

Michael Makutonin¹, Brian Desnoyers², Larry A. Nathanson², and Andrew C. Meltzer¹
¹George Washington University School of Medicine and Health Sciences ²Beth Israel Deaconess Medical Center, Harvard Medical School

Introduction

Large numbers of patients boarding in the emergency department (ED) while awaiting hospitalization have led to a crisis of overcrowding and reduced access to care. Accurate prediction of future ED admission may alleviate boarding crisis events by allowing additional inpatient nursing staff to be flexed in, increasing ED throughput preemptively.

Objectives

Leverage an admission prediction model to predict future boarding load through two retrospective months of 2019 and 2022 emergency department operations.

Methods

- An XGBoost model was trained to predict an admission target using features collected during the very early ED evaluation: vital signs, arrival modality, subjective pain score, emergency severity index, and a free text chief complaint.
- Chief complaint was abstracted using a bag of words model with a decision tree classifier to pick predictive words.
- Two models were created: one trained on records from Jan – Oct 2019 and the other on records from Nov 2021 – Aug 2022. Records with null features were dropped. 75% of records in each set were used for training and 25% for validation.
- Models were used to predict admission probability for each patient in the two months following their training data set (Nov – Dec 2019 and Sept – Oct 2022, respectively) at 30-minute intervals.
- Model accuracy was evaluated on the following metrics:
 - R^2 value for predicting boarders at 8h
 - % of guesses within 5 patients of the number of boarders at 8h
 - % of guesses within 5 patients of the number of total admissions necessary for the patients currently in the ED. This metric was tested against an algorithm that predicted admission for all patients with ESI score < 3.

Results

- A total of 131,705 ED encounters were included in the analysis with 10% of patients requested for admission.
- Bag of words model resulted in 151 unique 1- and 2-word common phrases to be used as training features.
- The admission prediction models achieved an AUC of 0.93 and an overall accuracy of 93%. These did not differ year-to-year.
- On validation workflow, models achieved better accuracy at predicting overall admissions than an ESI cutoff model (2019 model: 61% vs 53% within 5 patients; 2022 model: 86% vs 56% within 5 patients).

Figure 1a. 2019 Validation Performance

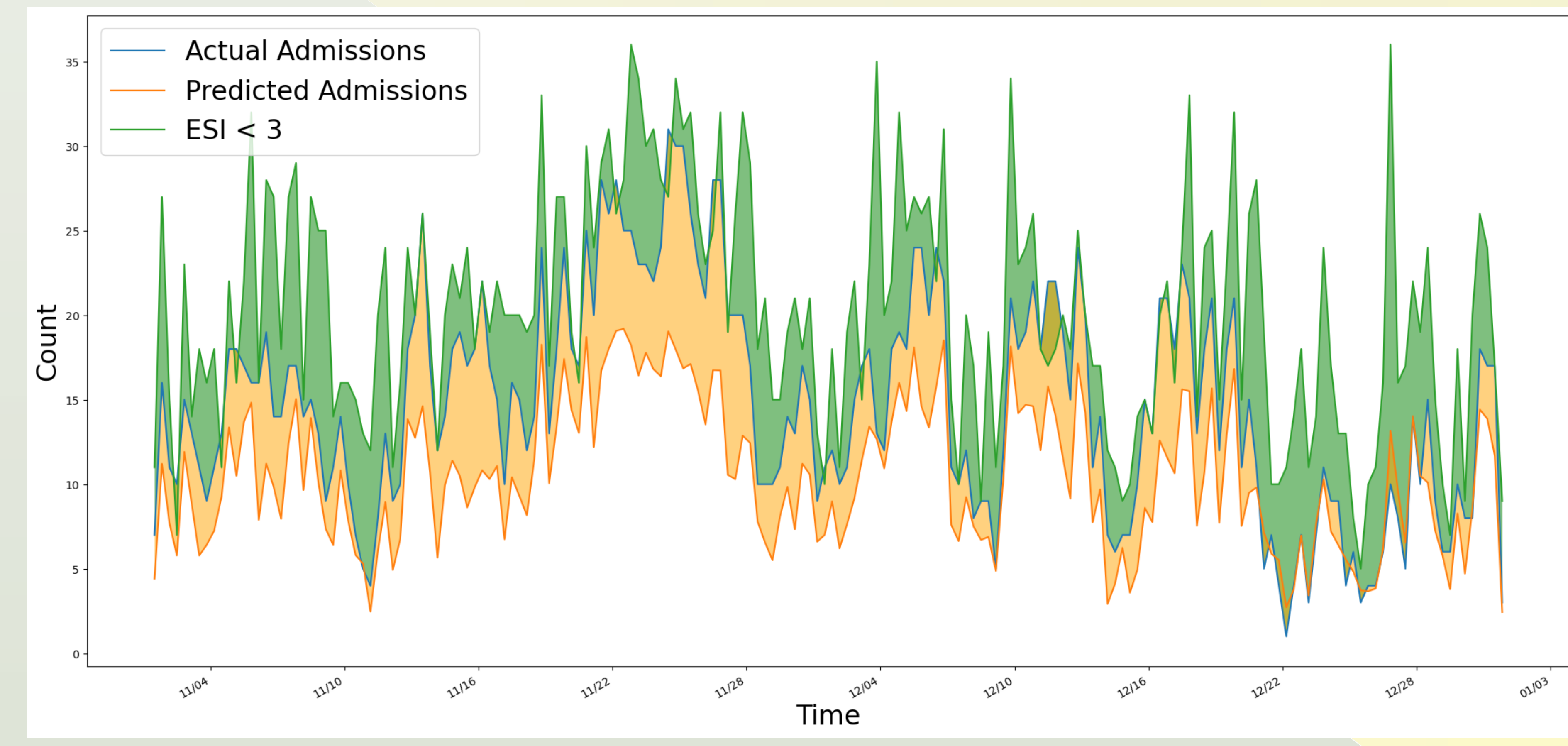


Figure 1b. 2022 Validation Performance

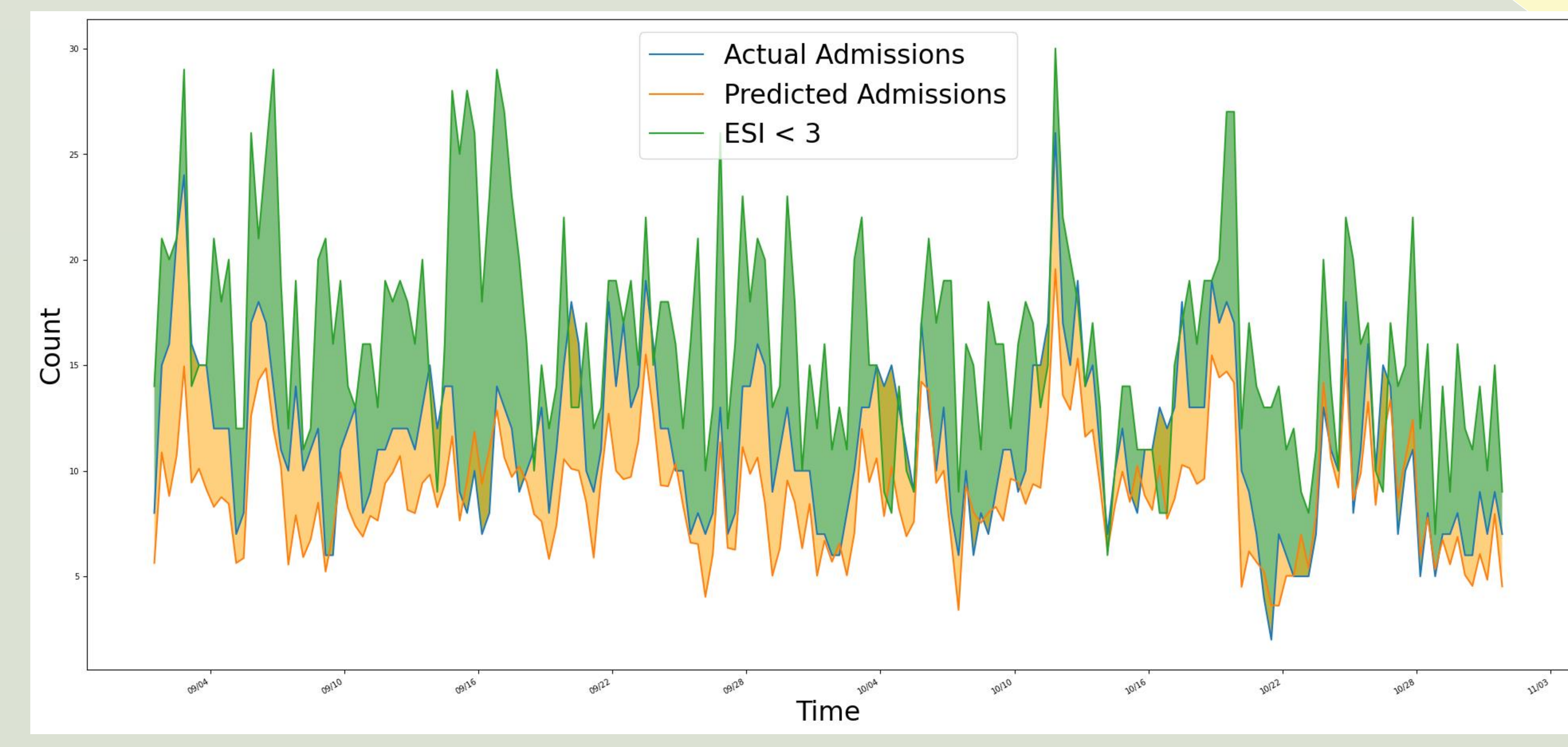


Table 1. Model Outcomes		
	2019 Model	2022 Model
Admission Prediction ROC AUC	0.93	0.93
R^2	0.81	0.50
Boarders at 8h (% accuracy \pm 5)	91%	94%
Admissions in ED (% accuracy \pm 5)	61%	88%
Admissions in ED (difference w/ ESI)	8%	32%

Conclusions

- Machine learning models can be used to effectively predict ED admissions and boarding from minimal data, which may allow for dynamic emergency department staffing.
- Future work should be focused on live emergency department deployment and generalizability to other ED settings.

Acknowledgements

This work was completed in part with assistance from Meylakh Barshay (former GW ED Research Coordinator), Dr. Bruno Petinaux (GWUH CMO), and Solomon Isaac (GWUH IT Department).