Modeling the cumulative incidence function of clustered competing risk data

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December/2020

Clustered competing risk data

Idea: causes competing by the occurence of an event such the

confiability analysis

failure of an industrial or electronic component

survival analysis

failure or progress of a patient or some biological process

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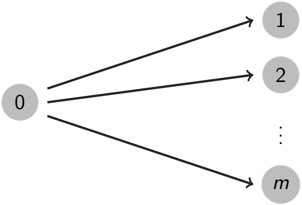
A typical data set consists of

Group	ID	Cause 1	Cause 2	Censorship	Time	Feature
1	1	Yes	No	No	10	A
1	2	No	No	Yes	8	A
2	1	No	No	Yes	7	B
2	2	No	Yes	No	5	A

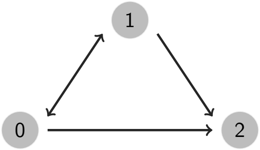
Survival data designs

Failure time process

Competing risk process

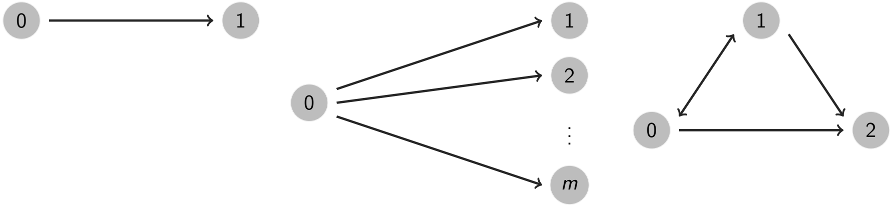


Multistate process



Survival data designs

Failure time process | Competing risk process | Multistate process



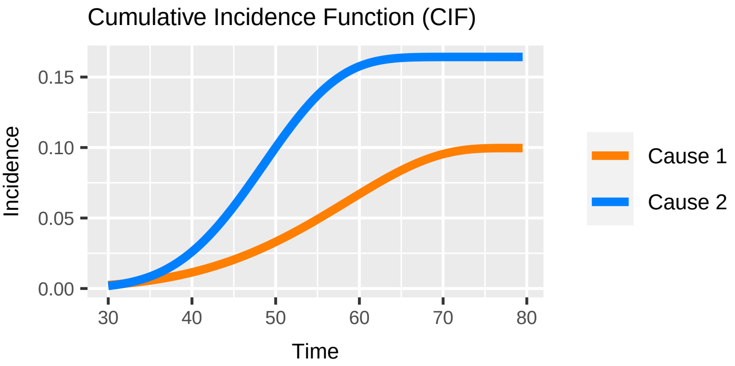
Survival modeling framework

We have to choose which scale we model the **survival experience**.
Usually, is the

$$\text{hazard (failure rate) scale}: \quad \lambda(t \mid x) = \lambda_0(t) \times c(x, \beta)$$

In the competing risk setting ...

a more attractive possibility is to work on the probability scale, focusing on the cause-specific



i.e.

$$\text{CIF} = \mathbb{P}[\text{ failure time} \leq t, \text{ a given cause} \mid \text{features }]$$

Main focus application: cancer incidence in twins

Clustered competing risks data

↳ Clusters? Families

↳Family studies

↳ Twins data

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Family studies $\Rightarrow$ within-family dependence

» Taking into account the within-family dependence may reflect both disease **heritability** and the impact of shared **environmental effects**

And what we do? A hierarchical approach

Thinking on two competing causes

... for the outcome y_{ijt} of a subject i, family j, in the time t, we have

$$y_{ijt} \mid \underbrace{\{u_{1j}, u_{2j}, \eta_{1j}, \eta_{2j}\}}_{\text{latent effects}} \sim \text{Multinomial}(p_{1ijt}, p_{2ijt}, p_{3ijt})$$

$$\begin{bmatrix} u_{1j} \\ u_{2j} \\ \eta_{1j} \\ \eta_{2j} \end{bmatrix} \sim \begin{matrix}\text{Multivariate} \\ \text{Normal}\end{matrix} \left(\begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma^2_{u_1} & \varrho_{u_1,u_2} & \varrho_{u_1,\eta_1} & \varrho_{u_1,\eta_2} \\ & \sigma^2_{u_2} & \varrho_{u_2,\eta_1} & \varrho_{u_2,\eta_2} \\ & & \sigma^2_{\eta_1} & \varrho_{\eta_1,\eta_2} \\ & & & \sigma^2_{\eta_2} \end{bmatrix} \right)$$

$$\begin{aligned} p_{kijt} &= \frac{\partial \text{CIF}}{\partial t} \\ &= \frac{\partial}{\partial t} \underbrace{\pi_k(X, u_1, u_2 \mid \beta)}_{\substack{\text{cluster-specific} \\ \text{risk level}}} \underbrace{\Phi[w_k g(t) - X^\top \gamma_k - \eta_k]}_{\substack{\text{cluster-specific} \\ \text{failure time trajectory}}}, \end{aligned}$$

$k = 1, 2$

Challenges

Thinking in the twins data application,
the small group/family size is a problem that implies in the following

$$\text{cycle}: \quad \begin{array}{c}\text{small}\\ \text{groups}\end{array} \Rightarrow \begin{array}{c}\text{little}\\ \text{information}\end{array} \Rightarrow \begin{array}{c}\text{complex}\\ \text{model}\end{array} \Rightarrow \begin{array}{c}\text{bigger number}\\ \text{of groups}\end{array}$$

... with this,
computational challenges appear and have also to be overcome

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Besides, the data is very simple ...

- we just know if the event occured (yes or no) and the time
  - with this, we have to be able to construct the cumulative incidence curves
- and we have to accommodate the within-family dependency
  - that can happen in different manners

Thank you

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