

External Validation and Calibration of Health Risk Models that Predict Readmission Risk in Patients with Heart Failure

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Purpose

This study aims to externally validate seven well-performing published health risk models that predict readmission risk in patients with heart failure on a new patient cohort.

Method

From systematic reviews, seven well-performing and recent health risk models for readmission in heart failure were selected on the following criteria: AUC above 0.7, logistic regression, complete reporting for reproduction, 20 predictors at maximum. The seven models are from Van Walraven (2010)¹, Zhang (2013)², Cubbon (2014)³, Huynh (2017)⁴, Leong (2017)⁵, and two models from Huynh (2015)⁶. For the external validation, we used data from the OPERA-HF study which includes patients hospitalized for heart failure at Hull and East Yorkshire Hospitals NHS Trust (UK) between 2012 and 2018. We went through the following stages of external validation: unadjusted calibration, calibration-in-the-large, logistic calibration, and model revision⁷. We measured performance indices of discrimination (AUC), calibration (mean estimated risk, intercept, slope, Estimated Calibration Index, calibration plot) and fit (Brier, Nagelkerke R² and log-likelihood).

Results

Achieving discrimination performance as claimed in the original publications proved to be challenging for all seven models when externally validating them on the OPERA-HF data. Models demonstrated fair discrimination after model revision, being a model re-estimation on the new data. Mean and weak calibration properties could be established using logistic calibration. Missingness of data to populate predictors and incomplete reporting of the model specification were a concern. Experimentation, proxy finding and imputation were required for predictors for which no data was collected in the OPERA-HF study. The model of Zhang et al (2013) provided most encouraging results in model reproducibility and performance in discrimination, calibration and fit (see Figure 1).

Conclusions

Assessing calibration and discrimination of health risk models on a new patient cohort is an often-overlooked prerequisite. More research should be devoted to the calibration, external validation, and actual deployment of such models in clinical practice. As we facing challenging in populating predictors with available data, we would encourage standardization efforts in predictor sets for heart failure risk models. Finally, publications should adhere to the TRIPOD reporting guideline to facilitate implementation and validation of these risk models.

EXTERNAL VALIDATION OF HEALTH RISK MODELS

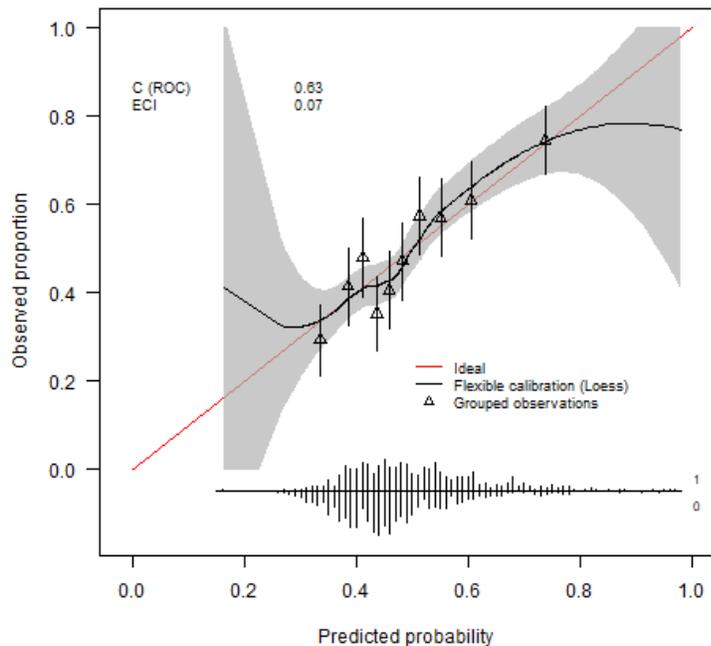


Figure 1. Calibration plot of Zhang² model after model revision. The gray area illustrates the confidence interval of the flexible calibration curve (black curve). The histogram at the bottom of the plot shows the predicted risk for patients with (1) and without (0) the event.

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EXTERNAL VALIDATION OF HEALTH RISK MODELS

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