Optimizing Liver Transplant Success: A Data-Driven Approach Incorporating MELD for Accurate Survival Prediction and Equitable Organ Allocation

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Model for End-Stage Liver Disease (MELD)score, a widely used tool, predicts 90-day waitlist-mortality but fails to account for post-transplant survival, leading to suboptimal organ allocation and poor long-term outcomes. This research proposes a systematic machine learning pipeline combining feature selection, predictive modeling, explainability analyses to assess clinical and donor variables' impact on 90-day post-transplant survival in liver transplant recipients. Using data from United Network for Organ Sharing (UNOS), comprising 341,208 candidates and 22,123 donors, study trained ML algorithms, Random Forest, LightGBM, Decision Tree, Hist Gradient Boosting, and XGBoost, on key clinical variables like sodium, bilirubin, creatinine, and cold ischemia time. XGBoost demonstrated superior performance, achieving 96% predictive accuracy, AUC of 0.85, outperforming MELD's 48% accuracy. Analysis identified critical predictors of survival such as cold ischemia time, donor cause of death, donor ICU stay, and recipient's clinical history, reaffirming the model's reliability to minimize organ wastage and accurately predict risk. While the ML model enhances prediction accuracy, its direct application in clinical settings is limited by complexity. The PRESTO (Predictive Evaluation for Survival and Transplant Outcomes)score and desktop software were developed to address this gap. The system integrates key variables from the ML pipeline into a Cox regression-based scoring model, with MELD for clinical adoption. Combining machine learning precision with PRESTO's practicality, this research delivers an actionable framework that improves survival outcomes, reduces organ wastage, and ensures equitable allocation, with potential applications in other organ transplants.

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