

Cardiovascular Disease Risk Prediction Using Machine Learning: A Prospective Cohort Study of 423,604 Participants

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Background: Identifying people at risk of cardiovascular diseases (CVD) is a cornerstone of preventative cardiology. Risk prediction models currently recommended by clinical guidelines are based on a limited number of predictors with sub-optimal performance across all patient groups.

Purpose: To test whether a state-of-the-art method machine learning (ML) method (AutoPrognosis) can improve the performance of risk predictions and discover novel CVD risk predictors.

Methods: AutoPrognosis is an algorithmic tool that automatically selects and tunes ensembles of ML models and learns the relative importance of different risk predictors. Using data on 473 variables collected for 423,604 participants without CVD at baseline in UK Biobank, we evaluated the accuracy of AutoPrognosis in predicting the participants' future CVD events. We compared the predictive accuracy of AutoPrognosis with a standard risk prediction score (Framingham score), a Cox proportional hazards (PH) model based on 7 conventional risk factors, and a Cox PH model based on all variables in the UK Biobank. Predictive performances were assessed using area under the receiver operating characteristic curve (AUC-ROC).

Results: Our AutoPrognosis model improved risk prediction (AUC-ROC: 0.764, 95% CI: 0.758-0.770) compared to Framingham score (AUC-ROC: 0.707, 95% CI: 0.703-0.711, $p < 0.001$), the Cox model with (AUC-ROC: 0.741, 95% CI: 0.736-0.746, $p < 0.001$), and the Cox model (AUC-ROC: 0.741, 95% CI: 0.736-0.746, $p < 0.001$). Our AutoPrognosis model included predictors that are not usually considered in existing risk prediction models, such as the individuals' usual walking pace and their self-reported overall health rating. Furthermore, our model substantially improved risk prediction in individuals with history of diabetes (AUC-ROC: 0.756, 95% CI: 0.745-0.767) compared to the Framingham score (AUC-ROC: 0.634, 95% CI: 0.625-0.673, $p < 0.001$).

Conclusion: Our AutoPrognosis improves the accuracy of CVD risk prediction in the UK Biobank population. Additionally, AutoPrognosis uncovered novel predictors for CVD disease that may now be tested in prospective studies.