BIOS 765 Homework 5

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I have not discussed the problems on this final problem set with anyone; I have not had any communications including email regarding the problems in this final set with anyone. I have not shared my work on this final problem set with anyone. I have not received help on this final problem set nor have I given help.
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Problem 1(a).

In this question, we would like to write out the main effects linear model for the empirical logit functions of the presence of complaints. The model is stated as follows:

$$E(\log(\frac{p_i}{1-p_i})) = \beta_0 + \beta_1 W_i + \beta_2 Y_i + \beta_3 S_i,$$

where p_i is the proportion of presence of complaints in the i^{th} population formed by the cross-classification of workplace conditions, years employment, and smoking. In addition, W_i represents the workplace condition for the i^{th} population (1 if dusty; -1 if not dusty), Y_i represents the years employment for the i^{th} population (1 if < 10; -1 if ≥ 10), and S_i represents the smoking for the i^{th} population (1 if yes; -1 if no).

Problem 1 (b).

Table 1 presents the weighted least squares estimates of the regression parameter and their standard errors.

Problem 1 (c).

The goodness-of-fit statistic for model fit in part (b) is that $Q_W = 8.76$, which asymptotically follows a χ^2_4 distribution, resulting in a p-value of 0.067, which is greater then 0.05. Therefore, the results support that this model has adequate fit.

Table 1: Analysis of Weighted Least Squares Estimates

Effect	Level	Estimate	SE
Intercept		-3.118	0.095
W	1	1.324	0.086
Y	1	-0.296	0.085
S	1	0.275	0.097

Problem 1 (d).

Now, we write out the main effects logistic regression model for the probability of the presence of complaints. The model is stated as follows:

$$\log(\frac{\pi_i}{1-\pi_i}) = \gamma_0 + \gamma_1 W_i + \gamma_2 Y_i + \gamma_3 S_i,$$

where $\pi_i = E(p_i)$ is the probability (the expectation of the proportion) of presence of complaints in the i^{th} population formed by the cross-classification of workplace conditions, years employment, and smoking. In addition, W_i represents the workplace condition for the i^{th} population (1 if dusty; -1 if not dusty), Y_i represents the years employment for the i^{th} population (1 if < 10; -1 if ≥ 10), and S_i represents the smoking for the i^{th} population (1 if yes; -1 if no).

Problem 1 (e).

Table 2 presents the maximum likelihood estimates of the regression coefficients and their standard errors for the model in part (d) side-by-side to those from part (b).

Table 2: Analysis of Parameter Estimates

		Model (b)		Model (d)	
Effect	Level	Estimate	SE	Estimate	SE
Intercept		-3.118	0.095	-3.162	0.098
W	1	1.324	0.086	1.334	0.085
Y	1	-0.296	0.085	-0.313	0.085
S	1	0.275	0.097	0.305	0.095

Problem 1 (f).

The goodness-of-fit statistic for model fit in part (e) is that $Q_L = 8.10$, which asymptotically follows a χ^2_4 distribution, resulting in a p-value of 0.088, which is greater then 0.05. Therefore, the results support that the model has adequate fit.

Problem 1 (g).

The model (b) and model (e) are similar in the sense that they are both modeling binary outcome, and both of them only contains the main effects and the interaction terms are not included. In addition, the two models are also asymptotically equivalent.

On the other hand, they are also different because the model in (b) models the expectation of the logit of the empirical proportion (i.e., the expectation is outside of the logit function), while the model in (e) models the logit of the underlying probability (i.e., the expectation is inside of the logit function).

Now, we interpret the results from the model in (e):

- In this logistic regression model, γ_1 is estimated to be 1.334 (with 95% confidence intervals (1.168, 1.500)). This result can be interpreted as that, conditional on years employment and smoking, the log odds ratio of the presence of complaints of a person who work in dusty workplaces and a person who do not work in dusty workplaces is estimated to be $2 \times 1.334 = 2.668$, with 95% confidence intervals (2.336, 3.001).

- In this logistic regression model, γ_2 is estimated to be -0.313 (with 95% confidence intervals (-0.479, -0.146)). This result can be interpreted as that, conditional on workplace conditions and smoking, the log odds ratio of the presence of complaints of a person whose years of employment less than 10 years and a person whose years of employment is at least 10 years is estimated to be $2 \times (-0.313) = -0.625$, with 95% confidence intervals (-0.959, -0.292).

- In this logistic regression model, γ_3 is estimated to be 0.305 (with 95% confidence intervals (0.119, 0.492)). This result can be interpreted as that, conditional on workplace conditions and years employment, the log odds ratio of the presence of complaints of a person who smoke and a person who does not smoke is estimated to be $2 \times 0.305 = 0.611$, with 95% confidence intervals (0.238, 0.984).

Problem 2 (a).

In Table 3, we present the total number of events, total number of days at risk, and the incidence density of disease for five different periods.

Table 3: Incidence Density of Disease at Each Period

Period	# Events	# Days at Risk	ID
1	5	591	0.008
2	9	642	0.014
3	25	679	0.037
4	20	712	0.028
5	19	683	0.028

Problem 2 (b).

Here, we would like to define a population-averaged longitudinal Poisson regression model for the incidence density of GTS. The model is expressed as follows,

$$\log(ID_{it}) = \beta_0 + \beta_1 \times MID_{it} + \beta 2 \times LATE_{it} + \beta_3 \times YRSWORK_{it} + \beta_4 \times MEDICINE_{it}$$

where ID_{it} is the incidence density of for the subject i at time t, MID_{it} is the dummy variable if the subject i is at the mid season at time t, $LATE_{it}$ is the dummy variable if the subject i is at the late season at time t, $YRSWORK_{it}$ is the number of years that subject i has worked in tobacco at time t, and $MEDICINE_{it}$ is represent whether subject i takes medicine to prevent getting sick at time t.

Problem 2 (c).

Here, we fit the model in part (b) under both working exchangeable and first order auto-regressive correlation matrices using the generalized estimating equations procedure. The GEE model fitting results using working exchangeable correlation matrix are presented in Table 4, whereas the GEE model fitting results using working first order auto-regressive correlation matrix are presented in Table 5.

Table 4: Analysis Of GEE Parameter Estimates (Exchangeable Working Correlation)

Effect	Estimate	Empirical SE	Model-based SE
Intercept	-8.169	0.397	0.308
MID	0.673	0.416	0.349
LATE	0.234	0.393	0.320
YRSWORK	-0.095	0.057	0.045
MEDICINE	1.878	0.314	0.256

Table 5: Analysis Of GEE Parameter Estimates (AR(1) Working Correlation)

Effect	Estimate	Empirical SE	Model-based SE
Intercept	-8.123	0.392	0.302
MID	0.685	0.405	0.349
LATE	0.246	0.383	0.325
YRSWORK	-0.101	0.057	0.044
MEDICINE	1.823	0.305	0.253

From Table 4 and Table 5, we can see that, in the presence of potential overdispersion, if we assume that $\phi = 1$, then regardless of whether we use exchangeable or first order auto-regressive working correlation matrices, the empirical SE resulted from the GEE model is always greater than the model-based SE. The reason is that, the empirical SE is not based on the scale parameter ϕ, while the model-based SE is based on ϕ, so that the empirical SE is a robust estimator, and the model-based SE is not robust in the presence of overdispersion.

Problem 2 (d).

In this question, we would like to calculate the incidence density ratio and corresponding 95% confidence interval using empirical standard errors and AR-1 correlation structure for each independent variables in the model. We also provide the interpretation and the conclusion to the results.

- After adjusting for the number of years working in tobacco and the status of whether the subjects take medicine to prevent getting risk, the incidence density ratio of the disease for the mid season and early season is estimated as 1.984, with confidence interval of (0.898, 4.387). Since the confidence interval includes the value of 1, we conclude that the incidence density for the mid season and that for early season are not significantly different after adjustment of other covariates.

- After adjusting for the number of years working in tobacco and the status of whether the subjects take medicine to prevent getting risk, the incidence density ratio of the disease for the late season and early season is estimated as 1.279, with confidence interval of (0.603, 2.710). Since the confidence interval includes the value of 1, we conclude that the incidence density for the late season and that for early season are not significantly different after adjustment of other covariates.

- After adjusting for the time period (coded as early, mid, or late season) and the status of whether the subjects take medicine to prevent getting risk, the incidence density ratio of the disease resulted in one unit increase in the number of years worked in tobacco is estimated as 0.904, with confidence interval of (0.809, 1.011). Since the confidence interval includes the value of 1, we conclude that the incidence density resulted in one unit increase in the number of years worked in tobacco is not significantly different after the adjustment of other covariates.

- After adjusting for time period (coded as early, mid, or late season) and the number of years working in tobacco, the incidence density ratio of the disease for the subjects who take medicine to prevent getting risk and those who do not is estimated as 6.189, with confidence interval of (3.406, 11.246). Since the confidence interval does not include the value of 1, we conclude that the incidence density for the subjects who take medicine to prevent getting risk is significantly different from that for those who do not, after the adjustment of other covariates.

Problem 3 (a).

In this question, we would like to conduct statistical test with minimal assumptions (randomization only) to assess the association of gender, genioplasty, and number of jaws with unusual feelings. We present and interpret the results of the hypothesis testing as follows:

- When we assess the association between gender and unusual feelings, our null hypothesis is that there is no association between gender and unusual feelings. Then by using

Mantel-Haenszel test, we obtain a Chi-square test statistic of 2.153, which follows a χ_1^2 distribution, and the corresponding p-value is 0.142, which is greater than 0.05, so we fail to reject the null hypothesis. Therefore, we conclude that we do not have sufficient evidence to reject the null hypothesis that there is no association between gender and unusual feelings.

- When we assess the association between genioplasty and unusual feelings, our null hypothesis is that there is no association between genioplasty and unusual feelings. Then by using Mantel-Haenszel test, we obtain a Chi-square test statistic of 2.020, which follows a χ_1^2 distribution, and the corresponding p-value is 0.155, which is greater than 0.05, so we fail to reject the null hypothesis. Therefore, we conclude that we do not have sufficient evidence to reject the null hypothesis that there is no association between genioplasty and unusual feelings.

- When we assess the association between the number of jaws and unusual feelings, our null hypothesis is that there is no association between the number of jaws and unusual feelings. Then by using Mantel-Haenszel test, we obtain a Chi-square test statistic of 0.354, which follows a χ_1^2 distribution, and the corresponding p-value is 0.552, which is greater than 0.05, so we fail to reject the null hypothesis. Therefore, we conclude that we do not have sufficient evidence to reject the null hypothesis that there is no association between the number of jaws and unusual feelings.

Problem 3 (b).

Now, we would like to conduct a statistical test with minimal assumptions to assess the association of age at surgery with unusual feeling. In this case, the null hypothesis is that there is no association between the age at surgery and unusual feelings. Then by using Mantel-Haenszel test, we obtain a Chi-square test statistic of 36.245, which follows χ_1^2 distribution, and the corresponding p-value is less than 0.001, which leads us to reject the null hypothesis. Therefore, we conclude that there is sufficient evidence for us reject the null hypothesis that there is no association between the age at surgery and unusual feelings.

Next, we would also like to calculate a statistic that summarizes the strength of the association between age at surgery and the extent of problems with unusual feelings at six months follow-up, where we have that,

$$r_{ac} = \sqrt{\frac{Q}{(n-1)}} = \sqrt{\frac{36.245}{(181-1)}} = 0.449.$$

Problem 3 (c).

Now, we would like to conduct a statistical test with minimal assumptions to assess the association of exercise group with unusual feeling. In this case, the null hypothesis is that there is no association between exercise group and unusual feelings. Then by using Mantel-Haenszel test, we obtain a Chi-square test statistic of 0.015, which follows χ_1^2 distribution, and the corresponding p-value is 0.903, which is greater than 0.05, so we fail to reject the null hypothesis. Therefore, we conclude that we do not have sufficient evidence to reject the null hypothesis that there is no association between the exercise group and unusual feelings.

Problem 3 (d).

First of all, we would like to test the hypothesis that the mean score for unusual feelings at six months post surgery does not differ between exercise groups. We provide the test results and interpretations to the unadjusted test as well as the adjusted test.

- **Unadjusted test:** The null hypothesis is that, without the adjustment for any covariates, the mean score for unusual feelings at six months post-surgery does not differ between exercise. The Chi-square test statistic is 0.015, which follows χ_1^2 distribution, and the corresponding p-value is 0.903, which is greater than 0.05, so we fail to reject the null hypothesis. Therefore, we conclude that we do not have sufficient evidence to reject the null hypothesis that, without the adjustment for any covariates, the mean score for unusual feelings at six months post-surgery does not differ between exercise groups.
- **Adjusted test:** The null hypothesis is that, after the adjustment for age, gender, genioplasty, and the number of jaws, the mean score for unusual feelings at six months post-surgery does not differ between exercise. The Chi-square test statistic is 0.074, which follows χ_1^2 distribution, and the corresponding p-value is 0.786, which is greater than 0.05, so we fail to reject the null hypothesis. Therefore, we conclude that we do not have sufficient evidence to reject the null hypothesis that, after the adjustment for age, gender, genioplasty, the mean score for unusual feelings at six months post-surgery does not differ between exercise groups.

The minimal assumption required for this model is the randomization to treatment. Comparing the results in this part with the test results in part (c), we can see that the unadjusted result in this part results in exactly the same p-value as the Mantel-Haenszel test in part (c). However, the adjusted test results in a different p-value, because it incorporates the effects of other covariables. Nevertheless, regardless of whether we adjust for other covariables, we fail to reject the null hypothesis, which means that we do not have enough evidence to reject the null hypothesis that there is no association between the exercise group and unusual feelings.

Problem 3 (e).

In this question, we would like to estimate the difference in mean scores for unusual feelings at six months follow-up post-surgery. In Table 6, we provide estimates and 95% confidence intervals for the mean difference with and without adjustment for covariables.

From Table 6, we can see that the variance reduction has been achieved through covariate adjustment. We can also interpret the results as follows. Since the difference in mean scores of zero implies no association between exercise group and unusual feeling, and we also observe

Table 6: Estimates and 95% CIs for the Mean Difference with and without Adjustment

Adjustment	Estimate	SE	95% CI	
Unadjusted	-0.023	0.188	-0.391	0.346
Adjusted	0.046	0.167	-0.281	0.372

that 0 is included in both of the CIs. Therefore, we can interpret the results such that the association between exercise group and unusual feeling is not detected, regardless of whether we adjust for other covariables. The underlying assumption behind the approach is the randomization to treatment, as well as the simple random sampling scheme of the samples from the target population.

Problem 4 (a).

In this question, we would like to derive the expression for $Var \begin{bmatrix} \bar{y}_1 \\ \bar{y}_2 \\ \bar{x}_1 \\ \bar{x}_2 \end{bmatrix}$ under the null hypothesis $H_0 : \gamma = 0$. We can re-express our data such that we have $y_1, \ldots, y_{n_1}, y_{n_1+1}, \ldots, y_n$, and $x_1, \ldots, x_{n_1}, x_{n_1+1}, \ldots, x_n$, where $n = n_1 + n_2$, and the first n_1 elements of y_i's and x_i's belong to group 1, while the remaining y_i's and x_i's belong to group 2. We also denote that $\bar{y} = \frac{1}{n}\sum_{i=1}^n y_i$ and $\bar{x} = \frac{1}{n}\sum_{i=1}^n x_i$. By applying the results from Appendix 6 of Notes 13, we have that,

$$Cov(\bar{y}_1, \bar{y}_1) = \frac{\sum_{i=1}^n (y_i - \bar{y})^2}{n(n-1)}(\frac{n}{n_1} - 1) = \frac{\sum_{i=1}^n (y_i - \bar{y})^2}{n(n-1)}(\frac{n_2}{n_1}),$$

$$Cov(\bar{y}_1, \bar{y}_2) = \frac{\sum_{i=1}^n (y_i - \bar{y})^2}{n(n-1)}(-1) = -\frac{\sum_{i=1}^n (y_i - \bar{y})^2}{n(n-1)},$$

$$Cov(\bar{y}_1, \bar{x}_1) = \frac{\sum_{i=1}^n (y_i - \bar{y})(x_i - \bar{x})}{n(n-1)}(\frac{n}{n_1} - 1) = \frac{\sum_{i=1}^n (y_i - \bar{y})(x_i - \bar{x})}{n(n-1)}(\frac{n_2}{n_1}),$$

$$Cov(\bar{y}_1, \bar{x}_2) = \frac{\sum_{i=1}^n (y_i - \bar{y})(x_i - \bar{x})}{n(n-1)}(-1) = -\frac{\sum_{i=1}^n (y_i - \bar{y})(x_i - \bar{x})}{n(n-1)}.$$

Then, the other components of the matrix can also be derived by using the similar reasoning. Therefore, we have that,

$$Var \begin{bmatrix} \bar{y}_1 \\ \bar{y}_2 \\ \bar{x}_1 \\ \bar{x}_2 \end{bmatrix} = \begin{bmatrix} (\frac{n_2}{n_1})Y & -Y & (\frac{n_2}{n_1})XY & -XY \\ -Y & (\frac{n_1}{n_2})Y & -XY & (\frac{n_1}{n_2})XY \\ (\frac{n_2}{n_1})XY & -XY & (\frac{n_2}{n_1})X & -X \\ -XY & (\frac{n_1}{n_2})XY & -X & (\frac{n_1}{n_2})X \end{bmatrix},$$

where,

$$X = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n(n-1)},$$

$$Y = \frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n(n-1)},$$

$$XY = \frac{\sum_{i=1}^{n}(y_i - \bar{y})(x_i - \bar{x})}{n(n-1)}.$$

Problem 4 (b).

Based on the results in part (a), we would like to derive the formula for $V_0 = Var\begin{bmatrix} d \\ u \end{bmatrix}$. We have that,

$$\begin{aligned}
V_0 &= \begin{bmatrix} 1 & -1 & 0 & 0 \\ 0 & 0 & 1 & -1 \end{bmatrix} \begin{bmatrix} (\frac{n_2}{n_1})Y & -Y & (\frac{n_2}{n_1})XY & -XY \\ -Y & (\frac{n_1}{n_2})Y & -XY & (\frac{n_1}{n_2})XY \\ (\frac{n_2}{n_1})XY & -XY & (\frac{n_2}{n_1})X & -X \\ -XY & (\frac{n_1}{n_2})XY & -X & (\frac{n_1}{n_2})X \end{bmatrix} \begin{bmatrix} 1 & 0 \\ -1 & 0 \\ 0 & 1 \\ 0 & -1 \end{bmatrix} \\
&= \begin{bmatrix} \frac{n}{n_1}Y & -\frac{n}{n_2}Y & \frac{n}{n_1}XY & -\frac{n}{n_2}XY \\ \frac{n}{n_1}XY & -\frac{n}{n_2}XY & \frac{n}{n_1}X & -\frac{n}{n_2}X \end{bmatrix} \begin{bmatrix} 1 & 0 \\ -1 & 0 \\ 0 & 1 \\ 0 & -1 \end{bmatrix} \\
&= \begin{bmatrix} \frac{nn_2+nn_1}{n_1n_2}Y & \frac{nn_2+nn_1}{n_1n_2}XY \\ \frac{nn_2+nn_1}{n_1n_2}XY & \frac{nn_2+nn_1}{n_1n_2}X \end{bmatrix} \\
&= \frac{(n_1+n_2)}{n_1n_2(n-1)} \begin{bmatrix} \sum_{i=1}^{n}(y_i-\bar{y})^2 & \sum_{i=1}^{n}(y_i-\bar{y})(x_i-\bar{x}) \\ \sum_{i=1}^{n}(y_i-\bar{y})(x_i-\bar{x}) & \sum_{i=1}^{n}(x_i-\bar{x})^2 \end{bmatrix} \\
&= \frac{n}{n_1n_2(n-1)} \sum_{j=1}^{2}\sum_{k=1}^{n_j} \begin{bmatrix} (y_{jk}-\bar{y})^2 & (y_{jk}-\bar{y})(x_{jk}-\bar{x}) \\ (y_{jk}-\bar{y})(x_{jk}-\bar{x}) & (x_{jk}-\bar{x})^2 \end{bmatrix},
\end{aligned}$$

where y_{jk} represents the k^{th} y_i in the j^{th} group, and the above expression coincide with what is given on page 11 of notes 19.

Appendix: SAS Code

```
************************************************
           Question 1
************************************************;

data q1;
input W Y S C count;
* cond: 1:dusty, -1:not dusty;
* empl: 1:<10, -1:>=10;
* smok: 1:yes, -1:no;
* comp: 1:yes, -1:no;
cards;
 1  1  1  1 30
 1  1  1 -1 203
 1  1 -1  1 7
 1  1 -1 -1 119
 1 -1  1  1 57
 1 -1  1 -1 161
 1 -1 -1  1 11
 1 -1 -1 -1 81
-1  1  1  1 14
-1  1  1 -1 1340
-1  1 -1  1 12
-1  1 -1 -1 1004
-1 -1  1  1 24
-1 -1  1 -1 1360
-1 -1 -1  1 10
-1 -1 -1 -1 986
;
run;

title '1 (b): WLS';
proc catmod data=q1 order=data;
  weight count;
  response logits;
  model C = W Y S / wls;
run;

title '1 (e): logistic regression';
data q1e;
input W Y S yes total;
* cond: 1:dusty, -1:not dusty;
* empl: 1:<10, -1:>=10;
* smok: 1:yes, -1:no;
* comp: 1:yes, -1:no;
cards;
 1  1  1  30 233
 1  1 -1   7 126
 1 -1  1  57 218
 1 -1 -1  11 92
-1  1  1  14 1354
-1  1 -1  12 1016
-1 -1  1  24 1384
-1 -1 -1  10 996
;
```

```
run;

proc genmod data=q1e;
  model yes/total = w y s / d=b link=logit;
run;

************************************************
           Question 2
************************************************;

data q2;
input ID   PERIOD  NUMSICK   DAYSRISK   YRSWORK   MEDICINE;
cards;
1     1       0         0          2         0
1     2       0         4          2         0
2     1       0         0          2         0
2     2       0         4          2         0
3     1       0         0          15        0
4     1       0         0          1         0
4     2       0         4          1         0
5     1       0         0          7         0
5     2       0         4          7         0
6     1       0         5          3         0
7     1       0         4          10        0
7     2       0         5          10        0
7     3       0         6          10        0
7     4       0         6          10        1
7     5       0         6          10        1
8     1       0         1          1         0
8     2       0         5          1         0
8     3       0         5          1         0
8     4       0         6          1         0
8     5       0         7          1         0
9     1       0         6          20        0
9     2       0         5          20        0
9     3       0         5          20        0
9     4       0         6          20        0
9     5       0         7          20        0
10    1       0         0          1         0
10    2       0         5          1         0
10    3       0         5          1         0
10    4       0         6          1         0
10    5       0         6          1         0
11    1       0         3          1         0
11    2       0         6          1         0
11    3       0         5          1         0
11    4       0         6          1         0
12    1       0         3          5         0
12    2       0         6          5         0
12    3       0         5          5         0
12    4       0         6          5         0
12    5       0         6          5         0
13    1       0         3          9         0
13    2       0         6          9         0
13    3       0         5          9         0
13    4       0         6          9         0
13    5       0         6          9         0
```

14	1	0	4	6	0
14	2	0	6	6	0
14	3	0	5	6	0
14	4	0	6	6	0
14	5	0	6	6	0
15	1	0	3	5	0
15	2	0	0	5	0
15	3	0	4	5	0
15	4	0	6	5	0
15	5	0	7	5	0
16	1	0	3	3	0
16	2	0	0	3	0
16	3	0	4	3	0
16	4	0	6	3	1
17	1	0	3	9	0
17	2	0	0	9	0
17	3	0	4	9	0
17	4	0	6	9	0
17	5	0	7	9	0
18	1	0	3	10	0
18	2	0	6	10	0
18	3	0	4	10	0
18	4	0	6	10	0
18	5	0	7	10	0
19	1	0	3	7	1
19	2	0	0	7	0
19	3	0	4	7	0
19	4	0	6	7	0
20	1	0	3	3	0
20	2	0	0	3	0
20	3	0	4	3	0
20	4	0	6	3	0
20	5	0	7	3	0
21	1	0	0	5	0
21	2	0	4	5	0
21	3	0	4	5	0
21	4	0	5	5	0
21	5	0	6	5	0
22	1	0	0	5	0
22	2	0	0	5	0
22	3	0	4	5	0
22	4	0	6	5	0
23	1	0	0	5	0
23	2	0	0	5	0
23	3	0	0	5	0
23	4	0	3	5	0
23	5	0	5	5	0
24	1	0	0	2	0
24	2	0	0	2	0
24	3	0	0	2	0
24	4	0	0	2	0
24	5	0	4	2	0
25	1	0	0	3	0
25	2	0	0	3	0
25	3	0	0	3	0
26	1	0	5	8	0
26	2	0	6	8	0

26	3	2	6	8	0
26	4	0	6	8	0
26	5	0	6	8	0
27	1	0	5	5	0
27	2	0	6	5	0
27	3	0	6	5	0
27	4	0	6	5	0
27	5	2	5	5	1
28	1	0	5	2	0
28	2	0	6	2	0
28	3	0	6	2	0
28	4	0	6	2	0
29	1	0	5	7	0
29	2	0	6	7	0
29	3	0	6	7	0
29	4	0	6	7	0
29	5	0	6	7	0
30	1	0	5	1	0
30	2	0	6	1	0
30	3	0	6	1	0
31	1	0	5	1	0
31	2	0	6	1	0
31	3	0	6	1	0
32	1	0	4	1	0
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57	2	0	5	2	0

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95	2	0	5	2	0

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108	4	0	6	10	0

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145	3	0	2	1	0
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148	3	1	6	1	0

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150	3	0	6	4	0
150	4	0	6	4	0
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163	3	0	4	10	0
163	4	0	6	10	0
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164	3	0	4	6	0
164	4	0	6	6	0
165	1	0	5	1	0
165	2	0	7	1	0
165	3	0	4	1	0
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201	5	0	6	2	0
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205	4	0	5	1	0
205	5	0	4	1	0
206	3	0	1	1	0
207	3	0	6	1	1
207	4	0	6	1	0
207	5	0	6	1	0
208	3	1	6	3	1
208	4	0	6	3	0
208	5	0	6	3	0
209	4	0	6	8	0
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222	3	0	0	4	0
222	4	0	6	4	0
222	5	1	6	4	1
223	3	0	0	1	0
223	4	0	6	1	0
223	5	1	6	1	0

```
224  3         0          6           1          0
224  4         0          6           1          1
224  5         0          6           1          0
225  3         0          6           1          0
225  4         0          6           1          0
225  5         0          6           1          0
226  3         0          6           2          0
226  5         0          6           2          0
228  4         0          5           1          0
228  5         0          6           1          0
229  4         2          2           3          0
229  5         0          6           3          0
230  4         1          5           1          0
230  5         0          6           1          0
231  4         0          2           2          0
231  5         1          6           2          0
;
run;

title '2 (a): ID at t1';
data t1;
  set q2;
  where period = 1;
run;

proc summary data=t1;
  var numsick daysrisk;
  output out=totals1 sum=;
run;

proc print data=totals1;
run;

title '2 (a): ID at t2';
data t2;
  set q2;
  where period = 2;
run;

proc summary data=t2;
  var numsick daysrisk;
  output out=totals2 sum=;
run;

proc print data=totals2;
run;

title '2 (a): ID at t3';
data t3;
  set q2;
  where period = 3;
run;

proc summary data=t3;
  var numsick daysrisk;
  output out=totals3 sum=;
run;
```

```
proc print data=totals3;
run;

title '2 (a): ID at t4';
data t4;
  set q2;
  where period = 4;
run;

proc summary data=t4;
  var numsick daysrisk;
  output out=totals4 sum=;
run;

proc print data=totals4;
run;

title '2 (a): ID at t5';
data t5;
  set q2;
  where period = 5;
run;

proc summary data=t5;
  var numsick daysrisk;
  output out=totals5 sum=;
run;

proc print data=totals5;
run;

title '2 (c): EX COR';
data q2;
  set q2;
  MID = (period = 3);
  LATE = (period = 4) or (period = 5);
run;

proc genmod data=q2;
  class id period;
  model numsick = mid late yrswork medicine /offset=daysrisk dist=p link=log
scale=1;
  repeated subject=id/withinsubject=period modelse type=exch;
run;

title '2 (c): AR1 COR';
proc genmod data=q2;
  class id;
  model numsick = mid late yrswork medicine /offset=daysrisk dist=p link=log
scale=1;
  repeated subject=id/ modelse type=ar;
run;

proc genmod data=q2;
  class id;
```

```
  model numsick = mid late yrswork medicine /offset=daysrisk dist=p link=log
scale=1;
  repeated subject=id/ modelse corr=ar(1);
run;

************************************************
           Question 3
************************************************;

data q3;
input idno   site  exercise $  baseunus  unus  genio $  jaws  gender
$ ageatsurg;
cards;
1       0      Sensory   1          1      Y        1      F        16
3       0      Opening   1          1      Y        2      F        21
4       0      Opening   1          2      N        2      M        31
5       0      Opening   1          3      Y        1      M        17
6       0      Sensory   1          1      N        2      M        21
7       0      Sensory   1          3      N        2      F        19
8       0      Sensory   1          3      Y        2      F        18
9       0      Opening   1          3      N        2      F        40
10      0      Sensory   1          1      N        1      F        38
11      0      Opening   1          3      N        1      F        48
12      0      Opening   3          2      N        1      F        51
13      0      Sensory   1          4      N        1      M        16
14      0      Sensory   7          3      N        2      F        32
15      0      Opening   4          3      N        2      M        23
16      0      Opening   1          4      N        1      M        31
17      0      Sensory   1          3      Y        2      F        34
18      0      Sensory   1          1      N        1      F        38
19      0      Sensory   1          3      N        2      M        23
20      0      Opening   1          1      N        2      F        16
21      0      Sensory   1          1      N        2      F        22
22      0      Opening   1          1      N        2      F        19
23      0      Opening   1          1      N        1      F        15
24      0      Sensory   1          1      N        2      M        17
25      0      Sensory   1          1      N        2      M        21
27      0      Opening   1          1      N        2      F        17
28      0      Opening   2          2      N        2      M        23
29      0      Opening   1          3      N        2      M        16
30      0      Sensory   1          1      Y        1      F        14
33      0      Opening   1          4      N        1      F        24
34      0      Sensory   1          4      N        1      F        45
35      0      Sensory   2          3      N        1      F        27
36      0      Sensory   1          1      N        1      F        49
37      0      Sensory   1          4      N        1      F        40
38      0      Sensory   1          4      N        1      F        16
39      0      Opening   1          1      Y        2      F        17
40      0      Opening   1          1      N        2      F        18
41      0      Sensory   1          2      N        2      F        20
42      0      Sensory   1          1      Y        2      F        14
43      0      Sensory   1          5      Y        2      M        35
44      0      Opening   1          5      Y        2      F        34
45      0      Opening   2          4      N        2      F        48
47      0      Opening   2          3      N        1      F        40
48      0      Opening   1          1      N        2      F        19
49      0      Sensory   1          1      Y        1      F        47
```

50	0	Sensory	1	6	N	2	F	21
51	0	Opening	1	2	N	1	F	16
52	0	Sensory	1	2	N	1	F	23
53	0	Sensory	1	2	Y	2	F	40
54	0	Sensory	1	1	Y	2	F	52
55	0	Opening	1	3	N	1	F	35
56	0	Sensory	1	1	N	2	F	18
57	0	Sensory	3	1	Y	1	F	16
58	0	Opening	1	1	N	1	M	32
59	0	Sensory	1	2	Y	2	F	42
60	0	Opening	1	2	Y	1	F	29
61	0	Sensory	1	2	Y	2	F	17
62	0	Opening	1	1	N	1	M	29
63	0	Sensory	1	1	Y	2	F	15
64	0	Opening	1	1	N	1	F	14
65	0	Opening	1	1	N	2	M	17
66	0	Opening	4	4	N	2	F	18
67	0	Sensory	1	1	Y	2	M	18
68	0	Sensory	1	1	Y	1	F	19
69	0	Sensory	1	1	N	1	M	21
70	0	Opening	1	1	Y	2	M	19
71	0	Opening	1	1	Y	2	F	35
72	0	Sensory	1	1	N	1	F	13
73	0	Opening	1	1	N	2	M	22
74	0	Sensory	1	1	N	1	F	19
75	0	Opening	1	1	N	1	M	17
76	0	Opening	1	1	Y	2	F	16
77	0	Opening	1	1	N	1	M	19
78	0	Opening	1	3	N	1	F	24
79	0	Sensory	1	1	N	1	F	17
80	0	Sensory	1	1	N	1	F	16
81	0	Sensory	1	2	Y	2	M	21
82	0	Opening	1	2	Y	2	F	16
83	0	Opening	1	3	Y	1	F	34
84	0	Opening	1	1	N	2	F	17
85	0	Opening	1	2	N	1	M	32
86	0	Sensory	2	3	N	1	F	46
87	0	Opening	1	6	N	1	F	46
89	0	Opening	1	3	N	1	F	44
90	0	Sensory	1	1	Y	2	M	49
101	0	Sensory	1	1	N	2	M	22
102	0	Opening	1	1	N	1	M	46
103	0	Opening	3	1	N	2	M	18
104	0	Opening	1	4	N	1	F	51
105	0	Sensory	1	1	N	2	M	19
203	1	Sensory	1	2	N	2	F	23
204	1	Opening	1	4	N	2	F	28
205	1	Sensory	5	4	N	2	F	47
206	1	Sensory	1	2	N	1	F	14
207	1	Sensory	2	2	Y	2	F	16
208	1	Sensory	1	6	N	1	F	50
209	1	Opening	1	1	N	1	F	15
210	1	Opening	1	2	Y	1	F	15
211	1	Sensory	1	1	N	2	M	16
212	1	Sensory	1	1	Y	1	M	16
213	1	Opening	1	1	Y	1	F	33
214	1	Opening	1	1	N	2	F	23

215	1	Sensory	1	1	N	1	M	14
216	1	Sensory	1	1	N	1	M	16
217	1	Opening	1	3	Y	2	F	37
218	1	Opening	1	1	Y	2	M	16
219	1	Sensory	1	3	N	1	F	44
221	1	Sensory	2	1	Y	2	F	16
222	1	Opening	1	1	N	1	M	25
223	1	Opening	1	4	Y	2	F	40
224	1	Sensory	1	2	N	2	F	38
225	1	Opening	1	3	N	2	F	36
226	1	Opening	1	3	N	1	M	15
227	1	Sensory	1	1	N	1	M	13
228	1	Sensory	1	1	N	1	F	14
229	1	Sensory	1	1	Y	1	F	14
231	1	Sensory	1	2	Y	1	M	16
232	1	Sensory	1	1	N	1	F	14
233	1	Sensory	2	2	N	1	F	17
234	1	Sensory	1	5	N	2	F	35
235	1	Opening	2	3	N	2	F	47
236	1	Opening	1	1	N	1	F	17
237	1	Opening	1	1	N	1	F	16
238	1	Sensory	3	1	Y	2	F	15
239	1	Opening	1	2	Y	2	F	42
240	1	Opening	1	1	Y	1	F	14
241	1	Sensory	1	4	N	1	F	36
242	1	Opening	1	1	N	1	F	19
243	1	Sensory	1	4	Y	2	M	37
244	1	Opening	1	2	N	2	F	15
245	1	Opening	1	1	N	1	F	17
246	1	Sensory	1	2	Y	1	F	40
247	1	Sensory	1	1	N	1	F	20
248	1	Sensory	1	1	N	2	F	38
249	1	Sensory	1	1	N	1	F	14
250	1	Opening	2	1	Y	2	F	15
251	1	Sensory	1	1	Y	1	M	16
252	1	Opening	1	1	N	1	F	15
253	1	Opening	1	2	N	1	M	15
254	1	Opening	1	1	N	1	M	16
255	1	Opening	1	1	Y	1	M	16
256	1	Opening	1	1	N	1	F	22
257	1	Opening	1	1	N	1	F	16
258	1	Sensory	1	1	N	1	F	14
259	1	Sensory	1	3	Y	1	F	49
260	1	Opening	1	2	N	1	F	28
261	1	Sensory	4	3	N	1	F	16
262	1	Sensory	1	6	N	1	F	40
263	1	Sensory	1	1	N	1	F	14
264	1	Opening	1	2	N	2	M	15
265	1	Opening	1	4	N	1	F	34
266	1	Sensory	1	1	N	1	F	16
267	1	Opening	1	1	Y	1	F	15
268	1	Opening	1	4	N	1	F	25
269	1	Sensory	1	3	N	1	F	48
270	1	Sensory	1	1	Y	2	F	46
271	1	Opening	1	1	N	2	F	31
272	1	Sensory	1	1	N	1	F	20
273	1	Opening	1	1	N	1	F	50

```
274     1      Sensory    1          3      Y        1      F        13
275     1      Opening    1          3      N        1      M        31
276     1      Opening    1          2      N        1      F        47
277     1      Sensory    1          1      N        1      F        13
278     1      Sensory    1          4      N        1      M        15
279     1      Opening    1          1      Y        1      F        15
280     1      Opening    1          2      N        1      M        13
281     1      Sensory    1          1      N        1      F        15
282     1      Opening    1          1      Y        1      M        15
283     1      Opening    1          1      N        1      F        15
284     1      Sensory    1          1      N        1      F        14
285     1      Opening    1          1      N        1      F        15
286     1      Sensory    1          1      Y        1      F        16
287     1      Opening    1          3      N        1      F        39
288     1      Opening    1          2      N        1      M        50
289     1      Opening    1          3      N        1      F        45
290     1      Sensory    2          1      N        1      M        16
291     1      Sensory    1          1      N        1      M        15
292     1      Sensory    1          1      Y        1      F        16
293     1      Opening    1          2      Y        2      F        24
294     1      Sensory    1          1      N        1      M        36
295     1      Opening    1          1      N        1      F        15
296     1      Opening    1          1      N        1      F        18
;
run;

title '3 (a): association of gender and unusual feelings';
proc freq data=q3;
  table gender*unus / noprint cmh;
run;

title '3 (a): association of genioplasty and unusual feelings';
proc freq data=q3;
  table genio*unus / noprint cmh;
run;

title '3 (a): association of number of jaws and unusual feelings';
proc freq data=q3;
  table jaws*unus / noprint cmh;
run;

title '3 (b): association of age and unusual feelings';
proc freq data=q3;
  table ageatsurg*unus /cmh nocol nopct measures;
  output measures out=stats;
run;

title '3 (c): association of exercise group and unusual feelings';
proc freq data=q3;
  table exercise*unus / noprint cmh;
run;

title '3 (d): unadjusted';
data q3;
    set q3;
    if exercise="Sensory" then tx=2;
        else if exercise="Opening" then tx=1;
```

```
      if genio="Y" then genio2=2;
        else genio2=1;
  if gender="M" then gender2=2;
        else gender2=1;
run;

%NParCov4(outcomes=unus,
          covars=,
              c=1,
          hypoth=NULL,
          strata=NONE,
          trtgrps=tx,
          transform=none,
          combine=NONE,
              exact=yes,
              nreps =5000,
              seed = 100,
          dsnin=q3,
          dsnout=out);
proc print data=_out_DEPTEST;
run;

title '3 (d): adjusted';
%NParCov4(outcomes=unus,
          covars= ageatsurg gender2 genio2 jaws,
              c=1,
          hypoth=NULL,
          strata=NONE,
          trtgrps=tx,
          transform=none,
          combine=NONE,
              exact=yes,
              nreps =5000,
              seed = 100,
          dsnin=q3,
          dsnout=out);
proc print data=_out_DEPTEST;
run;

title '3 (e): unadjusted';
%NParCov4(outcomes=unus,
          covars=,
              c=1,
          hypoth=alt,
          strata=NONE,
          trtgrps=tx,
          transform=none,
          combine=NONE,
              exact=yes,
              nreps =5000,
              seed = 100,
          dsnin=q3,
          dsnout=out);
proc print data=_out_DEPTEST;
run;

title '3 (e): adjusted';
```

```
%NParCov4(outcomes=unus,
          covars= ageatsurg gender2 genio2 jaws,
              c=1,
          hypoth=alt,
          strata=NONE,
          trtgrps=tx,
          transform=none,
          combine=NONE,
              exact=yes,
              nreps =5000,
              seed = 100,
          dsnin=q3,
          dsnout=out);
proc print data=_out_DEPTEST;
run;
```