SPACELABS HEALTHCARE

White Paper

Predictive Analytics

The Rothman Index - Improving Sepsis Outcomes

Helping Organizations to Reduce Sepsis Progression, Mortality and Costs

EXECUTIVE SUMMARY

Sepsis is a leading cause of hospital mortality and a major patient safety priority. Although early identification of septic patients is critical to improving outcomes, identifying sepsis is notoriously difficult. Existing tools, from simple systemic inflammatory response syndrome (SIRS) checklists to sophisticated electronic medical record (EMR) based-algorithms, are not up to the task, as they tend to suffer from impractically high numbers of false positives.

Focusing on the patient rather than the disease, healthcare systems that have implemented clinical care redesign initiatives that include leveraging the Rothman® Index as part of the clinical workflow have positively impacted quality metrics.[1] Houston Methodist Hospital has been able to decrease sepsis mortality by 11% despite already having an aggressive sepsis-screening program in place.[2] Similarly, the deployment of a care delivery model that includes use of the Rothman Index at Yale New Haven's Bridgeport Hospital has also had extremely positive results. Since launching their care redesign, Bridgeport Hospital achieved a 29% reduction in sepsis mortality and a 13% reduction in sepsis care costs, saving dozens of lives, and millions of dollars annually.[3]

REAL OUTCOMES: REDUCING SEPSIS MORTALITY AND COSTS

Multiple organizations have integrated the Rothman Index (RI) and simple RI-based rules into workflow to assist them in identifying at-risk patients, including patients on the sepsis spectrum. By efficiently identifying sepsis earlier, hospitals can initiate treatment sooner; this can prevent patients from advancing along the sepsis spectrum, and avert costly procedures and unnecessary stays in intensive care units.

Clinical care initiatives, including creation of a pro-active rapid response team that leverages the Rothman Index integrated into their Epic EMR, have helped Bridgeport Hospital in Connecticut to bring down mortality across the hospital, with a particularly large decrease in sepsis deaths.[3]

In Texas, the Houston Methodist Hospital integrated the Rothman Index into the workflow of floor nurses and a nurse practitioner team to improve care delivery processes.[1] In addition to major improvements in sepsis-related mortality, these hospitals have also achieved significant savings in sepsis-related cost of care. A detailed analysis by Bridgeport Hospital validated that they were able to reduce overall sepsis costs by an average of 13% (Figure 1).[3]

Getting ahead of patient deterioration is a patient safety imperative. Doing so effectively helps the patient population at large, while also tackling the challenge of early sepsis detection and intervention head-on. An approach based on identifying patients in need of intervention, and directing resources to their care, can have patient safety benefits that go beyond a strictly sepsis-directed effort.

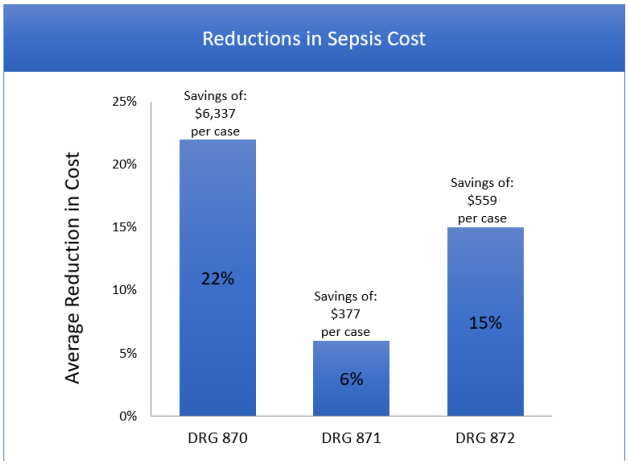

Figure 1 - Bridgeport Hospital's average cost-reduction for sepsis present on admission by DRG.

The Rothman Index's unique ability to capture patient condition coupled with the clear visual interface underpinned by simple Rothman Index warnings makes it a powerful adjunct to clinicians in their care of patients.

Clinical care redesigns that included using the RothmanIndex helped Yale New Haven Health's Bridgeport Hospital to reduce sepsis-related mortality by 29% and Houston Methodist Hospital to achieve an 11% reduction in sepsis mortality.

EARLY SEPSIS IDENTIFICATION IS CRITICAL

SEPSIS IS A HEALTHCARE IMPERATIVE

Sepsis is involved in a third to half of all hospital patient deaths[4] and has the highest hospital treatment expense of any condition in the United States – costing on the order of $24 billion annually (more than 6% of aggregate hospitalization costs).[5] Sepsis mortality rates range on average between 12% for patients with sepsis on admission to 35% for patients who develop sepsis during their stay in the hospital.[6,7] Sepsis is a global healthcare problem that afflicts more than a million patients a year in the United States alone.[8]

Even for patients who survive, the effects of having had sepsis can be devastating. Long-term medical consequences can include functional debilitation, a lower quality of life and shortened lifespan.[9,10]

EARLY RECOGNITION IS KEY

Sepsis is a rapidly progressing disease with higher costs and worse outcomes as the disease advances along the sepsis spectrum.[11,12]

Rapid intervention, including administration of antibiotics, is a cornerstone of the recent 2016 Surviving Sepsis Campaign guidelines[13] and is codified in CMS's Sepsis Core Measure ('Sep-1'). This measure is geared towards driving an aggressive timeline for sepsis treatment and in turn puts pressure on hospitals to identify sepsis earlier and more effectively.

NEEDLE IN A HAYSTACK

Over the years, the number of patients diagnosed as septic has increased even as the associated mortality has gone down. These trends are credited to a variety of factors including heightened awareness, enhanced screening, improved critical care services, and the proliferation of treatment bundles. Nevertheless, only around 5% of patients have sepsis on admission and fewer than 1% of patients develop sepsis in the hospital. Patients who do develop sepsis in the hospital typically have comorbidities which makes distinguishing them from other acute patients a major challenge. This is a very small target group to try to pick out from among the increasingly acute hospital population.

The significance of early identification and treatment cannot be overstated – one study reports that each hour of delay decreases likelihood of survival by 7.6%.[11,12]

A major difficulty in the early identification of sepsis is that the symptoms associated with sepsis are the same as many other conditions and diseases. This issue makes it particularly difficult to distinguish septic patients from other high-acuity patients in the hospital setting.

COMMON SEPSIS SCORES ARE INADEQUATE

Unfortunately, both systemic inflammatory response syndrome (SIRS) and quick Sequential (sepsis-related) Organ Failure Assessment (qSOFA) are notoriously non-specific. Anywhere from a quarter to a third of inpatients on medical and surgical floors fulfill SIRS criteria every day.[10] Making the problem even harder is the fact that many patients who are septic fail to meet SIRS criteria. Nor are SIRS criteria associated with mortality or length of stay.[16] Indeed, "the SIRS-based definition will identify most patients with a simple infection, even a common cold, as septic".[17] In 2016 the Society of Critical Care Medicine sepsis task force unanimously rejected SIRS as unhelpful for identifying sepsis.[14]

Even as guidance on diagnosis and treatment has changed, identifying sepsis patients has become increasingly difficult.

Even the most recent efforts to improve sepsis definitions have not solved these problems. Studies of qSOFA have failed to demonstrate its superiority to alternative scoring systems.[18,19] Attempts to apply other early warning systems, such as the Modified Early Warning Score (MEWS) and National Early Warning Score (NEWS) have been ineffective, with these scores exhibiting poor sensitivity and specificity for identifying septic patients unless geared towards critically ill patients far along the sepsis continuum.[20,21]

More complex EMR-based sepsis algorithms, such as Cerner's St. John Sepsis Agent, face many of the same limitations as SIRS. In fact, studies using the St. John Sepsis Agent have failed to demonstrate meaningful improvements in performance over SIRS.[22,23]

Epic has also rolled out a sepsis model which has been the subject of numerous critiques in the peer reviewed literature. The Epic model was found to have poor calibration and poor discrimination.[24] Indeed, disappointment with its poor performance has even raised serious questions about its safety for patients let alone efficacy for sepsis.[25] Epic has announced it would be rethinking and revising its approach to sepsis as a result.

SIRS	qSOFA
Temp >38ºC [100.4ºF] or <36ºC [96.8ºF]	Respiration Rate ≥ 22d
Heart rate > 90 Respiration rate >20 or Pa/CO_3 < 32 mm	Systolic BP ≤ 100 mmHg Altered mentation [Glasgow Coma Score < 15
WBC > 12,000/mm^3, <4,000/mm^3, or > 10% bands	

Table 1 - Clinical Elements of SIRS and qSOFA

MANUAL DOCUMENTATION

All sepsis screens entail some degree of manual data entry. In many cases this can run to pages of documentation and places a significant additional burden on clinicians, reducing the frequency with which sepsis screens can be run, and increasing the chance for human error in data entry and documentation.

Added to this, the high false positive rate of SIRS-based sepsis screens creates significant 'noise', generating a tremendous amount of excess assessment and documentation work for clinical staff, particularly nursing.

THE ROTHMAN INDEX REFRAMES THE PROBLEM

It is well established that sepsis is associated with progressive deterioration as a patient advances along the sepsis spectrum. Consequently, although not specifically geared towards sepsis, patients who are septic fall within the ability of the Rothman Index to help identify deteriorating patient condition.

This makes sense considering that the Rothman Index and its pediatric variant (pRI) includes all the clinical elements used in both SIRS and qSOFA, but also incorporate additional vital signs and labs, as well as a full range of body-system nursing assessments which are known to be leading indicators of deterioration.[26]

	# Inputs	Frequency of Calculation	Real-time	Med-Surg & ICU	Alerts on Score Value & Trend
Rothman Index	26	Continuous	Yes	Yes	Yes
SIRS	4	per-shift	No	Yes	No
qSOFA	3	per-shift	No	No	No
Cerner St. John	5-9	varies	No	Yes	No
MEWS	5	3-5x daily	No	No	No

Table 2 - Comparison of the Rothman Index to other Scoring Tools.

Generation of Rothman Index scores and warnings is not only effortless, but scores are calculated and checked against rule criteria on a continuous basis, rather than infrequently or sporadically as would be the case for manual sepsis screens.

The Rothman Index helps to effectively draw attention to patients who are deteriorating. In Figure 2, the Rothman Index graph tracks the physiologic deterioration associated with the progression of sepsis in an adult patient on a med/surg floor (black points) who developed sepsis in the hospital and deteriorated for more than two days before being transferred to the ICU (red points).

Figure 2 - Rothman Index (Patient Specific View)

To further enhance visibility, patients at an elevated risk are placed in a warning lane (Figure 3), rapidly drawing attention to the most concerning patients. No additional documentation is needed, and no extra steps are required by clinicians to generate Rothman Index scores.

From an operational standpoint, this has important implications for reducing the perceived false positive rate of warnings when one compares the Rothman Index to tools with a narrower, sepsis-specific, focus.

Tackling sepsis is both a clinical and quality imperative at hospitals across the country. The Rothman Index's ability to direct clinician attention to the early indications of patient deterioration offers a new and different approach and may help hospitals achieve significant, measurable improvements in the quality and cost of care delivered to septic patients.

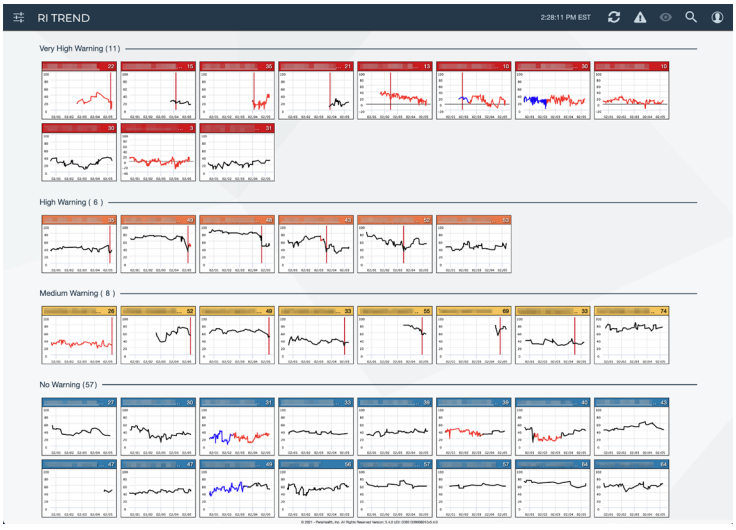

Figure 3 - Rothman Index (Array View)

REFERENCES

1 K. Walsh, S. Hamlin, and B. Askary, “Mortality Reduction Associated with Surveillance Using an EMR-Based Acuity Score at an Academic Medical Center,” BMJ Qual. Saf., 25 [12] 1014–1015 (2016).016.

2 K. Walsh and M. Rothman, “EMR Surveillance Intervenes to Reduce Risk Adjusted Mortality;” in HIMSS Conference, Las Vegas, 2016.

3 S. Mahfuz Hoq, “Rothman Index and Sepsis Survival”, PeraHealth Roundtable, Houston, TX, 2017.

4 M.D. Howell and A.M. Davis, “Management of Sepsis and Septic Shock,” JAMA, (2017).

5 C.M. Torio and B.J. Moore, “National Inpatient Hospital Costs: The Most Expensive Conditions by Payer, 2013: Statistical Brief #204;” in Healthc. Cost Util. Proj. HCUP Stat. Briefs. Agency for Healthcare Research and Quality (US), Rockville (MD), 2016.

6 S.L. Jones, C.M. Ashton, L.B. Kiehne, J.C. Nicolas, A.L. Rose, B.A. Shirkey, F. Masud, and N.P. Wray, “Outcomes and Resource Use of Sepsis associated Stays by Presence on Admission, Severity, and Hospital Type,” Med. Care, 54 [3] 303–310 (2016).

7 M. Rothman, M. Levy, R.P. Dellinger, S.L. Jones, R.L. Fogerty, K.G. Voelker, B. Gross, A. Marchetti, et al., “Sepsis as 2 problems: Identifying sepsis at admission and predicting onset in the hospital using an electronic medical record–based acuity score,” J. Crit. Care, 38 237–244 (2017).

8 D.D. Backer and T. Dorman, “Surviving Sepsis Guidelines: A Continuous Move Toward Better Care of Patients With Sepsis,” JAMA, (2017).

9 B.D. Winters, M. Eberlein, J. Leung, D.M. Needham, P.J. Pronovost, and J.E. Sevransky, “Long-term mortality and quality of life in sepsis: a systematic review,” Crit. Care Med., 38 [5] 1276–1283 (2010).

10 C. Brun-Buisson, “The epidemiology of the systemic inflammatory response,” Intensive Care Med., 26 [1] S064–S074 (2000).

11 R. Ferrer, I. Martin-Loeches, G. Phillips, T.M. Osborn, S. Townsend, R.P. Dellinger, A. Artigas, C. Schorr, et al., “Empiric antibiotic treatment reduces mortality in severe sepsis and septic shock from the first hour: results from a guideline-based performance improvement program,” Crit. Care Med., 42 [8] 1749–1755 (2014).

12 A. Kumar, D. Roberts, K.E. Wood, B. Light, J.E. Parrillo, S. Sharma, R. Suppes, D. Feinstein, et al., “Duration of hypotension before initiation of effective antimicrobial therapy is the critical determinant of survival in human septic shock,” Crit. Care Med., 34 [6] 1589–1596 (2006).

13 A. Rhodes, L.E. Evans, W. Alhazzani, M.M. Levy, M. Antonelli, R. Ferrer, A. Kumar, J.E. Sevransky, et al., “Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock: 2016,” Intensive Care Med., (2017).

14 M. Singer, C.S. Deutschman, C.W. Seymour, M. Shankar-Hari, D. Annane, M. Bauer, R. Bellomo, G.R. Bernard, et al., “The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3),” JAMA, 315 [8] 801–810 (2016).

15 R.P. Dellinger, M.M. Levy, A. Rhodes, D. Annane, H. Gerlach, S.M. Opal, J.E. Sevransky, C.L. Sprung, et al., “Surviving sepsis campaign: international guidelines for management of severe sepsis and septic shock: 2012,” Crit. Care Med., 41 [2] 580–637 (2013).

16 L. Douglas, A. Casamento, and D. Jones, “Point prevalence of general ward patients fulfilling criteria for systemic inflammatory response syndrome,” Intern. Med. J., 46 [2] 223–225 (2016).

17 M. Shankar-Hari, C.S. Deutschman, and M. Singer, “Do we need a new definition of sepsis?,” Intensive Care Med., 41 [5] 909–911 (2015).

18 J.-Y. Wang, Y.-X. Chen, S.-B. Guo, X. Mei, and P. Yang, “Predictive performance of quick Sepsis-related Organ Failure Assessment for mortality and intensive care unit admission in patients with infection at the ED,” Am. J. Emerg. Med., (2016).

19 M.M. Churpek, A. Snyder, X. Han, S. Sokol, N. Pettit, M.D. Howell, and D.P. Edelson, “qSOFA, SIRS, and Early Warning Scores for Detecting Clinical Deterioration in Infected Patients Outside the ICU,” Am. J. Respir. Crit. Care Med., (2016).

20 K.E. Henry, D.N. Hager, P.J. Pronovost, and S. Saria, “A targeted real-time early warning score (TREWScore) for septic shock,” Sci. Transl. Med., 7 [299] 299ra122 (2015).

21 J.W. Keep, A.S. Messmer, R. Sladden, N. Burrell, R. Pinate, M. Tunnicliff, and E. Glucksman, “National early warning score at Emergency Department triage may allow earlier identification of patients with severe sepsis and septic shock: a retrospective observational study,” Emerg. Med. J. EMJ, 33 [1] 37–41 (2016).

22 P. Ehrlichman, L. Trach, B. Patel, V. Maheshwari, and M. Seckel, “983: Sensitivity and Positive Predictive Value of a Cerner EMR Based Sepsis Recognition Tool,” Crit. Care Med., 42 A1597 (2014).

23 R.C. Amland and K.E. Hahn-Cover, “Clinical Decision Support for Early Recognition of Sepsis,” Am. J. Med. Qual. Off. J. Am. Coll. Med. Qual., 31 [2] 103–110 (2016).

24 A. Wong, E. Otles, J.P. Donnelly, A. Krumm, J. McCullough, O. DeTroyer-Cooley, J. Pestrue, M. Phillips, J. Konye, C. Penoza, M. Ghous, K. Singh, “External Validation of a Widely Implemented Proprietary Sepsis Prediction Model in Hospitalized Patients,” JAMA Intern Med. 2021 Aug 1;181(8):1065-1070. doi: 10.1001/jamainternmed.2021.2626. Erratum in: JAMA Intern Med. 2021 Aug 1;181(8):1144. PMID: 34152373; PMCID: PMC8218233.

25 C. Ross, “A STAT INVESTIGATION - Epic’s AI algorithms, shielded from scrutiny by a corporate firewall, are delivering inaccurate information on seriously ill patients,” (July 26, 2021).

26 M.J. Rothman, A.B. Solinger, S.I. Rothman, and G.D. Finlay, “Clinical implications and validity of nursing assessments: a longitudinal measure of patient condition from analysis of the Electronic Medical Record,” BMJ Open, 2 [4] (2012).2 [4] (2012).

SPACELABS HEALTHCARE

An OSI Systems Company