COMPETING RISKS

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FINE-GRAY MODEL

Conditional Processes

- What if independence **DOES NOT** seem reasonable?
- **Conditional processes** occur when these events are NOT independent of each other – conditional on each other.
- Two Common Approaches:
  1. Two-Stage Modeling
  2. Fine-Gray Model

Sub-Hazards

- By treating non-*k* events as censored, you are modeling the cause-specific hazard:

$$h_k(t) = -\frac{d}{dt}\log\big(1 - F(t)\big)$$

  which is the rate of event *k* for those still at risk at time *t* conditional on no event happening yet

- Instead, take the CIF's and look at the **sub-hazard**:

$$h_k^*(t) = -\frac{d}{dt}\log\big(1 - F_k(t)\big)$$

  which is the rate of event *k* for those still at risk at time *t* conditional on **event *k* not happening yet**

Proportional Sub-Hazard Model

- **Fine-Gray model** – replace the cause-specific hazard with the sub-hazard to get a propotional sub-hazard model:

$$\log h_k^*(t) = \log h_{0,k}^*(t) + \beta_1 x_{i,1} + \cdots + \beta_k x_{i,k}$$

- By using the CIF's rather than the overall survival function (i.e. $1 - F_k(t)$ vs. $1 - F(t)$), the risk set is adjusted to account for different events happening.
- Risks are essentially balanced by looking at the probability of one specific event type in the presence of other event types by keeping failures from other causes "at risk" for the particular event type we're focused on.

Fine-Gray Model – SAS

```
proc phreg data=Survival.Leaders;
    class region;
    model years*lost(0) = manner start military age conflict
                          loginc growth pop land literacy
                          region /
                          ties=efron rl eventcode=2;
run;
```

Fine-Gray Model – SAS

Model Information	
Data Set	SURVIVAL.LEADERS
Dependent Variable	years
Status Variable	lost
Event of Interest	2
Competing Events	1 3
Censored Value	0

Number of Observations Read	472
Number of Observations Used	438

Class Level Information				
Class	Value	Design Variables		
region	0	1	0	0
	1	0	1	0
	2	0	0	1
	3	0	0	0

Fine-Gray Model – SAS

Type 3 Tests			
Effect	**DF**	**Wald Chi-Square**	**Pr > ChiSq**
manner	1	0.0022	0.9628
start	1	4.9967	0.0254
military	1	0.2978	0.5853
age	1	7.9273	0.0049
conflict	1	0.0013	0.9707
loginc	1	4.2090	0.0402
growth	1	0.6014	0.4380
pop	1	0.6939	0.4048
land	1	0.1544	0.6944
literacy	1	0.3584	0.5494
region	3	1.1666	0.7610

Still need to do variable selection, but others appear closer to significant than when doing traditional competing risks.

Fine-Gray Model – R

```
lnat_data <- finegray(Surv(years, lost) ~ .,
                      data = leaders, etype = "Natural")

fg_nat <- coxph(Surv(fgstart, fgstop, fgstatus) ~ manner + start
                + military + age + conflict + loginc + growth
                + pop + land + literacy + factor(region),
                data = lnat_data, weight = fgwt)
summary(fg_nat)
```

Fine-Gray Model – R

```
## Call:
## coxph(formula = Surv(fgstart, fgstop, fgstatus) ~ manner + start +
##     military + age + conflict + loginc + growth + pop + land +
##     literacy + factor(region), data = lnat_data, weights = fgwt)
##
##   n= 3650, number of events= 27
##    (434 observations deleted due to missingness)
##
##                        coef  exp(coef)   se(coef)      z Pr(>|z|)
## manner           -2.243e-02  9.778e-01  5.895e-01 -0.038  0.96965
## start            -6.584e-02  9.363e-01  2.961e-02 -2.223  0.02618 *
## military         -3.031e-01  7.386e-01  6.564e-01 -0.462  0.64432
## age               4.920e-02  1.050e+00  1.835e-02  2.682  0.00732 **
## conflict         -1.794e-02  9.822e-01  4.808e-01 -0.037  0.97023
## loginc            5.326e-01  1.703e+00  2.606e-01  2.044  0.04095 *
## growth            9.729e-02  1.102e+00  8.441e-02  1.153  0.24907
## pop               2.283e-03  1.002e+00  2.150e-03  1.062  0.28838
## land             -7.216e-05  9.999e-01  1.585e-04 -0.455  0.64885
## literacy         -6.535e-03  9.935e-01  1.258e-02 -0.519  0.60343
## factor(region)1   3.697e-01  1.447e+00  7.384e-01  0.501  0.61662
## factor(region)2  -7.536e-01  4.707e-01  8.341e-01 -0.903  0.36627
## factor(region)3   1.069e-01  1.113e+00  7.141e-01  0.150  0.88096
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```