Novel Machine Learning on Asynchronous Clinical Pages to Predict Clinical Deterioration

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INTRODUCTION

Early warning scores (EWS) are widely used to predict clinical deterioration, but often suffer from poor sensitivity to detect acute events. We introduce a novel machine learning approach that analyzes the content of sequential clinical pages sent between clinicians as part of routine care delivery to improve the detection of clinical deterioration.

METHODS

- Clinical deterioration was defined as Rapid Response activation, unplanned transfer to an intensive care unit (ICU), or in-hospital cardiac arrest.
- We developed a long-short term memory (LSTM) algorithm to predict clinical deterioration events within the next 24 hours (Figure 1).
- The model used a sliding window approach, making a prediction using the ten most recent pages sent about a patient upon arrival of each new page.
- We excluded patients with a planned ICU stay, receiving end of life care, admitted for less than 24 hours, or who were the subject of less than 5 pages.
- Defined predicted events as any positive prediction made at any point within 24 hours prior to deterioration.

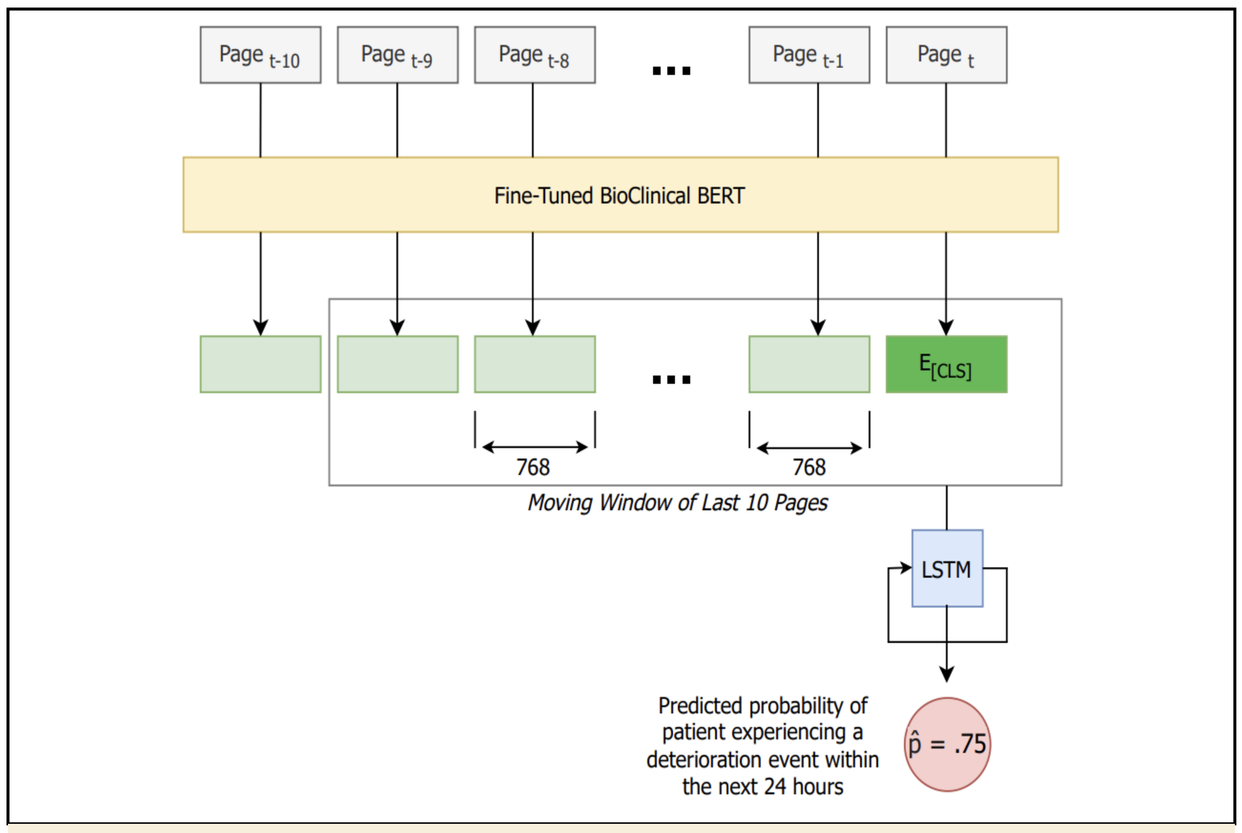


Figure 1. Overview of Machine Learning Pipeline

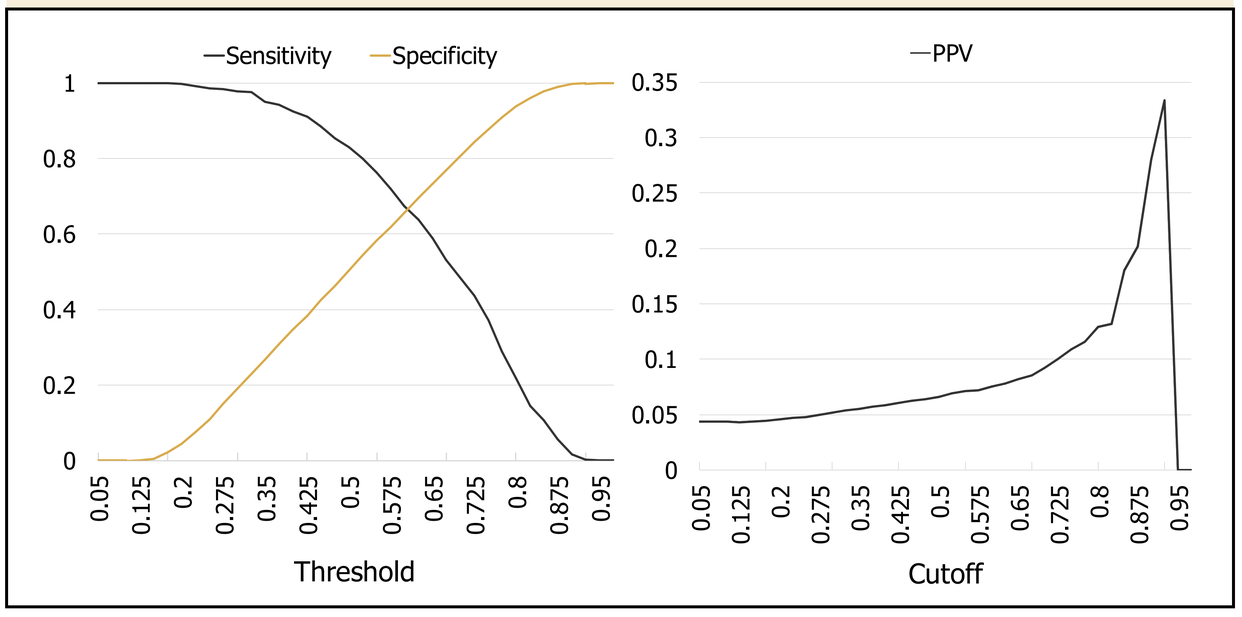
RESULTS

- 77,525 patients experienced 115,021 hospitalizations that met the study criteria, with deterioration events occurring in 4,092 (3.56%) of these hospitalizations.
- The model accurately identified 43.7% of imminent deterioration events with a specificity of 0.844 and an AUROC of 0.737 (Table 1).
- Figure 2 shows model performance across prediction thresholds. At a threshold of 0.5, we could detect 83.1% deterioration events with a specificity of .504. At a threshold of 0.85, we could detect 10.7% deterioration events with a specificity of 0.978.

Table 1. Model Comparison to Existing Warning Score

	Sensitivity	Specificity	AUROC	AUPRC	PPV	F1
Clinical Pages	0.437	0.844	0.737	0.102	0.101	0.163
EDI	0.284	0.878	0.697	0.189	0.071	0.114

Figure 2. Sensitivity, Specificity, and PPV by Prediction Threshold



CONCLUSION

Machine learning using pages leverages healthcare professionals' real-time clinical intuition and outperforms existing early warning scores. This system shows promise for improving patient outcomes without increasing clinician workload. Future work will refine these algorithms with a goal of implementation into clinical practice.

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