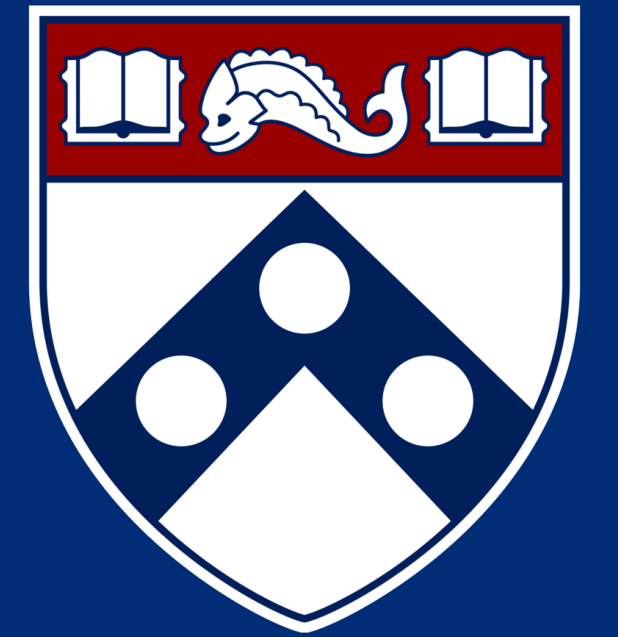# Evaluating a Facility-Profiling Metric based on Survival Probability: Application to U.S. Transplant Centers

Amelia H. Tran, Peter P. Reese, Douglas E. Schaubel

University of Pennsylvania Perelman School of Medicine

## Background of Facility Profiling

- **Evaluations of healthcare providers and medical centers of great interest** to patients, transplant professionals & medical practitioners
- In the US, **kidney transplant centers undergo two evaluations**: Organ Procurement and Transplantation Network (OPTN) and Centers for Medicare and Medicaid Services (CMS)
- **Post-transplant survival outcome** by transplant center ensures highest-quality care for patients
- **Standardized Mortality Ratio (SMR)** and **Prognostic Score based Weighting Approach** as evaluation metrics

*Wolfe, R. A. (1994). The standardized mortality ratio revisited: improvements, innovations, and limitations. American Journal of Kidney Diseases, 24(2):290–297*

## SMR Limitations and Motivation for Prognostic Score based Approach

- Center-specific SMR: $\text{SMR}_j = \frac{O_j}{E_j}$ for center $j$
- Center effect is determined by $Z_j = \frac{log(SMR_j)}{V\{log(SMR_j)\}} \sim N(0,1)$
- **SMR limitations**: unstable estimator, susceptible to model misspecification, indirect standardization method
- Motivation for *prognostic score based method*
- Defined as the association between observed covariates and potential outcome in one restriction group
- Prognostic score $\eta(X_i)$ from **center-stratified** Cox regression: $\lambda_{ij}(t; X_i) = \lambda_{0j}(t) \exp(\beta^T X_i)$ where observed data: $(U_i, \Delta_i, X_i, G_i)$

*Hansen, B. B. (2008). The prognostic analogue of the propensity score. Biometrika, 95(2):481–488.*

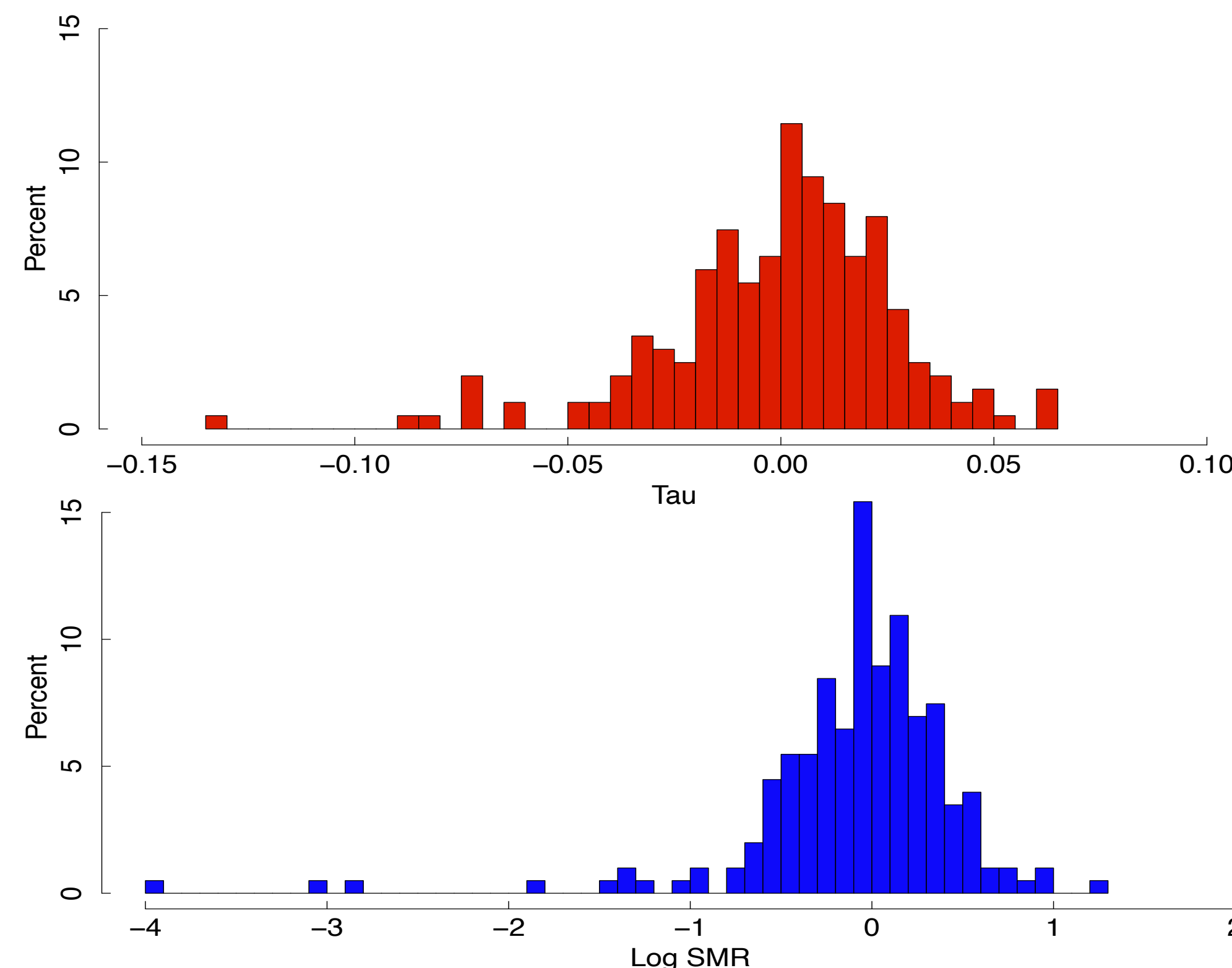## Developing Prognostic Score based Estimator

- Construct $R = 5$ **risk classes** based on quintiles of $\eta(X_i)$
- **Individual weight** is constructed: $\hat{w}_{ijr} = G_{ij} Q_{ir} \frac{n_j}{n_{jr}} \hat{p}_r$
- Estimator of **center-specific cumulative hazard**:

$$\widehat{\Lambda}_j^w(t) = \sum_{r=1}^{R} \sum_{i=1}^{n} \int_0^t \hat{\pi}_j(u)^{-1} \hat{w}_{ijr} \, dN_{ijr}(u)$$

$$\hat{\pi}_j(u) = \sum_{r=1}^{R} \sum_{i=1}^{n} \hat{w}_{ijr} Y_{ijr}(u)$$

- Center-specific **weighted survival**: $\hat{S}_j^w(t) = \exp\{-\widehat{\Lambda}_j^w(t)\}$
- **Estimator of interest**: $\hat{\tau}_j(u) = \hat{S}_j^w(t) - J^{-1} \sum_{m=1}^{J} \hat{S}_m^w(t)$



## UNOS Data Description

- Truncate at 1 year post-transplant: **83% censoring**
- Data from United Network for Organ Sharing (**UNOS**)
- Study population: **58,353 adults** with transplants
- Exclude centers < 25 transplants: **J = 201 centers**

## Results and Comparison

| Cross-classification | | $\tau(1)$ | | | |
|---|---|---|---|---|---|
| | | Better | Null | Worse | Total |
| **SMR(1)** | Better | 1 | 0 | 0 | 1 |
| | Null | 18 | 159 | 0 | 177 |
| | Worse | 0 | 18 | 5 | 23 |
| | Total | 19 | 177 | 5 | 201 |

## Discussion and Future Work

- We evaluate U.S. transplant centers by 1-year graft survival
- Metric agreement: 82%
- Spearman's correlation: −0.94
- Prognostic score based weighting approach:
  - *Robust to model mis-specification through simulations*
  - *Robust to number of risk classes, i.e. R = 5, 10, 20*
  - *Fair facility profiling by considering center covariates*
- Potential future work: evaluating **independent censoring** assumption and **covariate-by-center interaction**

*Lee, Y. and Schaubel, D. E. (2022). Facility profiling under competing risks using multivariate prognostic scores: Application to kidney transplant centers. SMMR, 31(3):563–575.*