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Application of Loglinear Modeling on Medical Data

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Abstract: - This paper makes use of log- linear model on the age, sex and blood group of staff In Akanu Ibiam Federal Polytechnic, Unwana. The model was used to study the association between these variables. Interactions between Age and Sex, Sex and Blood Group, Age and Blood Group in the fitted models were observed.

***Key words:** Hierarchical, log-linear, Interaction, Categorical.*

I. INTRODUCTION

The loglinear models otherwise called hierarchical models are fitted to the cell frequencies of a multi-way table in order to describe relationship among the categorical variables that form the table.

According to Oyejola 2003, the log-linear model expresses the logarithm of the expected cell frequency as a linear function of certain parameters in a manner similar to that of analysis of variance (ANOVA).

An important distinction; however between ANOVA and log-linear modeling is that in the latter, the focus is on the need to include interaction terms while in ANOVA, testing for main effects is often the primary interest. Log-linear goal is to see how few interactions are needed to estimate the cell frequencies. If there are no interaction terms then the factors are independent Angela Jeansonne (2002)

The pattern of association between the classificatory variables may be measured by computing some measures of association or by the fitting of a log-linear model. The multivariate generalization of Bartlett's work, beginning with the work of Roy and Kastenbaum (1956) form the basis of the log-linear approach to contingency tables though the pioneering work is given to Pearson and Yule.

Loglinear modeling (as in all Statistical modeling) is parsimony. Quite Often, modelers are faced with a problem of developing a model that is simple to interpret and smoothens rather than over fit the data.

II. ESTIMATION OF PARAMETERS

Two approaches are used in literature to estimate the parameters in the log-linear models; (1) minimum modified chi-square approach attributed to Grizzle etal (1969) and (2) minimum discrimination information approach. Both methods use maximum likelihood approach. For most contingency table problems, the minimum discrimination information approach yields maximum likelihood estimates.

Deming and Stephen (1940) describe the iterative proportional fitting algorithm for hierarchical log linear models, which is currently widely used. The Newton-Raphson method (Kennedy and Gentle, 1980) can also be used to obtain the estimates through iterative procedures.

III. LOG-LINEEAR MODEL

The models for contingency table data to be discussed in this section are very similar to those used for quantitative data, particularly in the analysis of variance. Such terms include main effects and interaction (First order, Second order etc.)

Suppose there is a multinomial sample of size n over the N=rc cells of a r x c contingency table. Under this scheme, the expected frequencies $\lambda_{ij} = np_{ij}$, where p_{ij} is the probability that an observation falls in category i of variable 1 and category j of variable 2, i = 1,…….,r; j = 1,…….,c.

Let n_{ij} be the corresponding observed frequencies under independence,

$p_{ij} = p_{i.}p_{.j} \Rightarrow \lambda_{ij} = n\, p_{i.}p_{.j}$ {note summing a subscript we replace by . (dot)}

$\log \lambda_{ij} = \log n + \log P_{i.} + \log P_{.j}$ denoting the row variable by 1 and the column variable by 2, we have the general model for two-way category tables given as; $\log \lambda_{ij} = \mu + \mu_{1(i)} + \mu_{12(ij)}$ where

$$\sum \mu_{1i} = \sum \mu_{2(j)} = \sum \mu_{12(ij)} = 0$$

Bishop, etal (1975) explained, that the μ-terms can be regarded as measures of departure from independence for the two variable arrangements. Assuming that λ_{ij} is the expected value of the independent Poisson random variables X and Y, the μ-terms can be estimated as follows:

We know that the Poisson joint mass function of λ_{ij} is

$$\pi_{ij}\, \frac{e^{-\lambda_{ij}} * \lambda_{ij}^{n_{ij}}}{n_{ij}!}$$

is the kernel of the log likelihood is

$L = \sum_{ij} n_{ij} \log\lambda_{ij} - \sum_{ij} \log n_{ij}!$

By substitution, we obtain

$L = \sum_{ij} n_{ij}(\mu + \mu_{1(i)} + \mu_{2(j)} + \mu_{12(ij)}) - \sum_{ij} \exp(\mu + \mu_{1(i)} + \mu_{2(j)} + \mu_{12(ij)}) - \sum_{ij} \log n_{ij}!$

Minimizing the equation to zero

$\frac{dL}{du} = \sum_{ij} n_{ij} - \sum_{ij} \exp(\mu + \mu_{1(i)} + \mu_{2(j)} + \mu_{12(ij)}) = 0$

Taking $\sum_i \mu_{1(i)} = \sum_j \mu_{2(j)} = \sum \mu_{12(ij)} = 0$;

$\sum_{ij} n_{ij} = \sum_{ij} e^{\mu}$

$\mu = \frac{\sum \log n_{ij}}{rc}$

Minimizing with respect to $\mu_{1(i)}$ and $\mu_{2(j)}$ and setting the appropriate terms to zero, $\mu_{1(i)}$ and $\mu_{2(j)}$ can be written as $\mu_{1(i)} = \frac{\sum_j \log n_{ij}}{r} - \mu$

$$\mu_{2(j)} = \frac{\sum_i \log n_{ij}}{r} - \mu \quad \text{and}$$

$$\mu_{12(ij)} = \sum_{ij} \log n_{ij} - \mu - \mu_{1(i)} - \mu_{2(j)}$$

Extending the dimension to three, the model is

$\text{Log}\lambda_{ijk} = \mu + \mu_{1(i)} + \mu_{2(j)} + \mu_{3(k)} + \mu_{12(ij)} + \mu_{13(ik)} + \mu_{23(jk)} + \mu_{123(ijk)}$

where $\sum \mu_{1(i)} = \sum \mu_{2(j)} = \sum \mu_{12(ij)} = 0$;

$i = 1, \ldots, r$

$j = 1, \ldots, c$

$k = 1, \ldots, bc$

$\mu = \frac{\sum \log n_{ijk}}{rcb}$

Similarly

$\mu_{1(i)} = \frac{\sum \log n_{ijk}}{Cb} - \mu$

$\mu_{2(j)} = \frac{\sum \log n_{ijk}}{rb} - \mu$ ~~and so on~~.

Let t = Age, b = Blood group, and S = Sex

$\lambda = {}_{e}\ \mu.t_i.b_j.s_k.tb_{ij}.ts_{ik}.bs_{jk}.tbs_{ijk}$

Taking Log $\lambda_{ijk} = \mu + t_i + b_j + s_k + tb_{ij} + ts_{ik} + bs_{jk} + tbs_{ijk} + e_{ijk}$ (where $\sum e_{ijk} = 0$)

SPSS (17.0) for windows was used in this study.

μ = Overall Mean

$\mu_{1(i)} = i^{th}$ levels of tribe.

$\mu_{2(j)} = j^{th}$ levels of blood group

$\mu_{3(k)} = k^{th}$ levels of sex

$\mu_{12(ij)}$= Interaction between the i^{th} level of tribe and j^{th} level of blood group. and so on.

The hierarchical modeling

Data:

AGE	SEX	BLOOD GROUP				TOTAL
		A	B	AB	O	
0-30 YEARS	MALE	8	7	1	13	29
	FEMALE	11	4	1	11	27
31 YEARS-ABOVE	MALE	6	2	-	-	29
	FEMALE	4	2	-	9	15
TOTAL		29	15	2	54	100

SOURCE: Akanu Ibiam Federal Polytechnic Medical centre.

The test for partial association shows that these interactions are significant at 5% level.

General Loglinear

Cell Counts and Residuals

SEX	AGE	BLOODGROUP	Observed Count	Observed %	Expected Count	Expected %	Residuals	Std. Residuals
MALE	19.00	O+	.000	.0%	.535	.5%	-.535	-.732
		A+	.000	.0%	.293	.3%	-.293	-.541
		B+	.000	.0%	.152	.2%	-.152	-.389
		AB+	.000	.0%	.020	.0%	-.020	-.142
	20.00	O+	.000	.0%	.535	.5%	-.535	-.732
		A+	.000	.0%	.293	.3%	-.293	-.541
		B+	.000	.0%	.152	.2%	-.152	-.389
		AB+	.000	.0%	.020	.0%	-.020	-.142
	21.00	O+	1.000	1.0%	.268	.3%	.732	1.415
		A+	.000	.0%	.146	.1%	-.146	-.383
		B+	.000	.0%	.076	.1%	-.076	-.275
		AB+	.000	.0%	.010	.0%	-.010	-.101
	22.00	O+	.000	.0%	.268	.3%	-.268	-.517
		A+	.000	.0%	.146	.1%	-.146	-.383
		B+	1.000	1.0%	.076	.1%	.924	3.358
		AB+	.000	.0%	.010	.0%	-.010	-.101
	23.00	O+	1.000	1.0%	1.071	1.1%	-.071	-.068
		A+	.000	.0%	.586	.6%	-.586	-.765
		B+	.000	.0%	.303	.3%	-.303	-.550
		AB+	.000	.0%	.040	.0%	-.040	-.201
	24.00	O+	1.000	1.0%	.803	.8%	.197	.220
		A+	.000	.0%	.439	.4%	-.439	-.663
		B+	.000	.0%	.227	.2%	-.227	-.477
		AB+	.000	.0%	.030	.0%	-.030	-.174
	25.00	O+	.000	.0%	.268	.3%	-.268	-.517
		A+	.000	.0%	.146	.1%	-.146	-.383
		B+	1.000	1.0%	.076	.1%	.924	3.358
		AB+	.000	.0%	.010	.0%	-.010	-.101
	26.00	O+	1.000	1.0%	2.141	2.2%	-1.141	-.780
		A+	1.000	1.0%	1.172	1.2%	-.172	-.159
		B+	1.000	1.0%	.606	.6%	.394	.506
		AB+	.000	.0%	.081	.1%	-.081	-.284
	27.00	O+	2.000	2.0%	1.874	1.9%	.126	.092
		A+	1.000	1.0%	1.025	1.0%	-.025	-.025
		B+	1.000	1.0%	.530	.5%	.470	.645
		AB+	1.000	1.0%	.071	.1%	.929	3.495
	28.00	O+	3.000	3.0%	2.409	2.4%	.591	.381
		A+	1.000	1.0%	1.318	1.3%	-.318	-.277
		B+	1.000	1.0%	.682	.7%	.318	.385
		AB+	.000	.0%	.091	.1%	-.091	-.302
	29.00	O+	.000	.0%	1.874	1.9%	-1.874	-1.369
		A+	2.000	2.0%	1.025	1.0%	.975	.963
		B+	2.000	2.0%	.530	.5%	1.470	2.018

	AB+	.000	.0%	.071	.1%	-.071	-.266
30.00	O+	4.000	4.0%	2.944	3.0%	1.056	.615
	A+	3.000	3.0%	1.611	1.6%	1.389	1.094
	B+	.000	.0%	.833	.8%	-.833	-.913
	AB+	.000	.0%	.111	.1%	-.111	-.333
31.00	O+	3.000	3.0%	1.606	1.6%	1.394	1.100
	A+	1.000	1.0%	.879	.9%	.121	.129
	B+	.000	.0%	.455	.5%	-.455	-.674
	AB+	.000	.0%	.061	.1%	-.061	-.246
32.00	O+	3.000	3.0%	1.874	1.9%	1.126	.823
	A+	1.000	1.0%	1.025	1.0%	-.025	-.025
	B+	1.000	1.0%	.530	.5%	.470	.645
	AB+	.000	.0%	.071	.1%	-.071	-.266
33.00	O+	4.000	4.0%	1.874	1.9%	2.126	1.553
	A+	1.000	1.0%	1.025	1.0%	-.025	-.025
	B+	.000	.0%	.530	.5%	-.530	-.728
	AB+	.000	.0%	.071	.1%	-.071	-.266
34.00	O+	2.000	2.0%	1.338	1.4%	.662	.572
	A+	1.000	1.0%	.732	.7%	.268	.313
	B+	.000	.0%	.379	.4%	-.379	-.615
	AB+	.000	.0%	.051	.1%	-.051	-.225
35.00	O+	2.000	2.0%	.803	.8%	1.197	1.336
	A+	.000	.0%	.439	.4%	-.439	-.663
	B+	.000	.0%	.227	.2%	-.227	-.477
	AB+	.000	.0%	.030	.0%	-.030	-.174
36.00	O+	1.000	1.0%	.803	.8%	.197	.220
	A+	.000	.0%	.439	.4%	-.439	-.663
	B+	1.000	1.0%	.227	.2%	.773	1.621
	AB+	.000	.0%	.030	.0%	-.030	-.174
37.00	O+	.000	.0%	.268	.3%	-.268	-.517
	A+	.000	.0%	.146	.1%	-.146	-.383
	B+	.000	.0%	.076	.1%	-.076	-.275
	AB+	.000	.0%	.010	.0%	-.010	-.101
38.00	O+	1.000	1.0%	.268	.3%	.732	1.415
	A+	.000	.0%	.146	.1%	-.146	-.383
	B+	.000	.0%	.076	.1%	-.076	-.275
	AB+	.000	.0%	.010	.0%	-.010	-.101
39.00	O+	1.000	1.0%	.535	.5%	.465	.635
	A+	.000	.0%	.293	.3%	-.293	-.541
	B+	.000	.0%	.152	.2%	-.152	-.389
	AB+	.000	.0%	.020	.0%	-.020	-.142
40.00	O+	.000	.0%	.268	.3%	-.268	-.517
	A+	.000	.0%	.146	.1%	-.146	-.383
	B+	.000	.0%	.076	.1%	-.076	-.275
	AB+	.000	.0%	.010	.0%	-.010	-.101
41.00	O+	.000	.0%	.268	.3%	-.268	-.517
	A+	.000	.0%	.146	.1%	-.146	-.383
	B+	.000	.0%	.076	.1%	-.076	-.275

		AB+	.000	.0%	.010	.0%	-.010	-.101
	42.00	O+	.000	.0%	.000	.0%	.000	.000
		A+	.000	.0%	.000	.0%	.000	.000
		B+	.000	.0%	.000	.0%	.000	.000
		AB+	.000	.0%	.000	.0%	.000	.000
	43.00	O+	1.000	1.0%	.803	.8%	.197	.220
		A+	1.000	1.0%	.439	.4%	.561	.846
		B+	.000	.0%	.227	.2%	-.227	-.477
		AB+	.000	.0%	.030	.0%	-.030	-.174
	44.00	O+	.000	.0%	.000	.0%	.000	.000
		A+	.000	.0%	.000	.0%	.000	.000
		B+	.000	.0%	.000	.0%	.000	.000
		AB+	.000	.0%	.000	.0%	.000	.000
	45.00	O+	1.000	1.0%	.535	.5%	.465	.635
		A+	1.000	1.0%	.293	.3%	.707	1.306
		B+	.000	.0%	.152	.2%	-.152	-.389
		AB+	.000	.0%	.020	.0%	-.020	-.142
	46.00	O+	1.000	1.0%	.268	.3%	.732	1.415
		A+	.000	.0%	.146	.1%	-.146	-.383
		B+	.000	.0%	.076	.1%	-.076	-.275
		AB+	.000	.0%	.010	.0%	-.010	-.101
FEMALE	19.00	O+	.000	.0%	.535	.5%	-.535	-.732
		A+	2.000	2.0%	.293	.3%	1.707	3.154
		B+	.000	.0%	.152	.2%	-.152	-.389
		AB+	.000	.0%	.020	.0%	-.020	-.142
	20.00	O+	2.000	2.0%	.535	.5%	1.465	2.002
		A+	.000	.0%	.293	.3%	-.293	-.541
		B+	.000	.0%	.152	.2%	-.152	-.389
		AB+	.000	.0%	.020	.0%	-.020	-.142
	21.00	O+	.000	.0%	.268	.3%	-.268	-.517
		A+	.000	.0%	.146	.1%	-.146	-.383
		B+	.000	.0%	.076	.1%	-.076	-.275
		AB+	.000	.0%	.010	.0%	-.010	-.101
	22.00	O+	.000	.0%	.268	.3%	-.268	-.517
		A+	.000	.0%	.146	.1%	-.146	-.383
		B+	.000	.0%	.076	.1%	-.076	-.275
		AB+	.000	.0%	.010	.0%	-.010	-.101
	23.00	O+	1.000	1.0%	1.071	1.1%	-.071	-.068
		A+	2.000	2.0%	.586	.6%	1.414	1.848
		B+	.000	.0%	.303	.3%	-.303	-.550
		AB+	.000	.0%	.040	.0%	-.040	-.201
	24.00	O+	2.000	2.0%	.803	.8%	1.197	1.336
		A+	.000	.0%	.439	.4%	-.439	-.663
		B+	.000	.0%	.227	.2%	-.227	-.477
		AB+	.000	.0%	.030	.0%	-.030	-.174
	25.00	O+	.000	.0%	.268	.3%	-.268	-.517
		A+	.000	.0%	.146	.1%	-.146	-.383
		B+	.000	.0%	.076	.1%	-.076	-.275
		AB+	.000	.0%	.010	.0%	-.010	-.101
	26.	O+	1.000	1.0%	2.141	2.2%	-1.141	-.780

00	A+	3.000	3.0%	1.172	1.2%	1.828	1.689
	B+	1.000	1.0%	.606	.6%	.394	.506
	AB+	.000	.0%	.081	.1%	-.081	-.284
27.00	O+	.000	.0%	1.874	1.9%	-1.874	-1.369
	A+	1.000	1.0%	1.025	1.0%	-.025	-.025
	B+	.000	.0%	.530	.5%	-.530	-.728
	AB+	1.000	1.0%	.071	.1%	.929	3.495
28.00	O+	2.000	2.0%	2.409	2.4%	-.409	-.264
	A+	.000	.0%	1.318	1.3%	-1.318	-1.148
	B+	2.000	2.0%	.682	.7%	1.318	1.596
	AB+	.000	.0%	.091	.1%	-.091	-.302
29.00	O+	1.000	1.0%	1.874	1.9%	-.874	-.638
	A+	2.000	2.0%	1.025	1.0%	.975	.963
	B+	.000	.0%	.530	.5%	-.530	-.728
	AB+	.000	.0%	.071	.1%	-.071	-.266
30.00	O+	2.000	2.0%	2.944	3.0%	-.944	-.550
	A+	1.000	1.0%	1.611	1.6%	-.611	-.481
	B+	1.000	1.0%	.833	.8%	.167	.183
	AB+	.000	.0%	.111	.1%	-.111	-.333
31.00	O+	2.000	2.0%	1.606	1.6%	.394	.311
	A+	.000	.0%	.879	.9%	-.879	-.937
	B+	.000	.0%	.455	.5%	-.455	-.674
	AB+	.000	.0%	.061	.1%	-.061	-.246
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	A+	2.000	2.0%	1.025	1.0%	.975	.963
	B+	.000	.0%	.530	.5%	-.530	-.728
	AB+	.000	.0%	.071	.1%	-.071	-.266
33.00	O+	1.000	1.0%	1.874	1.9%	-.874	-.638
	A+	1.000	1.0%	1.025	1.0%	-.025	-.025
	B+	.000	.0%	.530	.5%	-.530	-.728
	AB+	.000	.0%	.071	.1%	-.071	-.266
34.00	O+	.000	.0%	1.338	1.4%	-1.338	-1.157
	A+	1.000	1.0%	.732	.7%	.268	.313
	B+	1.000	1.0%	.379	.4%	.621	1.009
	AB+	.000	.0%	.051	.1%	-.051	-.225
35.00	O+	1.000	1.0%	.803	.8%	.197	.220
	A+	.000	.0%	.439	.4%	-.439	-.663
	B+	.000	.0%	.227	.2%	-.227	-.477
	AB+	.000	.0%	.030	.0%	-.030	-.174
36.00	O+	1.000	1.0%	.803	.8%	.197	.220
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	B+	.000	.0%	.227	.2%	-.227	-.477
	AB+	.000	.0%	.030	.0%	-.030	-.174
37.00	O+	1.000	1.0%	.268	.3%	.732	1.415
	A+	.000	.0%	.146	.1%	-.146	-.383
	B+	.000	.0%	.076	.1%	-.076	-.275
	AB+	.000	.0%	.010	.0%	-.010	-.101
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	A+	.000	.0%	.146	.1%	-.146	-.383
	B+	.000	.0%	.076	.1%	-.076	-.275
	AB+	.000	.0%	.010	.0%	-.010	-.101
39.	O+	1.000	1.0%	.535	.5%	.465	.635

	00	A+	.000	.0%	.293	.3%	-.293	-.541
		B+	.000	.0%	.152	.2%	-.152	-.389
		AB+	.000	.0%	.020	.0%	-.020	-.142
	40.00	O+	.000	.0%	.268	.3%	-.268	-.517
		A+	.000	.0%	.146	.1%	-.146	-.383
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		B+	.000	.0%	.076	.1%	-.076	-.275
		AB+	.000	.0%	.010	.0%	-.010	-.101
	42.00	O+	.000	.0%	.000	.0%	.000	.000
		A+	.000	.0%	.000	.0%	.000	.000
		B+	.000	.0%	.000	.0%	.000	.000
		AB+	.000	.0%	.000	.0%	.000	.000
	43.00	O+	1.000	1.0%	.803	.8%	.197	.220
		A+	.000	.0%	.439	.4%	-.439	-.663
		B+	.000	.0%	.227	.2%	-.227	-.477
		AB+	.000	.0%	.030	.0%	-.030	-.174
	44.00	O+	.000	.0%	.000	.0%	.000	.000
		A+	.000	.0%	.000	.0%	.000	.000
		B+	.000	.0%	.000	.0%	.000	.000
		AB+	.000	.0%	.000	.0%	.000	.000
	45.00	O+	.000	.0%	.535	.5%	-.535	-.732
		A+	.000	.0%	.293	.3%	-.293	-.541
		B+	.000	.0%	.152	.2%	-.152	-.389
		AB+	.000	.0%	.020	.0%	-.020	-.142
	46.00	O+	.000	.0%	.268	.3%	-.268	-.517
		A+	.000	.0%	.146	.1%	-.146	-.383
		B+	.000	.0%	.076	.1%	-.076	-.275
		AB+	.000	.0%	.010	.0%	-.010	-.101

Goodness-of-Fit Tests

	Chi-Square	df	Sig.
Likelihood Ratio	122.948	193	1.000
Pearson	153.003	193	.985

a. Model: Poisson

b. Design: Constant + SEX + AGE + BLOODGROUP + SEX * AGE + SEX * BLOODGROUP + AGE * BLOODGROUP + SEX * AGE * BLOODGROUP

K-Way and Higher-Order Effects

	K	Df	Likelihood Ratio		Pearson		Number of Iterations
			Chi-Square	Sig.	Chi-Square	Sig.	
K-way and Higher Order Effects[a]	1	223	258.400	.052	315.061	.000	0
	2	192	120.666	1.000	154.615	.978	2
	3	81	23.260	1.000	18.183	1.000	4
K-way Effects[b]	1	31	137.734	.000	160.445	.000	0
	2	111	97.407	.818	136.432	.051	0
	3	81	23.260	1.000	18.183	1.000	0

df used for these tests have NOT been adjusted for structural or sampling zeros. Tests using these df may be conservative.

a. Tests that k-way and higher order effects are zero.

Goodness-of-Fit Tests

	Chi-Square	df	Sig.
Likelihood Ratio	122.948	193	1.000

b. Tests that k-way effects are zero.

Partial Associations

Effect	df	Partial Chi-Square	Sig.	Number of Iterations
SEX*AGE	27	26.476	.492	2
SEX*BLOODGROUP	3	2.068	.558	2
AGE*BLOODGROUP	81	69.842	.807	2
SEX	1	2.282	.131	2
AGE	27	70.631	.000	2
BLOODGROUP	3	64.821	.000	2

Parameter Estimates

fect	ıramete	Estimate	Std. Error	Z	Sig.	95% Confidence Interval	
						ower Bound	Jpper Bound
:X*AGE*BLOODG ƆUP		.125	.831	.150	.880	-1.504	1.753
		-.566	.713	-.795	.427	-1.963	.830
		.191	.834	.229	.819	-1.443	1.826
		-.680	.710	-.957	.339	-2.072	.713
		.238	.833	.286	.775	-1.394	1.870
		.191	.834	.229	.819	-1.443	1.826
		.336	.734	.457	.648	-1.104	1.775
		-.100	.835	-.120	.904	-1.737	1.537
		-.147	.836	-.176	.860	-1.786	1.492
	)	-.214	.833	-.256	.798	-1.847	1.420
	.	-.100	.835	-.120	.904	-1.737	1.537
	!	.402	.738	.545	.586	-1.044	1.848
	}	.125	.585	.214	.831	-1.022	1.271
	⊦	-.566	.685	-.827	.408	-1.909	.776
	;	.191	.810	.236	.813	-1.397	1.779
	;	-.268	.575	-.466	.641	-1.395	.859
	'	.101	.821	.123	.902	-1.508	1.710
	}	.054	.822	.066	.948	-1.557	1.665
	)	-.214	.833	-.256	.798	-1.847	1.420
	)	-.100	.835	-.120	.904	-1.737	1.537
	.	.402	.738	.545	.586	-1.044	1.848
	!	.030	.531	.056	.955	-1.012	1.071
	}	-.281	.491	-.571	.568	-1.244	.682
	⊦	.096	.536	.179	.858	-.955	1.147
	;	.390	.639	.611	.541	-.862	1.642
	;	-.301	.536	-.562	.574	-1.352	.749
	'	.201	.666	.302	.763	-1.105	1.507
	}	-.024	.468	-.050	.960	-.941	.893
	)	.471	.672	.700	.484	-.847	1.789
	)	-.381	.518	-.736	.462	-1.395	.634
	.	-.689	.685	-1.006	.315	-2.033	.654

2	-.027	.506	-.053	.958	-1.019	.965
3	.731	.666	1.097	.272	-.575	2.037
4	.176	.457	.384	.701	-.720	1.072
5	.419	.500	.837	.403	-.562	1.399
6	-.601	.672	-.895	.371	-1.918	.715
7	-.087	.511	-.171	.864	-1.090	.915
8	.407	.703	.579	.563	-.971	1.785
9	-.189	.807	-.235	.815	-1.771	1.392
0	.580	.654	.887	.375	-.702	1.862
1	-.535	.538	-.994	.320	-1.589	.519
2	.223	.691	.323	.747	-1.131	1.576
3	.336	.518	.648	.517	-.680	1.352
4	-.100	.569	-.176	.860	-1.215	1.014
5	-.147	.797	-.185	.853	-1.709	1.414
6	.665	.668	.994	.320	-.645	1.974
7	-.027	.571	-.047	.963	-1.146	1.092
8	-.623	.695	-.897	.370	-1.984	.738
9	.115	.575	.201	.841	-1.012	1.242
0	-.027	.821	-.033	.974	-1.636	1.583
1	-.074	.822	-.090	.929	-1.685	1.538
2	-.214	.588	-.363	.717	-1.367	.939
3	-.100	.812	-.123	.902	-1.691	1.490
4	.402	.711	.566	.572	-.992	1.796
5	-.488	.734	-.665	.506	-1.928	.951
6	.174	.835	.209	.835	-1.462	1.811
7	.127	.836	.152	.879	-1.511	1.766
8	.336	.734	.457	.648	-1.104	1.775
9	-.100	.835	-.120	.904	-1.737	1.537
0	-.147	.836	-.176	.860	-1.786	1.492
1	-.076	.604	-.126	.900	-1.261	1.109
2	.037	.823	.045	.964	-1.577	1.651
3	-.010	.824	-.012	.990	-1.626	1.606
4	.061	.833	.073	.942	-1.572	1.694
5	.174	.835	.209	.835	-1.462	1.811
6	-.422	.738	-.572	.567	-1.868	1.024
7	-.488	.734	-.665	.506	-1.928	.951
8	.174	.835	.209	.835	-1.462	1.811
9	.127	.836	.152	.879	-1.511	1.766
0	-.076	.845	-.090	.928	-1.732	1.579
1	.037	.847	.044	.965	-1.622	1.696
2	-.010	.848	-.012	.991	-1.671	1.651
3	-.214	.588	-.363	.717	-1.367	.939
4	.449	.710	.633	.527	-.942	1.840
5	-.147	.813	-.181	.856	-1.740	1.446
6	-.076	.845	-.090	.928	-1.732	1.579
7	.037	.847	.044	.965	-1.622	1.696
8	-.010	.848	-.012	.991	-1.671	1.651
9	.198	.721	.275	.783	-1.215	1.612

	.312	.723	.431	.666	-1.106	1.730
	-.285	.824	-.345	.730	-1.900	1.331
X*AGE	-.250	.465	-.538	.590	-1.161	.661
	-.250	.465	-.538	.590	-1.161	.661
	.088	.469	.188	.851	-.831	1.007
	.088	.469	.188	.851	-.831	1.007
	-.250	.421	-.594	.552	-1.075	.575
	-.113	.443	-.255	.799	-.982	.756
	.088	.469	.188	.851	-.831	1.007
	-.155	.343	-.452	.651	-.827	.517
	.290	.345	.839	.402	-.387	.966
	.067	.359	.185	.853	-.638	.771
	.015	.387	.038	.969	-.745	.774
	-.007	.356	-.019	.984	-.704	.690
	.130	.414	.315	.753	-.682	.943
	.268	.390	.686	.493	-.497	1.033
	.088	.394	.224	.823	-.684	.861
	.015	.397	.037	.970	-.764	.794
	.015	.443	.034	.973	-.854	.884
	.088	.426	.208	.836	-.746	.922
	-.186	.469	-.397	.691	-1.105	.733
	.088	.469	.188	.851	-.831	1.007
	-.049	.448	-.109	.913	-.926	.829
	-.186	.469	-.397	.691	-1.105	.733
	-.186	.469	-.397	.691	-1.105	.733
	-.049	.489	-.100	.920	-1.007	.909
	.088	.426	.208	.836	-.746	.922
	-.049	.489	-.100	.920	-1.007	.909
	.226	.448	.504	.614	-.652	1.103
X*BLOODGROUP	.076	.131	.582	.561	-.181	.333
	-.037	.142	-.261	.794	-.316	.242
	.010	.148	.067	.947	-.281	.301
E*BLOODGROUP	-.610	.831	-.734	.463	-2.238	1.019
	.532	.713	.746	.456	-.865	1.928
	-.078	.834	-.094	.925	-1.712	1.556
	.195	.710	.274	.784	-1.197	1.587
	-.273	.833	-.328	.743	-1.905	1.359
	-.078	.834	-.094	.925	-1.712	1.556
	.003	.734	.005	.996	-1.436	1.443
	-.209	.835	-.250	.802	-1.846	1.428
	-.014	.836	-.017	.986	-1.653	1.625
	-.546	.833	-.655	.512	-2.179	1.087
	-.209	.835	-.250	.802	-1.846	1.428
	.535	.738	.725	.468	-.911	1.981
	.214	.585	.366	.714	-.932	1.361
	.257	.685	.375	.707	-1.085	1.599
	-.353	.810	-.435	.663	-1.941	1.235
	.607	.575	1.056	.291	-.520	1.734
	-.410	.821	-.500	.617	-2.020	1.199
	-.215	.822	-.262	.793	-1.827	1.396
	-.546	.833	-.655	.512	-2.179	1.087

-.209	.835	-.250	.802	-1.846	1.428
.535	.738	.725	.468	-.911	1.981
-.240	.531	-.451	.652	-1.282	.802
.521	.491	1.060	.289	-.442	1.483
.292	.536	.545	.586	-.759	1.342
-.492	.639	-.770	.441	-1.744	.760
.139	.536	.259	.795	-.911	1.189
-.215	.666	-.323	.746	-1.521	1.090
.449	.468	.959	.337	-.468	1.366
-.443	.672	-.659	.510	-1.760	.875
.557	.518	1.076	.282	-.458	1.572
-.600	.685	-.876	.381	-1.944	.743
.797	.506	1.574	.116	-.195	1.789
.187	.666	.281	.779	-1.119	1.493
.501	.457	1.096	.273	-.395	1.397
.457	.500	.913	.361	-.524	1.437
-.321	.672	-.478	.632	-1.638	.995
.787	.511	1.540	.124	-.215	1.790
-.104	.703	-.148	.882	-1.483	1.274
-.459	.807	-.568	.570	-2.040	1.123
-.155	.654	-.236	.813	-1.437	1.127
.563	.538	1.047	.295	-.491	1.618
-.047	.691	-.067	.946	-1.400	1.307
.553	.518	1.066	.286	-.463	1.569
.340	.569	.598	.550	-.774	1.455
-.563	.797	-.707	.479	-2.125	.998
-.217	.668	-.325	.745	-1.527	1.093
.414	.571	.725	.469	-.705	1.533
.059	.695	.085	.932	-1.302	1.421
.607	.575	1.056	.291	-.520	1.734
-.410	.821	-.500	.617	-2.020	1.199
-.215	.822	-.262	.793	-1.827	1.396
.278	.588	.473	.636	-.875	1.431
-.484	.812	-.596	.551	-2.074	1.107
.260	.711	.366	.714	-1.133	1.654
.003	.734	.005	.996	-1.436	1.443
-.209	.835	-.250	.802	-1.846	1.428
-.014	.836	-.017	.986	-1.653	1.625
.003	.734	.005	.996	-1.436	1.443
-.209	.835	-.250	.802	-1.846	1.428
-.014	.836	-.017	.986	-1.653	1.625
.415	.604	.687	.492	-.769	1.600
-.346	.823	-.421	.674	-1.960	1.267
-.151	.824	-.184	.854	-1.767	1.464
-.546	.833	-.655	.512	-2.179	1.087
-.209	.835	-.250	.802	-1.846	1.428
.535	.738	.725	.468	-.911	1.981
.003	.734	.005	.996	-1.436	1.443
-.209	.835	-.250	.802	-1.846	1.428
-.014	.836	-.017	.986	-1.653	1.625
-.409	.845	-.484	.629	-2.064	1.247
-.072	.847	-.085	.932	-1.731	1.587

2	.123	.848	.145	.884	-1.538	1.784
3	.278	.588	.473	.636	-.875	1.431
4	.066	.710	.092	.926	-1.326	1.457
5	-.289	.813	-.355	.722	-1.882	1.304
6	-.409	.845	-.484	.629	-2.064	1.247
7	-.072	.847	-.085	.932	-1.731	1.587
8	.123	.848	.145	.884	-1.538	1.784
9	-.134	.721	-.186	.853	-1.547	1.280
0	.203	.723	.280	.779	-1.215	1.621
1	-.151	.824	-.184	.854	-1.767	1.464
EX	.049	.084	.586	.558	-.115	.213
GE	-.195	.465	-.420	.674	-1.106	.715
	-.195	.465	-.420	.674	-1.106	.715
	-.259	.469	-.553	.580	-1.178	.660
	-.259	.469	-.553	.580	-1.178	.660
	.079	.421	.189	.850	-.746	.905
	-.058	.443	-.131	.896	-.927	.811
	-.259	.469	-.553	.580	-1.178	.660
	.533	.343	1.556	.120	-.139	1.205
	.491	.345	1.423	.155	-.185	1.168
0	.524	.359	1.458	.145	-.181	1.228
1	.344	.387	.889	.374	-.415	1.104
2	.597	.356	1.679	.093	-.100	1.295
3	.185	.414	.447	.655	-.627	.997
4	.323	.390	.827	.408	-.442	1.088
5	.290	.394	.736	.461	-.482	1.063
6	.217	.397	.545	.585	-.562	.996
7	-.058	.443	-.131	.896	-.927	.811
8	.016	.426	.037	.971	-.819	.850
9	-.259	.469	-.553	.580	-1.178	.660
0	-.259	.469	-.553	.580	-1.178	.660
1	-.122	.448	-.272	.786	-.999	.756
2	-.259	.469	-.553	.580	-1.178	.660
3	-.259	.469	-.553	.580	-1.178	.660
4	-.396	.489	-.811	.418	-1.355	.562
5	.016	.426	.037	.971	-.819	.850
6	-.396	.489	-.811	.418	-1.355	.562
7	-.122	.448	-.272	.786	-.999	.756
OODGROUP	.409	.131	3.119	.002	.152	.665
	.072	.142	.504	.614	-.207	.351
	-.123	.148	-.830	.406	-.414	.168

Backward Elimination Statistics

Step Summary

Step[a]			Effects	Chi-Square[c]	df	Sig.	Number of Iterations
0	Generating Class[b]		SEX*AGE*BLOODGROUP	.000	0	.	
	Deleted Effect	1	SEX*AGE*BLOODGROUP	23.260	81	1.000	4
1	Generating Class[b]		SEX*AGE, SEX*BLOODGROUP, AGE*BLOODGROUP	23.260	81	1.000	
	Deleted Effect	1	SEX*AGE	26.476	27	.492	2
		2	SEX*BLOODGROUP	2.068	3	.558	2

		3	AGE*BLOODGROUP	69.842	81	.807	2
2	Generating Class[b]		SEX*AGE, SEX*BLOODGROUP	93.101	162	1.000	
	Deleted Effect	1	SEX*AGE	25.987	27	.519	2
		2	SEX*BLOODGROUP	1.578	3	.664	2
3	Generating Class[b]		SEX*AGE, BLOODGROUP	94.680	165	1.000	
	Deleted Effect	1	SEX*AGE	25.987	27	.519	2
		2	BLOODGROUP	64.821	3	.000	2
4	Generating Class[b]		BLOODGROUP, SEX, AGE	120.666	192	1.000	
	Deleted Effect	1	BLOODGROUP	64.821	3	.000	2
		2	SEX	2.282	1	.131	2
		3	AGE	70.631	27	.000	2
5	Generating Class[b]		BLOODGROUP, AGE	122.948	193	1.000	
	Deleted Effect	1	BLOODGROUP	64.821	3	.000	2
		2	AGE	70.631	27	.000	2
6	Generating Class[b]		BLOODGROUP, AGE	122.948	193	1.000	

a. At each step, the effect with the largest significance level for the Likelihood Ratio Change is deleted, provided the significance level is larger than .050.

b. Statistics are displayed for the best model at each step after step 0.

c. For 'Deleted Effect', this is the change in the Chi-Square after the effect is deleted from the model.

Convergence Information[a]

Generating Class	BLOODGROUP, AGE
Number of Iterations	0
Max. Difference between Observed and Fitted Marginals	.000
Convergence Criterion	.250

a. Statistics for the final model after Backward Elimination.

Discussion:

The standardized residual show the presence of few outlier cells. The peason chi- Square test confirms that the following variables are indeed related (associated).

Age and Sex, Age and Blood Group and Sex and Blood Group.

The model showed that an interaction between age and blood group is significant, meaning one age dominates a particular blood group. Though this could be due to population from which the sample was taken. The age is dominated by working population.

There is also a relationship between blood group and sex, and finally the age and sex is significant too.

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APPENDIX

MEDICAL DATA

S/N	SEX	AGE	BLOOD GROUP
1.	M	24	0^+
2.	M	27	A^+
3.	F	26	A^+

4.	M	30	A^+
5.	F	33	0^+
6.	F	35	0^+
7.	F	26	A^+
8.	M	30	0^+
9.	M	28	0^+
10.	M	35	0^+
11.	F	28	0^+
12.	M	36	B^+
13.	M	45	0^-
14.	F	23	0^+
15.	F	30	A^+
16.	F	20	0^+
17.	F	19	A^+
18.	F	19	A^+
19.	F	23	A^+
20.	M	30	A^+
21.	M	28	A^+
22.	F	20	0^+
23.	M	35	0^+
24.	M	32	0^+
25.	M	46	0^+
26.	M	32	B^+
27.	M	21	0^+
28.	M	33	0^+
29.	F	28	B^+
30.	M	36	0^+
31.	M	34	0^+
32.	F	26	A^+
33.	F	27	A^+
34.	M	22	B^+
35.	F	40	B^+
36.	F	37	0^+
37.	M	25	B^+
38.	F	32	A^+
39.	F	28	0^+
40.	F	28	B^+
41.	F	29	0^+
42.	F	41	0^+
43.	F	43	0^+
44.	M	33	A^+
45.	F	29	A^+
46.	F	39	0^+
47.	F	31	0^+
48.	F	24	0^+
49.	M	30	A^+
50.	M	32	A^+
51.	M	28	0^+
52.	M	33	0^+
53.	M	31	A^+
54.	M	30	0^+
55.	M	27	AB^+
56.	F	30	0^+
57.	M	38	0^+
58.	M	27	0^+
59.	M	45	A^+
60.	M	43	0^+

61.	F	30	0^+
62.	F	34	B^+
63.	F	27	AB^+
64.	M	33	0^+
65.	M	30	0^+
66.	F	31	0^+
67.	F	34	A^+
68.	M	28	0^+
69.	F	30	B^+
70.	M	33	0^+
71.	F	33	A^+
72.	M	43	A^+
73.	M	48	0^+
74.	M	23	0^+
75.	M	34	A^+
76.	M	26	0^+
77.	F	24	0^+
78.	M	27	B^+
79.	F	36	0^+
80.	M	31	0^+
81.	M	27	0^+
82.	M	30	0^+
83.	M	29	B^+
84.	M	26	A^+
85.	M	31	0^+
86.	M	29	A^+
87.	M	32	0^+
88.	M	31	0^+
89.	F	26	0^+
90.	M	29	B^+
91.	F	32	A^+
92.	M	34	0^+
93.	M	29	A^+
94.	F	29	A^+
95.	M	28	B^+
96.	M	26	B^+
97.	F	23	A^+
98.	M	39	0^+
99.	M	32	0^+
100.	F	26	B^+