CENTER FOR HEALTHCARE ENGINEERING & PATIENT SAFETY
UNIVERSITY OF MICHIGAN

2018 Healthcare Engineering and Patient Safety Symposium

Development of a Predictive Model for Deceased Donor Organ Yield

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Research Goal

We aimed to compare different linear and non-linear statistical models to predict deceased donor organ yield. A model to accurately predict deceased donor organ yield can serve as an aid to assess organ procurement performance and forecast future organ availability.

Background

Development of predictive models for organ yield

2008
- Selck and coauthors created the first predictive model for organ yield using ordinary least squares regression models.[1]

2011
- Messersmith and coauthors extended Selck et al.'s work using multivariate logistic regression models to predict organ-specific likelihood of donation.[2]

2018
- We extend this work by modeling the organ yield as counts and developing a non-linear model to predict organ yield.

Figure 2

The Health Resource and Services Administration and the Centers for Medicare and Medicaid Services have focused in increasing organ yield to reduce the gap between the supply and demand of organs in the U.S.[1-2]

Solution Approach

Statistical Models

Linear models and extensions[3]	*Tree-based models[3]*
• Ordinary least squares (OLS) • Ordinal logistic regression (OLR) • Generalized linear model (GLM) • General additive model (GAM) • Multivariate adaptive regression splines (MARS) • Artificial neural networks (ANN)	• Classification and regression trees (CART) • Bootstrap aggregated CART • Random forest • Boosted CART (BOOSTCART) • Bayesian additive regression trees (BART)

Figure 3

The accuracy to predict deceased donor organ yield of several linear and non-linear statistical models was compared. The initial set of predictors for deceased donor organ yield were derived from published studies.[1-2]

Monte Carlo Cross-Validation

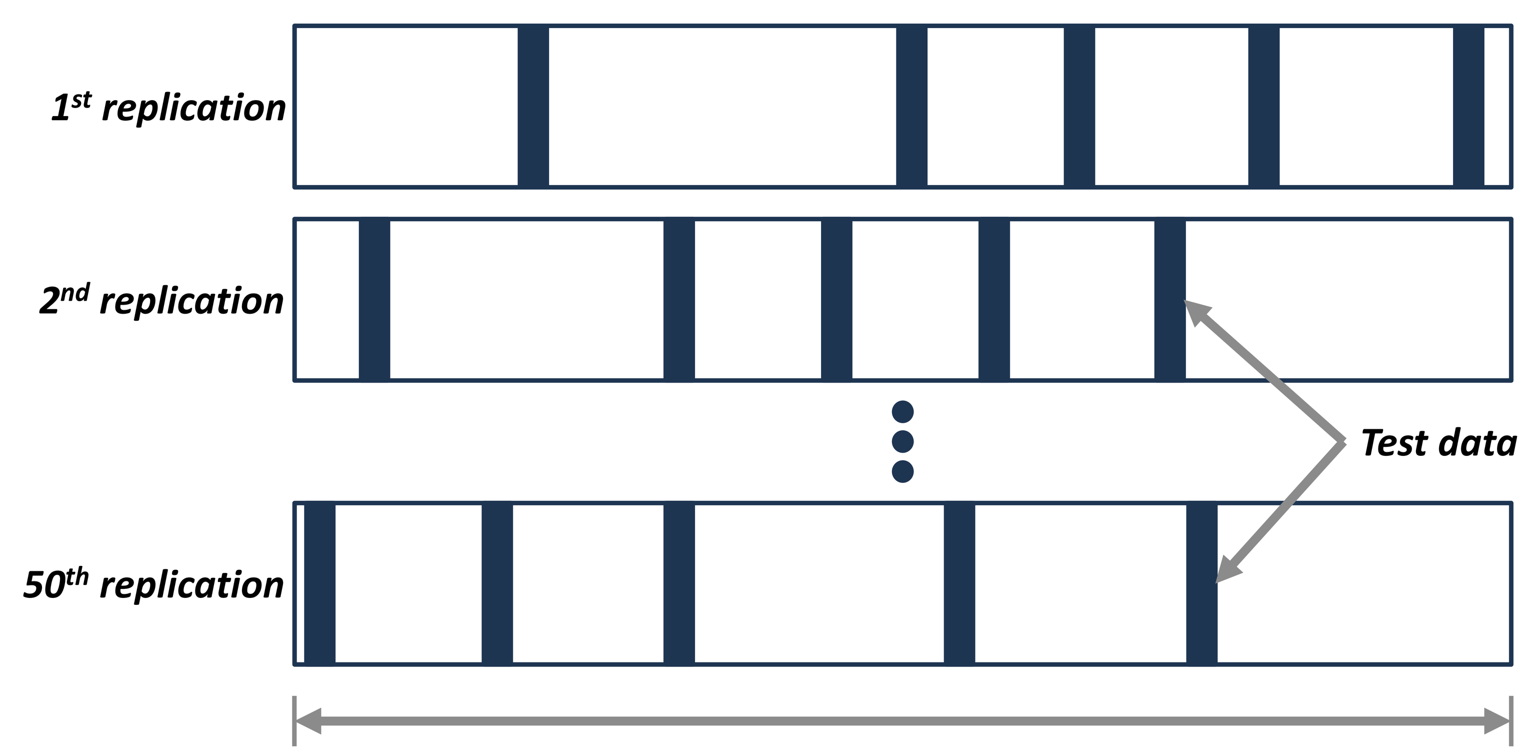


Figure 4

The statistical models were parameterized using data from the OPTN* from 2000 to 2016.[4] We used 80% of the data for derivation in a cross-validation analysis and the remainder of the data as a validation set. The cross-validation analysis was replicated 50 times and the hold-outs consisted of 20% of the derivation cohort.

*OPTN: Organ Procurement and Transplantation Network

Results

Predictive Accuracy Comparison

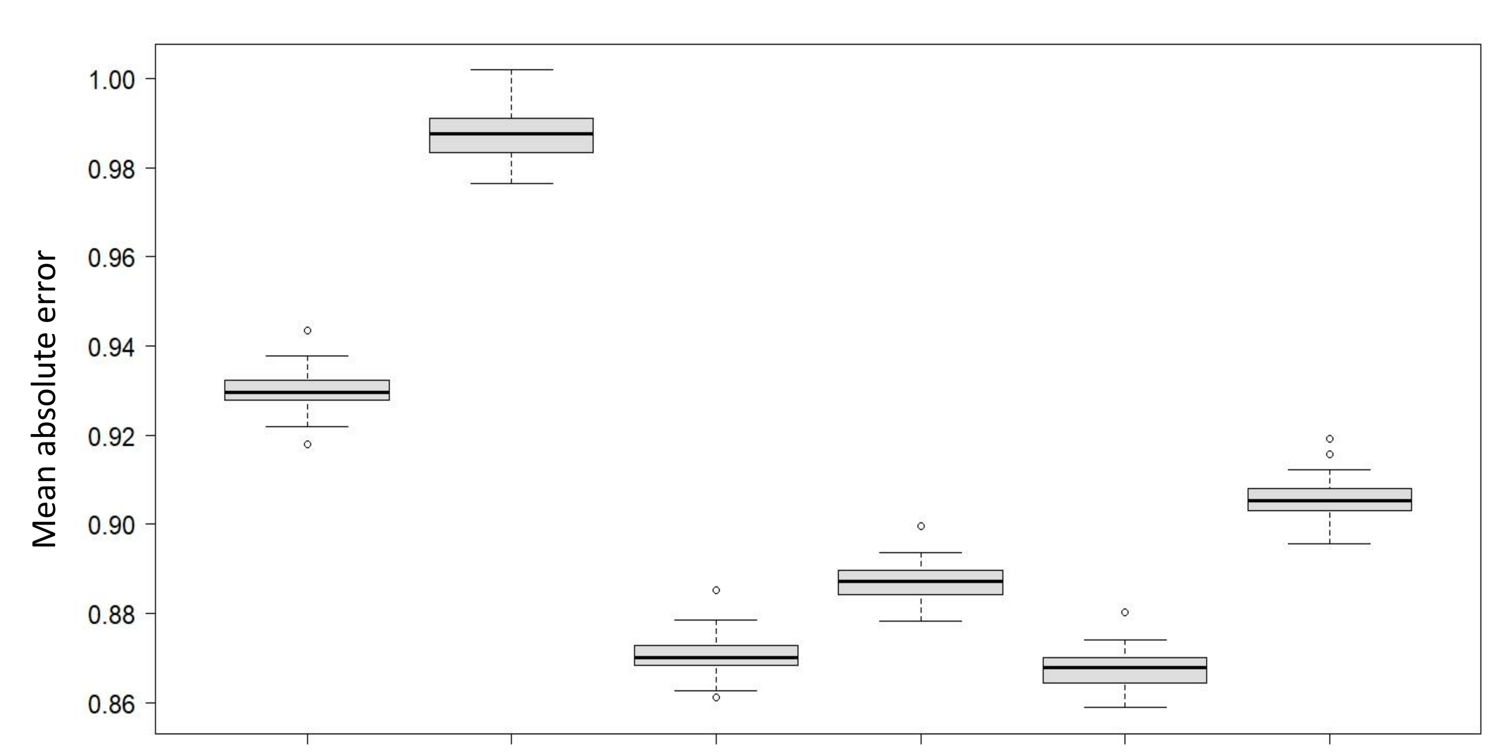
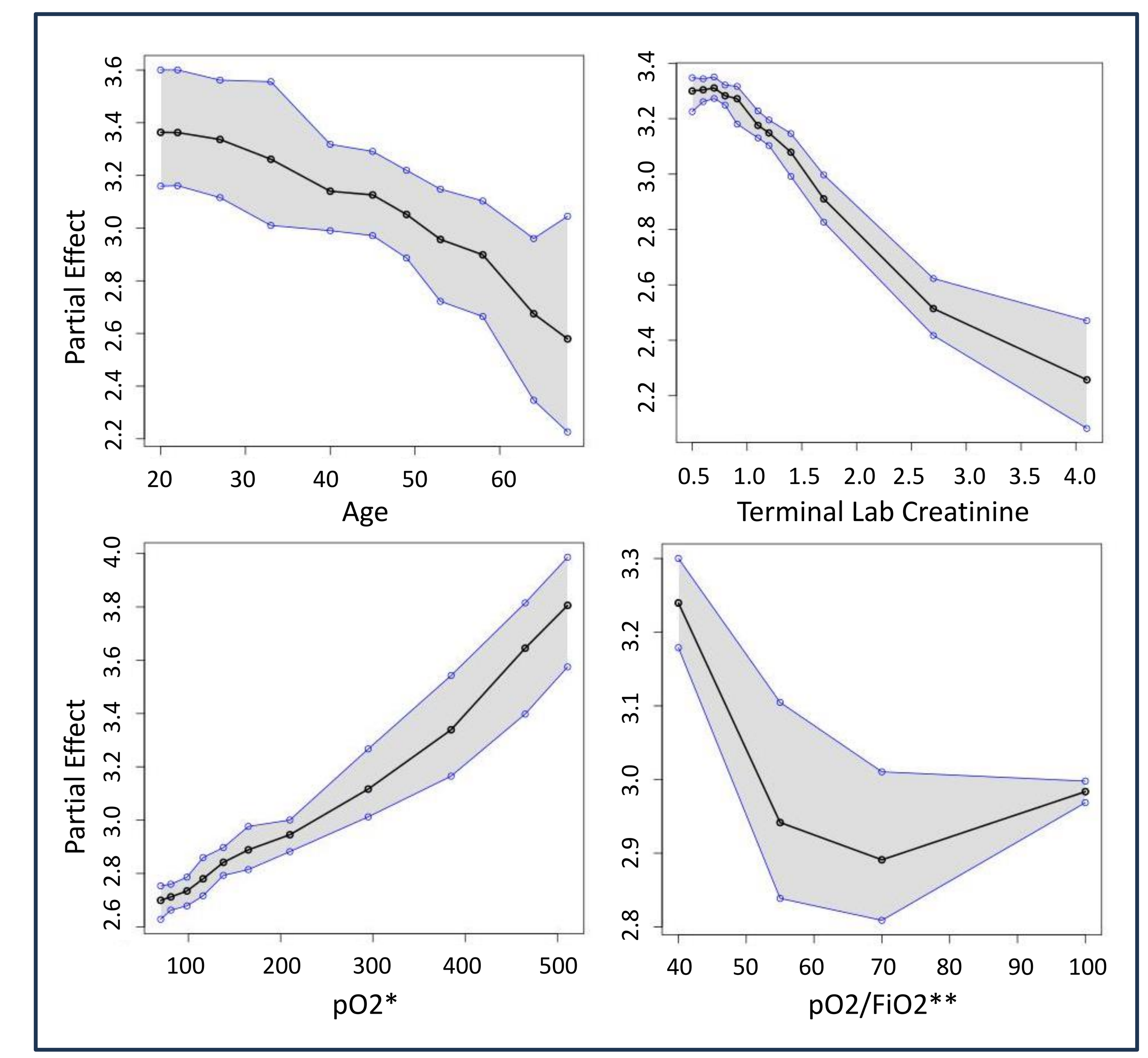


Figure 5

Mean absolute error (MAE) of best performing statistical models.[3] A BART resulted in the lowest error on predicting the number of organs transplanted per deceased donor.

Relationships Among Deceased Donor Organ Yield and Predictors



*pO2: Partial pressure of oxygen **FiO2: Fraction of inspired oxygen

Figure 6

Partial dependence plots of selected predictors. Non-linear positive and negative, and more complex relationships between deceased donor organ yield and its predictors were identified.

Impact

- Higher predictive accuracy for deceased donor organ yield was achieved.
- A BART would improve prediction from at least 63 organs per 1000 donors (compared to an ordinary least squares regression[1]) to at most 120 organs per 1000 donors (compared to an ordinal logistic regression[2]).

References

1. Selck FW, Deb P, Grossman EB. Deceased organ donor characteristics and clinical interventions associated with organ yield. Am J Transplant. 2008;8(5):965-974.
2. Messersmith EE, Arrington C, Alexander C, Orlowski JP, Wolfe R. Development of donor yield models. Am J Transplant. 2011;11(10):2075-2084.
3. Hastie T, Tibshirani R, Friedman J (2009). The Elements of Statistical Learning (Vol. 2). New York, NY: Springer New York.
4. U.S. Organ Procurement and Transplantation Network. Organ Procurement and Transplantation Network database from 2000 to 2017.

Acknowledgments