

Leveraging Deep Learning and Rapid Response Team Nurses to Improve Sepsis Management

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Introduction

Every day, about 9 patients develop sepsis in the Duke University Hospital (DUH) emergency department (ED) and these patients have nearly a 10% inpatient mortality rate. Early detection of sepsis leading to clinical intervention can improve outcomes for these patients. We developed a deep learning model to detect sepsis using 86 variables from our electronic health record (EHR) including patient demographics, comorbidities, vitals, lab results, and medication administrations [1]. The model combines a recurrent neural network with a multi-output Gaussian process. The model output is presented along with relevant physiologic measures to rapid response team (RRT) nurses within a custom-developed web application to facilitate rapid patient evaluation and delivery of 3-hour and 6-hour treatment bundle items. Taken together, the application and model designate the SepsisWatch program.

Clinical Integration and Deployment

Our transdisciplinary team represents a partnership across statistics, hospital medicine, critical care, and nursing, as well as the Duke Institute for Health Innovation (DIHI), Duke Health Technology Solutions (DHTS), Duke Clinical Research Institute (DCRI), and Data & Society (D&S). We worked closely with Duke's EHR vendor to develop services to extract data every 5 minutes to deploy the real-time SepsisWatch program. The system is deployed on-premise using Docker containers. Data from the EHR is first cleaned, normalized, and then grouped into clinically-relevant features. The RNN model and sepsis criteria are then executed and the outputs are made available through the web application [2]. Patients who meet our sepsis criteria are flagged as septic, regardless of risk. RRT nurses are instructed to evaluate high-risk and septic patients by reviewing the EHR, examining the patient, and discussing the patient with the covering nurses and physicians. For patients deemed appropriate for treatment, SepsisWatch tracks completion of the CMS 3-hour and 6-hour bundle items.

Impact Evaluation

SepsisWatch was launched in August 2018 in silent mode while the full launch covering the Duke University Hospital ED is scheduled for November 2018. SepsisWatch will be deployed in two 3-month phases to test workflows that shift an increasing number of tasks from ED providers to RRT nurses. We are partnering with the DCRI to complete the quantitative clinical trial analyses. The objective of SepsisWatch is to improve compliance with CMS 3-hour and 6-hour treatment recommendations. Other key performance indicators include length of stay, inpatient mortality, and time to treatment bundle items. We are partnering with D&S, a research institute focused on the social and cultural issues arising from data science technologies, to complete a qualitative evaluation. Through interviews and observations, we hope to understand SepsisWatch's effect on professional relationships, situational awareness, and clinical decision-making. Our goal is to describe the clinical and cultural impact of SepsisWatch on healthcare and pave the way for deployments of the system at external partner sites.

[1] J. Futoma et al. "An Improved Multi-Output Gaussian Process RNN with Real-Time Validation for Early Sepsis Detection". *MLHC*, 2017.

[2] A demo of the Sepsis Watch UI can be viewed at: <https://goo.gl/QG6Sm6>