# Flexible Group Fairness Metrics for Survival Analysis

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## Summary

← Biased survival models can lead to discrimination and disadvantage between groups of people in healthcare treatment.

← How to detect model bias in survival analysis is unclear.

→ We evaluate metrics for model-agnostic bias assessment.

→ We show which survival metrics recover biases.


## Caring about survival model fairness

- Survival models can infer risk of event (e.g., death) or predict remaining survival time.
- Decision makers use survival models in healthcare to diagnose patients and set future treatment courses.

→ Biased survival models disadvantage individuals, groups of people, or the intersection of multiple groups of people.

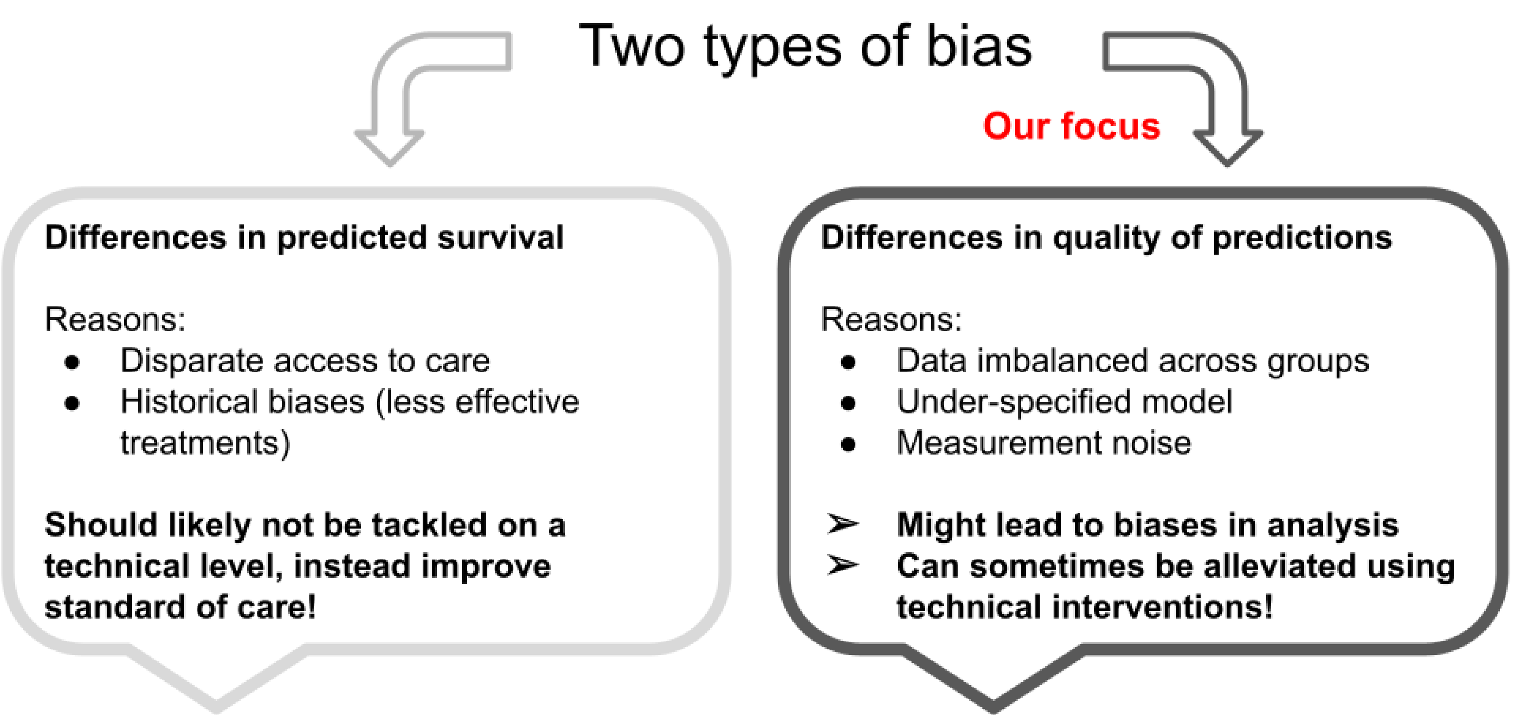
### Existing Gap

- How to assess bias in survival models is unclear.
- Existing metrics are limited to evaluating Cox PH models.

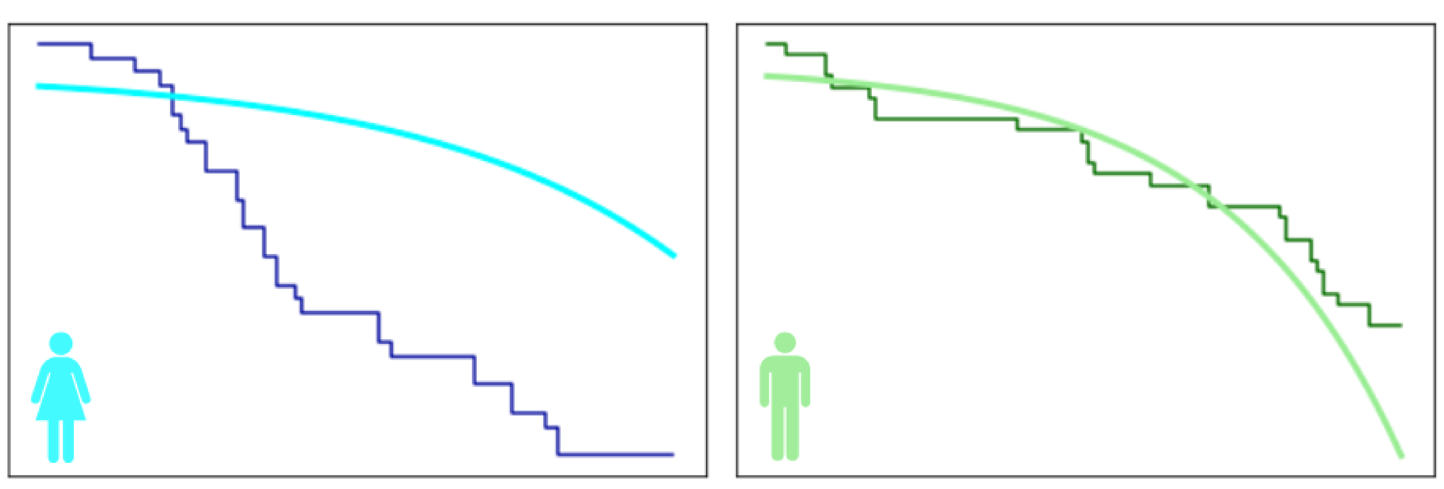
→ Need for model-agnostic survival fairness metrics.

## What is bias?

Definitions of bias depend on the required application. We focus on biases that describe a *difference in predictability* between groups. Such biases are often overlooked in practice.




**Defining model-agnostic survival fairness metrics** We define a class of fairness metrics, $\Delta_\Phi$, which depends only on the choice of survival metric, $\Phi$. Let $Y_{A=i}$ be the hypothetical survival outcome for patient $Y$ in protected group $A{=}i$ (e.g., gender=male), let $\hat{Y}_{A=i}$ be the survival prediction for this individual, and let $\Phi(\cdot,\cdot)$ be a survival metric:



$$\Delta_\Phi(Y,\hat{Y}) = \left|\Phi(\boxed{Y_{A=0}}, \boxed{\hat{Y}_{A=0}}) - \Phi(\boxed{Y_{A=1}}, \boxed{\hat{Y}_{A=1}})\right|$$

## Which metrics $\Phi$ capture group bias?

We simulate two sources of bias: (1) **Measurement error** by permuting covariates in a fraction, $\sigma$, of the disadvantaged population; and (2) **Representation bias** by undersampling a fraction, $\sigma$, of the disadvantaged population. We assess which $\Phi$ recover simulated biases over varying $\sigma$. Across 29 datasets we fit the regression model $\Delta_\Phi = \alpha + \sigma\beta$ and calculate the Spearman rank correlation $\rho(\Delta_\phi, \sigma)$. We say $\Phi$ recovers bias if $\beta$ and $\rho$ are significant ($p \leq 0.05$) after Holm's correction.

| $\Phi$ | $\alpha$ | $\beta$ | $\rho$ | $\alpha$ | $\beta$ | $\rho$ |
|---|---|---|---|---|---|---|
| | Permutation | | | Undersampling | | |
| RSBS | 0.049 | 0.078* | 0.976* | 0.035 | 0.066* | 0.855* |
| RISL | 0.045 | 0.063* | 0.976* | 0.033 | 0.058* | 0.891* |
| SNL | 0.018 | 0.001 | 0.248 | 0.014 | 0.083* | 1.000* |
| RCLL | 0.018 | 0.009 | 0.879* | 0.022 | 0.088* | 1.000* |
| $C_H$ | 0.024 | 0.129* | 1.000* | 0.017 | 0.083* | 1.000* |
| $C_U$ | 0.031 | 0.124* | 1.000* | 0.024 | 0.078* | 0.976* |
| CalA | 0.027 | 0.011* | 0.891* | -0.015 | 0.197* | 0.952* |
| CalD | 2.686 | 0.487 | 0.721* | 2.861 | 0.646 | 0.612 |

**Table:** Let $\Delta_\Phi = \alpha + \sigma\beta$ be our regression model. Table shows intercept, $\alpha$, slope, $\beta$, and Spearman rank correlation ($\rho$) for each $\Phi$ and permutation (left) and undersampling (right) biasing methods. '*' indicates $p \leq 0.05$ after Holm's correction.

## Conclusions

- Survival analysis requires strong ethical consideration. But the literature around survival fairness is in its infancy.

→ We have demonstrated how existing survival measures can be utilised to audit bias in algorithmic fairness.

→ We found existing discrimination, calibration, and scoring rule measures for capturing model-agnostic bias but these depend on bias type and still require expert knowledge.

→ Key research areas remaining: (1) understanding individual, intersectional, and counterfactual error-based fairness; (2) metrics for model-agnostic prediction-based fairness; (3) making survival fairness more accessible; (4) understanding how decision makers think about and utilise fairness.

## More Information

`https://arxiv.org/abs/2206.03256`

`https://github.com/Vollmer-Lab/survival_fairness`