Fall 2018

An interdisciplinary code sepsis team to improve sepsis bundle compliance in the emergency department

Jill M. Delawder
James Madison University

An Interdisciplinary Code Sepsis Team to Improve Sepsis Bundle Compliance in the Emergency Department

Jill M. Delawder

A Clinical Research Project submitted to the Graduate Faculty of

JAMES MADISON UNIVERSITY

In

Partial Fulfillment of the Requirements

for the degree of

Doctor of Nursing Practice

School of Nursing

December 2018

Faculty Committee:

Committer Chair: Linda Hulton PhD, RN

Committee Members/Readers:

Betsy Herron PhD, RN

Frederick Villiard PharmD, BCPS, BCCCP

Table of Contents

List of Tables

List of Figures

Abstract

Purpose: Sepsis is one of the leading causes of mortality with over 700,000 hospitalizations and 200,000 deaths annually. Various tools exist to aid in the early identification and treatment of sepsis including electronic alert systems, standardized order sets, nurse-initiated protocols and specialty trained teams. Despite available guidelines, mortality rates for severe sepsis and septic shock are near 50%.

Methods: The aims of this rapid cycle quality improvement project were 1) to develop and implement an interdisciplinary team to address early implementation of evidence-based sepsis bundles in the emergency department and 2) to compare sepsis bundle compliance three months pre-and three months' post-intervention implementation. The population included all patients' over 18 years of age presenting to the emergency department with clinical indications of sepsis, severe sepsis, or septic shock.

Results: The pre-post intervention analysis shows an improvement in time to each bundle element except antibiotics. There was statistical significance in time to second lactate. Statistical significance was noted in the fluid resuscitation volume met (p=.000), initial lactate collected within 180 minutes (p=.001), and second lactate within 360 minutes (.000). Mortality rates in patients with sepsis on presentation showed a steady decline from 12.45% in the first month pre-intervention to 4.55% in the last month post intervention.

Conclusion: Interdisciplinary teams can utilize existing knowledge, skills and tools to improve sepsis bundle compliance and mortality outcomes in sepsis patients presenting to the emergency department.

Key words: *interdisciplinary, sepsis alert, code sepsis, emergency department*

SEPSIS BUNDLE COMPLIANCE IN THE EMERGENCY DEPARTMENT

Introduction and Background

Sepsis is defined as suspected or confirmed infection combined with two or more systemic inflammatory response syndrome (SIRS) criteria (Dellinger et al., 2012). Severe sepsis is defined as sepsis with organ dysfunction or hypoperfusion and septic shock being the presence of sepsis unresponsive to fluid resuscitation (Dellinger et al., 2012). There continues to be controversy over the definition of sepsis as medical professionals and professional organizations attempt to identify the best indicators of this infectious and inflammatory process that can be so devastating. As the Centers for Medicare and Medicaid Services (CMS) continue to link reimbursement to sepsis quality metrics, many healthcare organizations have leveraged clinicians to address methods that may improve outcomes. To improve compliance with use of the sepsis bundles, many interventions have been suggested to aid clinicians and providers. However, currently there is no one intervention that has been identified to improve overall bundle compliance.

Problem

Sepsis is one of the leading causes of mortality with over 700,000 hospitalizations and 200,000 deaths annually (LaRosa, Ahmad, Feinberg, Shah, DiBrienza & Studer, 2012). The Society of Critical Care Medicine (SCCM) released guidelines, known as the Surviving Sepsis Campaign (SSC), that includes three and six-hour bundles meant to guide early identification and early goal directed therapy (EGDT) for the sepsis population (Dellinger et al., 2012). Bundle elements include antibiotic and fluid administration, as well as collection of blood cultures and lactate level. Various tools exist to aid in the early identification and treatment of sepsis including electronic alert

systems, standardized order sets, nurse-initiated protocols (NIPs) and specialty trained teams. In addition, despite available guidelines, mortality rates for severe sepsis and septic shock are near 50% (Schub & Schub, 2013). Even with evidence-based guidelines available to guide practice, many organizations continue to struggle with the outcome measure due to lack of compliance with the bundle elements (Semlar et al., 2015). Prior to implementation of the project, the project medical center utilized electronic sepsis screening, electronic sepsis alerts, NIPs, and standardized order sets. The medical center had the following pre-intervention bundle compliance: 1) initial lactate collected 92%, 2) correct antibiotic timely 84%, 3) blood cultures 90%, 4) adequate crystalloid fluid resuscitation 37%, 5) second lactate if initial lactate greater than 2mmoL 10%. Based on this initial organizational data, bundle requirements were being met 10% of the time with a concurrent mortality of one in every 64 patients.

Purpose

A review of internal audit data suggested that 90% of septic patients requiring hospitalization present to the emergency department (ED). That said, early recognition and intervention in the ED is essential for early goal-directed therapy and mortality reduction.

The purpose of this project was to determine if implementation of an interdisciplinary sepsis response team in the ED would result in improved bundle compliance and subsequent reduction in mortality. The purpose was to answer the following clinical question: “What is the effect of implementing a code sepsis team on outcome measures and sepsis bundle compliance compared to use of an electronic alert system, nurse-initiated protocols and standardized order sets alone?”

Review of the Literature

A systematic review of the 16 articles reviewed (see Appendix A) highlights that electronic sepsis screening tools and alerts are used in various ways, some that trigger the bedside nurse to contact a physician for further instruction, and others that trigger notification of a specialty trained team. In a study by Alsolamy et al. (2014), the electronic sepsis alert and provider notification preceded ICU transfer by a median of 4 hours. In a randomized controlled trial (RCT) where the charge nurse was notified via a paging system and subsequently expected to contact the provider for orders, 70% of patients in the intervention group had received greater than one intervention, or bundle element, compared to the control group ($p=.018$) (Semlar et al. (2015).

In two studies, a sepsis team was activated based on a positive sepsis screen. In one study, the physician was expected to validate the sepsis alert before activating a sepsis team (Hayden, et al., 2015) compared to automated overhead activation based on electronic screening (LaRosa et al., 2012). Sepsis bundle compliance was significantly higher ($p<.01$) in the post-intervention group in each of the three studies where a specially trained team was activated based on an automated sepsis alert (Hayden et al., 2015; LaRosa et al., 2012; Umscheid et al., 2015). There was also a notable decline in discharge to hospice, with an increase in survival at discharge and discharge to home (Hayden et al., 2015; LaRosa et al., 2012; Umscheid et al., 2015). One study showed a seven-fold reduction in mortality post implementation of a code sepsis team (LaRosa et al., 2012).

Two-studies assessed NIPs in early identification and treatment of sepsis. Bruce, Maiden, Fedullo and Kim (2015) found that upon a positive sepsis screen, the bedside

nurse was to contact the provider for validation to use NIPs. Bruce et al., (2015) found no significant differences in morality, fluid administration or hospital length of stay. Comparatively, a study by Gatewood et al. (2015) demonstrated that allowing the nurse to automatically initiate sepsis specific order sets that included diagnostic studies, as well as to administer the first liter of fluid resuscitation prior to contacting the physician resulted in a 154% improvement in sepsis bundle compliance and a pre-post intervention mortality reduction from 13.3% to 11.1%.

Standardized order sets are interventions that have been studied for use in guiding early identification and management of sepsis. In three of four studies, if the provider acknowledged that sepsis was present, the electronic health record (EHR) opened a sepsis management tool offering evidence-based orders (Hooper et al., Semlar et al., Kurczewski et al.). In a study by Hooper et al. (2012), sepsis assessments were performed by providers after an automated text alert was triggered by the EHR in 185 of 220 of cases. Hooper et al, (2012), found that the sepsis management tool was opened in less than 60% of cases in the study by Semlar et al. (2015), and orders placed via the tool less than 30% of the time.

The results of this systematic review suggest that evidence-based sepsis care implemented within the recommended timeline based on early identification through electronic triggers will improve patient outcomes, and that a specially trained team should be considered to improve sepsis bundle compliance. Results also support that bundled care driven only by physician orders are often include missed components. Findings support use of multiple tools and a collaborative approach to bundled sepsis care.

Project and Methods

Definitions

Sepsis- Suspected or confirmed infection plus two or more symptoms of systemic inflammatory response syndrome (SIRS)

Severe Sepsis- Sepsis with organ dysfunction or hypoperfusion

Septic Shock- Severe sepsis that is unresponsive to fluid resuscitation or lactate greater or equal to 4mmol/L

Hypoperfusion- Systolic blood pressure less than 90mmHg

Sepsis Bundle Components- Blood cultures, antibiotic administration, initial lactate within 720 minutes from time sepsis criteria met. Fluid resuscitation of 30ml/kg within 720 minutes of initial hypotension/hypoperfusion or lactate >4mmol/L. Second lactate collected within six hours from time sepsis criteria met if initial lactate >2mmol/L

Sepsis Alert- Key word communicated with switchboard for paging purposes and used in paging text context.

Framework

Dr. Thomas Nolan and colleagues Rapid Cycle Quality Improvement (RCQI) model was used for this project. This model contains two parts, the first of which must address 3 key questions (School of Public Health, 2016):

- What are we trying to accomplish? This question guides development of a measurable aim.
- How will we know that a change is an improvement? The second question assesses changes through trending data over time.

- What change can we make that will result in improvement? This question encourages new ideas that will help improve the overall aim.

Once these questions have been answered, organizations can conduct small tests of change, while measuring success or failure through outcome measures, and impact other changes that may lead to success of the overall aim (School of Public Health, 2016). This model assists organizations gain measurable and meaningful results in a short amount of time (School of Public Health, 2016). In part, this model reflects a plan, do, study, act methodology in which process owners continually monitor and trend change toward positive clinical results.

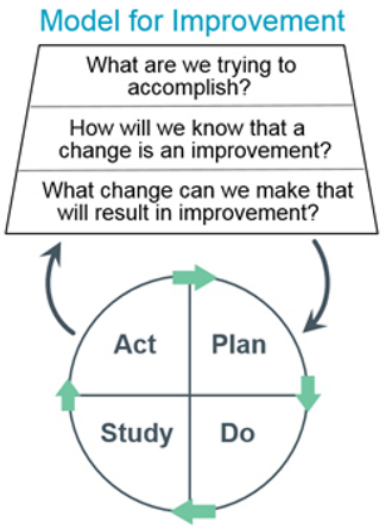


Figure 1. Rapid Cycle Quality Improvement Model
Developed by Dr. Thomas Nolan and Colleagues
Depicted by the Institute for Healthcare Improvement: http://www.ihi.org/resources/Pages/HowtoImprove/default.aspx

Population and Setting

This project was conducted in the 52 bed ED of a 238-bed community hospital in a mid-Atlantic state. The medical center's ED has an average volume of 75,000 annually with 35-38 admissions daily. The population assessed was all patient's over 18 years of age presenting to the ED with clinical indications and concurrent discharge ICD-10-CM

diagnosis code of sepsis, severe sepsis or septic shock for the time frames of April 1, 2017-June 30, 2017 and December 1, 2017-February 28, 2018. Exclusion criteria for this project were based on CMS exclusion criteria for the measure which includes orders for hospice.

Intervention

Phase 1 Team Development: The initial phase of this project began in April, 2017, by developing a project team that included key stakeholders. The team was composed of the following members: project lead (DNP student), quality department director and sepsis data coordinator, ED staff unit champion, ED physician champion, intensive care unit medical director (sepsis physician lead), ED pharmacist, ED satellite lab representative, respiratory therapy (RT), switchboard manager, clinical process improvement engineer and administrative sponsor. A code sepsis team charter (see Appendix B) was developed to outline the scope of the project, deliverables, operational outcomes and action items that the team would achieve.

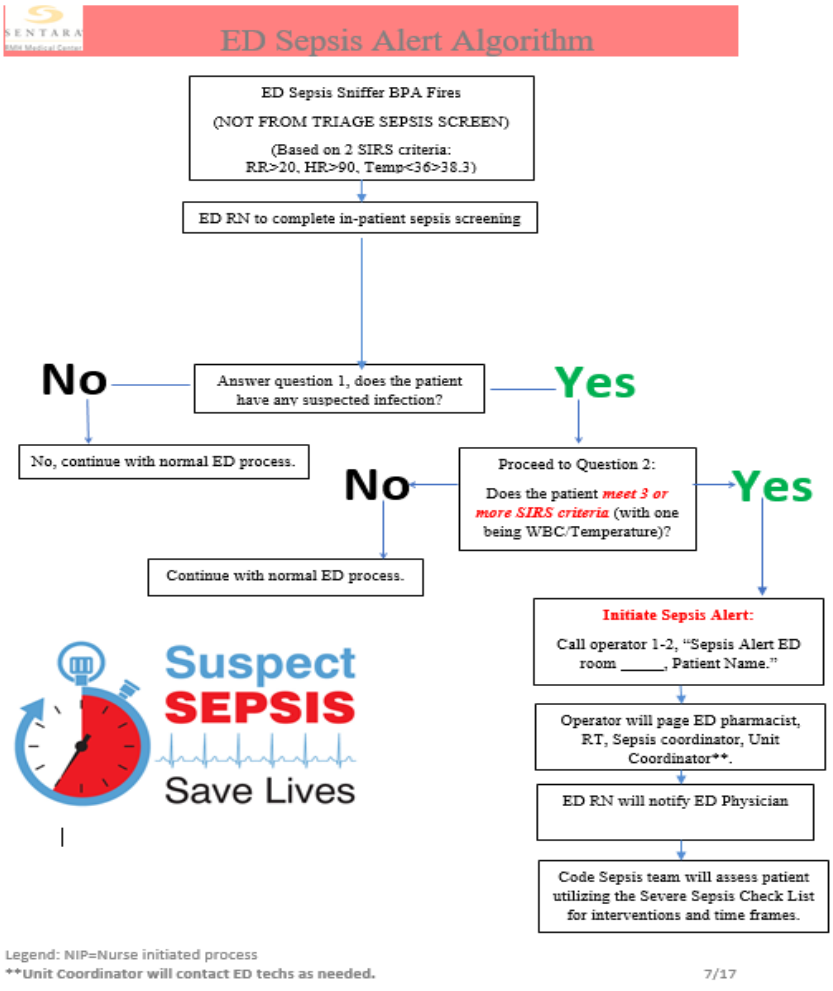
Phase 2 Process Development: In the second phase that began in June, 2017, the clinical process improvement engineer started mapping current ED practice with sepsis presentation. Meeting bi-weekly the team determined an appropriate process for how the nurse would page the code sepsis team upon electronic notification of sepsis to the bedside nurse. The process is outlined in an ED sepsis alert algorithm seen in Figure 2. This process included key words to be communicated to the switchboard to ensure the alert is translated to appropriate team members, who from the team would receive the page, and how they would respond to the page. The ED sepsis alert algorithm was developed to guide the nurse on when to initiate a sepsis alert. The nurses used an

existing best practice alert (BPA) to trigger completion of a full sepsis assessment. When completing the full sepsis screen, if the patient had suspected or confirmed infection along with 3 SIRS criteria, one being temperature or white blood cell count, the screen is considered positive and the nurse should proceed with a sepsis alert. Three SIRS criteria became the trigger for this project because the providers and bedside staff felt that two SIRS criteria would lead to a high volume of false positive alerts and alarm fatigue. The BPA itself fires from the electronic health record (EHR) based on 2 SIRS criteria (RR>20, HR>90, or temperature <36>38.3). To initiate a sepsis alert the nurse will call the switchboard and use the key words developed by the project team for consistency and clarity. The nurse would state, "Sepsis Alert ED Room 4, Patient Name or MR number". The page would then be sent to the unit coordinator, tech, pharmacist, respiratory therapist and sepsis project lead. The unit coordinator would notify the physician in closest proximity or the assigned provider (if the patient had already been assigned).

After determining a sepsis alert was indicated and paging the code sepsis team, the team would respond to the indicated patient room and begin a sepsis checklist (Appendix C) that outlines bundle elements by 1, 3, and 6-hour intervals. The group also worked to utilize the sepsis order set to ensure proper antibiotic orders, fluid resuscitation, and reflex lactates. Reflex lactates are orders within the EHR that will trigger a future order to collect a second lactate if the initial is greater than 2mmol/L. The sepsis checklist then followed the patient to the admitting unit and was used as part of the handoff between staff. Communication also occurred between the nurse and admitting provider to address any remaining bundle elements. Laboratory and RT determined that iSTAT technology, or the ability to collect and analyze blood samples at the bedside, was

not an option for our organization due to cost of equipment and required training time. NIPs utilized in the ED included obtainment of the following laboratory and diagnostic tests: lactic acid, basic metabolic panel (BMP), complete blood count (CBC) with differential, blood cultures, urinalysis, and chest radiograph.

Figure 2. ED Sepsis Alert Algorithm



Phase 3 Education: The third phase involved education of all areas involved in the project roll-out such as ED staff and physicians, satellite lab, main lab, pharmacy, respiratory therapy, ICU nurses, ICU physicians, and switchboard. Education was

provided by members of the code sepsis steering team and included in-services, quick tip sheets, and electronic communication. To ensure all hospital staff were aware of the quality improvement project, an article was placed in the "now you know" electronic communication. The education phase of the project began in early August 2017. Cycle one of RCQI began with a "mock" code sepsis drill prior to implementation for team members to ensure paging, equipment, and other processes were functioning as intended. The team identified that the page was being sent as low priority which was quickly corrected. No other issues were identified during the drill.

Phase 4 Implementation: Project implementation and RCQI cycle 2 began September 1, 2017. During the initial two months of the project no data was collected and RCQI processes were utilized to identify barriers based on team feedback and retrospective data review. The project team meet bi-weekly to review data metrics, process failures, and to develop action items to address barriers prior to collection of post-implementation data collection. The final three months of the project included data collection that was compared to pre-intervention data to assess success or failure of the project in improving compliance with sepsis bundle measures.

Timeline

April 1-June 30, 2017	Baseline Data
June 2017	Process Mapping
June-July, 2017	Project Plan Development
August 2017	Education
August 28, 2017	Mock Go-live (RCQI Cycle 1)
September 1, 2017	Project Implementation

September 1-December 1, 2017	RCQI (Cycle 2)
December 1-February 28, 2018	Post-intervention Data Collection

Evaluation

RCQI processes were used to evaluate code sepsis team function prior to post-intervention data collection. See phase 4 implementation under project plan for additional information regarding RCQI post code sepsis implementation. Process failures included issues with paging through switchboard, incomplete sepsis screening in the ED, failure of team to respond to sepsis alert page, and issues with timing for laboratory interpretation.

Ethical Considerations

This project was approved by the Institutional Review Board at Sentara RMH Medical Center and James Madison University in July 2017.

Sources of Data and Data Analysis

Data collection included three-months of baseline data and three-months of data post project implementation. A list of patients with sepsis present on admission (POA) flags for April, May, June 2017 and December 2017, January, February 2018 was provided to the primary investigator by Crimson, a billing and coding database. A random sampling of every third chart to total 30 charts per month were included in the analysis. Basic demographic information including age and gender were retrospectively collected from the EHR. Sepsis bundle data was collected through manual chart abstraction by the primary investigator. A comprehensive chart review was performed including vital signs, laboratory values, blood culture results, and medication

administration. Code sepsis paging information was collected from switchboard reports and mortality data was collected by Crimson.

Table 1.
Primary Outcome and Data Collection Variables

Primary Data	
	Demographics: Age, Gender
Yes/No	Code sepsis initiated
To be collected within 180 minutes from time sepsis criteria met	Time to Antibiotics
	Time to Initial Lactate
	Time to Blood Cultures
To be collected within 180 minutes from initial hypotension or lactate >4mmol/L	Fluid Resuscitation 30ml/kg
To be collected within 6 hours from time sepsis criteria met	2nd Lactate (If initial lactate >2mmol/L)
	Mortality

All data was retrospective and no patient identifiers were used in data analysis. Utilizing 3-months pre and 3-months post intervention data, data was entered into SPSS. Demographic data included age and gender. Categorical data were analyzed using chi-square tests. Continuous data were analyzed using an independent sample t-test. A bi-variate analysis was performed to determine if any demographic data impacted pre-post bundle measure results. (Appendix D: Data Collection Tool).

Results

A total of 180 patients with sepsis POA were included in the analysis. In a review of demographic data, the patient population ranged from 23 to 100 years old, with a mean

age of 70 years. There was also an equal number of male compared to female patients in pre-post data. In Table 2, a Chi square analysis review of bundle elements was completed for patient's meeting criteria. Results suggest that although timing for antibiotics did not improve, antibiotics were provided to more patients that met indication. Fluid resuscitation volume met increased from 31% at baseline to 80%. There was also statistical significance in number of patients who had an initial and 2nd lactate collected.

Table 2
Chi Square: Completion of Sepsis Bundle Measures Pre/Post Intervention

Variable	Group	Yes	No	Sig (2-Tailed)
Antibiotics	Pre	74	33	.881
180 min	Post	76	31	
Fluid	Pre	42	6 (NI=29)	.012*
Resuscitation 180 min	Post	27	2 (NI=78)	
Fluid	Pre	14	31	.000*
Resuscitation Volume Met	Post	21	5	
Initial Lactate	Pre	84	23	.001*
180 min	Post	101	6	
Blood Cultures	Pre	85	22	1.0
180 minutes	Post	85	22	
2nd Lactate 360	Pre	11	40 (NI=46)	.000*
minutes	Post	38	14 (NI=54)	

NI=Not Indicated
**=p<.05*

Table 3 reviews the sample t-test results, which compared the time to bundle elements pre and post intervention. The time to intervention was impacted for all but one bundle element. The time to antibiotics slightly increased in the post intervention period and there was no significant change in time to blood culture collection. The most frequently missed opportunity pre-intervention, which was a 21% compliance with

completion of the 2nd lactate, had a statistically significant improvement of 179 minutes or 78% in the post intervention period.

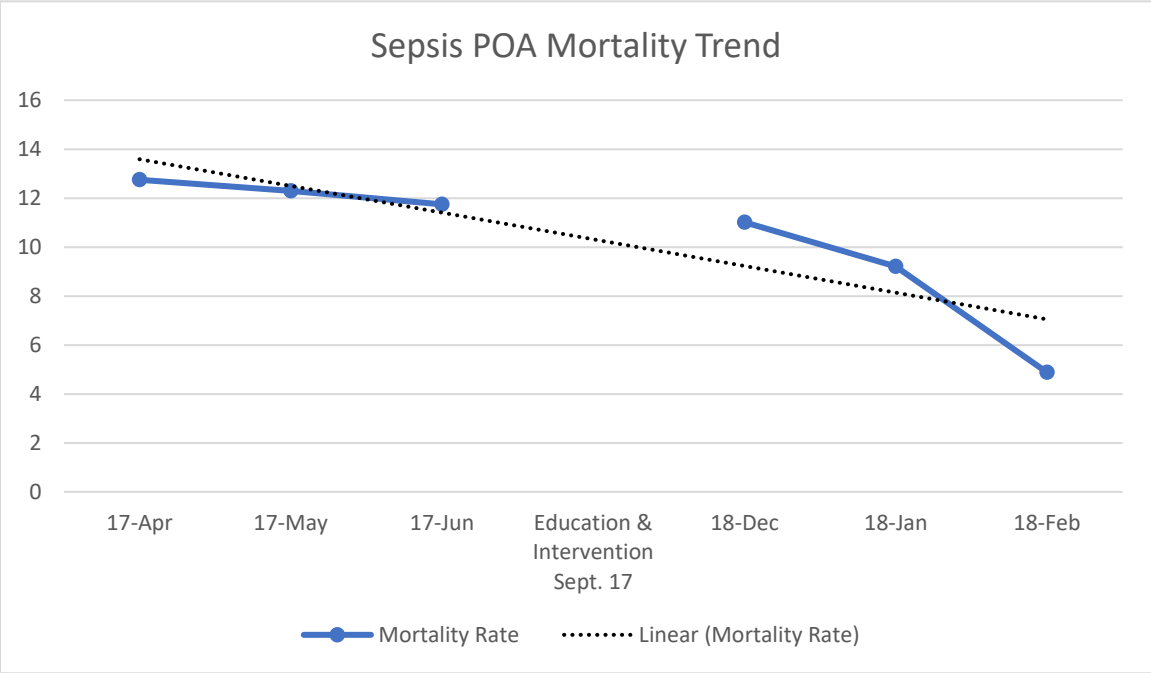
Table 3
Independent Sample T-test: Time in Minutes to Sepsis Bundle Measures Pre/Post Intervention

Variable	Group	N	Mean	Sig (2-Tailed)
Time to Antibiotics	Pre	104	162.96	.984
	Post	106	163.31	
Time to Blood Cultures	Pre	94	88.67	.265
	Post	94	71.81	
Time to Initial Lactate	Pre	94	83.98	.313
	Post	106	70.56	
Time to Fluid Resuscitation	Pre	42	67.60	.265
	Post	26	67.08	
Time to 2nd Lactate	Pre	26	484.92	.002*
	Post	42	305.86	

*=$p<.05$

While reviewing demographic data, an analysis of variance was performed. The analysis suggests that age did not impact pre-post data. It was, however, significant related to collection of blood cultures. The younger the patient, the more significant the delay in time to collection of blood cultures. This same analysis revealed a gender bias suggesting that female patients had a 40-50-minute delay in time to treatment. The gender bias was present in pre and post data. Data analysis also revealed an improvement from a baseline mortality rate of 12.75% with a steady decline to 4.88% in the final month of post intervention data. See Figure 3 for a complete mortality trend of patients with sepsis present on admission (POA) pre and post intervention.

Figure 3



Discussion

The purpose of this project was to determine if implementation of an interdisciplinary sepsis response team in the ED would result in improved bundle compliance and subsequent reduction in mortality. Only three studies reviewed addressed the use of a specially trained interdisciplinary team activated by an electronic sepsis alert to implement bundle elements (LaRosa et al., 2012; Hayden et al., 2015; Umscheid et al., 2015). A retrospective study suggests that an interdisciplinary team approach to sepsis care can be applied to inpatient medical response teams (Guirgis, et al., 2017). These results, in conjunction with the key findings of this quality improvement project show promise for implementing a code sepsis team, in addition to utilization of electronic alerts, nurse-driven protocols and order sets to improve bundle compliance and

patient outcomes. The program improved 4 out of 5 sepsis bundle measures, as well as mortality.

This program was developed prior to the release of the new SEP-3 definitions and followed SCCM and SEP-1 definitions. Early identification and management of sepsis is key to improving outcomes and the project team felt that allowing providers to initiate early care would help prevent complications in those patients without clear symptoms upon presentation. Key findings of this project include that although clinicians feared a high false positive alert rate, use of original guidelines would avoid missing patients who would require early bundled care. Investigation of the EHR, cultural, and systemic factors will continue in an effort to address gaps in care related to the gender bias revealed during data analysis. To address the age variance, an awareness initiative is being developed.

This project contributes to the literature by supporting previous study recommendations that an interdisciplinary approach and the combination of existing tools can improve sepsis outcomes and process measures. Anecdotal data regarding age and gender bias may be key to addressing bundle compliance in other organizations.

Limitations

This review had several limitations. By using three SIRS criteria rather than two, there were patients missed in the sepsis alert process. No false positive alerts were identified during chart review. During the post intervention time-period, a Hurricane in Puerto Rico destroyed several medical product manufacturing plants. The backorder of mini-bags led to removal of antibiotics from automated medication dispensing systems and alternative methods of administration to be utilized. Overall this led to a delay in

antibiotic administration. An issue involving blood culture reporting by emergency department providers also led to a reduction in blood culture collection practices in the post intervention period which may have skewed results. Corrective action has addressed the issue that was leading to the reduction in blood culture collection and supply of intravenous solution to stock antibiotics in medication dispensing systems has been resolved. Finally, despite involvement and education there remains variation in provider engagement. This is even more difficult when considering patients with uncomplicated sepsis and supporting the need for aggressive treatment. ED volumes fluctuate, and with a focus on throughput, engaging clinicians to ensure proper bed placement, even if diagnostic values do not appear critical is crucial.

Implications

As the prevalence of sepsis continues to rise, raising the cost of healthcare, insurance and regulatory entities have taken interest. In 2012 the National Quality Forum began work on endorsing sepsis measures, and now the Centers for Medicare and Medicaid Services (CMS) have started the initial phases of regulating sepsis outcomes related to use of the evidence-based bundle elements (Dellinger & Phillip, 2015).

Although various tools exist to aid clinicians in the early diagnosis and treatment of sepsis, no one tool alone has been shown to improve bundle compliance. However, this project, along with the literature reinforce that incorporating an interdisciplinary approach to existing decision support tools to improve care and patient outcomes. Healthcare organizations should consider adopting an interdisciplinary team approach to sepsis care in the emergency department to encourage a high reliability organization through the combination of diverse skills and perspectives.

Continuous education and awareness initiatives can help support sustainability and maintain focus on the importance of early recognition and goal-directed care. With the fast pace of healthcare, frequent reinforcement of the three and six-hour bundles, along with awareness of the current state for new and existing staff is key to success. As noted in the effect on blood culture collection during data analysis, process changes may un-intentionally affect multiple initiatives and therefore clear communication and involvement of key stakeholders is necessary to avoid unwanted effects on outcomes.

Based on the findings from this project, the medical center plans to complete a third cycle of RCQI by modifying the SIRS criteria to meet original guidelines. With executive support, an accountability process will also be developed and will incorporate outcomes into provider goals. Finally, the process will be applied to the inpatient medical response team protocol with the hope of reducing variation in sepsis care throughout the continuum. The success of the project has encouraged other facilities within the 12-hospital system to replicate the process.

Multiple studies exist on the use of clinical decision support tools developed for ED and inpatient use. Few studies highlight the use of interdisciplinary teams to address sepsis care in the ED and inpatient areas. More research is needed to support use of interdisciplinary teams and processes that can be utilized for both the ED and inpatient areas. Further research is needed on whether gender and age bias exist in other facilities and whether these results are generalizable, and further to address why these biases exist. Finally, with the new SEP-3 guidelines, studies are needed to better understand how the change in defining sepsis may affect early recognition, goal-directed therapy and overall patient outcomes. Although no one intervention has been shown to consistently improve

sepsis bundle compliance and outcome measures, this project supports that the combination of existing tools, in addition to a specially trained team can have a positive impact.

Appendix A: Summary of Studies Evidence Table

Author, Yr.	**Research Design**	**Level of Evidence***	**Sample Description and Size**	**Intervention (may be N/A)**	**Instruments with Validity and Reliability**	**Results/Statistical Evidence**	**Summary/ Conclusion**
Alsolamy et al. [1] (2014)	Prospective consecutive series	VI	n=220	1. Electronic sepsis alert system accuracy (If screen positive, an alert was generated to nurse worklist. Nurse then to notify provider using paging system) 2. To avoid multiple activations the alert was deactivated for 48 hours if the patient has suspected severe sepsis and septic shock 3. Time from alert to intensive care unit (ICU) transfer	1. Plan, Do, Study, Act (PDSA) cycles to test combinations of detection parameters 2. Emergency department (ED) and ICU physicians performed an independent assessment of patients for sepsis criteria 3. No mention of validity or reliability	1. Electronic sepsis screening tool had a sensitivity of 93% (95% CI=89-96%); specificity of 98%, positive predictive value of 20% and negative predictive value of 99.9%. Positive likelihood ratio 59.88 and negative likelihood ratio 0.069. 2. The electronic sepsis alert preceded ICU referral with a median of 4.02 hours (Q1-3, 1.25-8.55).	1. Use of proper clinical measures in an automated screening tool improves accuracy and specificity. 2. Specificity in a screening tool reduces the number of false-positive alerts, as well as alert fatigue in general 3. The screening tool was a good predictor of ICU referral through early recognition
Bruce et al. [2] (2015)	Retrospective chart review: Pre-post design	IV	n=195 with discharge diagnosis of severe sepsis or septic shock through either of 2 ED research sites	1. Nurse-initiated protocol (diagnostic workup for 2 or more SIRS criteria & suspected infection or signs of hypo-perfusion) Based on criteria, nurse would notify charge RN and physician. If physician identified probable sepsis, a	1. Data collection included ED admission time; patient age, sex, weight; volume of fluid infused; blood culture/lactate results; antibiotic administration time; organ dysfunction identified during ED stay; source of sepsis; hospital	1. No significant differences in patient characteristics were found between pre- and post-protocol groups 2. There was no significant difference between pre-and-post protocol groups in compliance with fluid administration	1. The nurse-initiated protocol with early identification of sepsis showed improvement in lactate, blood culture collection and antibiotic administration. 2. The nurse-initiated protocol included standing orders for diagnostic testing

				sepsis code was activated	length of stay (LOS); in-hospital mortality 2. Patients were categorized into 3 groups (pre-protocol, transition, and post-protocol) 3. X^2 tests, Mann-Whitney tests 4. Bivariate correlations were performed with the Kendall T test to identify in-hospital mortality predictive variables. Statistically significant variables were then entered into a multivariate logistic regression model with backward elimination of nonsignificant variables. (level of significance was set at $p<.05$)	(p=.139), hospital LOS (p=.762), or in-hospital mortality rate (p=.838). 3. There was statistically significant improvement in serum lactate and blood culture measurement between pre-and-post groups (p=.003) and in mean time to antibiotic administration (p=.021). 4. Several variables emerged as significant predictors of in-hospital mortality: respiratory dysfunction (OR=4.45, p=.007), CNS dysfunction (OR=2.71, p=.036), urinary tract infection (UTI) (OR=0.14, p=.019), vasopressor administration (OR=4.46, p=.004), and body weight (OR=0.97, p=.011). 5. Pneumonia as a source of sepsis, septic shock, metronidazole or	3. Sample size may have affected the significance 4. Study did not describe how a code sepsis was activated nor who responded to the alert

						vasopressor administration has significant positive associations with in-hospital mortality	
Damiani, E., et. al., (2015)	Meta-analysis	I (although search was for articles in which the intervention focused on old guidelines)	50 observational studies	1. The PI program could be any intervention aimed at improving compliance to one or more components of the 6-hour or 24-hour sepsis bundles based on 2004 or 2008 SSC guidelines 2. 31 were prospective 3. 11 retrospective 4. 11 historically controlled investigations 5. 38 single-center 6. 15 mult-center 7. 34% had educational or interventions implemented in the ED	8. Medline, ISI, were searched. 9. 5-month search 10. Keywords: sepsis, septic shock, bundle, bundled care, guidelines, surviving sepsis campaign, implementation, compliance, performance improvement/quality improvement program 11. English/peer reviewed articles	1. 48 studies evaluated changes in mortality following implementation of a PI program, these showed no significant decrease in mortality ($p<.001$) 2. Education alone improved compliance with complete resuscitation and management 3. The largest increase in adherence to 6-hour bundles was induced by interventions including both an education program and process change	1. Implementing protocolized sepsis care may favor prompt delivery of all recommender interventions in patients with higher risk of death 2. Many limitations to the included studies/variability among studies 3. Limitations to the search in the meta-analysis
Gatewood, et al. [3] 2015)	Retrospective cohort study	IV	624 patients admitted to the emergency department with a primary diagnosis of sepsis. Over 3 months.	1. Nurse-driven sepsis screening tool 2. Computer-assisted algorithm that generates "sepsis alert" trigger for clinical providers 3. Automated suggested sepsis-specific order set	1. Pearson's X^2 applied to compliance and mortality data 2. Validity and reliability data not mentioned.	1. 154% increase in bundle compliance (lactate, Antibiotics, fluid resuscitation, blood cultures) $p<0.001$ 2. 70% bundle compliance post implementation of nurse-screening and nurse-driven order set and provider order set	1. Inclusion of patients with uncomplicated sepsis may confound effects (mortality) 2. Use of automated electronic screening, alert systems, and sepsis specific order sets can improve overall sepsis bundle compliance and reduce mortality

				Compliance metrics were categorized as baseline, after go-live but prior to automated alerts, and after automated suggested order sets		3. Decrease in mortality rate from 13.3% pre-implementation to 11.1% post-implementation 4. Benefit of provider order set was guidance to empiric antibiotic nomograms	
Guidi et al. [4] (2015)	Prospective observational study	VI	Providers (MD, APCs), and RNs Convenience sample Providers completed 127 surveys (response rate of 51%), RNs completed 105 surveys (response rate of 43%)	N/A	1.16-item survey with categorical and Likert scale responses 2. Survey instrument validated internally by expert clinicians for response burden, clarity and consistency 3. Not validated externally *Survey items focused on 1) patient's condition before and after alert 2) whether alert provided new information 3) whether/how the alert changed patient management 4) whether the alert was useful, timely, and improved patient care*	1. Over the 6-week survey, 247 alerts were triggered. 2. Providers completed 127 surveys (51% response rate) 3. RN's completed 105 surveys (47% response rate) 4. Sepsis was the suspected trigger in 1/3 of cases 5. Management changed in over 50% of cases 6. 1/3 of providers felt the alert was helpful ¼ felt it improved patient care	1. Although only 1/3 of cases triggered were suspected to have sepsis, management changed in over 50% of cases. 2. RN's are more accepting of sepsis alert tools than providers. 3. Early recognition and treatment was perceived as positive by RN's 4. Some providers still feel that alerts are unnecessary since some patients were already suspected of having sepsis

Guirgis et al. (2017)	Retrospective quasi-experimental study	III	Pre-n=1637 Post n=1568 Sepsis present on admission & developed as an inpatient based on ICD 9 discharge codes	1. Sepsis education initiatives 2. Sepsis recognition=nurse screening/ED triage screen with physician initiated sepsis alert in ED and rapid response for inpatient units by nursing 3. RRT Screening with alert 4. Automated sepsis screening using a program within the HER 5. Sepsis Alert implementation with order set usage	NA	1. Reduction in the odds of death in the post intervention group (p<.046, OR=0.62) 2. Patients with sepsis on admission had reduced odds of death (OR=0.35) 3. Odds of inpatient death decreased by 22% for each additional previous ED visit	1. A comprehensive program for recognizing and managing sepsis is associated with improved outcomes 2. A team approach to sepsis care is associated with reduced inpatient sepsis mortality, ICU LOS, hospital LOS, mechanical ventilation use, and hospital charges.
Hayden et al. [5] (2015)	Retrospective quasi-experimental study	III	238 patients seen in emergency department triage n=108 pre-SWAT n=130 post-SWAT	1. Electronic Alert based on SIRS/Blood pressure 2. Sepsis workup and treatment (SWAT) group A or B 3. SWAT A consisted of patients with findings consistent with sepsis plus hypotension 4. SWAT B patients were those who met 2 or more SIRS criteria with suspected infection	1. Sample size of 130 subjects in the post intervention group was needed to achieve a 95% CI for a time-to-antibiotic reduction of 30 minutes 2. Data was abstracted retrospectively by 4 reviewers using standardized collection sheets. 3. Ambiguities were settled by consensus between 3 secondary reviewers 4. Medical records were re-reviewed at	1. Post SWAT patients had a higher number of SIRS criteria (p=.04) 2. Shock index was higher in the post-SWAT group (p<.01) 3. Segmented regression modeling (4 models) was used 4. Lactate testing increased by 27.5% in the post-SWAT group (p<.01) 5. Door-to-fluid (by 30-minutes) and door-to-antibiotic (p<.01) improved in the post SWAT group	1. Early recognition in ED triage, triggering a sepsis alert improves time to sepsis bundle interventions 2. Activating resources (1:1 RN, pharmacy, critical care consult) to the bedside for sepsis patients increases compliance with sepsis care

					random for concordance. In total 768 data points were re-abstracted with 751 in agreement (97.8%). 5. 100% agreement for ED arrival time, time of antibiotics, and time of intravenous fluid administration	6. No significant increases in the number of patients who were admitted to ICU (p=.27) 7. No significant change for in-hospital mortality (p=.38) 8. A notable decline in discharge to hospice (p=.05) *X^2 tests for proportions and sample t-tests were used for continuous variables*	
Hooper, et al. [6] (2012)	Randomized controlled trial	II	443 patients in the MICU 221 randomized to "Listening Application (LA)" group 222 randomized to control group	1. Listening Application (Electronic monitoring tool) 2. Provider paging/electronic alert via Starpanel (once acknowledged, if provider indicated patient not septic, the alert was then suppressed for7 days)	1. Sample size software calculated need for 120 alert events in each arm to detect a reduction of 60 minutes for the prompting of physicians to administration of antibiotics (power of .8) 2. Type 1 error probability associated with testing null hypothesis (.05) 3. If the LA was applied to all study participants,	1. Mann-Whitney U tests were used to compare intervention and control groups for primary endpoints 2. Physicians responded to alerts 84% of the time by acknowledging receipt of alert and documenting whether patient triggers were indicative of sepsis 3. No difference in mean time to antibiotics (3.4 v. 3.5 hrs)	1. Majority of patients enrolled in trial had received some type of sepsis care prior to arrival in MICU 2. Monitoring by listening application may not be sufficient to alter physician practices 3. Starpanel does not monitor "live" documentation but validated documentation within the EHR

					sensitivity for detecting sepsis is 99% and specificity is 82%. 4. Positive predictive value of the LA was 41%, with a negative predictive value of 97%	4. No significant difference in fluid resuscitation within 6 hours of diagnosis 5. X^2 tests were used to compare categorical data. No difference in ICU length of stay, hospital length of stay, or in-hospital mortality	
Kurczewski et al. [7] (2015)	Before-and-after study	IV	n=60 30 pre-intervention 30 post-intervention *Patients with ICD 9 coding for sepsis, severe sepsis, or septic shock were included	1. Computerized sepsis screening tool and alert 2. Screening tool identifies 2 or more modified SIRS criteria (heart rate set at 100bpm vs. standard 90bpm, to reduce number of false-positive alerts) 3. Alert appears in EHR and will only allow activity in chart until response documented. Responses differ depending on provider (MD, PA/NP, RN, PCA) 2. Sepsis related interventions (fluid and antibiotic administration,	1. Continuous data reported as medians with ranges 2. Students t test used for comparisons of parametric data 3. Categorical data reported as frequency distribution 4. X^2 or Fisher exact tests used to identify differences between groups 5. All tests were 2-tailed and $p<.05$ set for statistical significance 6. Priori calculations performed/identified a sample size of 60 (30 patients per group) would be	1. Primary outcome of time to initial sepsis-related intervention was a mean of 4.1 hours (pre-intervention) and 0.6 hours (post-intervention) (p=.02) 2. Secondary outcomes: median time to blood culture collection (13.2 vs 1.1; p=.04); median time to lactic acid collection (40.5 vs. 2.4; p=.02) 3. No difference in hospital LOS 4. Post-intervention group trended towards a reduced mortality	1. A computerized sepsis screening tool and alert system improves the ability to identify sepsis patients early and initiate goal-directed therapy in a timely manner 2. An alert that does not allow the provider to proceed without documenting a response encourages providers to address the issue early avoiding delay in treatment 3. Median time to primary and secondary outcome interventions was significantly reduced in the post-intervention group

				blood culture and lactate collection)	needed to see a time difference of 2.2 hours with a power of 80% (2-tailed) 7. Data not powered to determine a difference in patient mortality and overall outcomes		
LaRosa, et al. [8] (2012)	Prospective cohort study	IV	58 patients admitted to the ICU	1. Patients meeting 2 or more criteria on screening tool, triggered activation of code sepsis management alert response (SMART) team within 30 minutes of arrival to the ED 2. *(Responders included pulmonary or critical care fellow or attending, ICU nurse, respiratory care practitioner, and pharmacist)* 3. Standardized order set 4. Control group (patients admitted with severe sepsis or septic shock where a code SMART was	Validity and reliability was not mentioned	1. 32 patients triggered a code SMART 2. 7 others admitted to medical/surgical units, 2 of which were managed with code SMART 3. More patients in the code SMART group had two or three organs involved 4. Compliance with bundle elements occurred more in the code SMART group (sample t-test, $p<.01$) 5. Survival at discharge was significantly higher (logistic regression, $p<.04$) in the code SMART group with a 7-fold reduction in mortality	1. Use of a screening tool to trigger activation of a code SMART team significantly improves compliance with sepsis bundle elements, appropriate admission to the ICU and survival at discharge.

				not triggered) managed by same protocol at the discretion of the treating physician			
Manaktala, et al. [9] (2016)	Quasi-experimental pre-post-test design	III	n=1634 on 2 medical units 1170 control 464 Intervention group	1. Electronic clinical documentation system (CDS) surveillance 2. Mobile device and desktop alerts 3. 4 types of alerts were used: Informational prompts (tachycardia, etc.); Diagnostic alerts	1. Documentation within the EHR was adjusted to meet electronic rules to ensure accuracy 2. Parameters were adjusted based on subject matter experts for differing patient population to avoid inaccurate diagnosis	1. Sepsis related mortality was reduced by 53% in the post-intervention group (p=.03) 2. The post-implementation group had 2.1 times lower risk of death (OR 0.474, p=.04) compared to the pre CDS group	1. Electronic sepsis screening tools validated through comparison of physician chart review improve accuracy of screening and reduce risk of false-positive alert 2. Early recognition and alert to bedside

			*All patients admitted with at least one ICD-9 sepsis code was included in the study	(new sepsis or worsening sepsis); Advice alerts (providing evidence-based care such as fluids, antibiotics, etc.); Reminder alerts (to ensure alerts were addressed and physicians contacted) 4. Sepsis order sets	3. Use of ICD-9 codes as inclusion criteria 4. 2 Physician investigators reviewed patient records to diagnose presence and severity of sepsis for positive screens (for alert test characteristic) 5. A Kappa statistic was used to assess inter-rater reliability 6. The validity of sepsis alerts in comparison to gold-standard chart review was assessed 7. Multivariate logistic regression	3. Re-admission rates on the study-units were reduced from 19.08% to 13.21% (p=.05) 4. Kappa statistic for agreement between investigators on sepsis diagnosis was 0.67 5. The electronic sepsis screening tool had a sensitivity of 95% and 82% specificity compared to physician chart review	nurse promotes provider communication 3. Early recognition and proper treatment can reduce mortality and re-admission rates
Morr, M., et al. (2017)	Prospective cohort Study	III	110 patients with sepsis in the ED	1. 502 patients >18 y.o presenting to the ED during a 4-week study period were included 2. These cases were reviewed to determine if sepsis was recognized in the ED? What are possible influencing factors on missed sepsis diagnosis? How do recognition and classification of sepsis affect quality of care, admission to	1. To compare disease severity in different sepsis sub-groups, the MEWS, AVPU, and mMEDS scoring was used (which has been previously validated) 2. Charlson co-morbidity index (CCI) used to compare chronic disease burden	1. Patients were divided into 3 groups (non-SIRS, sepsis, severe sepsis) 2. Case evaluation revealed that 110 of the 502 patients suffered from infection 3. 54 patients met criteria for sepsis and 20 for severe sepsis 4. 35% of cases were identified appropriately 5. 65% were overlooked and only revealed by the study team	1. Inadequate perception of available vital signs 2. Only 41% of formal sepsis diagnoses were noted in the record 3. Incomplete listing of vital signs in discharge notes could be an independent risk factor for missed sepsis diagnoses

				the ICU, mortality, and LOS?		6. Hospital mortality 5.5% 7. 2/6 patients died in ICU	
Olenick, E., et al., (2017)	Descriptive retrospective study	IV	Only patients with a coded diagnosis of sepsis were analyzed	1. 7 hospitals using EPIC 2. Sepsis risk detection method (nurse screening tool, NST, or sepsis sniffer algorithm, SSA) 3. Time to first detection of sepsis high risk 4. NST screens with associated surveillance hours 5. Patients divided into 2 groups (sepsis high risk detected within or greater than 4 hours) to explore effect of time until detection on patient outcomes (LOS, direct costs, and mortality)	1. NST was derived from the surviving sepsis campaign's evidence-based criteria 2. SSA based on predefined clinical criteria designed to achieve: Establish criteria with strong face validity Accurately identify patients at high risk for sepsis Achieve a high negative predictive value Improve timeliness of sepsis detection Minimize manual workload associated with the NST	1. Overall the predictive accuracy for the NST proved higher than the SSA 2. SSA demonstrated a higher negative predictive value 3. The NST had a higher specificity 4. NST had a stronger relationship with sepsis diagnosis coding 5. SSA had a positive overall effect on the number of manual NST screens (NST required on admission, but subsequent screens were only needed based on SSA alert)	1. Leveraging automated technology, such as the SSA, may identify sepsis risk early and reduce manual efforts leading to more efficient distribution of nursing resources 2. The SSA should not be used for initial identification and should be followed by a NST for specificity (avoid alert fatigue)
Sawyer et al. [10] (2011)	Prospective observational pilot study	III	Total n=270 n=181 non-intervention group (NIG)	1. Electronic Sepsis Screening 2. Electronic automated sepsis alert page to unit charge nurse within	1. Sample size based on previous studies. 304 patients needed to achieve a statistical power of 80%	1. Within 12 hours of the sepsis alert, 70.8% of patients in the IG received >1 intervention compared to 55.8%	1. Automated sepsis screening tools and alert systems increase the rate of completion of

			n=89 Intervention group (IG)	10 minutes of identification (charge nurse to assess patient, contact provider who would then determine if treatment indicated) **Electronic tools and notifications only for intervention group* 3. Variables include sepsis bundle elements (antibiotic administration, fluid administration, blood cultures) to be completed within 12 hours of sepsis alert, and transfer to ICU, hospital mortality, LOS	2. Chi square and Fisher's exact tests performed for all dichotomous variables 3. Students t test performed for all continuous variables. 4. All tests two-tailed and a p vale of <.05 considered significant 5. Computerized prediction tool (PT) validated against cohorts from 2006-2007, with a positive predictive value of identifying a patient that transferred to ICU secondary to severe sepsis or septic shock was 19.5% with a negative predictive value of 95.8%.	of patients in the NIG (p=.018) 2. Antibiotic escalation (p=.035), fluid administration (p=.013). 3. Patients in both the IG and NIG had similar rates for transfer to ICU, although patients in the IG were likely to be transferred to ICU within 12 hours of sepsis alert (9% vs. 4.4%) 4. Hospital mortality and LOS were similar between both groups	sepsis bundle elements 2. PTs or screening tools upgraded to identify early clinical deterioration 3. PTs need refined to include health information technology bundles
Semler et al. [11] (2015)	Randomized controlled trial	II	1. 407 patients admitted during a 4-month period to a medical/surgical ICU with a diagnosis	1. Electronic sepsis alert to trigger provider (MD, NP) 2. Electronic sepsis assessment and management tool	1. Based on prior data, a sample size of 400 patients would achieve 80% power to detect a 1-hour decrease in time to completion of all 6-hour bundle elements with a type I error rate of 0.05	2. No statistical significance in difference of primary outcomes (time to completion of 6-hour bundle or each individual bundle element)- Kaplan-Meier method with log	1. Pulmonary sepsis most common cause 2. Most commonly used by advanced practice clinicians that consistently cared for patients in the ICU setting

			or sepsis on admission or in response to an electronic sepsis alert 2. 218 randomized to the integrated sepsis assessment/management tool group 3. 189 to pre-randomization management group			rank testing/Cox-proportional-hazards regression 3. No difference in ICU LOS, ICU-free days, ventilator-free days (VFDs) 4. Significance in use of tool by the SICU in 67.3% of cases compared to MICU at 36.5% (majority of study patients were admitted to MICU)- Logistic regression model with prespecified covariates 5. The tool was opened in less than 60% of cases with orders placed through the tool in less than 30%- Logistic regression model with prespecified covariates 6. Nurse Practitioners that consistently rotated through ICU used the tool most	3. Use of a sepsis management tool may improve sepsis care if utilized consistently
Umscheid et al. [12] (2015)	Pre-post design	IV	1. n=1140 across 3 hospitals in the University of Pennsylvania Health System	1. Early warning and response system (EWRS) 2. Efferent response arm included covering provider, bedside nurse, and rapid response	1. To establish a threshold for triggering the system, a derivation cohort was used 2. The EWRS was validated during the	1. Rapid response coordinators completed the follow-up assessment 95% of the time 2. The entire team performed bedside	1. A predictive early warning system can identify non-ICU patients before clinical deterioration. 2. An early alert system can

			(UPHS), non-critical care services 2. 595 pre-implementation 3. 545 post-implementation	coordinators who were required to complete a 3-question follow-up assessment in the EHR (were all 3 team members gathered, most likely condition triggering EWRS, whether management changes)	pre-implementation "silent" period. 3. The tool was validated and baseline data was gathered to which post-intervention data would be compared 4. During this time, new admissions could trigger the alert but notifications were not sent. 5. The first 30-days estimated the tool's screen positive rate, test characteristic, predictive values, and likelihood ratios. 6. Unadjusted analysis using the X^2 test for dichotomous variables and the Wilcoxon rank sum test for continuous variables compared demographics and most of the clinical process/outcome measures for those admitted during the "silent" period. 7. Multivariate regression models estimated impact of the EWRS on process and outcome	evaluation over 90% of the time 3. Team reported that over 90% of the time they were aware of sepsis prior to alert 4. In unadjusted and adjusted analysis, ordering of antibiotics, fluid boluses, lactate and blood cultures within 3 hours of the trigger significantly improved (p=<.01) 5. Hospital and ICU LOS were similar pre-and-post implementation 6. Transfer to ICU within 6 hours of the alert was increased by 50% 7. All mortality measures were improved in the post-implementation phase, but not statistically significant. 8. Discharge to home and sepsis documentation were significantly higher in the post-implementation phase	successfully deploy a multidisciplinary team for rapid bedside evaluation and initiation of early goal-directed therapy. 3. Although not statistically significant, an alert system and response team can lead to appropriate transfer to ICU, improved sepsis documentation, decreased mortality index and mortality, as well as increased discharge to home 4. The EWRS could help triage patients appropriate for transfer to ICU

					measures, adjusted for differences between patients in the pre-implementation and post-implementation periods. 8. Logistic regression models examined dichotomous variables 9. Continuous variables were examined using linear regression models. 10. Cox regression models looked at time from trigger to ICU transfer 11. Logistic regression also looked at odds of mortality between the silent and live periods with adjustment for expected mortality		

Appendix B: Code Sepsis Team Charter

SENTARA
RMH Medical Center

Project Code Sepsis

Project Scope: Develop and implement a comprehensive strategy for sepsis bundle compliance improvement in the emergency department.

Primary Deliverables:

- Develop and implement comprehensive strategy for Sepsis improvement.
- Deploy Sentara processes and tools as applicable.
- Improve sepsis bundle compliance
- Meet or exceed organizational improvement goals for Mortality for Sepsis patients.

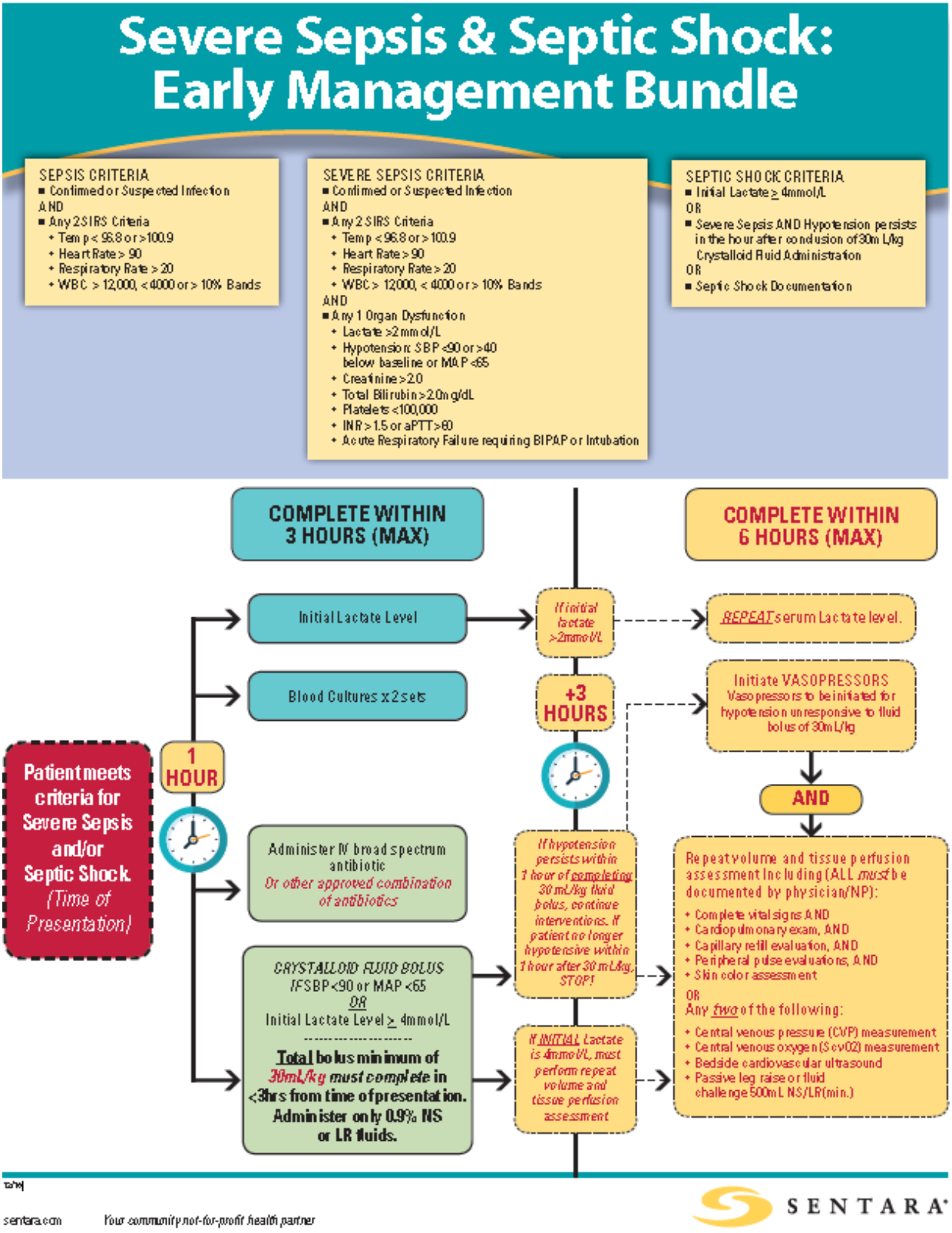
Operational Measures:

Primary Data	
Yes/No	Code sepsis initiated
To be collected within 180 minutes from time sepsis criteria met	Time to Antibiotics
	Time to Initial Lactate
	Time to Blood Cultures
To be collected within 180 minutes from initial hypotension or lactate >4mmol/L	Fluid Resuscitation 30ml/kg
To be collected within 6 hours from time sepsis criteria met	2nd Lactate (If initial lactate >2mmol/L)

Action Items:

1. Trigger for sepsis team activation
2. Sepsis team develop (who, how to respond)
3. Process mapping: ED sepsis screening and response
4. Paging Process
5. NIP use
6. Electronic order set
7. iStat inclusion for lactate
8. Education
9. Marketing/Awareness
10. Mock Code Sepsis Drill
11. Project Implementation (No data collection in initial 2 months, RCQI process)
12. Bi-weekly meetings during 2 month RCQI

Appendix C: Sepsis Checklist



CHECKLIST:
SEVERE SEPSIS / SEPTIC SHOCK

To be completed at the time of patient care to ensure that necessary actions are not missed.

Place patient sticker here

NOT A PERMANENT PART OF THE RECORD

This is not an order form - please obtain orders from a provider

SEPSIS BUNDLE

	TIME		
Time Zero	:	Severe Sepsis and/or Septic Shock Criteria Met	**Time Zero**
	☐	Order set initiated Y / N	
	:	Lactic Acid Level: _____mmol /L	If result > 2, repeat in 3 hours
	☐	Blood Culture set 1	After first attempt to obtain blood culture, document unsuccessful attempt in a nursing note and administer antibiotic
	☐	Blood Culture set 2	
HOUR 1	☐	Broad Spectrum Antibiotics	
		Crystalloid Fluid Bolus (30 ml/kg)	*Required for patients with SBP < 90, MAP < 65, Lactate ≥ 4.0 or Septic Shock documented*
		Please document end times in Epic	
	☐	_____ ml	
	☐	_____ ml	Actual Weight: _____kg x 30 = _____ml
	☐	_____ ml	Please notify provider after last bolus complete
HOUR 3	:	2nd Lactate Due: _____	Result: ____mmol/L
	:	Septic Shock Criteria Met	SBP<90, MAP<65 within 1 hour after crystalloid fluids, or Lactate > 4
	☐	Vasopressor within 6 hours if SBP still <90 or MAP <65 after 30 ml/kg bolus	
HOUR 6	:	Focused Exam within 6 hours (documented by provider) OR	Includes: vital signs, heart & lung sounds, skin color, capillary refill, peripheral pulses
		(Any 2 of the following): ___ CVP reading ___ ScvO2 Reading ___ Cardiac Ultrasound ___ Passive leg raise or fluid challenge (500 ml NS/LR + NICOM)	

Date: _____

Unit: _____

Your Name: _____

Comments Appreciated: _____

_____

Please Return form to Quality and Patient Safety.

Appendix D: Data Collection Tool

Baseline Data	**Average Age**	**Average Gender**	**Code Sepsis Initiated (% Compliant)**	**Time to Antibiotics (Within 180 minutes, % Complaint)**	**Time to Initial Lactate (Within 180 minutes, % Compliant)**	**Time to Blood Cultures (Within 180 minutes, % Compliant)**	**Fluid Resuscitation (30ml/kg) (Within 180 minutes of initial hypotension or lactate >4)**	**2nd Lactate (Within 6 hours of initial sepsis presentation if initial value >2mmol/L)**
Apr-17								
May-17								
Jun-17								
Post-Intervention Data								
Dec-17								
Jan-18								
Feb-18								

References

Alsolamy, S, Salamah, M, Thagafi, M, Al-Dorzi, H, Marini, A, Aljerian, N, Al-Enezi, F, et al. (2014). Diagnostic accuracy of a screening electronic alert tool for severe sepsis and septic shock in the emergency department. *BioMed Central Medical Informatics and Decision Making, 14*(105). Retrieved from PubMed.

Bruce, H, Maiden, J, Fedullo, P, & Kim, S. (2015). Impact of nurse-initiated ED sepsis protocol on compliance with sepsis bundles, time to initial antibiotic administration, and in-hospital mortality. *Journal of Emergency Nursing, 41*(2): 130-137.

Damiani, E., Donati, A., Serafini, G., Rinaidi, L., Adrario, E., Pelaia, P., Busani, S., et al. (2015). Effect of performance improvement programs on compliance with sepsis bundles and mortality: A systematic review and meta-analysis of observational studies. *Plos One, 10*(5), 1-24. doi:10.1371/journal.pone.0125827.

Dellinger, R., & Phillip, MD (2015). *The future of sepsis performance. Critical Care Medicine, 40(*9), 1787-1789. doi: 10.1097/CCM.0000000000001231.

Dellinger, R.P., Levy, M.M., Rhodes, A., Annane, D., Gerlach, H., Opal, S.M., Sevransky, J.E., et al. (2012). Surviving sepsis campaign: international guidelines for management of severe sepsis and septic shock. *Critical Care Medicine, 41*(2). doi: 10.1097/CCM.0b013e31827e83af.

Gatewood, MO, Wemple, M, Greco, S, Kritek, P, & Durvasula, R., (2015). A quality improvement project to improve early sepsis care in the emergency department. *BioMed Journal of Quality and Safety, 24*: 787-795.

Guidi, J. L., Clark, K., Upton, M. T., Faust, H., Umscheid, C. A., Lane-fall, M. B., Mikkelsen, M. E., et al. (2015). Clinical perception of the effectiveness of an automated early warning and response system for sepsis in an academic medical center. *Annals of the American Thoracic Society, 12(*1). doi: 10.1513/annalsATS.201503-129OC.

Guirgis, F. W., Jones, L., Esma, R., Weiss, A., McCurdy, K., Ferreira, J., Cannon, C., et al., (2017). Managing sepsis: Electronic recognition, rapid response teams, and standardized care save lives. *Journal of Critical Care*, 0883-9443. doi.org/10.1016/j.jcrc.2017.04.005.

Hayden GE, Tuuri, RE, Scott, R, Losek, JD, Blackshaw, AM, Schoenling, AJ, Nietert, PJ, et al. (2015). Triage sepsis alert and sepsis protocol lower times to fluids and antibiotics. *American Journal of Emergency Medicine, 34*(9).

Hooper, M. H., Weavind, L., Wheeler, A. P., Martin, J. B., Gowda, S. S., Semler, M. W., Hayes, R., M., et al. (2012). Randomized trial of automated, electronic monitoring to facilitate early detection of sepsis in the intensive care unit. *Critical Care Medicine, 40*(7). doi: 10.1097/CCM.0b013e318250a887.

LaRosa, J.A., Ahmad, N., Feinberg, M., Shah, M., DiBrienza, R., & Studer, S. (2012). The use of an early alert system to improve compliance with sepsis bundles and to assess impact on mortality. *Critical Care Research and Practice*, 1-8.

Kurczewski, L, Sweet, M, McKnight, R, & Halbritter, K. (2015) Reduction in time to first action as a result of electronic alerts for early sepsis recognition. *Critical Care Nursing Quality, 38*(2): 182-187.

Manaktala, S., & Claypool, S. (2016). Evaluating the impact of a computerized surveillance algorithm and decision support system on sepsis mortality. *Journal of the American Medical Informatics Association 24*(1), 88-95. doi: 10.1093.jamia./ocw056.

Morr, M., Lukasz, A., Rubig, E., Pavenstadt, H., & Kumpers, P. (2017). Sepsis recognition in the emergency department-impact on quality of care and outcome? *Emergency Medicine, 17*(11), 1-8. doi: 10.1186/s12873-017-0122-9.

Olenick, E., Zimbro, K., D'Lima, G., Schneider, P., & Jones, D. (2017). Predicting sepsis risk using the "sniffer" algorithm in the electronic medical record. *Journal of Nursing Quality Care, 32*(1), 25-31. doi: 10/1097/NCQ.00000000000198.

Sawyer, A. M., Deal, E. N., Labelle, A. J., Witt, C., Thiel, S. W., Heard, K., Reichely, R. M., et al. (2011). *Critical Care Medicine, 39*(3), 469-473. doi: 10.1097/CCM.0b013e318205df85.

Semlar, M.W., Weavind., L, Hooper, M.H., Rice, T.W., Gowda, S.S., Nadas, A., Song, Y., et al. (2015). An electronic tool for evaluation and treatment of sepsis in the ICU: a randomized controlled trial. *Critical Care Medicine,* 10(6): 1595-1602.

School of Public Health (2016). *Rapid Cycle Quality Improvement (RCQI): A Resource Guide to Accelerate Improvement Efforts for Health Resources and Services Administration (HRSA) Grantees.* Center for Health Workforce Studies: NY. Retrieved from http://www.healthworkforceta.org/wp-content/uploads/2016/06/RCQI_Resource_Guide.pdf.

Schub, E., & Schub, T. (2013). Sepsis and septic shock. *Cinahl Information Systems*, 1-3. Retrieved from CINAHL Plus with Full Text Database.

Umscheid, CA, Betesh, J, VanZandbergen, C, Hanish, A, Tait, G, Mikkelsen, M, French, B, et al. (2015). Development, implementation, and impact of an automated early warning and response system for sepsis. *Journal of Hospital Medicine, 10*(1); 26-31.