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Using GENMOD to Analyze Correlated Data on Military Health System Beneficiaries Receiving Inpatient Behavioral Health Care in South Carolina Health Care Systems

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ABSTRACT

Many SAS® procedures can be used to analyze large datasets with correlated data. This study was a secondary analysis of data obtained from the South Carolina Revenue and Fiscal Affairs Office (RFA), which includes medical claims from all health care systems in South Carolina (SC). We used the SAS procedure, GENMOD, to analyze a large dataset with correlated data from Military Health Care (MHS) system beneficiaries who received inpatient behavioral health care in South Carolina Health Care Systems from 2005 to 2014. Behavioral health (BH) was defined by Major Diagnostic Code (MDC) 19 (mental disorders and diseases) and 20 (alcohol and drug use). MDCs are formed by dividing all possible principal diagnoses from the International Classification Diagnostic (ICD-9) codes into 25 mutually exclusive diagnostic categories. The sample included a total of 6,783 BH visits and 4,827 unique military service members, veterans, and their adult and child dependents who have MHS insurance coverage. PROC GENMOD included a multivariate GEE model with type of BH hospitalization (mental health or substance abuse) as the dependent variable; and gender, race, age group, and discharge year as predictors. Hospital ID was used in the repeated statement with different correlation structures. Gender was significant for both independent correlation (p = .0001) and exchangeable structure (p = .0003). However, age group was significant using the independent correlation (p = .0160), but non-significant using the exchangeable correlation structure (p = .0584). SAS is a powerful statistical program for analyzing large, correlated datasets with categorical outcomes.

Keywords: SAS, Correlated data, GENMOD, Military, Veterans, Behavioral Health

INTRODUCTION

When analyzing large, correlated datasets with categorical outcomes, it is challenging for new investigators to determine what type of statistical procedures to use and which statistical software is most powerful and efficient. SAS is a powerful statistical software program that provides multiple efficient procedures for investigators to analyze large, correlated datasets. The SAS GENMOD procedure is used to perform general linear models as well as nonlinear and complex models including log-linear, logistic, or count models for categorical outcomes. GENMOD also accounts for correlated outcomes that can be expected in longitudinal studies when outcomes are measured over time. The GENMOD procedure also estimates generalized linear models with extensions that estimate mixed models with data from non-normal distributions. SAS provides practical and efficient ways to analyze correlated, longitudinal data with non-normal distributions.

PURPOSE

This study used the SAS GENMOD procedure to analyze a large, correlated dataset of behavioral health (mental health/substance use) hospitalizations of Military Health Care system (MHS) beneficiaries in South Carolina Health Care Systems from 2005 to 2014.

BACKGROUND

The Military Health System (MHS) is a global, integrated health care system that provides care to 9.6 million military personnel, veterans, and their family members[1]. The MHS has two components: direct care and purchased care. Direct care provides health care within military treatment facilities, and purchased care provides services in civilian health facilities by providers approved through TRICARE regional networks (e.g., TRICARE South) and paid for by the MHS.[1] Behavioral health conditions are significant health concerns for the U. S. military that negatively impact military readiness and health promotion[1-3]. These conditions include mental health and substance use disorders which are associated with functional impairment, decreased productivity, early attrition from military service, and increased health care utilization. Behavioral health conditions common among military and veteran populations include posttraumatic stress disorder, mood disorders, and alcohol, tobacco, and substance use disorders.[2-4]

METHODS

This study used data obtained from the South Carolina Revenue and Fiscal Affairs Office (RFA) and includes medical claims from all health care systems in South Carolina (SC). The sample for this study included all military personnel, veterans, and family members from all branches of military service who visited a hospital inpatient facility from January 1, 2005 to December 31, 2014 with Major Diagnostic Category (MDC) 19 (mental diseases and disorders) and 20 (alcohol and drug use or induced mental disorders) as the primary diagnosis on any medical claim. A total of 6,783 hospitalizations were included in the analytic sample. Patient characteristics included age group (0-17, 18-29, 30-59, 60+ years), gender (male/female), and race (White, Black, Other). Discharge year was categorized into two categories: 2005-2009 and 2010-2014. The outcome for this study was behavioral health (BH) hospitalization (mental health or substance abuse). PROC MEAN and PROC FREQ were used to describe patient characteristics by BH group. Chi-square tests examined bivariate associations between patient characteristics and BH group. PROC GENMOD analyzed correlated data using a multivariate GEE model with gender, race, age group, and discharge year as predictors. Hospital ID was used in the repeated statement with three different correlation structures to account for hospital-level clustering. All data analyses were performed using SAS/STAT® version 9.4[5].

RESULTS

Table 1 shows descriptive statistics for type of BH hospitalization, gender, race, age group, and discharge year. Approximately 83% of MHS hospitalizations had a primary diagnosis of mental health, 77.98% were for white patients, 60.21% were for female patients, 31.01% were for 30-59 year old patients, and 63.78% of BH hospitalizations were between 2005 and 20014.

Table 1: Frequency distribution of admission characteristics from 2005 to 2014.

BEHAVIORAL HEALTH HOSPITALIZATION				
BEHAVIORAL HEALTH HOSPITALIZATION	**Frequency**	**Percent**	**Cumulative Frequency**	**Cumulative Percent**
Mental Health	5653	83.34	5653	83.34
Substance Abuse	1130	16.66	6783	100.00

RACE GROUP				
RACE	**Frequency**	**Percent**	**Cumulative Frequency**	**Cumulative Percent**
White	5288	77.98	5288	77.98
African-American	1204	17.76	6492	95.74
other	289	4.26	6781	100.00
Frequency Missing = 2				

GENDER				
GENDER	**Frequency**	**Percent**	**Cumulative Frequency**	**Cumulative Percent**
Female	4084	60.21	4084	60.21
Male	2699	39.79	6783	100.00

AGE GROUP				
AGE	**Frequency**	**Percent**	**Cumulative Frequency**	**Cumulative Percent**
under 18	1295	19.09	1295	19.09
18-29 years	1481	21.84	2776	40.93
30-59 years	2103	31.01	4879	71.94
60 and over	1903	28.06	6782	100.00
Frequency Missing = 1				

DISCHARGE YEAR				
YEAR	**Frequency**	**Percent**	**Cumulative Frequency**	**Cumulative Percent**
2005 - 2009	4326	63.78	4326	63.78
2010 - 2014	2457	36.22	6783	100.00

Table 2 displays descriptive statistics of age and age by BH hospitalization. On average, BH hospitalizations were for MHS beneficiaries of 42.25 years of age (*sd* = 23.72 yrs). On average, BH hospitalizations for mental health diagnoses were for MHS beneficiaries of 40.71 years compared to 49.97 years for those hospitalized for substance abuse diagnoses.

Table 2: Descriptive statistics of age and age by behavioral health hospitalization from 2005 to 2014.

Analysis Variable: Patient Age				
N	**Mean**	**Std Dev**	**Minimum**	**Maximum**
6783	42.25	23.72	2.00	112.00

Analysis Variable: Patient Age						
Behavioral Health Hospitalization	***N* Obs**	***N***	**Mean**	**Std Dev**	**Minimum**	**Maximum**
Mental health	5653	5653	40.71	24.33	2.00	112.00
Substance abuse	1130	1130	49.97	18.56	14.00	94.00

Table 3 displays the frequency distribution of gender by BH hospitalization. Between 2005 and 2014, BH hospitalizations were more likely to be for mental health diagnoses than substance abuse diagnoses. BH hospitalizations for mental health diagnoses were more likely to be for women (62.46%) than men (37.54%). Overall, any BH hospitalizations were significantly more likely for women than men (60.21% vs. 39.79%).

Table 3: Frequency distribution of gender by behavioral health hospitalization from 2005 to 2014.

BEHAVIORAL HEALTH HOSPITALIZATION BY SEX			
Behavioral Health Hospitalization	**GENDER**		
Frequency Percent Row Pct Col Pct	**Female**	**Male**	**Total**
Mental Health	3531 52.06 62.46 86.46	2122 31.28 37.54 78.62	5653 83.34
Substance Abuse	553 8.15 48.94 13.54	577 8.51 51.06 21.38	1130 16.66
Total	4084 60.21	2699 39.79	6783 100.00

Statistic	**DF**	**Value**	**Prob**
Chi-Square	1	71.8992	<.0001
Likelihood Ratio Chi-Square	1	70.6327	<.0001
Continuity Adj. Chi-Square	1	71.3358	<.0001
Mantel-Haenszel Chi-Square	1	71.8886	<.0001

Statistic	DF	Value	Prob
Phi Coefficient		0.1030	
Contingency Coefficient		0.1024	
Cramer's V		0.1030	

Table 4 displays the frequency distribution of race by BH group. Between 2005 and 2014, there were no significant differences by racial group in BH hospitalizations for substance abuse or mental health diagnoses.

Table 4: Frequency distribution of race by behavioral health hospitalization from 2005 to 2014.

BEHAVIORAL HEATH HOSPITALIZATION BY RACE				
Behavioral Health Hospitalization	RACE			
Frequency Percent Row Pct Col Pct	White	African-American	Other	Total
Mental Health	4394 64.80 77.74 83.09	1002 14.78 17.73 83.22	256 3.78 4.53 88.58	5652 83.35
Substance Abuse	894 13.18 79.19 16.91	202 2.98 17.89 16.78	33 0.49 2.92 11.42	1129 16.65
Total	5288 77.98	1204 17.76	289 4.26	6781 100.00
Frequency Missing = 2				

Statistic	DF	Value	Prob
Chi-Square	2	5.9634	0.0507
Likelihood Ratio Chi-Square	2	6.5373	0.0381
Mantel-Haenszel Chi-Square	1	3.1357	0.0766
Phi Coefficient		0.0297	
Contingency Coefficient		0.0296	
Cramer's V		0.0297	

Table 5 displays the frequency distribution of age group by BH hospitalization. Between 2005 and 2014, BH hospitalizations for those age 30 and over were more likely than hospitalizations for those under age 30. BH hospitalizations for substance abuse diagnoses for those under age 18 was significantly less likely (3.27%) than for all other age groups.

Table 5: Frequency distribution of age group by behavioral health hospitalization from 2005 to 2014.

BEHAVIORAL HEALTH HOSPITALIZATION BY AGE GROUP					
Behavioral Health Hospitalization	**AGE GROUP**				
Frequency Percent Row Pct Col Pct	**under 18**	**18-29 years**	**30-59 years**	**60 and over**	**Total**
Mental Health	1258 18.55 22.26 97.14	1311 19.33 23.20 88.52	1565 23.08 27.69 74.42	1518 22.38 26.86 79.77	5652 83.34
Substance Abuse	37 0.55 3.27 2.86	170 2.51 15.04 11.48	538 7.93 47.61 25.58	385 5.68 34.07 20.23	1130 16.66
Total	1295 19.09	1481 21.84	2103 31.01	1903 28.06	6782 100.00
Frequency Missing = 1					

Statistic	DF	Value	Prob
Chi-Square	3	344.3652	<.0001
Likelihood Ratio Chi-Square	3	410.2414	<.0001
Mantel-Haenszel Chi-Square	1	230.7508	<.0001
Phi Coefficient		0.2253	
Contingency Coefficient		0.2198	
Cramer's V		0.2253	

Table 6 displays the frequency distribution of discharge year by BH group. Overall, between 2005-2009 and 2010-2014, there was no significant difference in the distribution of BH hospitalizations (substance abuse or mental health) between each time period.

Table 6: Frequency distribution of discharge year by behavioral health group from 2005 to 2014.

BEHAVIORAL HEALTH HOSPITALIZATION BY DISCHARGE YEAR			
Behavioral Health Hospitalization	**DISCHARGE YEAR**		
Frequency Percent Row Pct Col Pct	**2005 - 2009**	**2010 - 2014**	**Total**
Mental Health	3580 52.78 63.33 82.76	2073 30.56 36.67 84.37	5653 83.34
Substance Abuse	746 11.00 66.02 17.24	384 5.66 33.98 15.63	1130 16.66
Total	4326 63.78	2457 36.22	6783 100.00

Statistic	DF	Value	Prob
Chi-Square	1	2.9465	0.0861
Likelihood Ratio Chi-Square	1	2.9687	0.0849
Continuity Adj. Chi-Square	1	2.8313	0.0924
Mantel-Haenszel Chi-Square	1	2.9461	0.0861
Phi Coefficient		-0.0208	
Contingency Coefficient		0.0208	
Cramer's V		-0.0208	

Overall, results from Table 3-6 indicated that there were significant associations between gender ($p < .0001$) and age group ($p < .0001$) by BH hospitalizations. However, there were no significant associations for race ($p = .0507$) and discharge year ($p = .0861$) by BH hospitalization.

Table 7 shows estimates for GEE analysis from GENMOD procedures with different correlation structures with BH hospitalization as a dichotomous outcome (mental health or substance abuse). Gender was significant for both the independent correlation (p = .0001) and exchangeable correlation (p = .0003) structures. However, age group was significant for the independent correlation (p = .0160), but non-significant for the exchangeable correlation structure (p = .0584). Discharge year and race were significant in both the independent correlation and exchangeable correlation structure models. The unstructured correlation structure was examined, but the model did not converge. See SAS syntax in the Appendix.

Table 7: GEE analysis for GENMOD procedure with different correlation structures.

Variables	DF	Independent X^2 Value	P-Value	Exchangeable X^2 Value	P-Value
Discharge year (ref = 2005-2009)	1	1.14	0.2848	.13	.7209
Sex (ref = male)	1	16.53	**<.0001**	13.14	**0.0003**
Race group (ref = white)	2	1.55	0.4599	1.07	0.5292
Age group (ref = under 18)	3	10.32	**0.0160**	7.47	0.0584

CONCLUSION

In this study, the GENMOD procedure was used to examine dichotomous outcomes from a large, correlated dataset. GENMOD is a powerful SAS procedure to use to analyze general linear models as well as general estimating equations when the data are correlated. This study indicated that, if adjustments for correlated data are not made, different results may be obtained. Ideally, it is prudent to examine different correlation structures and distributions when modeling correlated dichotomous outcomes. SAS is one of the most powerful statistical programs for the analysis of large, correlated datasets.

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Appendix

SAS Syntax

```
ods rtf; ods listing close;

proc freq data=three;
tables hid bh raceg sex ageg yearg;
title ' Frequency tables    ';
run;

proc freq data=three;
tables Bh *(sex raceg yearg ageg)  / chisq;
title ' Frequency tables   ';
run;

proc means data=three  maxdec=2;
     var  age;
    TITLE1 'Mean';
run;

proc means data=three  maxdec=2;
  class bh;
  var  age;
    TITLE1 'Mean / by group';
run;

ods rtf close;
ods listing;
quit;
run;

ods rtf;
ods listing close;

proc genmod data=three descending;
          class hid raceg (ref="White")  sex (ref="M")  ageg (ref="under 18")  yearg (ref="2005 - 2009") /
               param=ref ;
model bh = yearg sex raceg ageg / dist=bin link=logit type3 scale=deviance;
repeated  subject = hid  /corr=ind ;
title ' genmod model /uncorrelated';
run;

proc genmod data=three descending
          class hid raceg (ref="White")  sex (ref="M")  ageg (ref="under 18")  yearg (ref="2005 - 2009") /
          param=ref ;
          model bh = yearg sex raceg ageg / dist=bin link=logit type3 scale=deviance   ;
          repeated  subject = hid /corr=exch ;
          title ' genmode model/ exchangeable correlated' ;
run;

ods rtf close;
ods listing;
quit;
run;
```