

# A Multilevel Model for Precision Oncology

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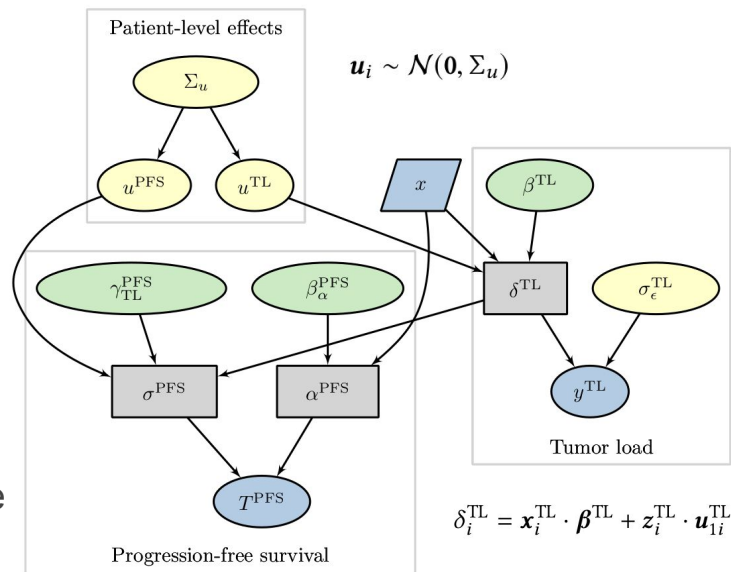
**Motivation:** Oncologists need better tools to predict treatment outcomes for cancer patients who have exhausted the standard of care for their disease.

**Challenges:** Data for clinical decision making in late-stage cancers is often sparse, with many more predictors than observations. There are often disparate measurements that may share causal relationships with one another.

**Solution:** A Bayesian hierarchical model for treatment outcomes that incorporates patient-specific features, treatment interactions, interpretable causal relationships, and informative priors.

## Model

- Outcomes are generalized linear multilevel responses
- Patient-level effects,  $u$  are interpreted as sources of variation beyond measured predictor variables,  $x$
- Outcomes can share causal relations, i.e., one outcome can be the predictor for another outcome
- TL = tumor load, spatial extent of solid tumor
- PFS = progression-free survival, time-to-disease progression or death



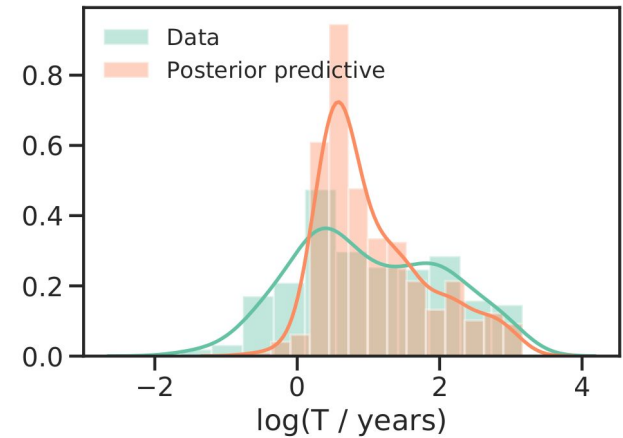
$$\mathcal{L}_{\text{obs}}^{\text{PFS}}(T_i) = \frac{\alpha_i}{T_i} \left( \frac{T_i}{\sigma_i^{\text{PFS}}} \right)^{\alpha_i} \left( 1 + \left( \frac{T_i}{\sigma_i^{\text{PFS}}} \right)^{\alpha_i} \right)^{-2}$$

$$\sigma_i^{\text{PFS}} = \exp(\gamma_{\text{TL}}^{\text{PFS}} \delta_i^{\text{TL}} + z_i^{\text{PFS}} \cdot u_i^{\text{PFS}})$$

$$\alpha_i = \exp(x_i^\alpha \cdot \beta_\alpha)$$

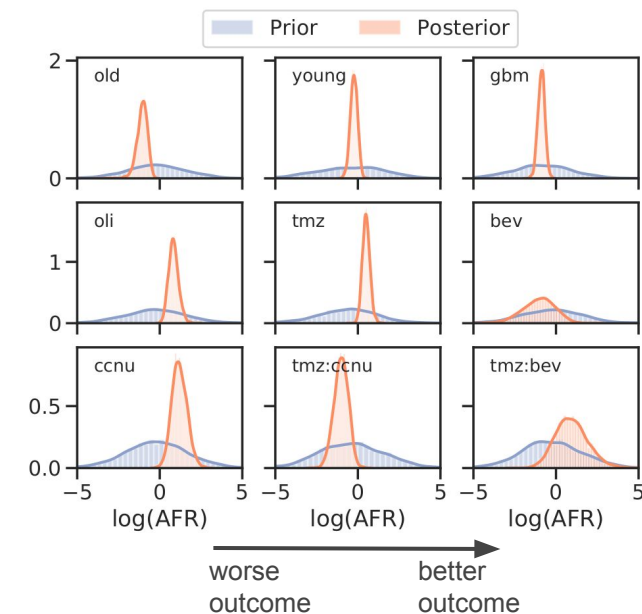
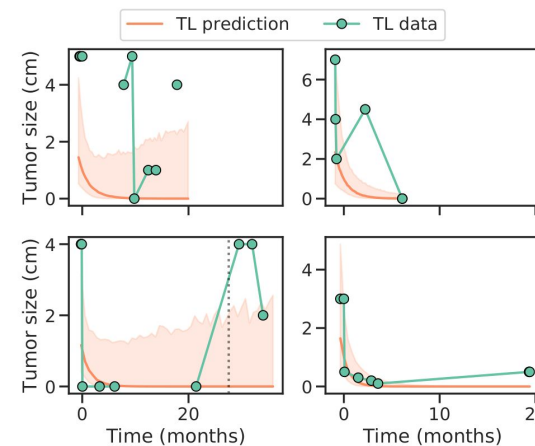
## Data

- 362 patients with high grade gliomas from the Musella Foundation Virtual Trial Registry
- Outcomes: progression-free survival (PFS) + tumor load (TL)
- Predictors of age, diagnosis, treatments (14), and interaction terms



## Results

- Potential evidence for treatment interactions
- Model fit to PFS yields sensible predictions for held-out TL data



- Searched for correlations between patient-level effects on PFS and treatments
- Notable deviations from normality in random effects may indicate important as-of-yet unmeasured predictors of treatment outcomes

