Life-Saving Data: How Integrating Real-Time Surveillance & Analytics in Clinical Systems Reduced Sepsis Mortality at Huntsville Hospital
Life-Saving Data: How Integrating Real-Time Surveillance & Analytics in Clinical Systems Reduced Sepsis Mortality at Huntsville Hospital
Conflict of Interest

Stephen Claypool, MD, is a salaried employee of Wolters Kluwer.
Learning Objectives

1. Analyze clinical workflows, protocols and information to identify negative impacts on sepsis rates.

2. Discuss the impact of leveraging EMR data with surveillance, analytics, mobile alerts and intuitive clinical decision support for the early detection and treatment of sepsis.

3. Design a change management strategy, including escalation protocols to increase adherence and bundle compliance.

4. Analyze data and adjust rule parameters to support specific patient populations.
Sepsis by the Numbers

- In 2009, 1.6 million patients in the U.S. were treated for septicemia and 258,000 lives were lost.
- The cost to treat U.S. patients for septicemia in 2011 was approximately $20 billion, making it the single most expensive condition treated in U.S. hospitals.
- According to a 2013 report by the University of Pennsylvania’s School of Medicine, sepsis is one of the most common causes of death in hospital critical care units.
Huntsville Hospital

- Community owned and operated
  - Volunteer board
  - No tax support
- Regional provider serving the Tennessee Valley
- Established in 1895 as a small infirmary
- 2\textsuperscript{nd} largest hospital in Alabama
- 5\textsuperscript{th} largest publically owned health system
- 941 beds between three campuses
- 740 Physicians, 613 Allied Health Professionals
- 42,000 inpatient discharges annually
- 165,000 ED visits
- 10,500 employees
Background: The Sepsis Pilot

Study Setting/Site
- Huntsville Hospital—2 study floors (58 beds)
  - 2 respiratory care units
  - 1 general medical unit

Why Huntsville?
- Huntsville Hospital had identified reducing sepsis mortality and severity as a priority.
- Internal initiatives had only achieved suboptimal results
Baseline Data: Huntsville Hospital

**Average Length of Stay**

<table>
<thead>
<tr>
<th>Category</th>
<th>HH (All Units)</th>
<th>National Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOS Category 1</td>
<td>15.7%</td>
<td>9.2%</td>
</tr>
<tr>
<td>LOS Category 2</td>
<td>7.1%</td>
<td>5.8%</td>
</tr>
</tbody>
</table>

**Mortality**

<table>
<thead>
<tr>
<th>Category</th>
<th>HH (All Units)</th>
<th>National Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality rate Category 1</td>
<td>38.5%</td>
<td>19.4%</td>
</tr>
<tr>
<td>Mortality rate Category 2</td>
<td>9.5%</td>
<td>8.5%</td>
</tr>
</tbody>
</table>

*January – June 2013*

- **Category 1**: Discharges meeting the “Surviving Sepsis” campaign definition
- **Category 2**: Discharges with sepsis infection related codes
Huntsville Hospital: Sepsis Incidence Comparison to Other Hospitals (by DRG)

Sepsis incidence was calculated by:

<table>
<thead>
<tr>
<th>DRGs Used</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>870</td>
<td>SEPTICEMIA OR SEVERE SEPSIS W MV 96+ HOURS</td>
</tr>
<tr>
<td>871</td>
<td>SEPTICEMIA OR SEVERE SEPSIS W/O MV 96+ HOURS W MCC</td>
</tr>
<tr>
<td>872</td>
<td>SEPTICEMIA OR SEVERE SEPSIS W/O MV 96+ HOURS W/O MCC</td>
</tr>
</tbody>
</table>
Huntsville Hospital: Sepsis Incidence Comparison to Other Hospitals (by DRG)

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Huntsville Hospital</td>
<td>Mean 0.52%</td>
</tr>
<tr>
<td>Alabama Averages</td>
<td>Mean 0.81%, Median 0.66%</td>
</tr>
<tr>
<td>Similar Sized Hospitals (+/-10% Total Discharges)</td>
<td>Mean 0.348%, Median 0.185%</td>
</tr>
<tr>
<td>National Averages</td>
<td>Mean 0.88 %, Median 0.63 %</td>
</tr>
</tbody>
</table>

From this data, we can infer that more patients present to Huntsville Hospital with sepsis than the national average for similar sized hospitals, but fewer than the average Alabama hospital.
Huntsville Hospital: Change Management Process

Life-Saving Data: How Integrating Real-Time Surveillance & Analytics in Clinical Systems Reduced Sepsis Mortality at Huntsville Hospital
Huntsville Hospital: Change Management Process

- Formed nursing unit teams
- Created Sepsis and Physician steering committees
  - Facilitate progress across unit teams
  - Create excitement, awareness and uptake amongst the diverse clinical members
  - Educate other members of the hospital about sepsis and improvement effort
  - Leadership of the overall program
- Provided formal, didactic education sessions
- Created order sets and established protocols, including protocol to draw POC screening lactates
Point of Care Alerting

- Sepsis outcomes can improve with change management and Institute for Healthcare Improvement (IHI) compliance\(^1,2\), yet traditional electronic alerting systems for sepsis have fairly poor sensitivity & specificity\(^3\), leading to alert fatigue and negligible impact on care.

- We decided to combine change management efforts and electronic alerting functionality to improve IHI treatment compliance.


Point of Care Alerting

- The focus of the electronic alerting was to reduce alert fatigue.
- Emphasis was placed on building an expansive set of rules to create very high sensitivity and specificity.
- The system was designed to push evidence-based advice directly to the point of care via smart devices carried by nursing staff. Advice followed the protocols drafted by the change management process.

**Hypothesis**: a combination of change management and a more advanced alerting system will result in the reduction of sepsis mortality.
The Integrated Alerting Platform

Cloud-based Platform
- Runs rules and alerts
- Manages security and reporting/analytics

Surveillance Engine
- Gathers comorbidities, medications, vitals, nursing notes, lab results, etc., from the EHR

EHR
- The central repository for patient information

Alerts
- High sensitivity and specificity
- Pushed to multiple device types
Alert types

**Surveillance Diagnosis**
- Identify SIRS, Infection, Sepsis, Severe Sepsis, Severe Sepsis with Hypotension, Septic Shock
- Each must be acknowledged, either by agreeing or disagreeing

**Advice**
- Evidence based, follows IHI guidelines
- Also tailored to specific comorbid conditions and to each site.
- E.g. “use order set titled XXX”, “Call rapid response team versus house officer”, nursing staff to draw lactate. Includes medications to match formulary

**Close the loop** reminder alerts.
- Every alert requires acknowledgement
- Escalation per site protocol
- Workflow reminders (re-check BP)
Rules Are Complex, Specific and Sensitive

Start with Surviving Sepsis guidelines and enhance to improve “sensitivity” and “specificity”

- **Disease-specific rules**
  - Account for lab abnormalities due to liver disease, chronic renal disease, heart failure, alcohol withdrawal, malignancy, emphysema, etc.
  - For example: lactate tests are usually elevated in patients with cirrhosis, so interpretation of lactate values is different in liver disease compared to healthy patients

- **Medication-specific rules**
  - These rules account for lab abnormalities due to medications
  - For example: warfarin & INR, heparin & PTT, etc.

**200+ rules, based on patient-specific variations.**
Life-Saving Data: How Integrating Real-Time Surveillance & Analytics in Clinical Systems Reduced Sepsis Mortality at Huntsville Hospital
Dashboard Continuously Updated with Latest Data Displayed for Nurses & Doctors

Dashboard displays quick snapshot of patient’s clinical picture 24x7.
Example Screen – Real time Screening, 200+ Rules

SMART rules in the engine factor in comorbidities that mimic sepsis to prevent false positive alerts, resulting in high specificity, minimal alert fatigue and high user compliance.
Outcomes studied in 2 phases:

1. **Pre-Go Live (Control Period),** with retrospective analysis of records over a span of almost 3 years

2. **Post-Implementation (Study Period),** with electronic alerting added to the change management process, from March, 2014 - December, 2014

*The implementation period from October, 2013-February, 2014 was not included in the analysis.*
## Methodology of Outcomes Analysis

<table>
<thead>
<tr>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>• All patients with sepsis as determined by ICD9 (International Classification of Diseases, 9th Revision) codes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Limitations of ICD9</th>
</tr>
</thead>
<tbody>
<tr>
<td>• ICD9 coding is known to miss cases of sepsis … sepsis will only be codified if physicians document sepsis in the chart. This method therefore misses some cases. PPV estimated ~70%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rationale for using ICD9</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Less resource intensive than chart review</td>
</tr>
<tr>
<td>• Queries can be run pre &amp; post POC Advisor, so we can use this method to compare Control &amp; Study periods</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sepsis Screening Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 3 units – 2 Pulmonary (RCU), 1 Gen Med (7W-M)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Patients sent directly to ICU or cared for in the ICU &gt; 4 days before pilot units</td>
</tr>
<tr>
<td>• Palliative / end-of-life-care patients that did not receive full treatment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rationale for Exclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>• POC Advisor did not have an opportunity to impact the outcome of patients that had sepsis diagnosed in the ED and were sent to the ICU. Ditto for end-of-life patients that were not treated</td>
</tr>
</tbody>
</table>

---

**Advanced directives for limited care were established by clinician chart review**

**The bulk of the data was obtained from a database export from Huntsville and was analyzed by database query. Only limited care assessments were Physician Personnel.**
Results

Analytics effort comprised of:

- **Sepsis Outcome Measures**
  - Mortality
  - 30-day Readmission Rates
  - Length of Stay
- **Test Characteristics**
  - Positive Predictive Value
  - Sensitivity & Specificity
  - Lactate, Alerting Stats (#, overrides, response times, etc.)
- **Bundle Compliance with IHI Guidelines**
## Methodology for Calculating Sepsis Mortality

**Control Period:** 1\(^{st}\) Jan ‘11 – 30\(^{th}\) Sep ‘13  
**Study Period:** 1\(^{st}\) Mar ‘14 - 31\(^{st}\) Dec ‘14

<table>
<thead>
<tr>
<th>Control</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>5414</td>
<td>1974</td>
</tr>
<tr>
<td>1170</td>
<td>464</td>
</tr>
<tr>
<td>608</td>
<td>251</td>
</tr>
<tr>
<td>566</td>
<td>212</td>
</tr>
<tr>
<td>51</td>
<td>9</td>
</tr>
</tbody>
</table>

- All Patients with Sepsis Hospital Wide  
- Sepsis Patients on Screening Units  
- Excluding Patients Who Went to ICU First  
- Excluding Patients Who Had Limited Care  
- Limit to Patients Who Died

All steps with the exception of excluding limited care patients were done by query of hospital billing data. For determining limited care, two physicians performed chart review.
Sepsis (Incidence) by ICD9 on Sepsis Floors (Before & After)

Sepsis Cases on Sepsis Screening Units (Pre & Post)

Life-Saving Data: How Integrating Real-Time Surveillance & Analytics in Clinical Systems Reduced Sepsis Mortality at Huntsville Hospital
If documentation improvements due to heightened sepsis awareness from the sepsis program resulted in an increase in ICD9 cases, it probably would be more impactful on sepsis screening floors.

Note that Huntsville has had a sepsis documentation improvement team for several years. Is that influencing ICD9 capture?
Mortality per Sepsis Cases

Sepsis mortality on sepsis screening units*

9%

51/566

4.2%

9/212

53% Reduction in Mortality

* This is the subset of cases that could be influenced by POC Advisor, i.e. after excluding comfort care cases and those that went to the ICU first.
† P-value calculated using Fisher Exact Test
Sepsis Mortality Over Time

Sepsis Deaths per 1000 Hospital Days on the Sepsis Screening Floors

51 Deaths per 1000 Hospital Days

29 Deaths per 1000 Hospital Days

51/1004

9/305

43% Reduction in Mortality
Sepsis Mortality: **Non-Screening Floors by ICD9**

Some may argue that the drop in mortality on sepsis screening floors may be due to hospital-wide education and improved sepsis awareness. This doesn’t appear to be the case since mortality from sepsis did NOT improve on non-sepsis screening floors.
30 Day Readmission, Sepsis Patients, Screening Floors*

30 Day Readmission, Sepsis Patients on Screening Floors*

30% Change

**Control**

19.08%

108/566

**Study**

13.21%

28/212

P-value = 0.057

*This is the subset of cases that could be influenced by POC Advisor, i.e. after excluding comfort care cases and those that went to the ICU first.*
Length of Stay, Sepsis Cases, Screening Floors*

* This is the subset of cases that could be influenced by POC Advisor, i.e. after excluding comfort care cases and those that went to the ICU first.

Control Period

8.72

Sepsis

0.64

ICU

1.44

Other Units

Study Period

8.19

6.68

0.38

0.13

*P-value > 0.05

Life-Saving Data: How Integrating Real-Time Surveillance & Analytics in Clinical Systems Reduced Sepsis Mortality at Huntsville Hospital
Length of Stay, Hospital Wide (Excluding Study Population)

Life-Saving Data: How Integrating Real-Time Surveillance & Analytics in Clinical Systems Reduced Sepsis Mortality at Huntsville Hospital

* This is the subset of cases that could NOT be influenced by POC Advisor, i.e. it included patients who went to the ICU first or never went to the sepsis screening floor.
Summary of Outcomes Measures

Primary Endpoint
- Lower Mortality

Secondary Endpoints
- Fewer Readmissions in 30 days
- Shorter Lengths of Stay (Not Statistically Significant)
Life-Saving Data: How Integrating Real-Time Surveillance & Analytics in Clinical Systems Reduced Sepsis Mortality at Huntsville Hospital
Sensitivity/Specificity Achievement
Removes the Barrier of “Alert Fatigue”

<table>
<thead>
<tr>
<th>Sensitivity, Sepsis</th>
<th>95%</th>
<th>High Sensitivity—Minimal missing cases of sepsis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity, Severe Sepsis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specificity, Sepsis</td>
<td>82%</td>
<td>High Specificity—Minimal alert fatigue</td>
</tr>
<tr>
<td>Specificity, Severe Sepsis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

High Sensitivity—Minimal missed cases of sepsis
High Specificity—Minimal alert fatigue

Sensitivity and Specificity calculations performed April-June, 2014. Calculations were stopped after June because of the extensive resource effort to conduct thorough chart review on all cases.
Summary of Test Characteristics

- An advanced alerting system built with hundreds of CDS rules to take into account co-morbid conditions that mimic and complicate sepsis can yield highly accurate alerts.
Sepsis Bundle Compliance

Assessment of Compliance with Major IHI Surviving Sepsis Campaign Bundles. (Comparison ranges from Levy, et al.)

- **Initial Lactate Measured**: 62% (61-78%)*
- **Blood Cultures Ordered Before Antibiotics**: 80% (64.5-78.3%)*
- **Broad spectrum Antibiotics Orders**: 100% (60.4-67.9%)*
- **Fluid Resuscitation for Hypotension**: 42% (60-77%)*


*All observations except fluids are from 1 month of patient data, from August, 2014. Fluids compliance reviewed for 2 months, August – Sept, 2014*
Financial Impact

- We also assessed the potential financial income, details not reviewed here, but there is potentially a positive impact via:
  - Cost reduction with improved LOS
  - Revenue recovery secondary to improved documentation of sepsis, leading to improved coding & appropriate reimbursement
Summary of Bundle Compliance

- Regardless of the accuracy of the CDS alerting system and the robustness of established protocols, ongoing change management efforts are needed to ensure appropriate treatment is given by all care providers.
Limitations

- Single center, longitudinal retrospective analysis
- Limited to General Medicine and Respiratory Care Units
- ICD9 diagnoses are known to miss cases of sepsis because they rely on physician documentation, which is often incomplete
- Still working on change management
  - Sub optimal IV fluid resuscitation for severe sepsis with hypotension and septic shock
  - Have not yet added physicians to the alerting system
Conclusion

- Implementing a sepsis improvement program that consists of:
  - Change management to institute sepsis screening protocols and order sets
  - An integrated electronic surveillance system for sepsis that sends alerts to the point of care
  - Improves sepsis mortality and other outcome measures
Questions

Stephen Claypool, MD
Medical Director
Innovation Lab

Steve.Claypool@wolterskluwer.com

Joycelyn Craighead, RN, MSPH, BSN, CPHQ
Director of Quality

Joycelyn.Craighead@hhsys.org