Effect of a Machine Learning-Based Severe Sepsis Prediction Algorithm on Patient Survival and Hospital Length of Stay

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Introduction

Severe sepsis is a leading cause of death in the United States and costs health care systems over $20 billion annually. Methods have been developed to electronically monitor patients for severe sepsis, but few have provided predictive capabilities to enable early intervention.

Hypothesis

Patient length of stay (LOS) and in-hospitality mortality rate decrease with the use of a machine learning-based severe sepsis prediction algorithm (*InSight*™, Dascena, Inc.) for emergency and inpatients.

Methods

Randomized clinical trial from 12/16 to 02/17 in two mixed medical-surgical intensive care units at the University of California, San Francisco (UCSF) Medical Center.

- Severe sepsis prediction algorithm monitored a total of 32 patient beds
- A patient's vital signs and selected lab results were abstracted from UCSF's EHR software, APeX (Epic Systems Corp.), into the prediction algorithm
- Patients assigned to experimental or control group based on random allocation sequence, and healthcare providers, patients, and investigators were blinded to patient assignment
- Patients in control group received the normal standard of care and were monitored by the existing EHR-based severe sepsis detector
- Patients in experimental group were monitored by the prediction algorithm *InSight* in addition to the existing severe sepsis detector
- If the machine learning algorithm forecasted a patient as trending towards severe sepsis, the charge nurse on duty was notified via a phone call

Results

One hundred forty two patients were assessed (*Table 1*) with the top three originating units being the emergency department, transfer center, and medical-surgical general ward. Demographics and comorbidities between the groups were not significantly different. In-hospital and ICU length of stay (LOS) was lower in the control group. A two sample *t*-test was performed for LOS. Further, in-hospital mortality was significantly lower in the experimental group, and was analyzed using a two-proportion *z*-test. *InSight* has been shown to be much better at predicting sepsis than other common scoring systems (*Figure 1*).

Outcome	Control (*N*=75)	Experimental (*N*=67)	% Decrease	*P*
Hospital Length of Stay (days)	13.0 (1.23)	10.3 (0.912)	20.6%	.042
ICU Length of Stay (days)	8.40 (0.881)	6.31 (0.666)	24.9%	.030
In-Hospital Mortality Rate	21.3% (4.76%)	8.96% (3.51%)	58.0%	.018

Table 1. Differences in hospital length of stay (LOS), ICU LOS, and in-hospital mortality between the experimental and control groups. The mean and the standard error (in parentheses) for each outcome are noted in the table. All outcomes demonstrate statistically significant reductions when using *InSight* (P < .05).

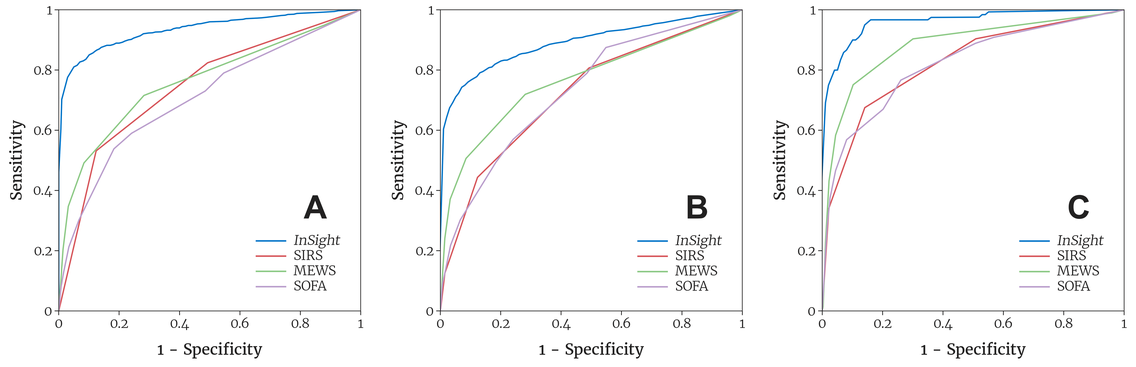

Figure 1. Receiver Operator Characteristic (ROC) curves for *InSight* and common scoring systems at time of (**A**) sepsis onset, (**B**) severe sepsis onset, (**C**) four hours before septic shock onset. (SIRS – systemic inflammatory response syndrome, MEWS – modified early warning score, SOFA – sequential organ failure assessment.)

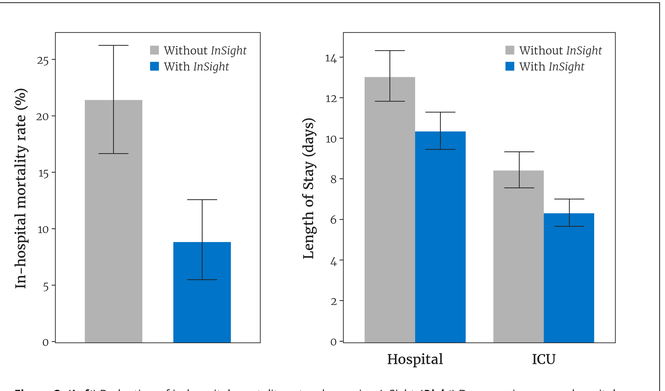

Figure 2. (***Left***) Reduction of in-hospital mortality rate when using *InSight*. (***Right***) Decrease in average hospital and ICU length of stay with the use of *InSight*. The error bars represent one standard error above and below the mean in-hospital mortality rate and length of stay, respectively.

Conclusions

- A machine learning-based sepsis prediction tool may improve patient outcomes and decrease sepsis related costs.
- This is the first randomized clinical trial of an electronic sepsis monitoring tool to achieve statistically significant decreases in hospital length of stay and in-hospital mortality.
- In future studies, we intend to validate the performance of this prediction algorithm in hospitals with varying demographic and clinical characteristics as well as in non-critical care units.

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