Machine Learning-Based Prediction of Cardiac Arrest Outcome Using a Large Multi-Center Database

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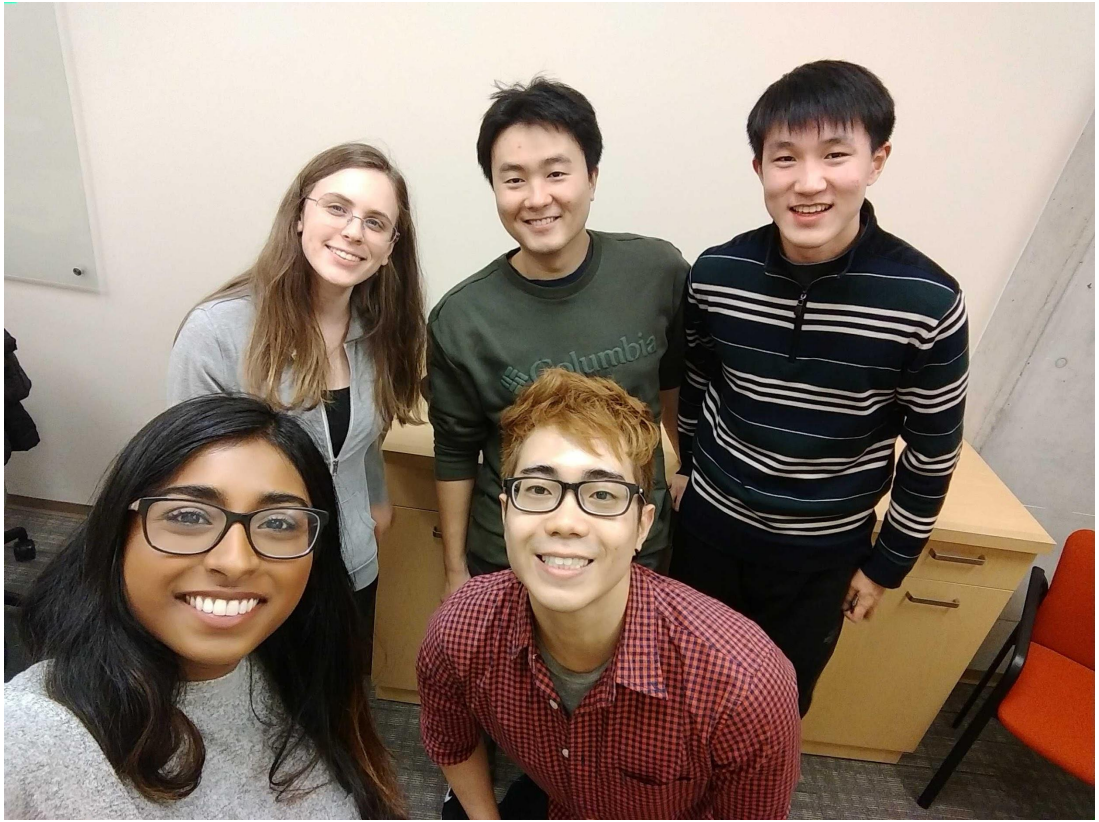
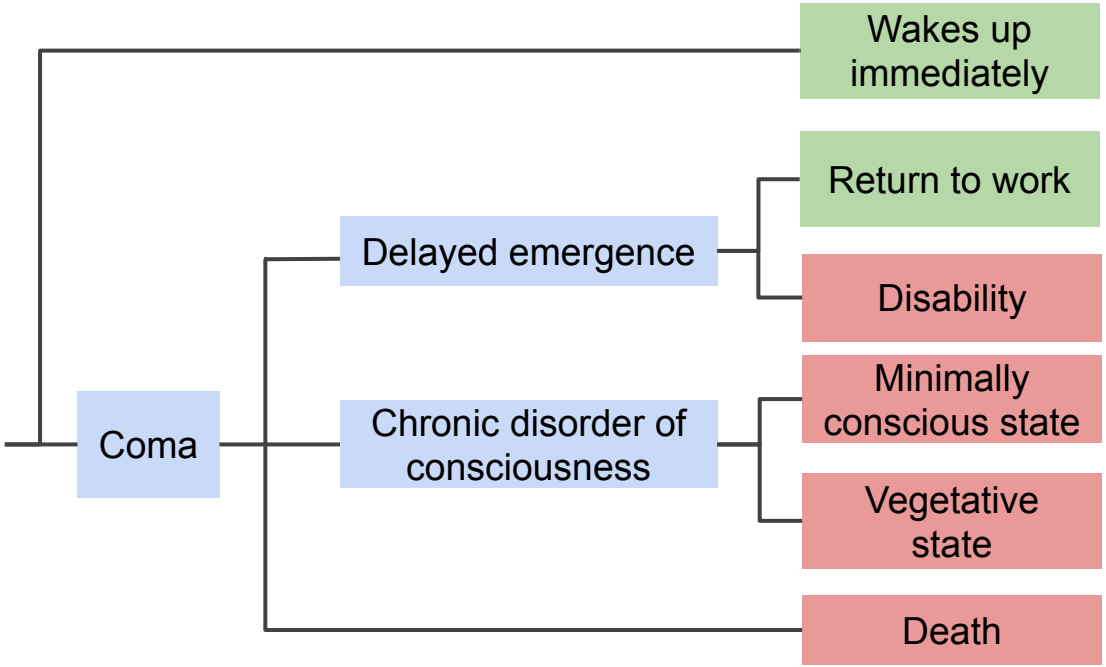


Problem Introduction

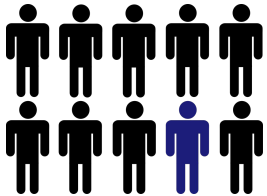


Significance and Innovation

$140,000 cost incurred

per QALY for continuing aggressive treatment in high-risk patients

Fewer than 10%



leave hospital without neurological damage

Large Unmet Need

for accurate and reliable methods to predict post-CA prognostication

We bring to the table...

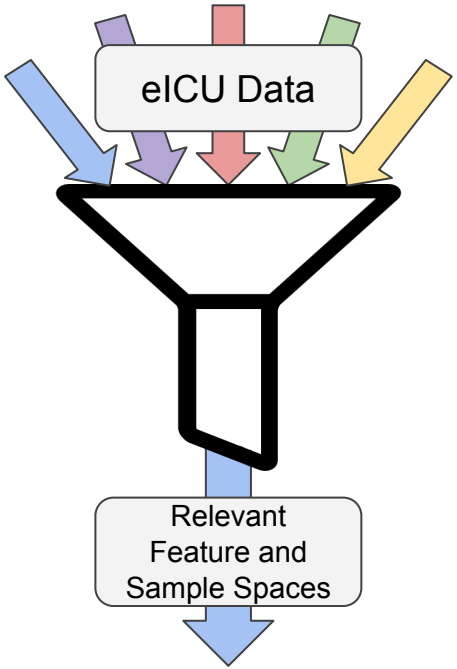
Integration of physiological time series

Large database from 200+ hospitals

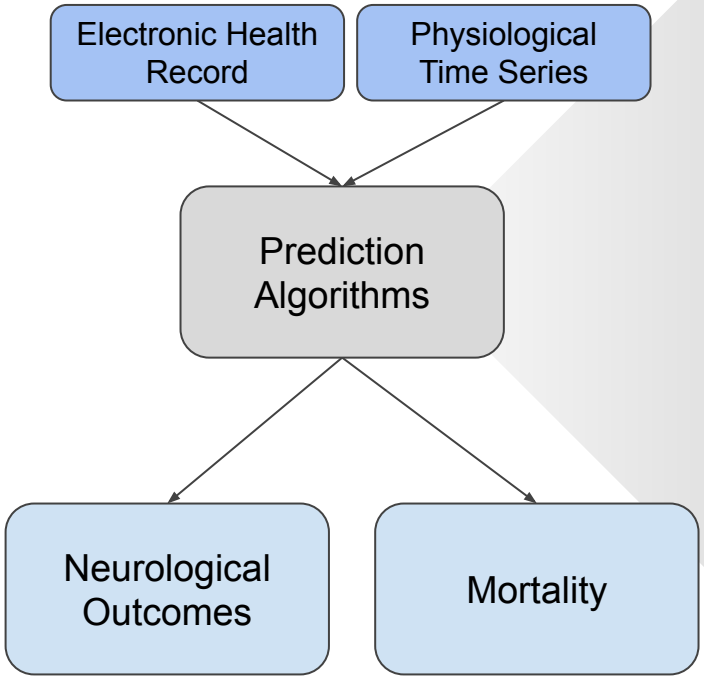
Clinical and engineering expertise

Approach

Aim 1: Data preprocessing and data exploration



Aim 2: Prediction of cardiac arrest outcomes



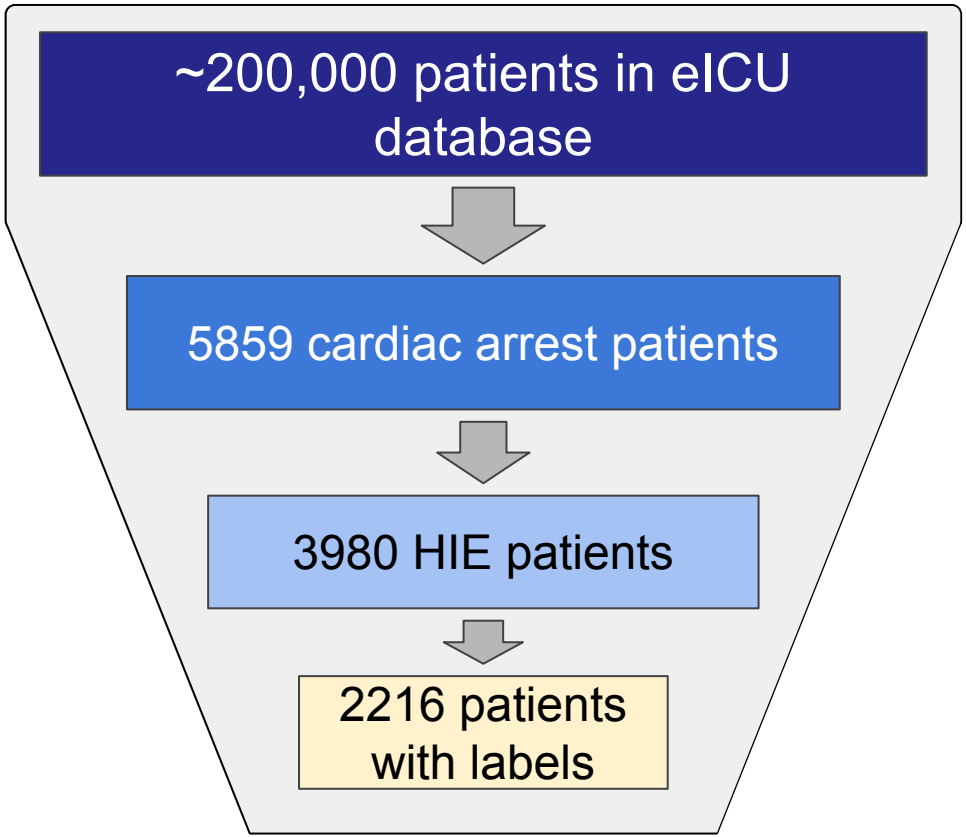
Machine Learning Algorithms:

- GLM: LASSO & Elastic Net
- Random Forest
- Gradient Boosting
- XGboost
- Neural Networks (LSTM, GRU)

Model Refinement:

- Transfer Learning
- Optimization Techniques
- Combination of Models (stacking)

Selecting Population, Features, and Labels



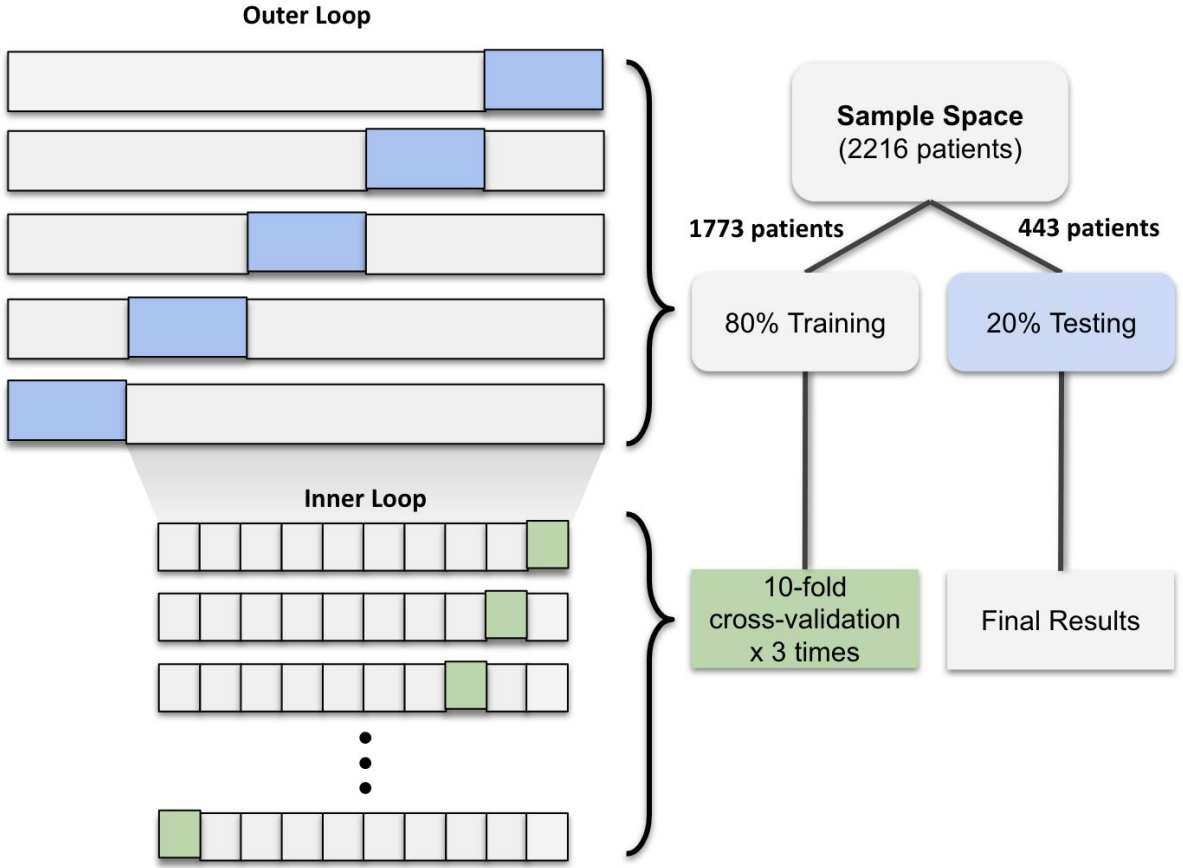
Feature Space

Time-Series (first 24 hours)	Numerical	Categorical
Blood Pressure	pH	Cardiac Arrest Location
SPO2	Age	Intubation
Respiratory Rate	GCS at admission	Initial Rhythm
Heart Rate	pCO_2	Sex
...	...	...

Label Spaces

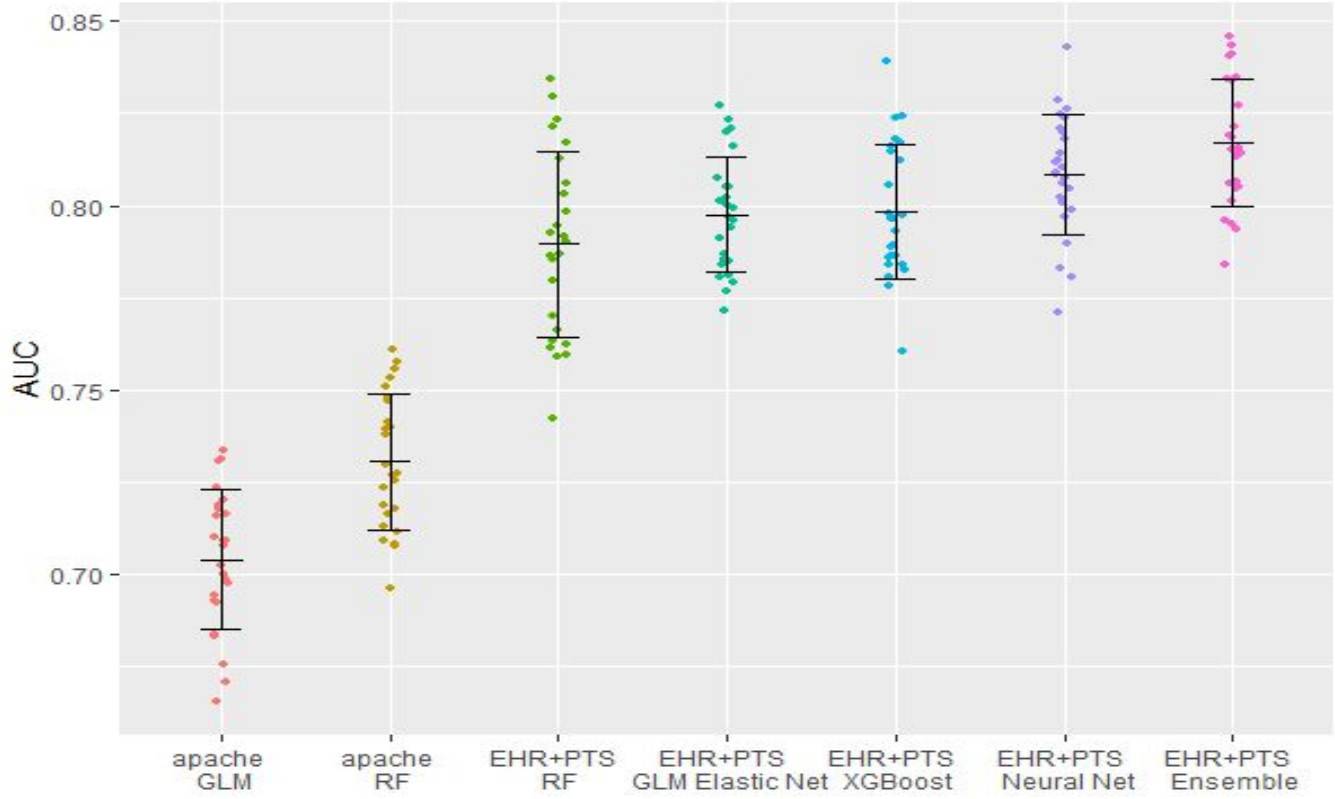
Bad Neurological Outcome	Expired
Good Neurological Outcome	Alive

Supervised Learning Pipeline



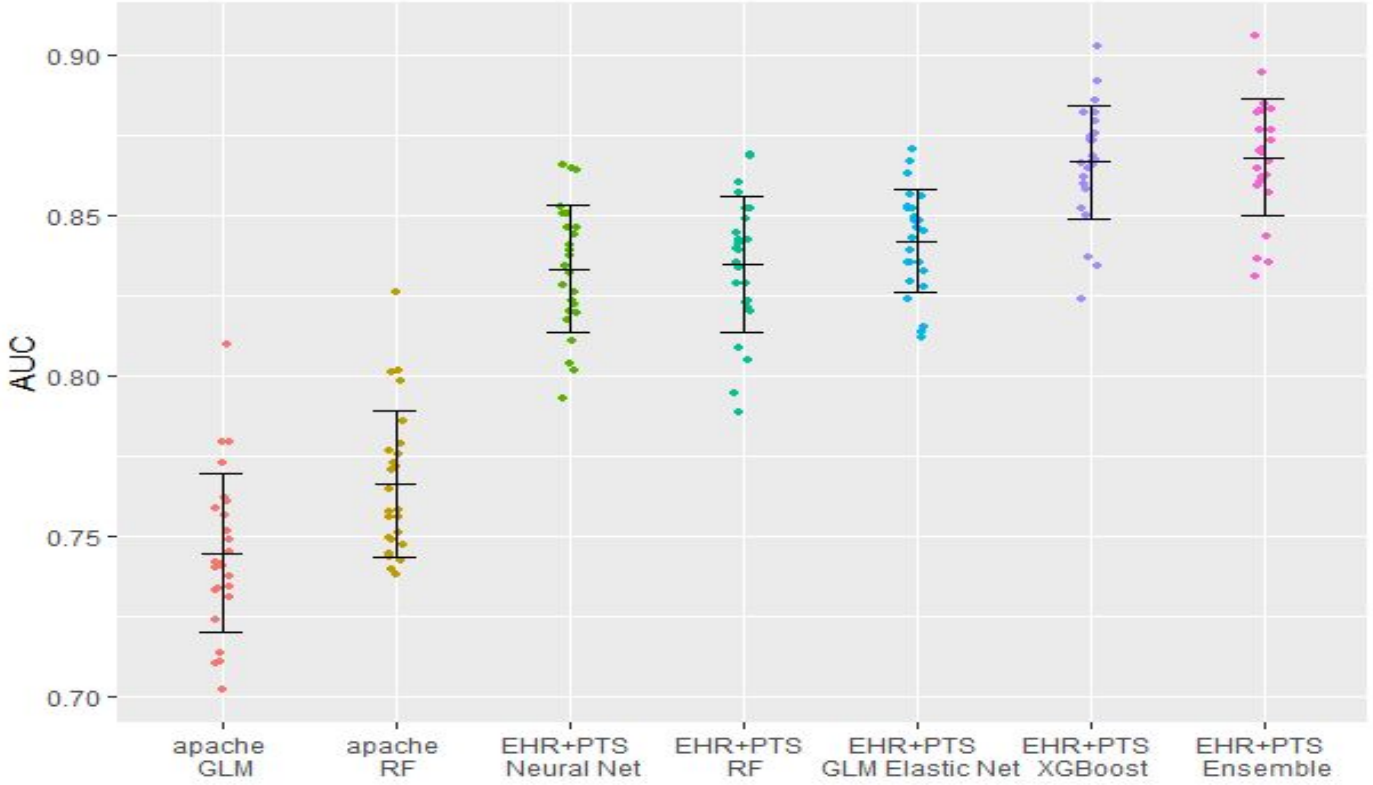
Results

Mortality Outcome



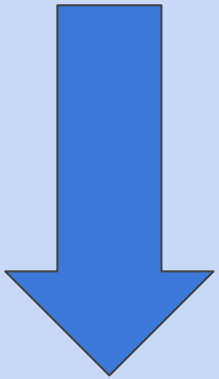
Results

Neurological Outcome



Transfer Learning Approach

Pre-train Neural Network on ~140,000 patients



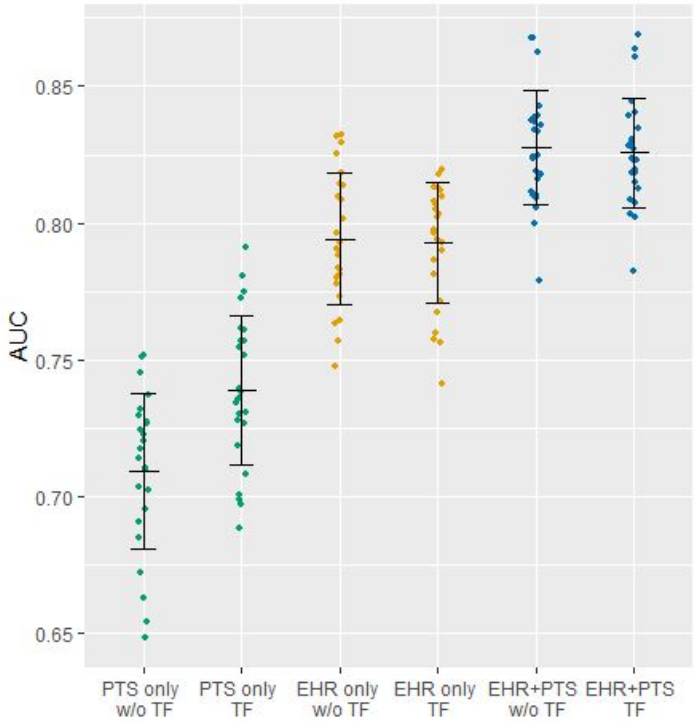
Apply Transfer Learning weights to our CA patients

Pre-training Performance

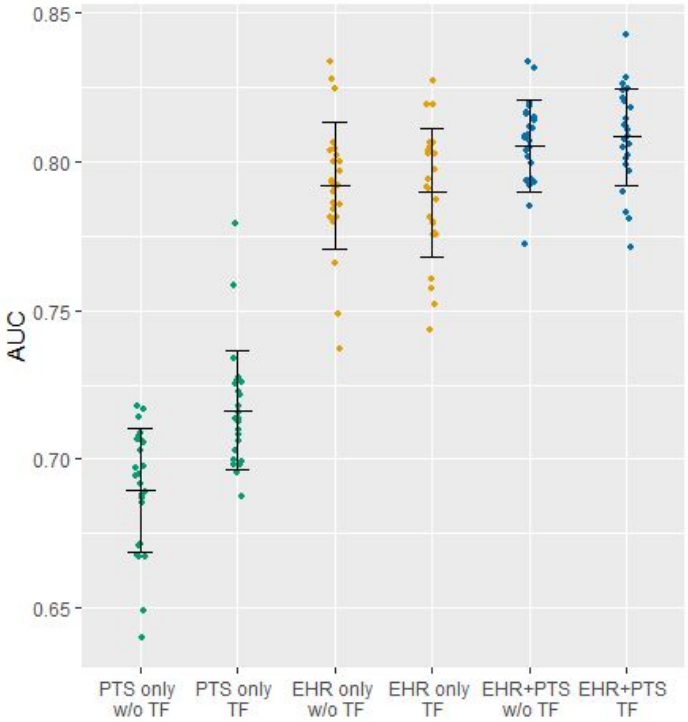
	Net	Validation AUC (~10000 patients)	Test AUC (~10000 patients)
EHR	Fully-connected neural network	0.89	0.87
PTS	Convolutional neural network	0.84	0.85
EHR+PTS	Fully-connected + convolutional neural network	0.90	0.90

Deep Learning Results

Neurological Label Applied

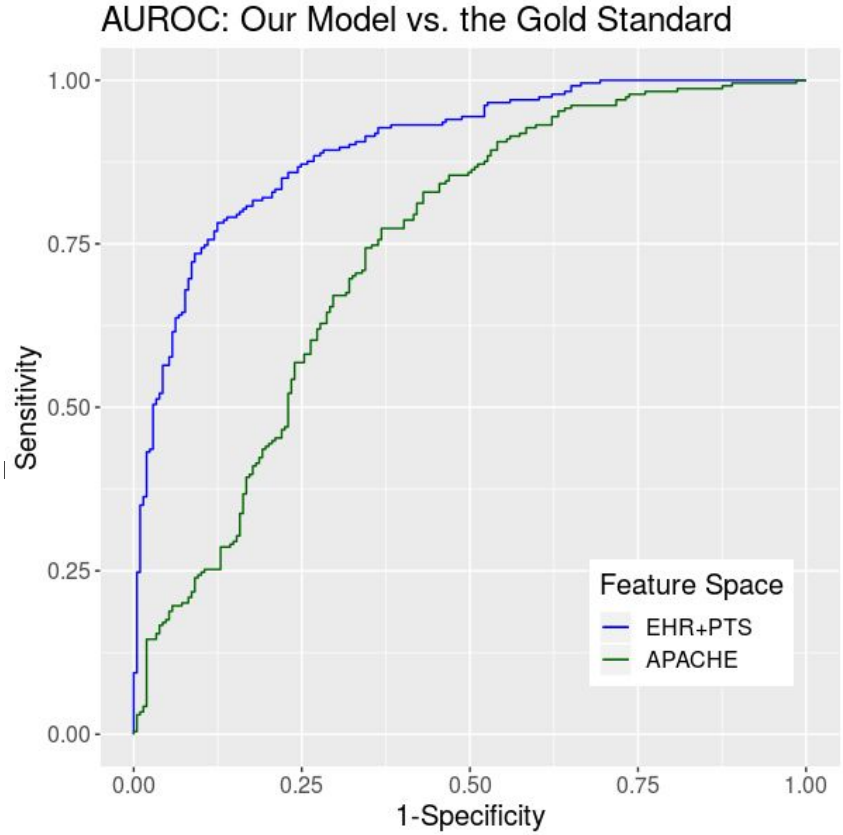


Mortality Label Applied



Results

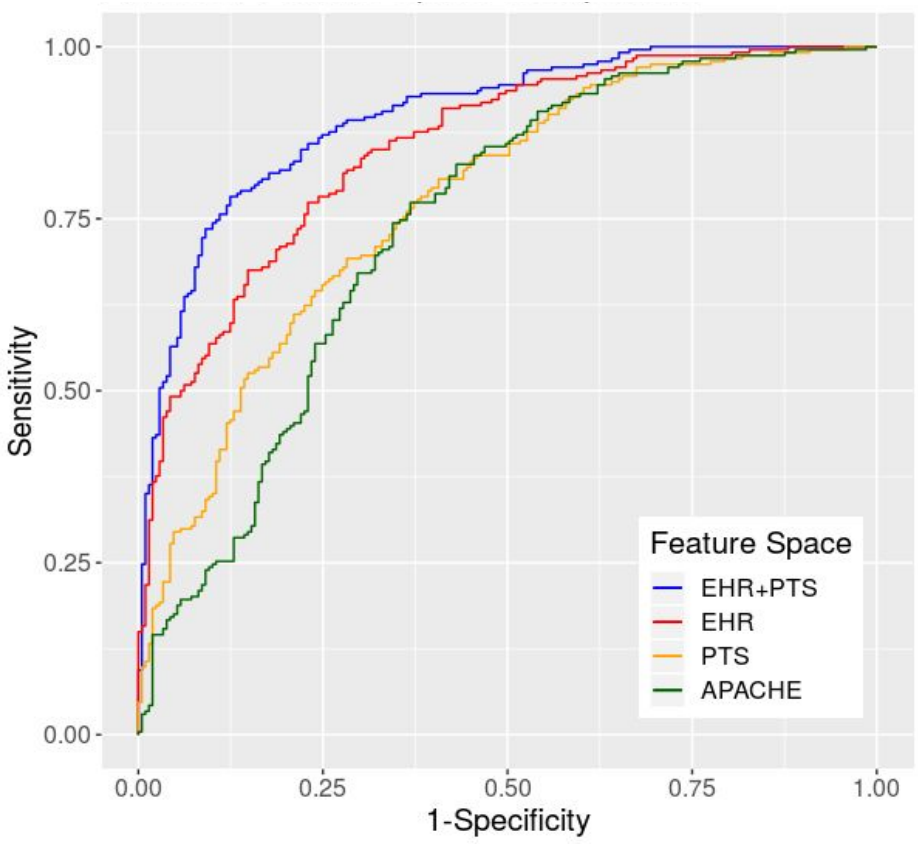
Neurological Outcome



	Clinical Baseline	Our Model
Area Under the ROC Curve	0.74	0.87
Sensitivity	0.77	0.78
Specificity	0.63	0.88

Results

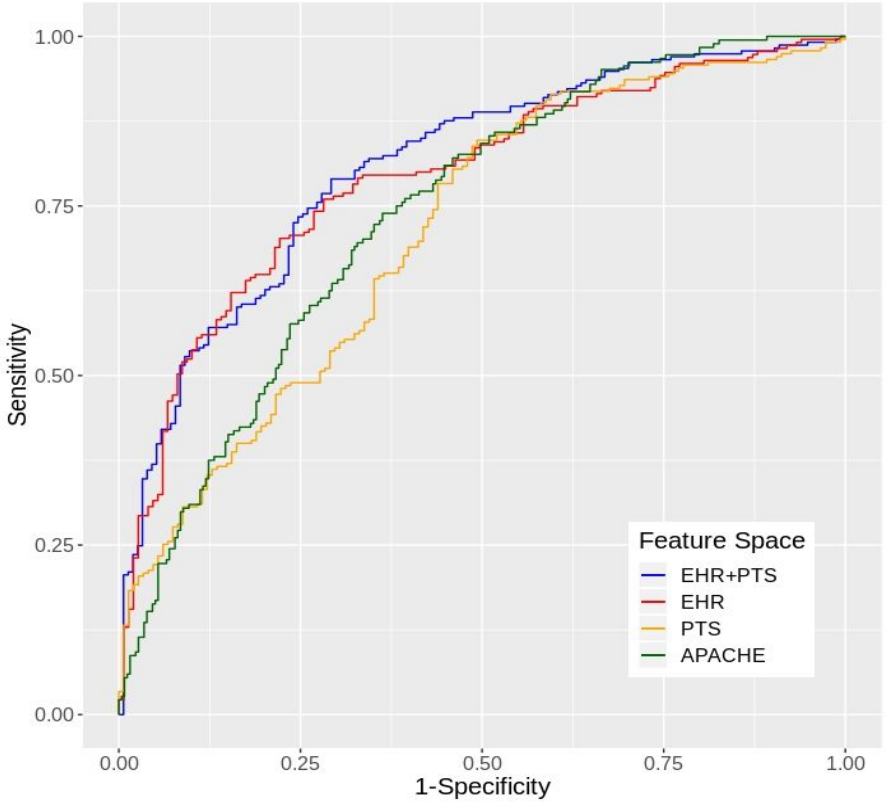
Feature Space Comparison Neurological Outcome



	Clinical Baseline	EHR	PTS	EHR + PTS
AUC	0.74	0.83	0.78	0.87
Sensitivity	0.77	0.77	0.66	0.78
Specificity	0.63	0.77	0.74	0.88

Results

Feature Space Comparison Mortality

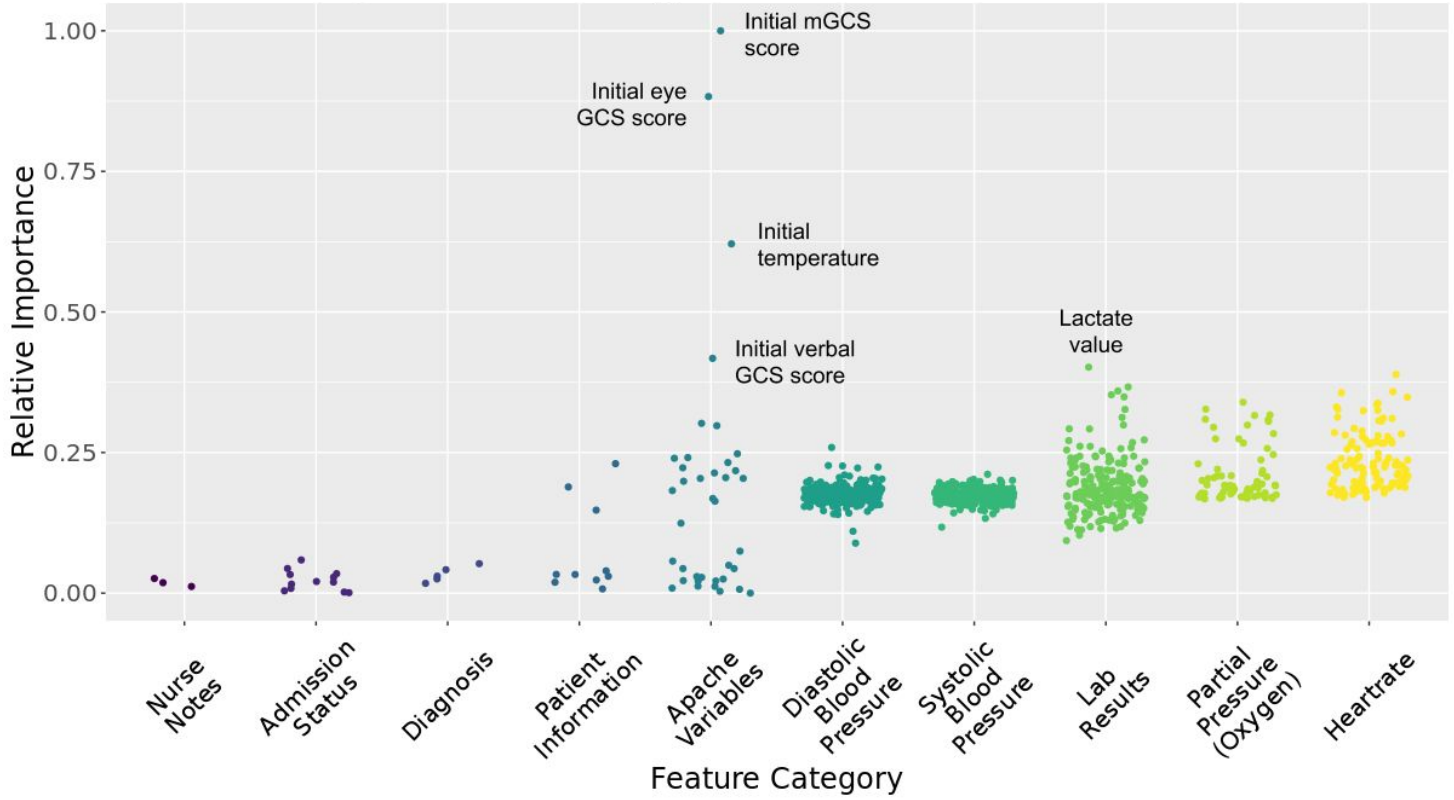


	Clinical Baseline	EHR + PTS
AUC	0.75	0.81
Sensitivity	0.86	0.78
Specificity	0.56	0.71

*Additional optimization being performed

Results

Feature Space Analysis Neurological Outcome



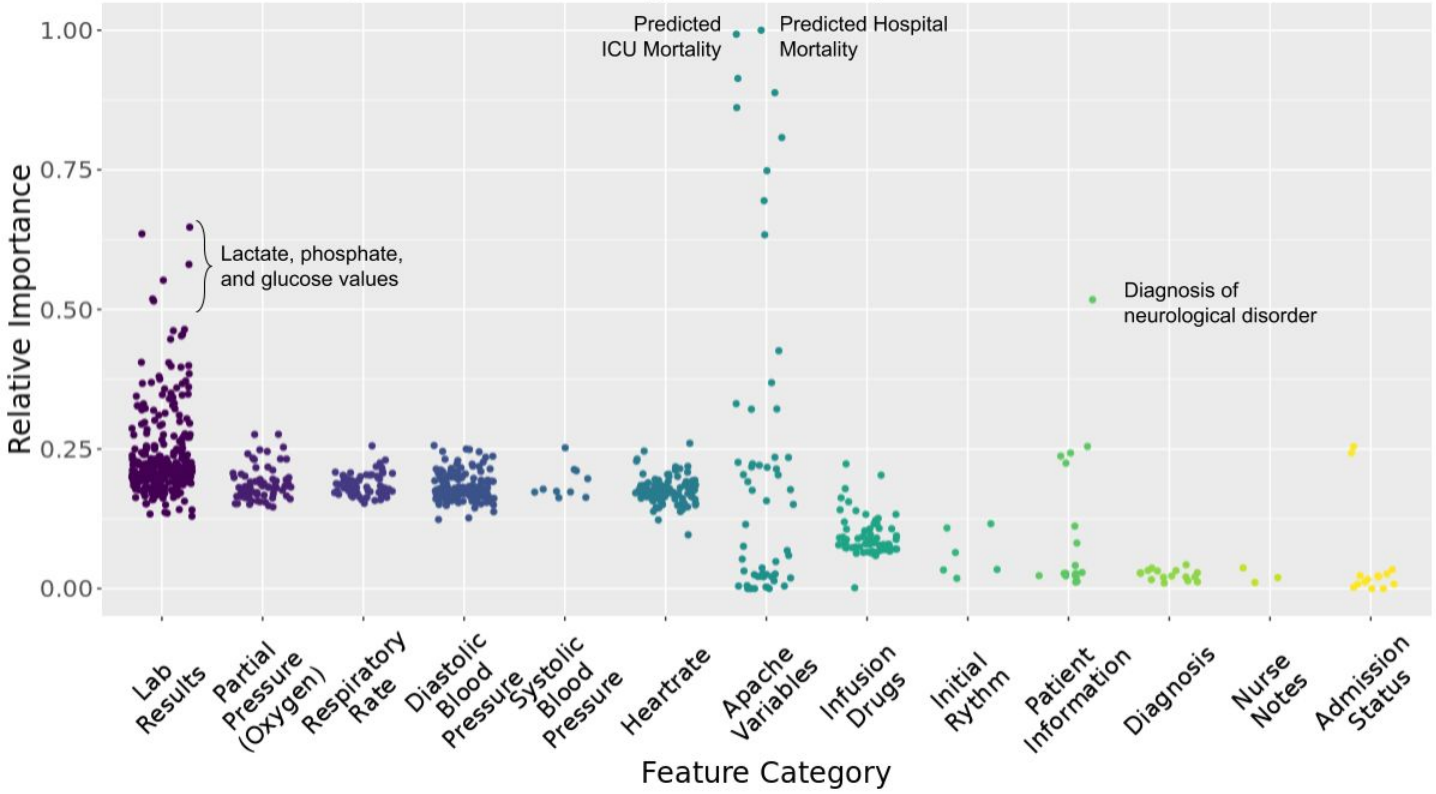
Results

Feature Space Analysis Neurological Outcome

Feature ranking	Feature type	Correlation (+/-) with good outcome
1	GCS at ICU admission	+
2	Worst motor GCS	+
3	Worst eye GCS	+
4	Worst temperature	+
5	Sofa score	-
6	Worst verbal GCS	+
7	Mean lactate level	-
8	Heart rate fluctuation	+
9	Dexmedetomidine infusion drug	+
10	Maximum lactate level	-

Results

Feature Space Analysis Mortality Outcome



Conclusion and Future Work

Conclusion

With further validation, our model could:

- aid physicians in clinical decision making to allocate appropriate treatment regimens
- help identify previously overlooked predictive features which merit further investigation

Future Work

1. Publication
2. Get access to the additional datasets for external validation
   - MIMIC III
   - Entire eICU database

Acknowledgements

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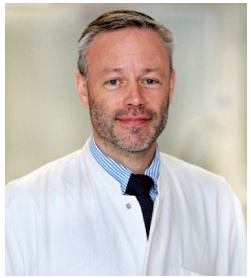

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Thank you for listening!

Questions? Comments?