by first obtaining a bootstrap sample the same size as the original dataset by sampling with replacement from the original dataset. We then fit the logistic model described above on the bootstrap sample. We used the exact same methods described above to obtain an expected death rate for each hospital during period 39 for the bootstrap sample. We repeated this process 1000 times. We therefore had 1000 expected death rates for each of the 44 hospitals. For each hospital we found the 2.5th and 97.5th percentile of the distribution

of expected death rates. These formed the lower and upper bounds of the 95% confidence interval for the expected death rate for each hospital. If the 95% confidence interval for the expected death rate did not contain the observed death rate then we would conclude that the observed death rate is statistically signficantly different from the expected death rate at a significance level of alpha equal to 0.05. The second method was to create a percent difference between the observed and expected death rate. This was done by dividing the observed death rate by the expected death rate and then subtracting this fraction by 1 and multiplying by 100. This gave a percent difference between the observed and expected death rates where positive percentages indicating that the observed rate was larger than the expected rate and negative percentages indicating that the observed rate was lower than the expected rate. The investigator stated that percentage differences greater than or equal to 20% were considered clinically significant differences.

Results

Upon investigating the patterns of missingness for each variable that had missing data we found that BMI, procedure type, and ASA appeared to be missing completely at random and each had less than 10% missing data. We also noticed that BMI data was completely missing for hospital 30 during period 39. Albumin data was about 62% missing and appeared to be missing at random. Missingess of albumin seemed to depend on ASA level (figure 1). For patients with an ASA of 1, 2, or 3 albumin was 100% missing. For patients with an ASA of 4 albumin was about 50% missing, and for patients with ASA of 5 there was no missing albumin data. The observed death rate was for subjects missing albumin data was 2.89%, which is lower than the observed death rate of 3.9% for subjects who were not missing albumin data (table 3). General summary statistics for all subjects during period 39 can be found in table 1.

A comparison of observed and expected death rates for each hospital can be found in table 2. Every hospital except for hospitals 8 and 25 had observed death rates that were

statistically significantly diffferent from the expected death rate based on the boostrap 95% confidence intervals. Therefore, the observed death rates were very close to the expected death rates for hospitals 8 and 25. An expected death rate was not able to be calculate for hospital 30 because it was excluded from the model due to having no BMI data. The observed death rate for hospital 30 was 8.55%, which was fairly high compared to observed death rates at other hospitals. There were many hospitals whose observed death rates were lower than the expected death rates, indicated by a negative percent difference of -20% or lower. Of these hospitals, a few notable hospitals that had the best clinically observed rates compared to expected rates were hospitals 9, 19, 32, 33, 42, and 44. These hospitals had 0% observed moratlity rates. There were also a number of hospitals that had observed death rates that were clinically worse than the expected rate, indicated by a positive percent difference greater than 20%. Of these hospitals whose observed death rates were worse than expected there were a couple that stood out by having 100% or larger percent differences between observed and expected. These were hospitals 7, 17, 23, 31, and 34.

Conclusions

Based on the results of this analysis, we conclude that hospitals 9, 19, 32, 33, 42, and 44 could be useful hospitals to visit to learn what they might be doing differently that led to their lower than expected death rates. We would also recommend visiting hospitals 7, 17, 23, 31, and 34 because they had death rates that worse than expected. It may be helpful to visit these hospitals to attempt to identify any reasons these hospitals had higher than expected death rates. The executives may also want to visit or inquire with hospital 30 to determine why their BMI data was completely missing.

The interpretation of these results may be limited by the missing data for ASA, procedure type, and BMI. However, because these variables were less than 10% missing and appeared to be missing completely at random they likely did not bias our results. Albumin was left out of the final model based on its missingness. Albumin appeared to be missing at random based

on the levels of ASA and there was around 60% missing albumin data. Including albumin in the model would have greatly reduced our sample size. Also, because albumin data was only available for patients with an ASA of 4 or 5 (the most sick patients) including it in the model could have biased our results. If executives would like to use albumin in future models, we recommend they try to increase reporting of albumin. A final limitation of our results is that our bootstrap confidence intervals were very narrow. All but 2 hospitals were considered to have observed death rates that were statistically significantly different than the expected rates. Therefore, this metric for assessing significance of the difference between observed and expected rates may not be particularly useful. For future analyses, we may want to use a different method for assessing statistical significance.

Reproducible Research Information

The code for this report can be found in the "Code" folder within the "Project2" folder in my github directory. The pdfs of the output for the code run can also be found my github directory in the "ModelsOutput" folder within the "Results" folder within the "Project2" folder. My github directory is as follows: BIOS6623-UCD/bios6623-micpalumbo. A description of each of the files in my "Project2" folder including this report can be found in the readme.md file within the "Project2" folder. The code I used to read in the data can be found in the file "Proj2DataCleaning.sas" located in the code folder described above. I received VA dataset 1.

Appendix

Table 1: Summary of Descriptive Statistics For All Patients in Period 39

N total = 4424

Variable	N missing (%)	Mean(sd)	Frequency (%)
death30 = yes	0		145 (3.28%)
proced = CABG	252 (5.7%)		3380 (76.4%)
asa	336 (7.59%)		
1			6 (0.14%)
2			190 (4.29%)
3			813 (18.38%)
4			3070 (69.39%)
5			9 (0.20%)
bmi	418 (9.45%)	28.58 (3.83)	
albumin	2695 (60.92%)	3.89 (0.498)	

Table 2: Comparison of Observed and Expected Mortality Rates Across Hospitals

hospital	observed	expected	95% CI lower bound	95% CI upper bound	% difference
1	1.1494253	3.139434	2.830480	3.446971	-63.3874961
2	0.9433962	3.450346	3.168306	3.751599	-72.6579200
3	4.0000000	3.343630	3.094547	3.631858	19.6304722
4	4.2553191	3.190637	2.929298	3.450513	33.3689443
5	0.8695652	3.343891	3.091108	3.586968	-73.9954039
6	1.9230769	3.008655	2.734810	3.298530	-36.0818419
7	6.6666667	3.138386	2.876702	3.377324	112.4234134
8	3.3333333	3.301779	3.024483	3.583258	0.9556767
9	0.0000000	3.233683	2.959866	3.539838	-100.0000000
10	2.0000000	3.222698	2.948745	3.529879	-37.9401979
11	1.1111111	3.016565	2.735391	3.281540	-63.1663412

hospital	observed	expected	95% CI lower bound	95% CI upper bound	% difference
12	4.0816327	3.364442	3.082663	3.660675	21.3167714
13	4.7619048	3.268253	2.992609	3.538694	45.7018402
14	0.9708738	2.955341	2.690287	3.215191	-67.1484966
15	2.8571429	3.181449	2.923502	3.437849	-10.1936700
16	0.9009009	3.131699	2.881695	3.368316	-71.2328369
17	13.9784946	3.471540	3.216191	3.717780	302.6597248
18	2.1052632	3.148128	2.892952	3.410357	-33.1265091
19	0.0000000	3.082361	2.802802	3.353274	-100.0000000
20	2.0408163	2.811216	2.549687	3.086175	-27.4045098
21	5.4347826	3.186944	2.900551	3.465924	70.5327140
22	2.3255814	3.177975	2.934288	3.449331	-26.8219057
23	6.1855670	3.032150	2.747213	3.319548	103.9994006
24	3.8461538	3.330773	3.072465	3.607245	15.4732966
25	3.1578947	3.150556	2.889649	3.441893	0.2329251
26	4.0404040	3.312326	3.011151	3.643619	21.9808580
27	2.0202020	3.281621	3.003000	3.554783	-38.4388952
28	4.9504950	3.276887	3.014775	3.570365	51.0730992
29	1.9047619	3.121410	2.868807	3.393146	-38.9775125
30	8.5470085	NA	NA	NA	NA
31	6.7307692	3.141080	2.888584	3.407313	114.2820332
32	0.0000000	3.261059	2.957669	3.570567	-100.0000000
33	0.0000000	3.260468	2.981829	3.548957	-100.0000000
34	14.1414141	3.171045	2.902485	3.444156	345.9544244
35	5.9523810	3.151376	2.859043	3.438363	88.8819782
36	1.0101010	2.984120	2.711795	3.237896	-66.1507957

hospital	observed	expected	95% CI lower bound	95% CI upper bound	% difference
37	3.7383178	3.072036	2.828190	3.332945	21.6886249
38	0.8849558	3.057755	2.784440	3.343556	-71.0586395
39	3.9603960	3.140693	2.882605	3.409793	26.0994161
40	2.3255814	3.077861	2.814130	3.341537	-24.4416343
41	4.3103448	3.148139	2.902511	3.399105	36.9172336
42	0.0000000	2.980346	2.737250	3.227317	-100.0000000
43	2.4096386	3.222851	2.980914	3.489942	-25.2327015
44	0.0000000	3.221015	2.955274	3.459613	-100.0000000

Table 3: Missingness of Albumin by Mortality Rate

Missingness of Albumin 1

The FREQ Procedure

Frequency
Percent
Row Pct
Col Pct

Table of albumin_missing by death30			
albumin_missing	death30 0	death30 1	Total
0	9631 36.32 96.10 37.55	391 1.47 3.90 45.05	10022 37.79
1	16019 60.41 97.11 62.45	477 1.80 2.89 54.95	16496 62.21
Total	25650 96.73	868 3.27	26518 100.00

Figure 1: Missingness of Albumin Across Levels of ASA