

Prognostic value of non-invasive filling-pressure derived estimates for 90-day non-elective all-cause hospitalisation following right heart catheterisation

Author list: Andrew Sauer¹, Kunjan Bhatt², Timothy Fendler³, Owais Dar⁴, Derek So⁵, Anthony Carnicelli⁶, Mads Ersbøll⁷, Rohan Goswami⁸, Susanna Mak⁹, Colm McCabe¹⁰, Tomas Mellberg¹¹, Parth Patel¹², Jozef Bartunek¹⁴, Peter Cowburn¹⁵, Patrick Campbell¹⁶, Stuart Russell¹⁷, Aditya Parikh¹⁸, Rimsha Hasan¹⁹, Marat Fudim²⁰, TM. Martyn²¹, Adriana Luk¹³

Background: Right atrial pressure (RAP) and pulmonary capillary wedge pressure (PCWP) reflect haemodynamic congestion and are associated with hospitalisation.

- We defined a continuous *congestion index* (ACI = RAP + 4 × PCWP) to emphasise left-sided filling pressure (PCWP) relative to right-sided pressure (RAP) based on ~80% of hospitalisations in CAPTURE-HF having elevated PCWP.
- Using a non-invasive multisensor device recordings (Seismic, Acoustic, Visual and Electric: SAVE System) and demographic data were acquired within 30 minutes of a right heart catheterisation (RHC), we trained and tested two machine-learning models to estimate (i) ACI and (ii) PCWP ‘traffic-light’ classifier.

Hypothesis: Non-invasively estimated congestion index (ACI) and PCWP traffic-light classification at RHC are prognostic of 90-day non-elective all-cause hospitalisation; combining them improves risk stratification vs. either approach alone.

Methods: In CAPTURE-HF Phase 1, 1,206 patients were enrolled across 14 sites in 6 countries (~50% US), and had 90-day follow-up.

Congestion index & PCWP traffic-light derivation:

- Reference ACI was derived from invasive RAP and PCWP values.
- PCWP traffic-light thresholds were set at: <15 mmHg (green) and >20 mmHg (red).

Predictions: We generated cross-validated (CV) estimates (3 seeds; 5-fold CV) for ACI (regression model) and traffic-light classes (classification model).

ML-model architecture: XGBoost gradient-boosted decision trees. Input features comprised ~1,000 variables (~800 sensor features and ~200 demographic features).

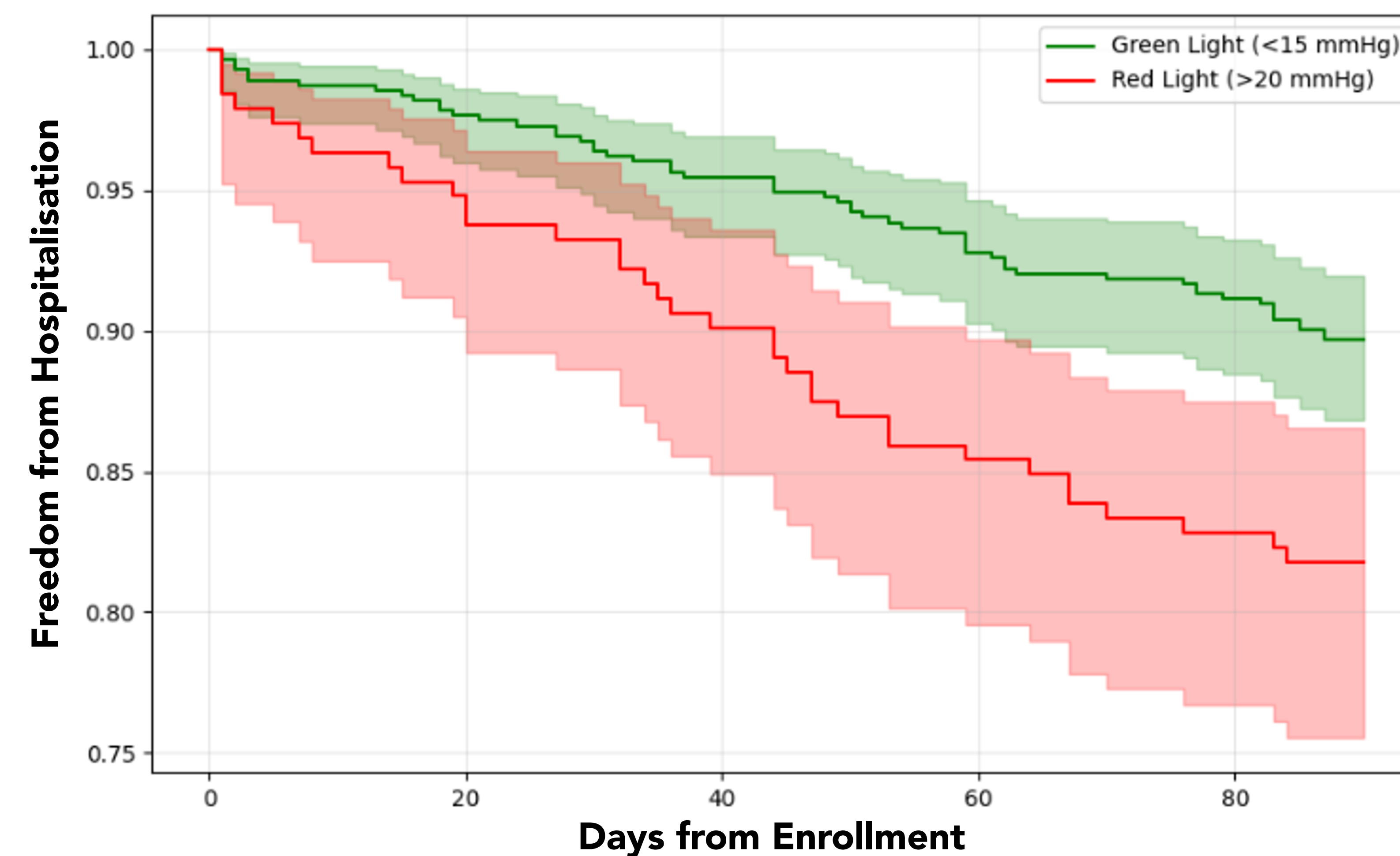
Missing value & imbalance handling: Imputed with column-wise means. Class imbalance was handled with inverse-frequency class weighting.

Hyperparameter optimisation: Nested GridSearchCV within each outer CV fold

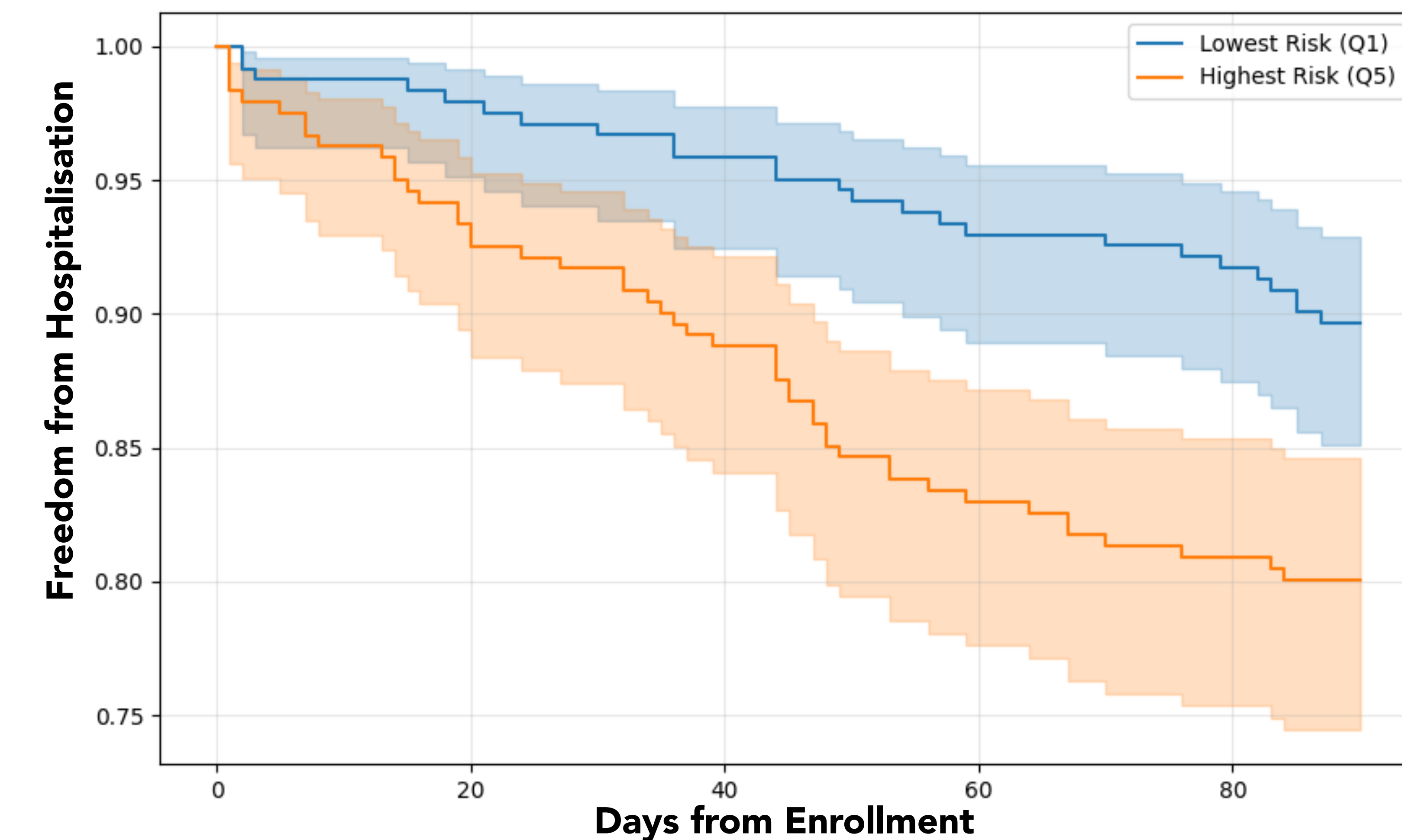
Analysis:

- Time-to-first non-elective all-cause 90-day hospitalisation was analysed using Kaplan-Meier estimates using estimated ACI quintiles and PCWP traffic-light classes based on out-of-fold predictions.
- Log-rank tests for group comparisons and Cox proportional hazards regression for hazard ratios (95% CI). Patients without events were censored at 90 days.

Prognostic Value of Green vs. Red Pulmonary Capillary Wedge Pressure (PCWP) Traffic Light (Green = PCWP < 15, Red = PCWP > 20 mmHg) for All-cause Non-elective Hospitalisation



Prognostic Value of Congestion Index (Q5, Q1) for All-Cause Non-elective Hospitalisation



Results: Overall, 14.4% (177/1230) had hospitalisation within 90d. 2 deaths were reported.

- Estimated ACI quintiles showed a risk ratio (RR) of 2.1 (Q5/Q1: 20.6%/9.8%; p<0.005).
- Estimated PCWP-traffic-light had a RR of 1.83 (green 11.4% and red 20.9%; p<0.005).
- Combining both ACI and PCWP traffic-light class, strengthened risk stratification: patients with top quintile ACI and “red” traffic-light had the greatest event rate (22.9%)

Conclusions:

- Non-invasively estimated ACI and a PCWP traffic-light classification model stratified 90-day hospitalisation risk after Right Heart Catheterisation.
- Both red traffic-light class and top quintile ACI identifies a higher-risk subgroup
- Combining ACI and PCWP traffic-light improved risk discrimination
- A PCWP-traffic light and a congestion index built on RAP and PCWP may aid risk stratification and inform discharge decision-making & post-discharge management.
- Further validation in an independent HF cohort is warranted.

Total Subjects	1230
Age (years), Mean (SD)	63.4 (14.4)
Female Sex, N (%)	460 (37.4%)
BMI (kg/m ²), Mean (SD)	28.7 (6.6)
Baseline RAP (mmHg), Mean (SD)	8.6 (5.7)
Baseline PCWP (mmHg), Mean (SD)	15.6 (8.4)
Baseline Cardiac Index, Mean (SD)	2.47 (0.93)
90-Day Non-Elective Hosp., N (%)	177 (14.4%)
Survival Analysis	
ACI (Q5 vs Q1 Reference)	
Hazard Ratio (95% CI)	2.10 (1.45-3.05)
Risk Ratio (Q5/Q1)	2.10
Log-Rank P-Value	< 0.005
Traffic Light (Red vs Green) for PCWP	
Hazard Ratio (95% CI)	1.87 (1.23-2.85)
Log-Rank P-Value	< 0.005