Joint Model Formula and Description

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## Joint Model for Longitudinal and Survival Data

### Longitudinal Submodel

The longitudinal process is modeled using a linear mixed-effects model:

where: - is the observed longitudinal outcome for subject at time , - is the design matrix for fixed effects with coefficient vector , - is the design matrix for random effects with individual-specific random effects , - is the residual error, assumed to follow a normal distribution with variance .

### Survival Submodel

The survival process is modeled using a Cox proportional hazards model, where the hazard function is:

where: - is the baseline hazard function, - is the vector of baseline covariates with associated coefficients , - represents the true (unobserved) longitudinal outcome, - is the association parameter linking the longitudinal and survival processes.

### Joint Model Framework

The joint model combines the above submodels by linking the longitudinal outcome to the hazard function via the true underlying trajectory . This approach accounts for measurement error and provides a more accurate estimate of the relationship between the longitudinal and survival processes.

### Implementation in R

To fit a joint model in R, we can use the JM or joineR package. For example:

library(JM)  
fit\_lme <- lme(Y ~ time + covariates, random = ~ time | ID, data = long\_data)  
fit\_surv <- coxph(Surv(time, event) ~ covariates, data = surv\_data)  
fit\_joint <- jointModel(fit\_lme, fit\_surv, timeVar = "time", method = "weibull-PH")  
summary(fit\_joint)

This code fits a joint model where the longitudinal trajectory is linked to survival through a shared parameter model.