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Mitigating Bias In Machine Learning: Improving Minority-specific Graft Failure Survival Prediction With Synthetic Minority Oversampling

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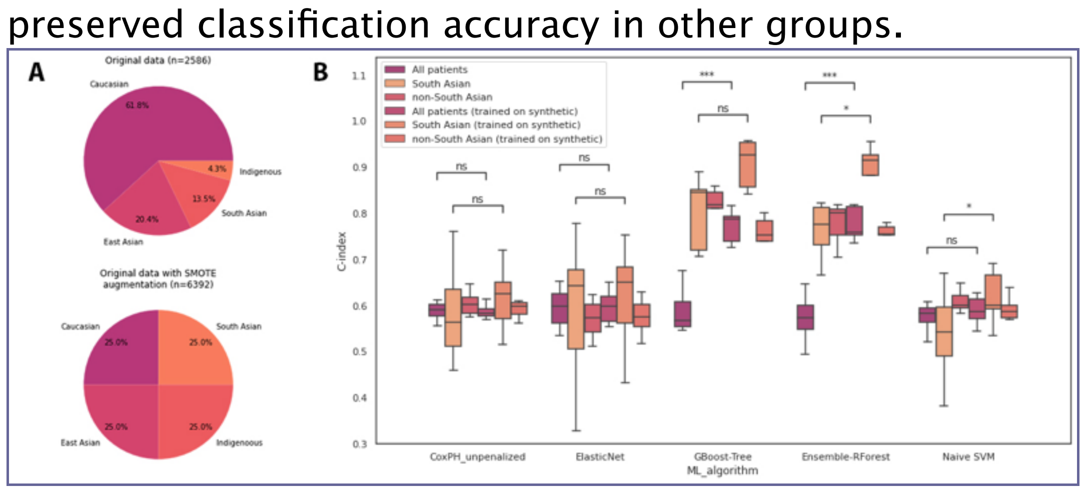
Abstract:
***Purpose:** Machine learning (ML) methods are understood to carry potential for bias, as they typically maximize accuracy for majority groups at the expense of underrepresented minorities. Here we show an example of underprediction hazard associated with disregarding class imbalance in a multiethnic transplant recipient population with multiple ML methods, and demonstrate one approach to imbalanced learning: the synthetic minority oversampling technique (SMOTE), which improves accuracy by generating 'new patients' through a K-nearest-neighbours algorithm.
***Methods:** Pre- and post-transplant patient data, including self-reported ethnicity, was retrieved from 2586 kidney transplants performed from 2009-2019 in Vancouver between 2 major urban hospitals. Time-to-graft-failure was the outcome of interest. Analysis was limited to the four most populous self-reported ethnicities (Caucasian (61.8%), East Asian (20.4%), South Asian (SA, 13.5%), Indigenous (4.3%)). SMOTE was applied to artificially generate non-Caucasian patient entries, and appended to the original data.
Four ML approaches were investigated: Cox proportional hazards (CR), CR with elastic-net penalty (ECR), gradient-boosted regression trees (GBT), random survival forests (RF), and naive SVM. For each method, survival concordance index was calculated for whole-group, other ethnicities-only, and SAs-only, as trained with original data, and with data generated via SMOTE. Mean c-indexes were compared via Welch's t-test for each model's accuracy for SAs and all-subjects when trained on original data vs. synthetic data. For all learners, grid-search for hyperparameter and feature selection, and 10-fold test/train cross-validation was conducted, with test groups only derived from non-augmented data.
***Results:** After SMOTE, there were 6392 patients, 25% in all four groups (Fig 1A). All learners on un-augmented data trended towards less accurate hazard estimates associated with SA ethnicity (versus non-SAs) than when trained on augmented data (Fig 1B). C-indexes for these models are improved for survival estimation in SA patients after applying SMOTE ($p<0.05$ for RF and SVM). C-indexes in all-subjects trend to also improve after SMOTE ($p<0.05$ in GBT, RF).
***Conclusions:** In this empiric study, we found that the SMOTE algorithm could be applied to positive effect in improving ML prediction for a selected minority class with preserved classification accuracy in other groups.



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