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Survival Analysis
Biostatistics 140.641
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FINAL EXAM

1. (a) Characterize survival analysis. (no more than 100 words for your answer).

   (b) Define the proportional hazards model in two cases: (i) time-independent covariates, and (ii) time-dependent covariates.

   (c) Define 'independent censoring' in a one sample setting. Define 'independent censoring' in the the proportional hazards model with time-independent covariates.

   (d) What is "informative censoring"? Discuss the possible occurrence of informative censoring in a clinical treatment-control study.

2. Let $(y_1, \delta_1), \ldots, (y_n, \delta_n)$ represent the observed data and let $y_{(1)} < y_{(2)} < \ldots < y_{(k)}$, $k \leq n$, be the distinct, uncensored and ordered failure times. Under which situation will the Kaplan-Meier estimate $\hat{S}(y_{(k)}^{+})$ equal 0? Give a detailed discussion and interpret the result (Hint: Think of the practical applications where $\hat{S}(y_{(k)}^{+}) > 0$ or $= 0$).

3. Use the two-sample proportional hazards model to analyze the treatment/control data:

Treatment:	7,	9^+,	11,	12
Control:	0,	6^+,	7^+	

   (a) Write out the partial likelihood function and describe the estimation procedures (Note: You don't need to calculate the partial likelihood estimate here).

   (b) Are you concerned about the small sample size in (a)? Explain.

   (c) Suppose the censoring mechanism is independent. Calculate the Kaplan-Meier estimate for the treatment data.

4. Assume the failure time T has the exponential density $f(t) = \theta e^{-\theta t}$, $t, \theta > 0$.

(a) Identify the hazard function of T.

(b) Denote the hazard function of T by $\lambda(t)$. Verify that for a positive constant b, the random variable bT has the hazard function $\lambda(t)/\text{b}$. Interpret the result.

5. Consider a parameterized proportional hazards model

$$\underline{\text{model I}}: \quad \lambda(t|\, x) = \theta e^{\beta x}, \qquad \theta > 0,$$

where $\lambda(t)$ denotes a hazard function, x is the covariate and β is a real-valued parameter. Consider an alternative model (parameterized accelerated failure time model)

$$\underline{\text{model II}}: \quad T = T_0 e^{\alpha x},$$

where T_0 is the 'baseline failure time', x is the covariate, and α is a real-valued parameter.

(a) Interpret Model I.

(b) Interpret Model II.

(c) Identify the situation when Models I and II are equivalent to each other. (Note: Two models are said to be equivalent if they include the same class of failure time distributions.)