SESSION 5 – SOLUTIONS

PROPORTIONAL ODDS MODELLING PRACTICAL

1) **Testing for Treatment effect**

Model 1 fits a proportional odds model involving only the factor DRUG.

(a) Looking at the likelihood ratio test, is the drug effect statistically significant?

From the output Model 1 gives

Diff (–2 Log L) = 661.196 – 653.416 = 7.780, $\chi^2(1)$, p = 0.0053

$\therefore$ significant difference between the treatments.

(b) Using the parameter estimate calculate the odds ratio (Painendil : Control). Does your value imply an advantage or disadvantage for the Painendil group?

$\hat{\theta} = \widehat{DRUG} = 0.6501$

Odds ratio (Painendil : Control): $\psi = e^{\hat{\theta}}$
$= e^{0.6501}$
$= 1.916$

$\psi > 1$ therefore Painendil is more advantageous than control.

(c) Calculate a 95% confidence interval for this odds ratio.

$\hat{\theta} = 0.6501 \qquad se(\hat{\theta}) = 0.2347$

95% C.I. for $\hat{\theta}$: $[\hat{\theta} \pm 1.96\, se(\hat{\theta})]$

$= [0.6501 \pm 1.96\,(0.2347)]$

$= [0.190 \;,\; 1.110]$

95% C.I. for $\hat{\psi}$: $\exp[\hat{\theta} \pm 1.96\, se(\hat{\theta})]$

$= [1.209 \;,\; 3.035]$

2) **Studying a combination of terms**

(a) *Model 2 fits AGE as a covariate. Is it a statistically significant predictor?*

Reduction in ($-2 \text{ Log } \hat{L}$) due to AGE = 77.747, $p < 0.0001$

(b) *Model 3 builds on model 2 and adds SEX to the model. Using -2LogLs calulate the influence of SEX on the pain score adjusted for age.*

Model AGE gives

$$-2 \text{ Log } \hat{L} = 583.449$$

Model AGE + SEX gives

$$-2 \text{ Log } \hat{L} = 577.078$$

Reduction in ($-2 \text{ Log } \hat{L}$) due to SEX (adjusted for age)

$$= 583.449 - 577.078 = 6.371$$

$\sim \chi_1^2$ highly significant

(c) *Model 4 fits AGE , SEX and DRUG. What is the odds ratio for a male patient relative to a female patient?*

Odds ratio = 0.534

Males are far more likely to experience more pain than females!

(d) *Using the parameter estimates from Model 4, calculate the odds ratio for a male patient aged 42 receiving Painendil to a male patient aged 58 receiving Control. Write down your conclusion.*

Model selected:

$$\log\left[\frac{Q_k(\underline{z}_i)}{1-Q_k(\underline{z}_i)}\right] = \alpha_k + \eta(\underline{z}_i), \quad k = 1,\ldots,m-1$$

where $\eta(\underline{z}_i) = \beta_1 z_{i1} + \beta_2 z_{i2} + \beta_3 z_{i3}$

$$\underline{z}_i' \equiv (z_{i1}, z_{i2}, z_{i3})$$

z_{i1} = age

$$z_{i2} = \begin{cases} 0: \text{ if sex} = 2 \text{ (Female)} \\ 1: \text{ if sex} = 1 \text{ (Male)} \end{cases}$$

$$z_{i3} = \begin{cases} 0: \text{ if drug} = 1 \text{ (Control)} \\ 1: \text{ if drug} = 2 \text{ (Painendil)} \end{cases}$$

For male patient, aged 42, receiving Painendil

$$\hat{\eta}(42,1,1) = \hat{\beta}_1 42 + \hat{\beta}_2 1 + \hat{\beta}_3 1$$

For male patient, aged 58, receiving Control

$$\hat{\eta}(58,1,0) = \hat{\beta}_1 58 + \hat{\beta}_2 1 + \hat{\beta}_3 0$$

Log odds ratio (male, 42, Painendil) relative to (male, 58, Control)

$$= \hat{\eta}(42,1,1) - \hat{\eta}(58,1,0)$$

$$= \hat{\beta}_1(42 - 58) + \hat{\beta}_3$$

$$= (-\,0.1197 \times -\,16) + 0.7347 = 2.6499$$

Odds ratio $= e^{\hat{\theta}} = e^{2.6499} = 14.15$

Male patient aged 42, receiving Painendil is far more likely to experience less pain.

3) **Fitted probabilities**

(a) Using the parameter estimates from Model 5 calculate the fitted probabilities for each age group and pain score.

To calculate the fitted probabilities

$\hat{\alpha}_1 = -\,3.3079$	Ageg 20-29 $= \hat{\beta}_1 = 3.3368$
$\hat{\alpha}_2 = -\,2.0611$	Ageg 30-39 $= \hat{\beta}_2 = 2.3385$
$\hat{\alpha}_3 = -\,0.3638$	Ageg 40-49 $= \hat{\beta}_3 = 1.3069$

$$\begin{aligned} \hat{Q}_1(20\text{-}29) &= P(C_1 \text{ or better ; } 20\text{-}29) \\ &= P(\text{None; } 20\text{-}29) \\ &= (1 + e^{-(\hat{\alpha}_1 + \hat{\beta}_1)})^{-1} \\ &= (1 + e^{-(-3.3079 + 3.3368)})^{-1} = 0.5072 \end{aligned}$$

$$\hat{Q}_2(20\text{-}29) = P(C_2 \text{ or better; } 20\text{-}29)$$
$$= P(\text{Slight or None; } 20\text{-}29)$$
$$= (1 + e^{-(\hat{\alpha}_2+\hat{\beta}_1)})^{-1}$$
$$= (1+e^{-(-2.0611+3.3368)})^{-1} = 0.7817$$

$$\hat{Q}_3(20\text{-}29) = P(C_3 \text{ or better; } 20\text{-}29)$$
$$= P(\text{Moderate, Slight or None; } 20\text{-}29)$$
$$= (1 + e^{-(\hat{\alpha}_3+\hat{\beta}_1)})^{-1}$$
$$= (1+e^{-(-0.3638+3.3368)})^{-1} = 0.9513$$

$$\hat{Q}_4(20\text{-}29) = P(C_4 \text{ or better; } 20\text{-}29)$$
$$= P(\text{Severe, Moderate, Slight or None; } 20\text{-}29)$$
$$= 1$$

$$\hat{Q}_1(30\text{-}39) = P(C_1 \text{ or better; } 30\text{-}39)$$
$$= (1 + e^{-(\hat{\alpha}_1+\hat{\beta}_2)})^{-1}$$
$$= (1 + e^{-(3.3079+2.3385)})^{-1} = 0.2750$$

$$\hat{Q}_2(30\text{-}39) = P(C_2 \text{ or better; } 30\text{-}39)$$
$$= (1 + e^{-(\hat{\alpha}_2+\hat{\beta}_2)})^{-1}$$
$$= (1 + e^{-(-2.0611+2.3385)})^{-1} = 0.5689$$

$$\hat{Q}_3(30\text{-}39) = P(C_3 \text{ or better; } 30\text{-}39)$$
$$= (1 + e^{-(\hat{\alpha}_3+\hat{\beta}_2)})^{-1}$$
$$= (1 + e^{-(-0.3638+2.3385)})^{-1} = 0.8781$$

$$\hat{Q}_4(30\text{-}39) = P(C_4 \text{ or better; } 30\text{-}39)$$
$$= 1$$

$$\hat{Q}_1(40\text{-}49) = P(C_1 \text{ or better; } 40\text{-}49)$$
$$= (1 + e^{-(\hat{\alpha}_1+\hat{\beta}_3)})^{-1}$$
$$= (1 + e^{-(-3.3079+1.3069)})^{-1} = 0.1191$$

$$\hat{Q}_2(40\text{-}49) = P(C_2 \text{ or better; } 40\text{-}49)$$
$$= (1 + e^{-(\hat{\alpha}_2+\hat{\beta}_3)})^{-1}$$
$$= (1 + e^{-(-2.0611+1.3069)})^{-1} = 0.3199$$

$$\hat{Q}_3(40\text{-}49) = P(C_3 \text{ or better; } 40\text{-}49)$$
$$= (1 + e^{-(\hat{\alpha}_3+\hat{\beta}_3)})^{-1}$$
$$= (1 + e^{-(-0.3638+1.3069)})^{-1} = 0.7197$$

$\hat{Q}_4(40\text{-}49) \quad = \ P(C_4 \text{ or better; } 40\text{-}49)$
$\quad = \ 1$

$\hat{Q}_1(50\text{-}59) \quad = \ P(C_1 \text{ or better; } 50\text{-}59)$
$\quad = \ (1 + e^{-(\hat{\alpha}_1)})^{-1}$
$\quad = \ (1 + e^{3.3079})^{-1} = 0.0353$

$\hat{Q}_2(50\text{-}59) \quad = \ P(C_2 \text{ or better; } 50\text{-}59)$
$\quad = \ (1 + e^{-(\hat{\alpha}_2)})^{-1}$
$\quad = \ (1 + e^{2.0611})^{-1} = 0.1129$

$\hat{Q}_3(50\text{-}59) \quad = \ P(C_3 \text{ or better; } 50\text{-}59)$
$\quad = \ (1 + e^{-(\hat{\alpha}_3)})^{-1}$
$\quad = \ (1 + e^{0.3638})^{-1} = 0.4100$

$\hat{Q}_4(50\text{-}59) \quad = \ P\ (C_4 \text{ or better; } 50\text{-}59)$
$\quad = \ 1$

(b) *Compare these fitted probabilities with the observed percentages in the cross-tabulation of AGEG by PAIN shown below.*

Table of ageg by pain					
ageg (Age of Patient - Grouped)	**pain (Pain score at 24 hrs)**				
Frequency (Row %)	**None**	**Slight**	**Moderate**	**Severe**	**Total**
20 - 29	25 50.00	15 30.00	7 14.00	3 6.00	50
30 - 39	21 25.30	25 30.12	31 37.35	6 7.23	83
40 - 49	11 14.67	13 17.33	29 38.67	22 29.33	75
50 - 59	2 6.25	4 12.50	6 18.75	20 62.50	32
Total	59	57	73	51	240

Fitted Proportions

Ageg	C_1 None	C_2 Slight	C_3 Moderate	C_4 Severe
20 - 29	0.5072	0.2745	0.1696	0.0487
30 - 39	0.2750	0.2939	0.3092	0.1219
40 - 49	0.1191	0.2008	0.3998	0.2803
50 - 59	0.0353	0.0776	0.2971	0.5900

Observed Proportions

Ageg	C_1 None	C_2 Slight	C_3 Moderate	C_4 Severe
20 - 29	0.5000	0.3000	0.1400	0.0600
30 - 39	0.2530	0.3012	0.3735	0.0723
40 - 49	0.1467	0.1733	0.3867	0.2933
50 - 59	0.0625	0.1250	0.1875	0.6250

Fitted proportions very close to observed proportions, apart from oldest age group.
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Appendix 1 - Solutions in SAS Output

Model 1: Testing for drug effect

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                      Model 1: Testing for drug effect

                           The LOGISTIC Procedure

                             Model Information

    Data Set                      WORK.POPAIN
    Response Variable             pain                Pain score at 24 hrs
    Number of Response Levels     4
    Model                         cumulative logit
    Optimization Technique        Fisher's scoring


                Number of Observations Read         240
                Number of Observations Used         240


                              Response Profile

                   Ordered                          Total
                     Value     pain             Frequency

                         1     None                    59
                         2     Slight                  57
                         3     Moderate                73
                         4     Severe                  51

      Probabilities modeled are cumulated over the lower Ordered Values.


                         Class Level Information

                                                Design
                   Class     Value            Variables

                   drug      Control                 0
                             Painendil               1


                         Model Convergence Status

              Convergence criterion (GCONV=1E-8) satisfied.


              Score Test for the Proportional Odds Assumption

                   Chi-Square       DF     Pr > ChiSq

                       1.9302        2         0.3809


                           Model Fit Statistics

                                                 Intercept
                                  Intercept            and
                 Criterion             Only     Covariates

                 AIC                667.196        661.416
                 SC                 677.638        675.339
                 -2 Log L           661.196        653.416
```

Model 1: Testing for drug effect

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	**7.7797**	**1**	**0.0053**
Score	7.7253	1	0.0054
Wald	7.6733	1	0.0056

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
drug	1	7.6733	0.0056

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	None	1	-1.4680	0.2000	53.8807	<.0001
Intercept	Slight	1	-0.3906	0.1768	4.8813	0.0271
Intercept	Moderate	1	1.0115	0.1894	28.5123	<.0001
drug	**Painendil**	**1**	**0.6501**	**0.2347**	7.6733	0.0056

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
drug Painendil vs Control	**1.916**	**1.209**	**3.035**

Model 2: Fit age

Model 2: Fit age

Number of Observations Read	240
Number of Observations Used	240

Response Profile

Ordered Value	pain	Total Frequency
1	None	59
2	Slight	57
3	Moderate	73
4	Severe	51

Probabilities modeled are cumulated over the lower Ordered Values.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	667.196	591.449
SC	677.638	605.371
-2 Log L	**661.196**	**583.449**

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	**77.7474**	**1**	**<.0001**
Score	65.5030	1	<.0001
Wald	68.2727	1	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept None	1	3.1126	0.5271	34.8715	<.0001
Intercept Slight	1	4.4183	0.5620	61.7995	<.0001
Intercept Moderate	1	6.1775	0.6299	96.1753	<.0001
age	1	-0.1170	0.0142	68.2727	<.0001

Model 3: Fit age and sex

Model 3: Fit age and sex

Number of Observations Read	240
Number of Observations Used	240

Response Profile

Ordered Value	pain	Total Frequency
1	None	59
2	Slight	57
3	Moderate	73
4	Severe	51

Probabilities modeled are cumulated over the lower Ordered Values.

Class Level Information

Class	Value	Design Variables
sex	Male	1
	Female	0

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	667.196	587.078
SC	677.638	604.482
-2 Log L	**661.196**	**577.078**

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	84.1177	2	<.0001
Score	69.8479	2	<.0001
Wald	72.8086	2	<.0001

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	None	1	3.5285	0.5579	40.0050	<.0001
Intercept	Slight	1	4.8806	0.5968	66.8718	<.0001
Intercept	Moderate	1	6.6374	0.6652	99.5521	<.0001
age		1	-0.1176	0.0142	68.3433	<.0001
sex	Male	1	-0.6431	0.2536	6.4287	0.0112

Model 4: Fit age, sex and drug

Model 4: Fit age, sex and drug

Number of Observations Read	240
Number of Observations Used	240

Response Profile

Ordered Value	pain	Total Frequency
1	None	59
2	Slight	57
3	Moderate	73
4	Severe	51

Probabilities modeled are cumulated over the lower Ordered Values.

Class Level Information

Class	Value	Design Variables
sex	Male	1
	Female	0
drug	Control	0
	Painendil	1

Score Test for the Proportional Odds Assumption

Chi-Square	DF	Pr > ChiSq
21.0295	6	0.0018

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	667.196	579.940
SC	677.638	600.824
-2 Log L	661.196	567.940

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	93.2563	3	<.0001
Score	77.1117	3	<.0001
Wald	77.0909	3	<.0001

Model 4: Fit age, sex and drug

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
age	1	69.0338	<.0001
sex	1	6.0508	0.0139
drug	1	8.9761	0.0027

Analysis of Maximum Likelihood Estimates

Parameter			DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	None		1	3.2056	0.5671	31.9584	<.0001
Intercept	Slight		1	4.5883	0.6036	57.7912	<.0001
Intercept	Moderate		1	6.3763	0.6687	90.9256	<.0001
age		$\hat{\beta}_1$	1	**-0.1197**	0.0144	69.0338	<.0001
sex	Male	$\hat{\beta}_2$	1	**-0.6277**	0.2552	6.0508	0.0139
drug	Painendil	$\hat{\beta}_3$	1	**0.7347**	0.2452	8.9761	0.0027

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
age	0.887	0.863	0.913
sex Male vs Female	**0.534**	**0.324**	**0.880**
drug Painendil vs Control	2.085	1.289	3.371

Model 5: Fit only age as a factor

Model 5: Fit only age as a factor

Number of Observations Read	240
Number of Observations Used	240

Response Profile

Ordered Value	pain	Total Frequency
1	None	59
2	Slight	57
3	Moderate	73
4	Severe	51

Probabilities modeled are cumulated over the lower Ordered Values.

Class Level Information

Class	Value	Design Variables		
ageg	20 - 29	1	0	0
	30 - 39	0	1	0
	40 - 49	0	0	1
	50 - 59	0	0	0

Score Test for the Proportional Odds Assumption

Chi-Square	DF	Pr > ChiSq
8.1957	6	0.2241

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	667.196	608.359
SC	677.638	629.243
-2 Log L	661.196	596.359

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	64.8370	3	<.0001
Score	55.4303	3	<.0001
Wald	59.3031	3	<.0001

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
ageg	3	59.3031	<.0001

Model 5: Fit only age as a factor

Analysis of Maximum Likelihood Estimates

Parameter			DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	None	$\hat{\alpha}_1$	1	**-3.3079**	0.4052	66.6547	<.0001
Intercept	Slight	$\hat{\alpha}_2$	1	**-2.0611**	0.3811	29.2546	<.0001
Intercept	Moderate	$\hat{\alpha}_3$	1	**-0.3638**	0.3506	1.0764	0.2995
ageg	20 - 29	$\hat{\beta}_1$	1	**3.3368**	0.4719	50.0037	<.0001
ageg	30 - 39	$\hat{\beta}_2$	1	**2.3385**	0.4227	30.6135	<.0001
ageg	40 - 49	$\hat{\beta}_3$	1	**1.3069**	0.4137	9.9777	0.0016

Appendix 2 - Solutions in R Output

Model 1: Testing for drug effect

```
Logistic Regression Model

lrm(formula = PAIN ~ DRUG, data = popain)

Frequencies of Responses

  Severe Moderate   Slight     None
      51       73       57       59

                     Model Likelihood     Discrimination    Rank Discrim.
                        Ratio Test           Indexes          Indexes

Obs           240    LR chi2       7.78    R2       0.034    C       0.567
max |deriv| 3e-07    d.f.             1    g        0.326    Dxy     0.134
                     Pr(> chi2) 0.0053     gr       1.386    gamma   0.265
                                           gp       0.081    tau-a   0.101
                                           Brier    0.246


               Coef    S.E.   Wald Z Pr(>|Z|)
y>=Moderate     1.0115 0.1896  5.33  <0.0001
y>=Slight      -0.3906 0.1754 -2.23  0.0259
y>=None        -1.4680 0.1983 -7.40  <0.0001
DRUG=Painendil  0.6501 0.2344  2.77  0.0056


Deviance (-2 Log L)
 661.1961 653.4164


                Wald Statistics          Response: PAIN

 Factor     Chi-Square d.f. P
 DRUG       7.69       1    0.0056
 TOTAL      7.69       1    0.0056


             Effects              Response : PAIN

 Factor                    Low High Diff. Effect S.E. Lower 0.95 Upper 0.95
 DRUG - Painendil:Control 1   2    NA    0.65   0.23 0.19       1.11
  Odds Ratio              1   2    NA    1.92     NA 1.21       3.03
```

Model 2: Fit age

```
Logistic Regression Model

lrm(formula = PAIN ~ AGE, data = popain)

Frequencies of Responses

  Severe Moderate   Slight     None
      51       73       57       59

                         Model Likelihood     Discrimination    Rank Discrim.
                            Ratio Test           Indexes           Indexes

Obs           240     LR chi2      77.75     R2        0.296    C       0.735
max |deriv| 3e-07     d.f.             1     g         1.329    Dxy     0.469
                      Pr(> chi2) <0.0001     gr        3.778    gamma   0.470
                                             gp        0.274    tau-a   0.351
                                             Brier     0.197


            Coef    S.E.   Wald Z Pr(>|Z|)
y>=Moderate  6.1776 0.6324  9.77  <0.0001
y>=Slight    4.4184 0.5628  7.85  <0.0001
y>=None      3.1127 0.5294  5.88  <0.0001
AGE         -0.1170 0.0142 -8.21  <0.0001


Deviance (-2 Log L)
 661.1961 583.4487


                Wald Statistics          Response: PAIN

 Factor     Chi-Square d.f. P
 AGE        67.46      1    <.0001
 TOTAL      67.46      1    <.0001
```

Model 3: Fit age and sex

```
Logistic Regression Model

lrm(formula = PAIN ~ AGE + SEX, data = popain)

Frequencies of Responses

  Severe Moderate   Slight     None
      51       73       57       59

                        Model Likelihood     Discrimination    Rank Discrim.
                           Ratio Test            Indexes           Indexes

Obs            240     LR chi2      84.12     R2        0.316     C        0.746
max |deriv| 3e-07     d.f.             2     g         1.398     Dxy      0.491
                       Pr(> chi2) <0.0001     gr        4.046     gamma    0.492
                                              gp        0.284     tau-a    0.368
                                              Brier     0.195


            Coef    S.E.   Wald Z Pr(>|Z|)
y>=Moderate  6.6376 0.6655  9.97  <0.0001
y>=Slight    4.8807 0.5991  8.15  <0.0001
y>=None      3.5286 0.5598  6.30  <0.0001
AGE         -0.1176 0.0144 -8.18  <0.0001
SEX=Male    -0.6429 0.2562 -2.51  0.0121
```

Deviance (-2 Log L)
661.1961 **577.0785**

```
                Wald Statistics          Response: PAIN

 Factor     Chi-Square d.f. P
 AGE        66.99      1    <.0001
 SEX         6.30      1    0.0121
 TOTAL      71.62      2    <.0001
```

Model 4: Fit age, sex and drug

```
Logistic Regression Model

lrm(formula = PAIN ~ AGE + SEX + DRUG, data = popain)

Frequencies of Responses

  Severe Moderate   Slight     None
      51       73       57       59

                         Model Likelihood     Discrimination    Rank Discrim.
                            Ratio Test           Indexes           Indexes

Obs            240      LR chi2      93.26    R2       0.344    C       0.755
max |deriv| 5e-07       d.f.             3    g        1.476    Dxy     0.510
                        Pr(> chi2) <0.0001    gr       4.374    gamma   0.511
                                              gp       0.291    tau-a   0.382
                                              Brier    0.193


                    Coef    S.E.   Wald Z Pr(>|Z|)
y>=Moderate          6.3768 0.6732  9.47  <0.0001
y>=Slight            4.5886 0.6100  7.52  <0.0001
y>=None              3.2060 0.5731  5.59  <0.0001
AGE           β̂1    -0.1197 0.0145 -8.23  <0.0001
SEX=Male      β̂2    -0.6276 0.2586 -2.43  0.0152
DRUG=Painendil β̂3    0.7346 0.2449  3.00  0.0027


Deviance (-2 Log L)
 661.1961 567.9398


                Wald Statistics          Response: PAIN

 Factor     Chi-Square d.f. P
 AGE        67.74      1    <.0001
 SEX         5.89      1    0.0152
 DRUG        9.00      1    0.0027
 TOTAL      77.20      3    <.0001


             Effects              Response : PAIN

 Factor                    Low High Diff. Effect S.E. Lower 0.95 Upper 0.95
 AGE                       40   41    1    -0.12  0.01 -0.15      -0.09
  Odds Ratio               40   41    1     0.89    NA  0.86       0.91
 SEX - Male:Female          1    2   NA    -0.63  0.26 -1.13      -0.12
  Odds Ratio                1    2   NA     0.53    NA  0.32       0.89
 DRUG - Painendil:Control   1    2   NA     0.73  0.24  0.25       1.21
  Odds Ratio                1    2   NA     2.08    NA  1.29       3.37
```

Model 5: Fit only age as a factor

```
Logistic Regression Model

lrm(formula = PAIN ~ AGEG, data = popain)

Frequencies of Responses

  Severe Moderate   Slight     None
      51       73       57       59

                            Model Likelihood     Discrimination    Rank Discrim.
                               Ratio Test           Indexes          Indexes

Obs           240       LR chi2      64.84     R2       0.253     C       0.705
max |deriv| 1e-07       d.f.             3     g        1.146     Dxy     0.411
                        Pr(> chi2) <0.0001     gr       3.145     gamma   0.552
                                               gp       0.242     tau-a   0.307
                                               Brier    0.208
```

		Coef	S.E.	Wald Z	Pr(>|Z|)
y>=Moderate	$\hat{\alpha}_3$	**-0.3641**	0.3664	-0.99	0.3204
y>=Slight	$\hat{\alpha}_2$	**-2.0614**	0.3961	-5.20	<0.0001
y>=None	$\hat{\alpha}_1$	**-3.3083**	0.4181	-7.91	<0.0001
AGEG=20 – 29	$\hat{\beta}_1$	**3.3371**	0.4831	6.91	<0.0001
AGEG=30 – 39	$\hat{\beta}_2$	**2.3389**	0.4334	5.40	<0.0001
AGEG=40 – 49	$\hat{\beta}_3$	**1.3072**	0.4285	3.05	0.0023

```
Deviance (-2 Log L)
 661.1961 596.3591

               Wald Statistics          Response: PAIN

 Factor     Chi-Square d.f. P
 AGEG       57.52      3    <.0001
 TOTAL      57.52      3    <.0001
```