A Clinical Decision Support tool to identify predictors of decompensation, acute-on-chronic liver failure and mortality in liver cirrhosis – a multicentre SingHealth Chronic Liver Disease Registry (SoLiDaRity-DAM)

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Background

Chronic liver disease, particularly cirrhosis, poses a significant health burden in Singapore, resulting in substantial mortality rates. Timely identification of decompensation and acute-on-chronic liver failure (ACLF) in cirrhosis patients is crucial to reduce mortality and improve outcomes. In this study, we address the pressing need for predictive tools by leveraging electronic health records (EHR) and advanced machine learning techniques to develop an automated clinical decision support system SoLiDaRity-DAM. This system aims to predict decompensation events, facilitate timely referral for liver transplantation, and enhance patient care in cirrhosis management.

Method

SoLiDaRity-DAM encompasses a comprehensive approach to converting longitudinal structured patient data from EHR sources into predictive algorithms and machine learning models. The development process places a strong emphasis on merging clinical expertise with statistical methods.

The outcome variables of this study were :

- decompensation
- time to decompensation

Any information collected in the SoLiDaRity Registry was considered a predictor of these outcomes, including demographic factors, biomarker levels during cirrhosis diagnosis, and the presence of comorbidities.

Results

Figure 1: The natural progression of cirrhosis in a patient, highlighting critical liver-related events (shown in red boxes) such as cACLD, decompensation, ACLF, and mortality.

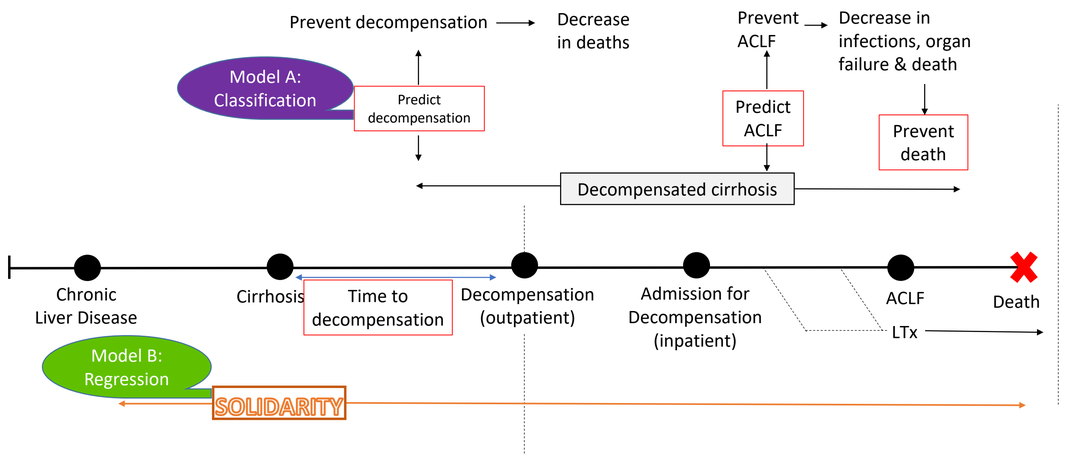


Figure 2: Flowchart of selection of patients

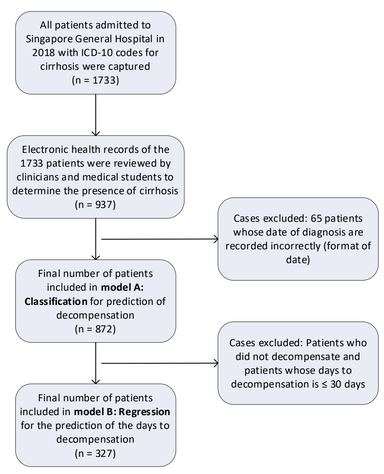
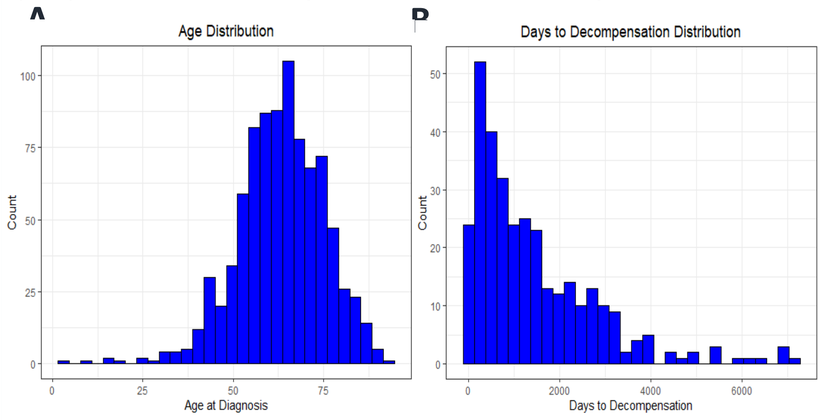


Figure 3 ↓: Presenting characteristics of cirrhotic patients in the SoLiDaRity Registry (n = 872)

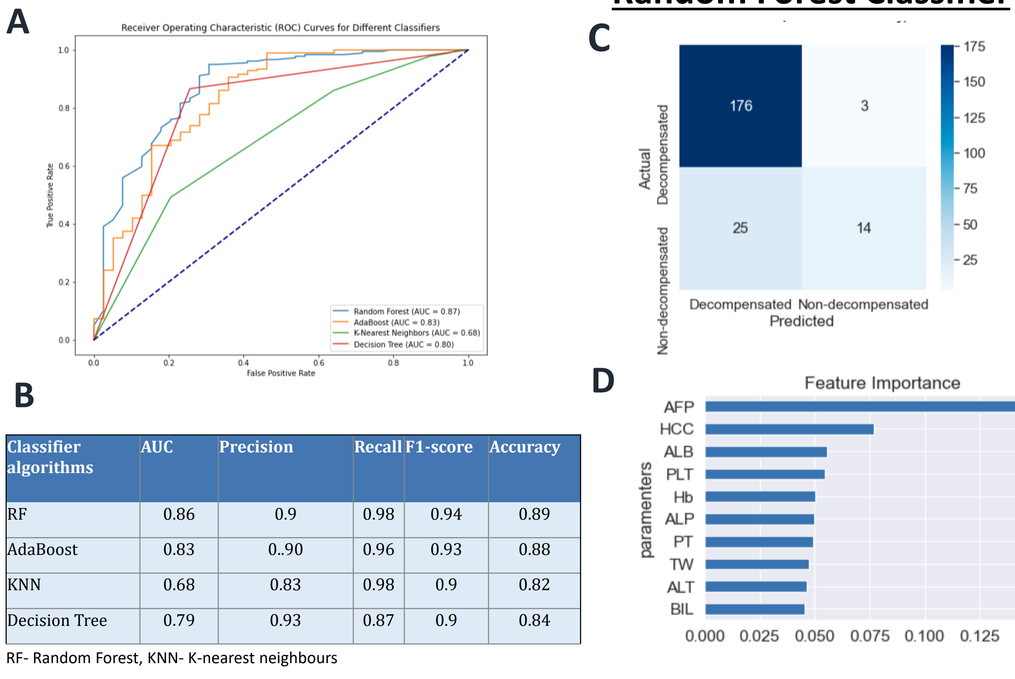
Baseline Characteristics		Total (n = 872)
		n (%)
Age at diagnosis (mean (SD))		63.14 (12.00)
Gender	Female	310 (35.6)
	Male	562 (64.4)
Race	Chinese	657 (75.3)
	Malay	61 (7.0)
	Indian	75 (8.6)
	Others	79 (9.1)
Etiology	NAFLD/NASH	224 (25.7)
	Hepatitis B	245 (28.1)
	Hepatitis C	54 (6.2)
	Alcohol	95 (10.9)
	AIH	15 (1.7)
	PBC	24 (2.8)
	Cryptogenic	131 (15.0)
	Coinfection/Others	84 (9.6)

Figure 4. Histograms showing the distribution of Age (A) and Time to decompensation (B) in cirrhotic patients of the study. (C) The average time to decompensation for each etiology of cirrhosis. Within the patient cohort, those diagnosed with Autoimmune Hepatitis (AIH) demonstrate the quickest onset of decompensation.↓



Classification Model

Random Forest Classifier



B

Classifier algorithms	AUC	Precision	Recall	F1-score	Accuracy
RF	0.86	0.9	0.98	0.94	0.89
AdaBoost	0.83	0..90	0.96	0.93	0.88
KNN	0.68	0.83	0.98	0.9	0.82
Decision Tree	0.79	0.93	0.87	0.9	0.84

RF- Random Forest, KNN- K-nearest neighbours

←Figure 5 In this proof-of-concept (POC) study, we have tested 4 Random Forest Classifier models using clinically annotated data from our registry. The objectives of the classifier model (Model A) was to predict the likelihood of cirrhosis patients developing decompensation based on collected clinical indicators.
(A) ROC curves and AUC of the four classification models for LOS prediction.

(B) The prediction performance of the four classification models for decompensation prediction.

(C) The best classifier, Random Forest Classifier, achieved an accuracy score of ~89%, highlighting its potential for identifying patients at risk of decompensation.

(D) Feature selection further revealed the top 10 ranking variables, with biomarkers like Alpha Fetoprotein (AFP) and the presence of Hepatocellular Carcinoma (HCC) and various biomarkers (ALB) standing out as critical factors in distinguishing patients with decompensated cirrhosis.

Regression Model

A

Model	Loss functions			
	RMSE	MSE	MAE	MRE
Linear Regression	0.92	0.84	0.96	2.305
Lasso MSE	1	1	0.75	1
Ridge MSE	0.92	0.84	0.69	2.299
Random Forest	0.39	0.15	0.29	4.015
Gradient Boost Regression	0.43	0.18	0.34	3.914

B

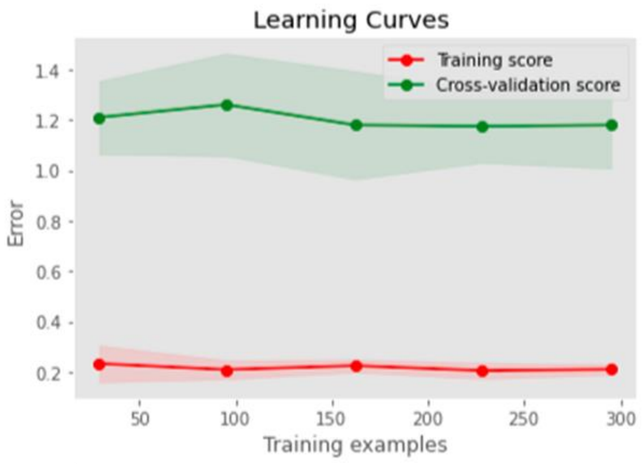


Figure 6 ↑: (A) The prediction performance of the five regression models for prediction of decompensation. Random Forest is identified as the best model based on its lowest loss function values. (B) The visualization of the loss function or the total error performance measure of the best performing model, Random Forest, for training and validation datasets.

Conclusion

SoLiDaRity-DAM demonstrates the feasibility of utilising AI and machine learning techniques to predict decompensation events in cirrhosis patients with high accuracy. By integrating clinical expertise and EHR data, this AI-powered clinical decision support system holds promise in improving patient outcomes by enabling timely interventions, including the referral for liver transplantation. The development of SoLiDaRity-DAM represents a crucial step towards personalised, data-driven cirrhosis management, with the potential to significantly reduce mortality and healthcare costs in Singapore's population.