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Homework 5

1. Cox model:

$$h(t, x, \beta) = h_0(t) \times e^{\beta x}$$

Where $h_0(t)$ is the baseline hazard function, β is the regression coefficient of MI. $x = miord$.

Null hypothesis: There is no difference of the rate of death between patients with first time MI and patients with MI recurrence. ($\beta = 0$)

Alternative hypothesis: There is a difference of the rate of death between patients with first time MI and patients with MI recurrence. ($\beta \neq 0$)

Test statistics: Wald Chi-Square, $\chi^2 = 9.4063$

Degrees of freedom: $df = 1$

P-value: 0.0022

SAS output:

Analysis of Maximum Likelihood Estimates							
Parameter	DF	Parameter Estimate	Standard Error	Chi-Square	Pr > ChiSq	Hazard Ratio	Label
miord	1	0.42662	0.13910	9.4063	0.0022	1.532	MI Order (0=First, 1=Recurrent)

Conclusion: At the 0.05 significance level, there is strong statistical evidence to conclude that the death rate differs significantly between patients with first-time MI and patients with recurrent MI.

2. Cox model:

$$h(t, x_1, x_2, x_3, x_4, \beta) = h_0(t) \times e^{\beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4}$$

Where $h_0(t)$ is the baseline hazard function, β_1 is the coefficient of MI order, β_2 is the coefficient of age category, β_3 is the coefficient of BMI, β_4 is the coefficient of cohort year. $x_1 = miord, x_2 = age\ c, x_3 = bmi, x_4 = year.$

Null hypothesis: $\beta_2 = \beta_3 = \beta_4 = 0$

Alternative hypothesis: At least one of $\beta_2, \beta_3, \beta_4 \neq 0$

Test statistics: LR Chi-Square, $\chi^2 = 134.13$

Degrees of freedom: $df = 3$

P-value: $p < 0.0001$

SAS output:

Obs	m1_neg2logl	m2_neg2logl	lr_chisq	df	p_value
1	2446.017	2311.887	134.130	3	<.0001

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Conclusion: At the 0.05 significance level, Model 2 is significantly better than Model 1. The addition of age category, BMI, and cohort year substantially improves the model fit.

3. Cox model:

$$h(t, x_1, x_2, x_3, x_4, \beta) = h_0(t) \times e^{\beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_1 x_2}$$

Where $h_0(t)$ is the baseline hazard function, β_1 is the coefficient of MI order, β_2 is the coefficient of age category, β_3 is the coefficient of BMI, β_4 is the coefficient of cohort year, β_5 represents the interaction between MI order and age category. $x_1 = miord, x_2 = age\ c, x_3 = bmi, x_4 = year.$

SAS output:

Analysis of Maximum Likelihood Estimates									
Parameter	DF	Parameter Estimate	Standard Error	Chi-Square	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Limits		Label
miord	1	1.82893	0.48376	14.2933	0.0002	6.227	2.413	16.072	MI Order (0=First, 1=Recurrent)
age_c	1	0.82303	0.10080	66.6618	<.0001	2.277	1.869	2.775	Age Category (1:<60, 2:60-69, 3:70-79, 4:80+)
bmi	1	-0.04833	0.01539	9.8602	0.0017	0.953	0.925	0.982	Body Mass Index
year	1	0.31123	0.09803	10.0797	0.0015	1.365	1.126	1.654	Cohort Year (1=1997, 2=1999, 3=2001)
miord_age	1	-0.50673	0.14239	12.6653	0.0004	0.602	0.456	0.796	Interaction: MI Order * Age Category

Estimated Covariance Matrix						
Parameter		miord	age_c	bmi	year	miord_age
miord	MI Order (0=First, 1=Recurrent)	0.2340241010	0.0321483911	0.0001820750	-.0002072797	-.0659396761
age_c	Age Category (1:<60, 2:60-69, 3:70-79, 4:80+)	0.0321483911	0.0101615119	0.0003916256	0.0001293515	-.0095531704
bmi	Body Mass Index	0.0001820750	0.0003916256	0.0002368696	0.0000147387	-.0000500464
year	Cohort Year (1=1997, 2=1999, 3=2001)	-.0002072797	0.0001293515	0.0000147387	0.0096096076	0.0000784790
miord_age	Interaction: MI Order * Age Category	-.0659396761	-.0095531704	-.0000500464	0.0000784790	0.0202736092

Hazard ratio:

$$\begin{aligned}\log(HR) &= \beta_1 + \beta_5 \times 2 \\ &= 1.82893 + (-0.50673) \times 2 \\ &= 0.81547\end{aligned}$$

95% CI:

$$\beta = \beta_1 + \beta_5 \times 2$$

$$SE(\beta) = \sqrt{var(\beta_1) + 4 \times var(\beta_5) + 2 \times 2 \times cov(\beta_1, \beta_5)} = 0.2266$$

$$CI = \left(e^{\beta - 1.96 \times SE(\beta)}, e^{\beta + 1.96 \times SE(\beta)}\right) = (1.4496, 3.5242)$$

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SAS output:

Estimate										
Label	Estimate	Standard Error	z Value	Pr > |z|	Alpha	Lower	Upper	Exponentiated	Exponentiated Lower	Exponentiated Upper
Recurrent vs First MI at age 60-70	0.8155	0.2266	3.60	0.0003	0.05	0.3713	1.2597	2.2603	1.4496	3.5242

4. The probability that this patient survives more than a year is 0.542482.

SAS code:

```
data patient_profile;
    input miord age_c bmi year miord_age;
    datalines;
1 4 30 3 4
;
run;

proc phreg data=mi_data_int plots(cl)=survival;
    model lenfol*fstat(0) = miord age_c bmi year miord_age / ties=EFRON;

    baseline covariates=patient_profile
             out=survival_curve
             survival=surv_prob
             lower=lcl
             upper=ucl;
run;
```

```
/* Print survival probability at first 20 event times */
proc print data=survival_curve(obs=366);
    var lenfol surv_prob lcl ucl;
    format surv_prob lcl ucl 8.6;
    title "Survival Probabilities at Various Time Points";
run;
```

SAS output:

86	359	0.545735	0.431312	0.690513
87	363	0.542482	0.427823	0.687870
88	382	0.539147	0.424240	0.685177