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MODEL FOR CLINICAL MANAGEMENT USING BODY MASS INDEX OF DIABETES PATIENTS

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ABSTRACT

The importance of body weight of patients on admission in the management of diabetes was studied using Data from the University of Ilorin Teaching Hospital on the management of diabetes. Weight was partitioned into three groups: underweight, normal weight and overweight. Three models were used for comparison: a model that used weight of diabetes patient as a covariate, a second that used both weight and admitting blood sugar reading of diabetes patients as covariates and the third separate models for each of the three weight groups of diabetes patient as covariate.

Results showed that the latter model performed better than the earlier two models that were considered on this study based on the adjusted R^2. Also our finding revealed that the minimum expected days to bring down the blood sugar level to threshold value are: 8 days for underweight, 12 days for normal weight and 27 days for overweight.

KEYWORDS: BMI, weight, admitting blood sugar reading, obesity, repeated measures, covariate, non-linear model, correlated errors.

1. INTRODUCTION:

Obesity is a nutritional disorder that is characterized by excessive accumulation of fat in any or all of the subcutanenus tissues, omentum and viscera and muscles. Obesity in diabetes is common in the developed world because of gross overeating and eating of high fat and refined carbohydrate foods. Its high prevalence in developing countries is associated with poverty, ignorance about good nutrition and ideal body weight and consumption of excessive amount of carbohydrate. See Kwawukume and Emuveyan(2002). Body mass index (BMI) is used to measure obesity and because it is caused as described above it may be a factor in developing diabetes. It is the most appropriate measure for assessing weight change since weight readily changes more rapidly than height. Therefore in an attempt to determine how an erstwhile high blood sugar level can be brought down to the threshold value, this work introduces BMI into the follow-up study of in-patient diabetes patients as a covariate.

In this paper, the methodology of analysis is presented in section two. In section three we use the re-analyzed of UITH (University of Ilorin Teaching Hospital) data and end this paper with a conclusion in section four.

2. METHODOLOGY:

Let y_{ijt} be the response observed on the i^{th} subject in group j at time t, i= 1,2,…, n_j, j = 1,…,J and t = 1,2,…, T_i. Let $\underset{\sim}{X}' = (X_1,...,X_k), \sum n_j = n$. be the vector of covariates. Using the model which is an extension of that used by Abidoye and Jolayemi (2005), (2006) and Jolayemi and Abidoye (2005) that introduced some covariates into the system of equations the general model is given as

$$E(y_{ijt}) = f_1(\underset{\sim}{X}_1, \underset{\sim}{\theta}_1) + f_2(t, \underset{\sim}{\theta}_2) \qquad (2.1)$$

where f_1 represents the function for the covariate and f_2 the function representing the model for the repeated observations. f_1 and f_2 may be linear or non-linear, although f_1 is usually linear, see example from Draper & Smith (1966). The Expected Mean (EM) or Newton – Raphson algorithm may be used to estimate $\underset{\sim}{\theta}^1 = (\underset{\sim}{\theta}_1^1, \underset{\sim}{\theta}_2^1)$ as described explicitly in Abidoye and Jolayemi (2006) using Least Square Estimation Methodology. Further explanation on curve fitting can also be found in McCullagh & Nelder (1989), Jolayemi (1995), Oyejola & Jolayemi(1997).

The first model to be considered in this study is fully discussed in Abidoye and Jolayemi (2006), where the covariate is admitting blood sugar reading. In this connection the model is generally given by

$$E(y_{ijt}) = f_1(\underset{\sim}{X}_1, \underset{\sim}{\theta}_1) + f_2(t, \underset{\sim}{\theta}_2) \qquad (2.2)$$

Next let X_1 represent weight and X_2 initial blood sugar reading on admission.

For the diabetes data,

$$f_1(X_1, \theta_1) + f_2(X_2, \theta_2) = \theta(X_{1j} - \bar{X}_{1.}) + \lambda(X_{2j} - \bar{X}_{2.}) \qquad (2.3)$$

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Where j = 1, 2, 3 represents the three BMI groups. $X_{1i}\, and X_{2i}$ represent weight and admitting blood sugar readings respectively, $\bar{X}_{1.} = \sum_j X_{1i} / n_j$ and $\bar{X}_{2.} = \sum_j X_{2i} / n_j$ and α_j and β_{jt} represents parameter estimate in the model.

Obviously, because of the repeated nature of y_{ijt} , $\mathrm{cov}(y_{ijt}, y_{i'j't'}) \neq 0$ to ensure errors.

Indeed, $\mathrm{cov}(y_{it}, y_{i(t+j)}) = \sigma^2 \rho^j$ is assumed and this was recognized and used in the analysis. If desirable, it is not difficult to partition the data according to the severity level of diabetes of the patient as adopted by Abidoye and Jolayemi (2006).

3. RE- ANALYSIS OF DIABETES DATA:

The body mass index was classified into three groups: underweight is measure 19.8 kg/m^2 and below (group1), normal weight is measure between 19.9 - 29.9 kg/m^2 (group2) and overweight is measure above 30 kg/m^2 (group3) as reported by Kwawukume and Emuveyan(2002).

First, assume equation (2.2) and let weight be the covariate. Then

$$E(y_{it}) = \theta(X_{1i} - \bar{X}_{1.}) + e^{\alpha+\beta} \quad \text{.......................................} (3.1)$$

where $\bar{X}_{1.}$ is as defined earlier.

Table 3.1 is the ANOVA table arising from equation (3.1) providing an adjusted R^2=0.632, which is an improvement of above 10% in explained variability compared to the nonlinear model that does not consider any covariate. The estimates of the parameters are $\hat{\theta} = 0.014 \pm 0.0021$, $\hat{\alpha} = 2.432 \pm 0.036$ and $\hat{\beta} = -0.040 \pm 0.0021$ each of which is significant at 5% level.

Table 3.1: ANOVA table for equation (3.1) for the diabetes clinical management

Source	D.F	SS	MS	F
Regression	3	20345.63	6781.88	607.15
Parameter estimate:				
θ	1	9748.95	9748.95	872.77
α	1	6358.01	6358.01	569.20
β	1	4238.67	4238.67	379.47
Error	1063	11870.49	11.17	
Total	1066	32216.12		

Second, assume equation (2.1) is

$$E(y_{it}) = \theta(X_{1i} - \bar{X}_{1.}) + \lambda(X_{2i} - \bar{X}_{2.}) + e^{\alpha+\beta t} \quad \text{.......................................} (3.2)$$

where $\bar{X}_{1.}$ and $\bar{X}_{2.}$ are as defined earlier.

Table 3.2 is the ANOVA table for equation (3.2) providing an adjusted R^2= 0.672, which is an improvement of above 17% in explained variability to the nonlinear model that does not consider the included covariates. The estimates of the parameters are $\hat{\theta} = 0.010 \pm 0.0001$, $\hat{\lambda} = 0.014 \pm 0.0022$, $\hat{\alpha} = 2.10 \pm 0.000003$ and $\hat{\beta} = -0.021 \pm 0.00013$ each of which is significant at 5% level.

Table 3.2: ANOVA table for equation (3.2) for the diabetes clinical management.

Source	D.F	SS	MS	F
Regression	4	21635.22	5408.81	543.05
Parameter estimate:				
θ	1	7239.62	7239.62	726.87
λ	1	6841.04	6841.04	686.85
α	1	4251.24	4251.24	426.83
β	1	3303.32	3303.32	331.66
Error	1062	10580.90	9.96	
Total	1066	32216.12		

Next, a further possible improvement for the re-analysis of the data is having the model given by

$$E(y_{it}) = \lambda(X_{2i} - \bar{X}_{2.}) + e^{\alpha_j+\beta_{jt}} \quad \text{.......................................} (3.3)$$

arising from the gains observed in table 3.3 where j= 1,2,3 represent the three BMI groups using initial blood sugar as the covariate and $\bar{X}_{2.}$ is as defined earlier. The goodness-of-fit is assessed in table 3.3 with an adjusted R^2 = 0.705. The estimates of the parameters are $\hat{\lambda}$ = 0.032 $\pm$ 0.0004, $\hat{\alpha}_1$ = 2.40 $\pm$ 0.0024, $\hat{\alpha}_2$ =2.11 $\pm$ 0.001, $\hat{\alpha}_3$ = 2.04 $\pm$ 0.006, $\hat{\beta}_1$ =-0.02 $\pm$ 0.00017, $\hat{\beta}_2$ =-0.010 $\pm$ 0.0028, and $\hat{\beta}_3$ =-0.04 $\pm$ 0.00031.

Table 3.3: ANOVA table for equation (3.3) using initial blood sugar as the covariate.

Source	D.F	SS	MS	F
Regression	7	22721.84	3245.98	361.87
Parameter estimate:				
λ	1	9824.06	9824.06	1095.21
α	3	7569.78	2523.26	281.30
β	3	5328.00	1776.00	197.996
Error	1059	9494.28	8.97	
Total	1066	32216.12		

Finally, a further possible improvement is to consider the model

$$E(y_{it}) = \theta_j(X_{2i} - \bar{X}_2) + e^{\alpha_j + \beta_j t} \quad \ldots\ldots (3.4)$$

Table (3.4) is the ANOVA table for equation (3.4) providing an adjusted R^2 = 0.764 to assess goodness – of –fit. (This provided above 26% gain in explained variability). The estimates of the parameters are $\hat{\theta}_1$ = 0.51 $\pm$ 0.001, $\hat{\alpha}_1$ = 2.64 $\pm$ 0.05, $\hat{\theta}_2$ = 0.21 $\pm$ 0.007 $\hat{\alpha}_2$ =2.49 $\pm$ 0.03, $\hat{\alpha}_3$ = 2.04 $\pm$ 0.006, $\hat{\beta}_1$ =-0.06 $\pm$ 0.005, $\hat{\beta}_2$ =-0.02 $\pm$ 0.0008, $\hat{\beta}_3$ =-0.014 $\pm$ 0.0002 and $\hat{\theta}_3$ =0.19 $\pm$ 0.004

Table3.4: ANOVA table for equation (3.4) with weight as covariate.

Source	D.F	SS	MS	F
Regression	9	24601.64	2733.52	379.66
Parameter estimate:				
θ	3	10201.41	3400.47	472.29
α	3	8691.62	2897.21	402.39
β	3	5708.61	1902.87	264.29
Error	1057	7614.48	7.20	
Total	1066	32216.12		

4. CONCLUSION

Results show that the improvement in bringing down the blood sugar level depends on the weight of the diabetes patients as well as the reading of the admitting blood sugar level. This was shown clearly in equation (3.4) and its goodness-of-fit. In this regard, the data on diabetes should be analyzed within each BMI group of diabetes patients including the initial blood sugar reading as a covariate. The re-analysis shows that the expected minimum number of days for the management to bring down the blood sugar level to an acceptable value can be evaluated using the estimated values of the parameters in equation (3.4). Indeed, the expected minimum number of days for management to bring down the blood sugar level to acceptable value 5.6 millimoles/litter found to be 8days for underweight, 12days for normal weight and 27days for overweight. Consequently, the expected cost of management each time the blood sugar reading is excessive could be determined.

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