Contents

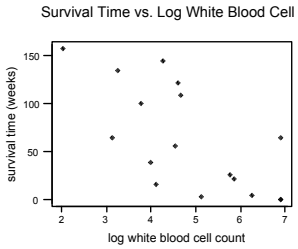
- Individual hazard rate $h_i(t)$
  - e.g. $T_i \sim Ex(\lambda_i)$ with
    $$f_i(t) = \lambda_i e^{-\lambda_i t}$$
  - could estimate λ_i individually
  - Better: link λ_i together – fewer parameters
  - e.g. $E[T_i] = \lambda_i^{-1} = \alpha + \beta x_i$
    - (exponential regression)
    - (c.f. Normal regression)

- Estimate α & β by ML – standard theory
  - Construct likelihood by
    $f(t_i)$ for uncensored and
    $S(t_i)$ for censored observations
  - Get estimates and CI for λ_i from α & β
  - Strictly need condition $\alpha+\beta x_i>0$ (since $\lambda_i>0$)

- Example

myelogenous leukemia survival times with covariate white blood cell count

Patient	WBC×10^2	Survival Time (weeks)
	(AG positive) n=17	
1	23	65
2	7.5	156
3	43	100
4	26	134
5	60	16
6	105	108
7	100	121
8	170	4
9	54	39
10	70	143
11	94	56
12	320	26
13	350	22
14	1000	1
15	1000	1
16	520	1
17	1000	5
Median values	100	56



$$\hat{\alpha} = 240, \hat{\beta} = -44; \hat{\text{var}}(\hat{\alpha}) = 95.5, \hat{\text{var}}(\hat{\beta}) = 20.1, \hat{\text{cov}}(\hat{\alpha}, \hat{\beta}) = -1914$$

- Minitab implementation
- Stat>Reliability/Survival> Regression with Life Data
  - Actually models log(survival) so different answers [slightly] from above
- Similarly S-Plus and **R**, details in notes

- **TwoSample Example**
  - $h_1(t)=\lambda_1$ and $h_2(t)=\lambda_2$
  - Define dummy variable
    0 for group 1, 1 for group 2
  - $h(t;x) = \lambda e^{\beta x} = \lambda$ for x=0 (group 1)
    or $= \lambda e^{\beta}$ for x=1 (group 2)
  - The sign of β determines whether
    $\lambda_2>\lambda_1$ ($\beta>0$) or $\lambda_1>\lambda_2$ ($\beta<0$)

- Notes
  - $\log_e h(t;x)=\log_e(\lambda)+\beta x$
    i.e. *loglinear model* for hazard function
  - guarantees h(t;x)>0
  - extend to several groups with $h(t;\underline{x})=\lambda e^{\underline{\beta}'\underline{x}}$
  - Could let $\underline{x}$ be any vector of
    - covariates
    - prognostic factors

- allowing for covariates gives
  more sensitive tests
- can correct for imbalance
  in initial randomization
- incorporating prognostic factors for
  investigating factors in their own right
- can investigate ***interactions***
  - see later re interactions
  - see later for implementation **R**
    of parametric and non-parametric models