Implementing a Deterioration Index Score & Narrator to Improve Sepsis Identification and Management

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Abstract

Problem: Approximately 35% of deaths in hospitals are related to sepsis, a commonly preventable condition. In a medical-surgical unit at a regional hospital, the risk for sepsis alert fired about 902 times per month between July and December of 2020. Of those alerts, 83% were accepted without further documented action taken by nurses. Lack of action for high sepsis warning alerts resulted in delayed recognition of sepsis and poor patient outcomes.

Purpose: The purpose of this quality improvement project was to improve early identification and management of sepsis by developing a standardized process for nurses to use in response to sepsis alerts.

Methods: A sepsis workgroup developed a new alert based on the Epic Deterioration Index and Sepsis Scores. The intervention consisted of a screening tool that generates a sepsis alert for nurses in the electronic medical record once criteria are met. A sepsis treatment-bundle tasks list which follows an evidence-based algorithm then guides the nurse through recommended interventions to better monitor adherence and outcomes. The nurses on the unit received training on the new alert and sepsis narrator. Nurses received the alert once the deterioration index reached 60%. Collected data included length of stay for sepsis patients and time to antibiotic administration. Control charts and run charts were used to examine the outcomes.

Results: The deterioration index and sepsis treatment guide positively impacted patient outcomes. The length of stay for sepsis patients decreased by an average of 4.9 days following the intervention. The percent of patients receiving antibiotics within the recommended 3 hours of identification increased by 33%.

Conclusion: Sepsis can cause poor patient outcomes, decreased quality of life, and mortalities for hospitalized patients. The deterioration index score and sepsis treatment bundle guide are beneficial in assisting nurses with clinical decision-making and earlier treatment of sepsis.

Implementing a Deterioration Index Score & Sepsis Narrator

Sepsis is a bloodstream infection that typically triggers a rapid deteriorating response in the body (CDC, 2021). This response can be life-threatening, yet preventable in many cases with prompt and early identification and treatment. In the United States, one-third of deaths that occur in hospitals are related to sepsis (CDC, 2018). Although all populations are vulnerable to sepsis, the World Health Organization ([WHO], 2020) identifies hospitalized patients as higher risk. In Maryland, 11.3% of deaths were caused by sepsis in 2019; Sepsis has been the eighth leading cause of death in the state for about three years (CDC, 2021).

A Medical Surgical Unit (MSU) at a regional, hospital in Maryland serves many high risk for sepsis individuals. In the last six months of 2020, the risk for sepsis best practice alert (BPA) was fired 902 times on average per month to warn nurses of possible sepsis. Amongst those alerts, 83% of them were overridden or accepted without further, documented action taken. During the COVID-19 pandemic, the MSU primarily cared for patients infected with the coronavirus. The body tends to have a dysregulated immune response to the coronavirus, making individuals more prone to developing sepsis (Cheney, 2020). The population on the MSU usually consists of adults with acute medical or surgical issues with higher risks of sepsis. Therefore, early identification and proper management are priority goals for achieving optimal patient outcomes.

The electronic health record system, EPIC developed a sepsis prediction score intended to accurately predict a patient's risk of sepsis (Bennett et al., 2019). Even with the presence of this high-quality tool, nurses using it appropriately remained a problem. On the MSU, sepsis BPAs fired once a patient is automatically flagged as a high risk for sepsis based upon the sepsis score. Appendix A delineates a map of the prior process flow. A practice change was deemed necessary to increase the appropriate use of the sepsis score. The purpose of this quality improvement (QI)

project was to initiate a deterioration index with sepsis score alert, and a standardized sepsis narrator for nurses to improve early identification and management of sepsis.

Evidence Review

A literature review was conducted to identify the best evidence-based practice changes needed to improve the timely identification of sepsis. Upon analysis, a common theme of early warning scores and clinical decision support systems (CDSS) was recognized. Early warning scores are an efficient way of communicating risks for sepsis in patients. Although the components of each early warning score assessment tool vary slightly, collective findings conclude that the scores escalate timely patient care. A systematic review of randomized controlled trials found that CDSS's were effective at improving sepsis tool adherence by automatically delivering recommendations in real-time to nurses to facilitate decision-making interventions regarding sepsis (Bright et al., 2012).

Bright et al.'s (2012) systematic review included studies in clinical settings that utilized paper-based or computer-based CDSS's. The intervention served as reminders to clinicians to acknowledge sepsis alerts and then guided them through a decision-making algorithm that followed nationally recommended treatments for sepsis. The meta-analysis of the studies suggested that CDSS's improved morbidity outcomes for septic patients. This level of evidence is rated as level one with a B quality rating. Although CDSS's were proven to be effective in reducing costs, adverse effects, and morbidity, there are no consistent, clear applications of CDSS's generalizable to multiple locations. The sample population was homogenous and applicable to all hospitalized adults, although the process improvement differed in different facilities. There is high certainty that the benefits of CDSS's are moderate to substantial. Recommendations were aimed at further research.

Alternate studies utilized different early warning score (EWS) assessment tools to prompt nurses to further assess the patients. Downey et al. (2017) conducted a systematic review of qualitative, quantitative, and mixed-method studies. While this study looked at clinical settings with a variety of different EWSs, McColl et al. (2017) further evaluated the sensitivity and specificity of various tools and made adjustments to create a more efficient, high-quality tool. McColl et al. (2017) evaluated the root causes of non-compliance rates with the current EWS and adjusted the patient criteria required to receive an alert and the sepsis bundle interventions. Mortality rates pre- and post-changes were evaluated. Septic mortality rates decreased by 13.4% after the revamped tool was initiated. The overall quality of this study was rated B with a level three of evidence.

Overall, studies investigating the effectiveness of screening tools and computer-guided sepsis algorithms helped alert nurses of potential deterioration in patients. Algorithms created from sepsis bundles and early warning scores with high specificity and sensitivity influenced earlier treatment interventions in septic patients. Tables 1 and 2 contain a detailed evidence review table and synthesis of each study.

Theoretical Framework

The Synergy Model is a middle-range theory originally developed in 1996 used to support the framework of critical care nursing certifications (Hardin & Kaplow, 2017). The fundamental idea of this model is that the patients' characteristics and needs influence the nurses' competencies needed to attain optimal patient care (Hardin & Kaplow, 2017). When nursing skills are inspired from patient characteristics, synergy transpires leading to best practice. The Synergy Model identifies patient characteristics that describe their health and illness, as well as nursing competencies considered essential for providing quality care. Refer to Figure 1 for a diagram of the Synergy Model and its characteristics.

Concerning the early identification of sepsis, patients' characteristics change rapidly and are important to note upon initial presentation for early treatment to occur. Decreased stability, increased complexity, and unreliable predictability are all patient characteristics in the Synergy Model which are also consistent with early warning signs of sepsis (Hardin & Kaplow, 2017). The practice issue of nurses ignoring the signs of deterioration creates a barrier in attaining synergy. Clinical judgment, advocacy, collaboration, and systems thinking are all nursing competencies described by the Synergy Model and necessary to respond to potential sepsis patients. The process flow of receiving an alert in response to patient characteristics, identifying potential sepsis, and demonstrating nursing characteristics that align with evidence-based treatment plans can create synergy, thus improving patient outcomes.

The implementation of this project required complex innovation utilizing a framework described by Helfrich et al. (2007). This conceptual framework highlights the concept of implementation climate and the importance it has on receiving buy-in from many stakeholders. Figure 2 displays the components of the framework and their relationships with each other. Sepsis was a valued topic at this organization because it affects healthcare costs and patient outcomes. The development of a sepsis workgroup including leadership and organizational members was attainable because sepsis is considered a priority. Unit sepsis champions were recruited during the education and training phase to help promote and provide accountability on the unit. This framework suggests that multiple approaches to implementation lead to improved effectiveness (Helfrich et al., 2007). The use of multiple ways to incorporate the communication of sepsis scores amongst staff helped to reach the goals of the project.

Methods

An early warning score and sepsis bundle algorithm was initiated on a medical-surgical, inpatient unit to improve early identification of sepsis in adult patients. All patients admitted to

the MSU and diagnosed with sepsis during the implementation period were included in this project. Sepsis education and training were provided to the nurses on the unit. In-services, support, and information were provided to nursing staff. Due to social distancing, a training module and post-quiz was created and assigned to all nursing staff via the Health Stream System to ensure compliance.

An early warning score (EWS), the Deterioration Index (DI) with a new threshold of 60 was initiated to make alerts more sensitive and specific to patients at high risk of deterioration and becoming septic. The computer-generated DI alert notifies nurses every time a patient meets the criteria, using objective data entered into the electronic medical record. Visual reminders of the recommended steps to take following a DI alert were created on badge cards, laminated, and given to all nurses. The sepsis tasks checklist required nurses to review the associated sepsis score, assess the patient and notify the provider using SBAR communication. Once sepsis was determined, a sepsis bundle order set was placed, and nurses obtained blood cultures and administered antibiotics within three hours of receiving the alert. An image of the sepsis bundle tasks checklist card and a link to the PowerPoint training provided to nurses are provided in Appendix B.

Clinical judgment was taken into consideration with the immunocompromised patients who are more vulnerable. Lower thresholds were set due to their lessened immune systems. These patients were considered septic and received treatment with milder signs and symptoms compared to the non-immunocompromised patients. Patients admitted with a COVID-19 diagnosis were also carefully considered as their DI scores may be high due to the virus infection and mask underlying sepsis infections.

The percentage of nurses that completed the sepsis educational training was measured as a structural outcome. Education was provided with a variety of time offerings to promote flexibility

and broad inclusion. The training was also offered virtually on the Health Stream platform for nurses to complete at their leisure and promote compliance.

Process outcome measures included the percentage of DI alerts acknowledged, and the number of sepsis bundle tasks lists completed. The proportion of patients who received antibiotic administration within 3 hours of sepsis identification, and the length of stay (LOS) for septic patients admitted in the MSU were outcome measures used to track implementation progress and impact. Sepsis champions were identified and prepared to support, market, and contribute to the development of the project. Recruited champions were charge nurses to ensure consistent support and reminders in daily huddles.

A weekly report was run to identify how many nurses completed the education training with a passing score. A data collection tool was used to de-identify nurses by assigning randomized codes to each nurse to track who needed reminders to complete the training. DataBay, an electronic application that pulls data from the electronic medical records (EMR) was used to track weekly measures of the number of DI BPAs acknowledged in the MSU, LOS for septic patients and sepsis mortality rates. Further analysis and chart audits were conducted to determine the percentage of patients diagnosed with sepsis that received antibiotics within 3 hours of identification. Gathered data from the EMR did not include any patient or staff identifiers. All electronic files and data containing identifiable information were protected to prevent access by unapproved users and locked in the champion's office. Data collection tools were used to de-identify and protect the privacy of patients and confidentiality of data. Reference Appendix C for data collection tools.

Results

Descriptive statistics were calculated for the sample of nurses (*n=75*) available throughout the implementation period in the MSU (please see Table 3). The nursing experience level of this

unit was primarily less than 2 years of experience, and 92% of the nurses were females. 76% of the nurses were bachelor's degree prepared nurses. The DI and sepsis education training uploaded to Health Stream was completed by 85% of the nurses in the MSU. There was a large flex pool of nurses who occasionally floated to work in the MSU. These nurses were not included in the education rollout as they were not consistent staff in the MSU. Throughout the education rollout, there were changes to the staffing on the unit. Some travel and agency nurses ended their contracts prior to the completion of the implementation phase. Due to this, there was a threat to 100% compliance with the sepsis bundle intervention. Additional in-services were scheduled during various shifts to capture weekend and night shift workers. The goal of providing additional education sessions was to achieve the structural goal of having 100% of the nurses in the MSU receive training.

A total of 55 patients met inclusion criteria of having a diagnosis of sepsis in the MSU and a DI score of 60 or greater. The LOS for sepsis patients went from an average of 12.5 days pre-intervention to 7.6 days post-intervention. Figure 3 displays a control chart demonstrating that the average LOS for patients diagnosed with sepsis remained within the upper and lower control limits for majority of the intervention period excluding one out-of-control data point. This special cause of variation was analyzed and found to be due to difficulties with finding sub-acute rehab placement.

The evidence-based Press Ganey Sepsis Bundle was utilized to create the 3-hour goal for administering the first dose of antibiotics after recognition of sepsis. Although the antibiotic administration time goal was met intermittently, the percent of patients receiving antibiotics within 3 hours of identification increased by 33% post intervention compared to pre-intervention. Overall, there was an upward trend in the percentage of patients identified as septic who received

their first dose of antibiotics within three hours as seen in Figure 4. A significant decline in this percentage during weeks 12 and 14 is attributed to a COVID-19 surge during the pandemic.

It is important to analyze the limitations and changes that were made during this quality improvement project. The sepsis bundle tasks list created on badge cards was made in place of the originally proposed electronic-based sepsis narrator. Due to emergency efforts put forth against the pandemic taking precedence, the development of this technological component was delayed. Upon initiation of the DI alert, nursing feedback concluded that the alerts fired excessively, causing alert fatigue and lower motivation towards action. The DI alert parameters were changed and the threshold for firing was raised to 60 to make them more specific to anticipated sepsis patients and decrease alert fatigue.

Discussion

Sepsis is a medical emergency with unacceptably high inpatient mortality rates and adverse outcomes. Appropriate and timely antibiotic treatment is one of the key goals of therapy to prevent deaths and life-threatening complications. When treating suspicious or confirmed cases of sepsis, nurses should ensure the administration of antibiotics within the first three hours of diagnosis, according to the Press Ganey recommendations. The findings support an association between computer-based sepsis alerts with treatment-guided checklists and a decrease in time till antibiotic administration in septic patients. It was found that the average time taken prior to administration of the first dose of antibiotics decreased after implementation of the DI with sepsis score and the sepsis bundle task list.

Although the LOS for sepsis patients decreased by an average of 4.9 days after the intervention was implemented, there was no identified trend between the LOS of septic patients and the intervention. The variation in patients' days of hospitalization during the implementation of the DI score and sepsis bundle task lists conclude that there was no constant, significant improvement

in LOS. The presence of COVID infected patients admitted to the unit threatened internal validity. COVID patients presented with similar signs and symptoms of sepsis and typically experienced many complications related to respiratory distress, extending their LOS in the hospital. It is difficult to determine whether the LOS was attributed to the diagnosis of sepsis or the diagnosis of COVID.

The acknowledgement and utilization of the new alert and treatment bundle increased. Nurses' compliance with follow-up assessments, communication with providers and documentation of a concern for sepsis in patients improved 17% to 47%. The underutilization of computer-based, best-practice alerts and recommendations has been proven to lead to poorer patient outcomes. Compliance with nursing response to alerts can also decrease complications of sepsis in hospitalized patients.

There were several limitations in this project. Due to the COVID-19 pandemic, other priorities took precedence over the project during its time. The original sepsis narrator build was delayed and sepsis bundle checklists including all the tasks that were in the bundle were provided instead. This visual reminder and reference were attached to nurses' badges to serve as an easily accessible guide. It is anticipated that a sepsis narrator within the electronic health record would provide direct access to required documentation, further improving compliance. Group gatherings, meetings and huddles were also minimized, limiting the number of individuals in a room to five and below. Due to the capacity restrictions, education and training were transitioned to an online platform rather than in person to promote social distancing during the pandemic.

Conclusion

The findings support an association between DI alerts with decision support tasks lists and a decrease in time until antibiotic administration. Findings conclude that the acknowledgement and utilization of the new alert and treatment bundle decrease patients' LOS. Outcomes

contribute to earlier identification and management of septic patients and decrease costs of sepsis management in the hospital.

The goal of this quality improvement project was not only to improve early identification of sepsis in the MSU, but also to sustain these practice interventions to ensure optimal patient outcomes. The sepsis workgroup developed in this project involved leadership members such as directors of the department and clinical educators. Their engagement early in the process and through the implementation is likely to continue with successful outcomes of the project. Receiving buy-in from many stakeholders highlights the concept of implementation climate discussed in the implementation theory described by Helfrich et al. (2007). Sepsis is a valued topic at this organization because it can affect healthcare costs and patient outcomes. Through education and training, sepsis champions on the unit were assigned based on volunteering. Their role was to help facilitate the change and continue the process after the implementation period, as well as recruit other champions. Sepsis and deterioration index alert education will be embedded into the new hire packets. The structural changes of the sepsis bundle narrator embedded into the electronic health record (EHR) are intended to have a great long-lasting impact because the EHR is utilized so frequently by nursing. Sustainability includes

In future quality improvement projects implementing similar interventions, recommendations for including providers in the educational training of the project would be made. Providers are expected to place the sepsis order set once the nurse communicates a concern for sepsis and discussion results in an agreed upon risk for sepsis. Including providers could provide an understanding behind the urgency of administering antibiotics, obtaining labs, and completing other time-sensitive tasks that require an order from providers. In reviewing literature, evidence revealed the prevalence of patients presenting with signs and symptoms of sepsis in the Emergency Departments prior to getting admitted inpatient. Future suggestions would include

implementing the project intervention in the emergency medicine environment to optimize capturing and identifying septic patients as early as possible in their presentation.

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McColl, T., Gatien, M., Calder, L., Yadav, K., Tam, R., Ong, M., Taljaard, M., & Stiell, I. (2017). Implementation of an Emergency Department Sepsis Bundle and System Redesign: A Process Improvement Initiative. *CJEM, 19*(2), 112-121. doi:10.1017/cem.2016.351

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Tables

Table 1

Evidence Review Table

Citation: McColl, T., Gatien, M., Calder, L., Yadav, K., Tam, R., Ong, M., Taljaard, M., & Stiell, I. (2017). Implementation of an Emergency Department Sepsis Bundle and System Redesign: A Process Improvement Initiative. *CJEM, 19*(2), 112-121. doi:10.1017/cem.2016.351					Level 3
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
The purpose of the study was to evaluate the effect of a quality improvement sepsis management bundle on mortality and sepsis protocol compliance. The sepsis bundle protocol existed but with high noncompliance rates.	Controlled trial without randomization. Assess pre- and post-intervention outcomes.	Sampling Technique: Convenience Eligible: 633 adult patients presenting to the ED at Ottawa academic hospital with suspected or two or more signs of sepsis (ie: temp > 38C, HR > 90, RR >20 or altered amental status) Exclusion: Patients under the age of 18, patients with obvious minor infections, same-day discharges, and patients who died within 1 hour of ED presentation were excluded. Accepted: 352 adult patients presenting with two or more sepsis symptoms per the existing SIRS criteria protocol. Depending on the timeframe in which they presented, the patients presenting in the first 5 months of study	Control: This pre-intervention group was observed and data was collected identifying barriers and noncompliance with RNs using the Sepsis Treatment Early Protocol (STEP) that Ottawa Hospital implemented in 2008. There was underutilization of the protocol. Intervention: Assessment of the current sepsis protocol led to a revamped tool, mitigating some of the root causes of noncompliance. RNs were trained on how to verbally address physicians with sepsis concerns, education was provided to all staff on the importance of early identification	DV: Mortality rates caused by sepsis. Mortality was determined by analyzing the patients' electronic health records. Secondary outcomes included the time from sepsis criteria presentation to IV fluids administration and the time from sepsis criteria presentation to antibiotic administration. These outcomes helped to determine the compliance rates of RNs using the STEP tool. The use of vasopressors, ICU admissions and lactate levels were also used to identify morbidity of sepsis.	Statistical Procedures and Results: Mortality rates were significantly lower in the post-intervention group (30.7% versus 17.3%; 95% CI 9.8–17; p=0.006). There was a higher rate of the STEP tool utilization in the post-intervention group (a 60.2% increase, p<0.001). There was a shorter time interval from triage to IV fluid administration, and triage to antibiotic administration in the intervention group. Additionally, there was also a lower rate of vasopressor requirement and ICU admissions in the post-intervention group. Of note, a higher percentage of lactate clearance in the post-intervention group was found when the protocol was used (23.3% versus 29.3%, p=0.05). The quality improvement sepsis

		were placed in the control group. The patients presenting in the following 4 months of the study were placed in the intervention group in order to compare outcomes pre- and post-intervention. Control: 167 adult patients in the pre-intervention group Intervention: 185 adult patients in the post-intervention group Power analysis: no power analysis provided	of sepsis and outcomes. Vitals and assessment were changed to be done promptly within an hour of patient presentation. The STEP tool assessment was changed from q8 hrs to q4 hrs. Several departmental morbidity and mortality rounds, group presentations, luncheons, and visual aids in the department including posters, brochures and pocket cards were used to emphasize.	Measurement: Chi-square test was used for nominal data variables to measure outcomes. For ordinal variables, the Mann-Whitney U test; and for continuous variables, the unpaired two-tailed t-test was used. Change from pre- to post-intervention in the outcomes was described using absolute risk difference together with 95% confidence intervals (CI). Change in continuous outcomes with skewed distributions was described using medians and interquartile range and tested for statistical significance using Wilcoxon two-sample test.	management bundle including, education, reinforcement, and more frequent and immediate assessments of the patients led to decreased mortality rates and increased nurse compliance with the STEP tool.
Citation: Downey, C. L., Tahir, W., Randell, R., Brown, J. M., & Jayne, D. G. (2017). Strengths and limitations of early warning scores: A systematic review and narrative synthesis. *International Journal of Nursing Studies, 76.* 106-119. https://doi.org/10.1016/j.ijnurstu.2017.09.003					Level 5
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
The purpose of this review is to address the knowledge gap and provide a systematic review or research, highlighting the benefits and identifying areas for future	Systematic review & narrative synthesis of qualitative, quantitative, and mixed- methods studies.	Search Strategy: A search was conducted using databases: Medline, PubMed, CINAHL and the Cochrane Library. The Boolean phrases "warning score", and	Intervention: Studies shared the intervention of sepsis identification tools including the Modified Early Warning Signs (MEWS) tool, VitalPac Early Warning Signs	DV: outcomes measured included ICU admissions and discharges, and the number of cardiac arrests in septic patients. Death rates in a non-randomized	Statistical Procedures and Results: Boyle (2003) reported that many early warning scoring systems are largely unproven and could prove to be over-sensitive and unspecific. However, the MEWS tool is one of

improvement with early warning score tools. Recommendations are provided.		"monitoring/Physiologic" were used. 825 articles were found. 393 were duplicates and 432 abstracts were reviewed. Extraction: duplicate articles (393), articles about pediatrics (59), articles not about vital signs (105) and non-relevant articles (4). Eligible: 232 Qualitative & quantitative studies that used adult populations and a pre-existing, evidence-based sepsis tools (ie: MEWS, VIEWS, CEWS, etc.) PRISMA: Included decision making process in keeping or omitting studies from the systematic review. Power analysis: No power analysis is provided or applicable for the sample size of a systematic review.	(VEWS) tool and Chelsea Early Warning Scores (CEWS). Strengths and Limitations of the uses of these tools were evaluated in the studies. Interventions varied slightly amongst studies using different "early warning score" tools. However, the purpose of each tool was similar in helping to identify a decompensating patient as soon as possible using national sepsis criteria.	controlled study were used as a measurable outcome as well. The impact on communication amongst MDs and nurses was also measured using a questionnaire given before and after the initiation of early warning score tools.	the most widely used sepsis tools and has a 100% sensitivity and a 98.3% specificity in identifying deteriorating septic patients. A limitation to the use of these tools identified is the need for practitioner engagement. Many nurses fail to use the tools or respond to the alerts due to process flaws and barriers in the workplace environment and culture. This narrative synthesis identifies early warning tools as efficient ways of identifying sepsis (especially MEWS) but low compliance rates with practitioners. It is suggested to not use early warning score tools in brain injury patients due to their deficits masking some sepsis symptoms. Overall, MEWS was suggested as an evidence-based early warning score tool to use. Based on the weaknesses identified with the use of the tools, it is recommended to increase alerts to RNs, make tool utilization more frequent, educate staff on sepsis tools and improve communication to MDs.

Citation: Bright, T. J., Wong, A., Dhurjati, R., Bristow, E., Bastian, L., Coeytaux, R. R., Samsa, G., Hasselblad, V., Williams, J. W., Musty, M. D., Wing, L., Kendrick, A. S., Sanders, G. D., & Lobach, D. (2012). Effect of Clinical Decision-Support Systems. *Annals of Internal Medicine.* https://doi.org/10.7326/0003-4819-157-1-201207030-00450					Level 1
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
The purpose of this study is to evaluate the effect of Clinical Decision Support Systems (CDSS) on clinical outcomes, health care processes regarding sepsis identification, workload and efficiency, patient satisfaction, cost, and provider use and implementation.	Data synthesis and systematic review of randomized-controlled trials.	Search Strategy: A search was conducted using MEDLINE, CINAHL, PsycINFO, and Web of Science. Investigators independently screened reports to identify randomized trials published in English of electronic CDSSs that were implemented in clinical settings; used by practitioners to aid decision making regarding utilizing sepsis tools. Eligible: 15,176 article abstracts were originally screened. 160 randomized trials of CDSSs implemented in real clinical settings and used by health care providers to aid decision	Intervention: Implementation of a Clinical Decision Support System (CDSS) used to improve the workflow and process of utilizing sepsis tools. The use of CDSS will help to identify barriers in the use of sepsis tools, therefore helping to improve clinical outcomes, healthcare processes, efficiency and costs. The CDSS involved interventions that were developed, paper-based, or standalone systems and automatically delivered recommendations in real time to enable decision making during	DV: Studies reported at least one of the following types of outcomes: *clinical* (length of stay, morbidity, mortality, health-related quality of life, and adverse events), *health care process* (recommended preventive care, clinical study, or treatment ordered or completed), *user workload and efficiency* (user knowledge, number of patients seen, clinician workload, and efficiency), *relationship-centered* (patient satisfaction), economic (cost and cost-effectiveness), or *use and implementation by a health care*	Statistical Procedures and Results: Meta-analysis of the studies suggested that CDSSs improved morbidity outcomes (relative risk, 0.88 [95% CI, 0.80 to 0.96]). We rated this level of evidence as moderate. Most studies were good quality, and many of the interventions were evaluated in multiple institutions. However, the interventions were often paper-based or standalone systems implemented in academic or Veterans Affairs settings and were targeted toward a single condition. It is concluded that the use of a CDSS can improve the compliance of sepsis tools used in clinical care.

		making at the point of care or for sepsis identification were included. Exclusion: We excluded studies that described nonelectronic CDSSs, included fewer than 50 participants, were not published in English, described closed-loop systems that did not involve a provider, evaluated systems that required mandatory compliance with the CDSS, or evaluated only the performance of the system as opposed to its effect on clinical practice. Group Homogeneity: Studies were heterogeneous in populations, settings, and outcomes. Publication bias and selective reporting cannot be excluded.	the health care provider–patient encounter. These recommendations included reminders to complete sepsis bundle tools. Only 7 of the interventions required a mandatory response or justification for not adhering to the recommendation.	*provider* (acceptance, satisfaction, use, and implementation). Mortality rates and adverse effects were measured as outcomes. These variables were evaluated to compare between groups that did get a CDSS and groups that did not.	

Table 2

Synthesis Table

Level of Evidence	# of Studies	Summary of Findings	Overall Quality
III	**1**	McColl et al. (2017) found that mortality rates were 13.4% lower in septic patients once nurses were educated on sepsis and encouraged to use the sepsis identification assessment tool, STEP. Identifying flaws in the current use of STEP such as infrequent assessments, lack of RNs understanding sepsis and poor communication skills between RNs and providers led to a quality improvement plan set to mitigate all of these root causes. STEP is an evidence-based tool that was underutilized. However, there was a 60.2% increase in compliance in the post-intervention group.	B, no randomization was used. Participants were chosen based upon specific criteria. Although the study sample was homogenous, there was no power analysis reported making it difficult to determine whether sample size was adequate. The study consisted of many components contributing to a quality improvement intervention, making causal effect difficult to discern. Results were consistent amongst all outcome variables. Recommendations were aimed at further research.
V	**1**	Downey et al. (2017) found that early warning scores provide efficient communication and timely escalation of patient care. This review has proven that early warning scores are successful in predicting and improving patient outcomes across a range of settings and populations. The most important advantage of early warning scores is that they are easy to use and interpret, and so provide a common language across healthcare providers and specialties. However, inaccurate recordings or inappropriate reaction to abnormal scores, and infrequent utilization can undermine the benefits of these systems.	C, Suggestions of using an early warning score tool were dependent upon specific types of patients. Recommendations cannot be generalized to all adult patients, threatening external validity. The evidence search summary was explained in detail and the conclusions are definite. The recommendations are consistent based on the comprehensive literature review and the evidence is referenced. However, the recommendations are based on evaluating strengths and weaknesses of the intervention, rather than comparing an intervention group versus a control group. This makes it difficult to determine causal effect.
I	**1**	Bright et al. (2012) found that both commercially and locally developed CDSSs are effective at improving health care process measures across diverse settings, more specifically improving sepsis tool adherence, and decreasing sepsis morbidity. Cost effectiveness was improved significantly by 82%. Evidence for clinical, economic, workload, and efficiency outcomes remains sparse.	B, Although CDSSs were proven to be effective in reducing costs, adverse effects and morbidity, there are no consistent, clear applications of CDSSs generalizable to multiple locations. The studies included contain different root causes to the noncompliance of using sepsis tools. The sample population was homogenous and applicable to all adults although the process improvement differs in different facilities. There is high certainty that the benefits of CDSSs are moderate to substantial. Recommendations were aimed at further research.

Table 3

MSU RNs Demographic Information (n=75)

Category	No. (%)
Age	
<25 years	51 (68%)
26-45 years	13 (17%)
>46 years	11 (15%)
Education	
Associates	3 (4%)
BSN	57 (76%)
MSN	30 (20%)
Gender	
Male	6 (8%)
Female	69 (92%)
RN Experience	
0-2 years	43 (58%)
2-5 years	10 (13%)
5-10 years	3 (4%)
>10 years	19 (25%)

Figures

Figure 1

Synergy Model

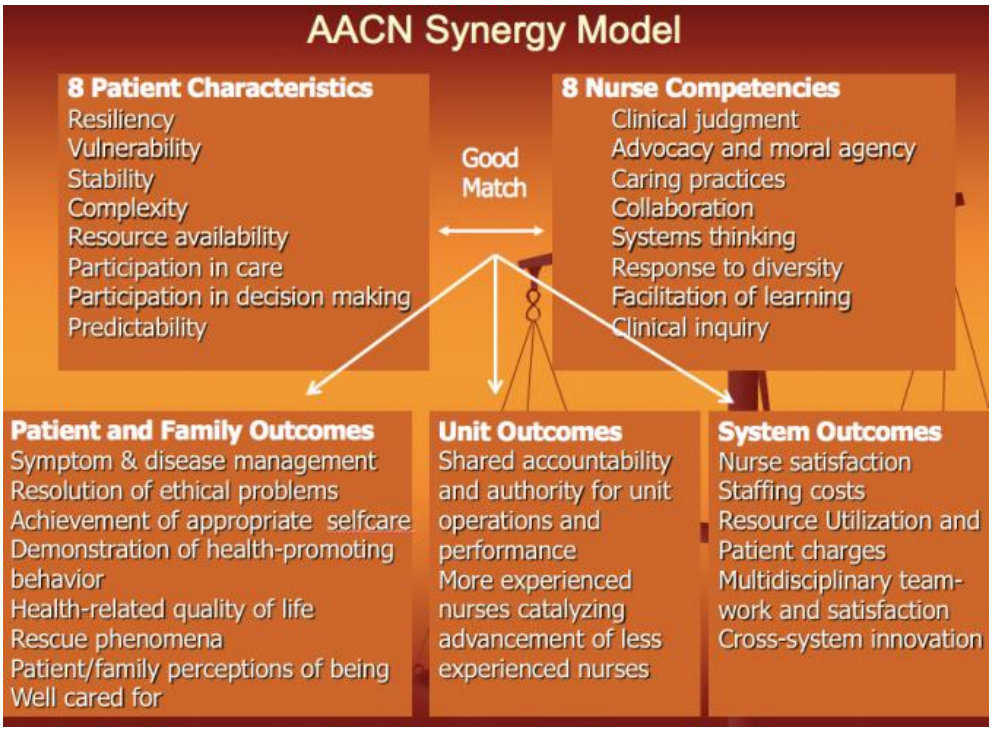


Figure 2

Conceptual Framework of Complex Innovation Implementation

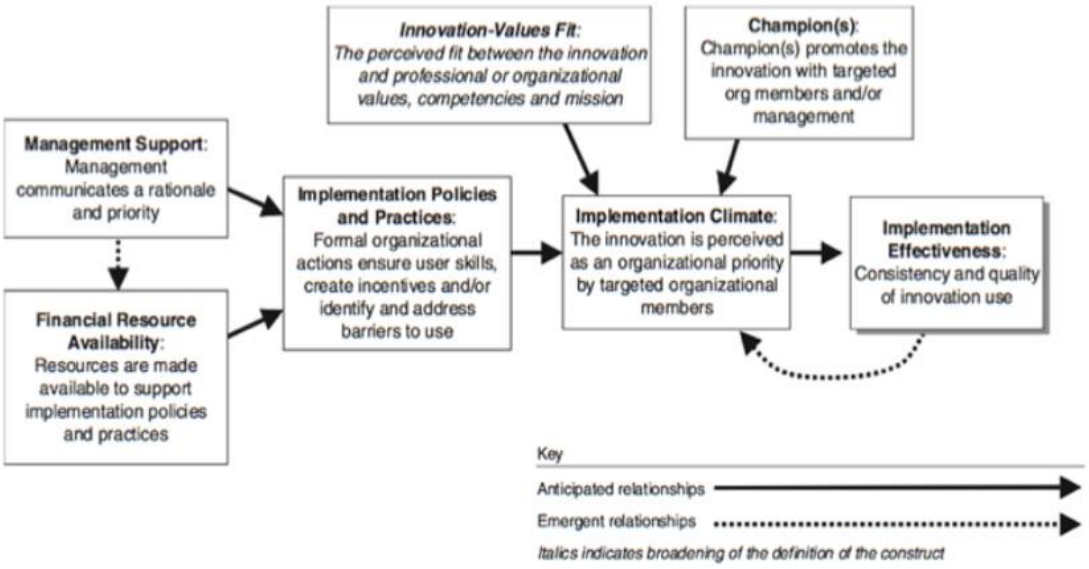


Figure 3

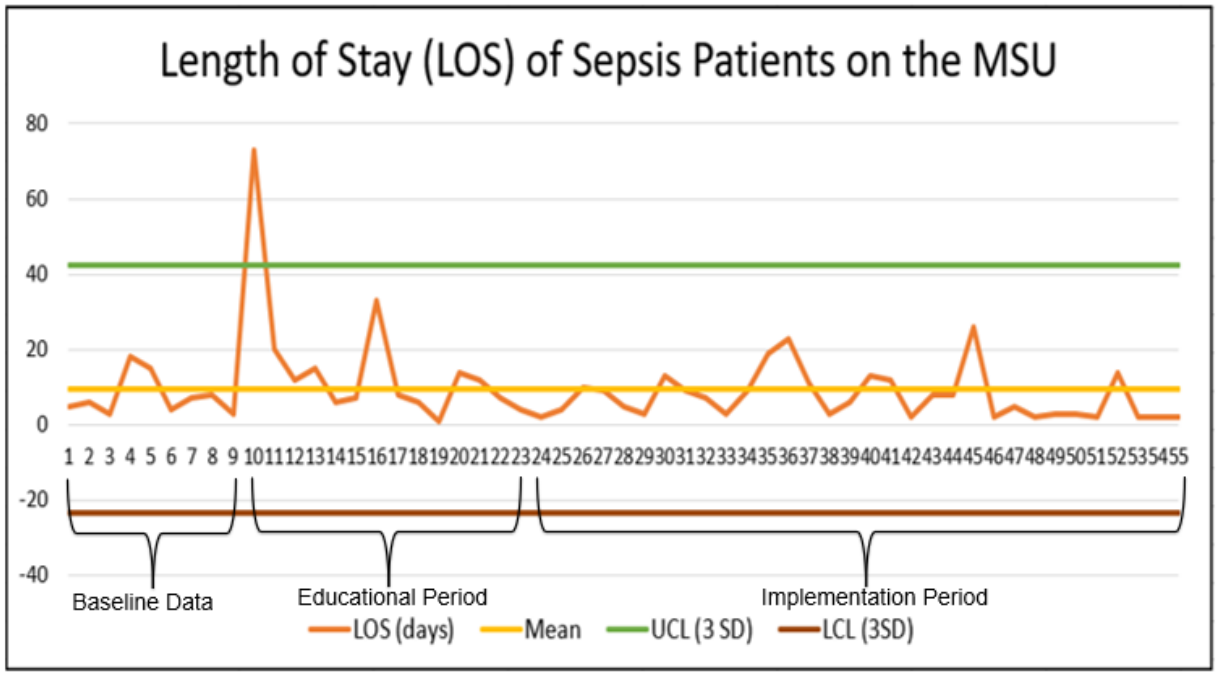
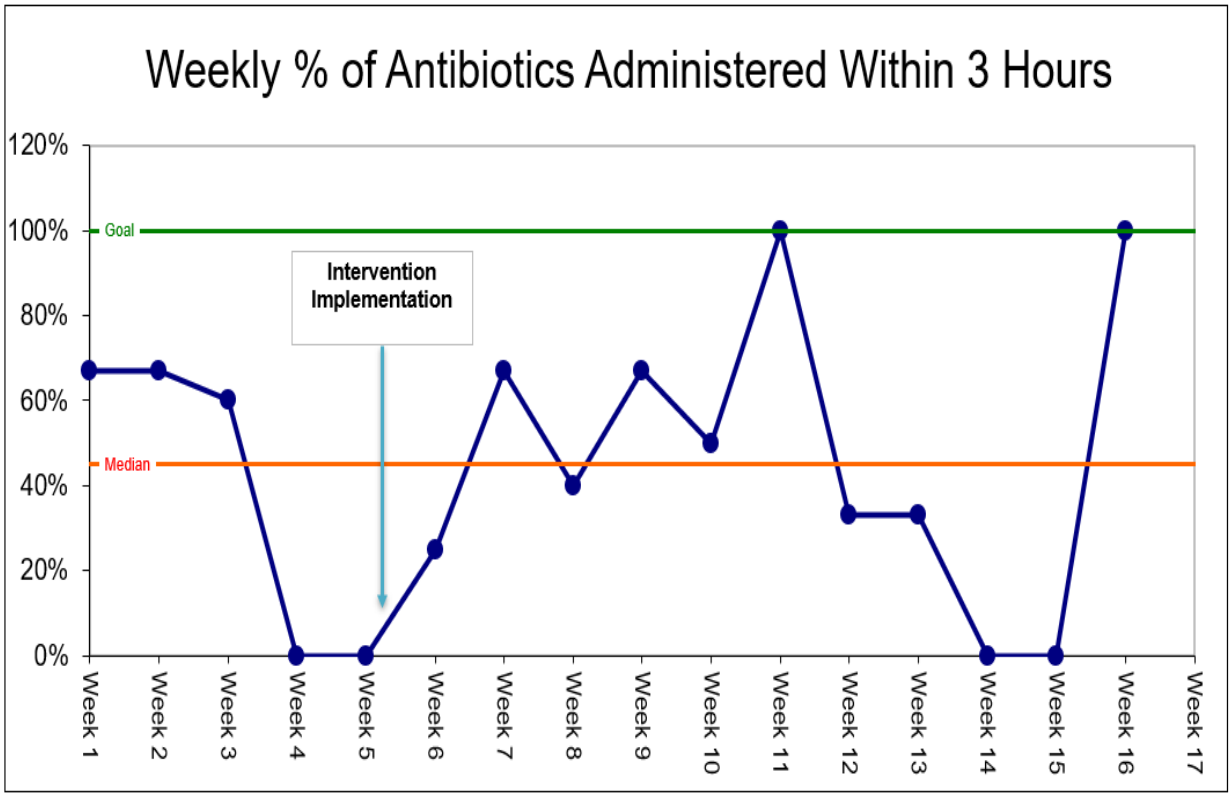
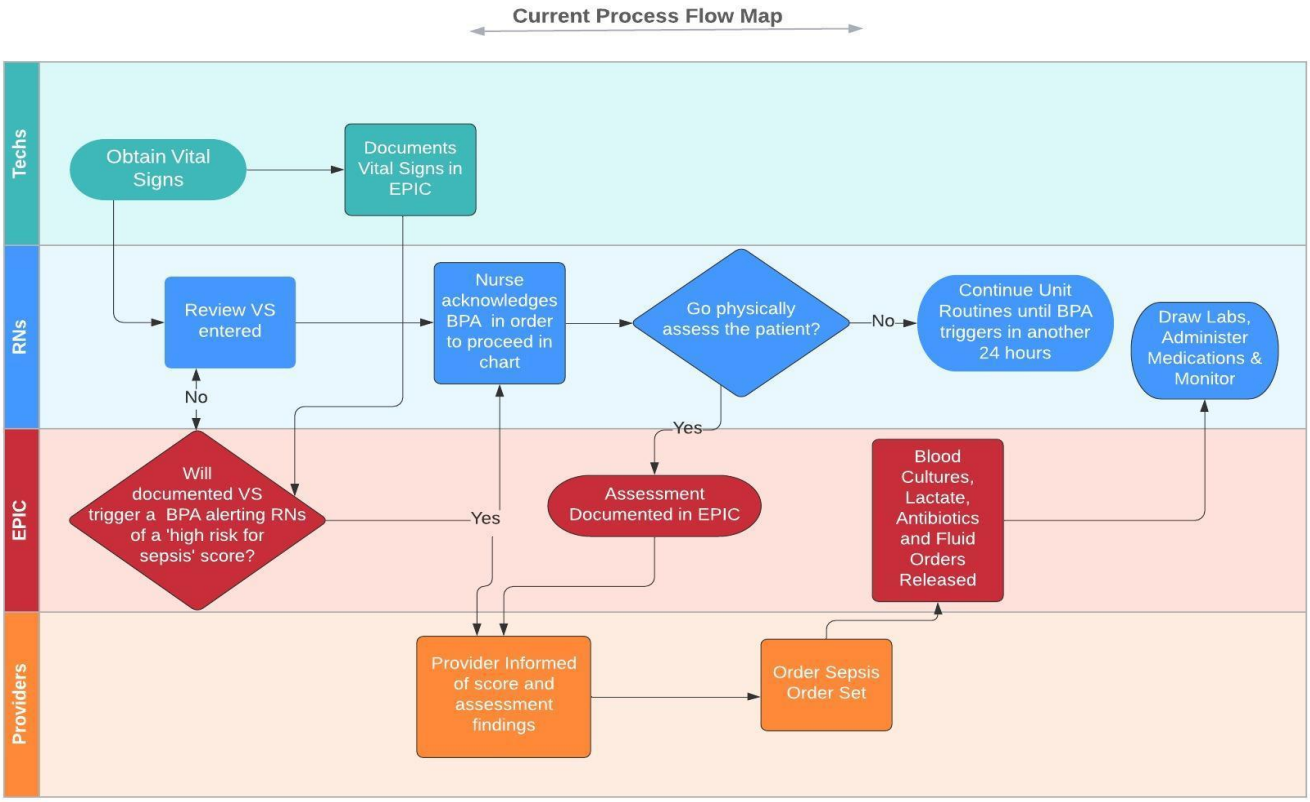

Length of Stay (LOS) of Sepsis Patients on the MSU
80
60
40
20
0
-20
-40
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55
Baseline Data
Educational Period
Implementation Period
LOS (days)
Mean
UCL (3 SD)
LCL (3SD)

Figure 4


Weekly % of Antibiotics Administered Within 3 Hours
120%
100%
80%
60%
40%
20%
0%
Goal
Median
Intervention Implementation
Week 1
Week 2
Week 3
Week 4
Week 5
Week 6
Week 7
Week 8
Week 9
Week 10
Week 11
Week 12
Week 13
Week 14
Week 15
Week 16
Week 17

Appendix A


Current Process Flow Map
Techs
RNs
EPIC
Providers
Obtain Vital Signs
Documents Vital Signs in EPIC
Review VS entered
No
Nurse acknowledges BPA in order to proceed in chart
Go physically assess the patient?
No
Continue Unit Routines until BPA triggers in another 24 hours
Draw Labs, Administer Medications & Monitor
Yes
Will documented VS trigger a BPA alerting RNs of a 'high risk for sepsis' score?
Yes
Assessment Documented in EPIC
Blood Cultures, Lactate, Antibiotics and Fluid Orders Released
Provider Informed of score and assessment findings
Order Sepsis Order Set

Appendix B

Implementation Tools & Aids

Sepsis Treatment

Sepsis Management Steps
---3-Hour Bundle---

- The DI Score reaches 60 and best practice alert notifies RN
- Check risk for sepsis score. ≥10 is concerning.
- Obtain vital signs and assess the patient for signs & symptoms of sepsis.
- Notify the provider using SBAR communication.
- Sepsis bundle order set is placed.
- Obtain blood cultures and lactate prior to administering antibiotics
- Administer fluids if hypotensive.

DI & Sepsis Education MSU.pptx

Appendix C

Data Collection Tools

Code for RN	Received Sepsis Education (Yes =1)	Received Sepsis Education (No =0)

De-Identified Patient ID	Risk for Sepsis Score ≥ 10 & DI >60 (Yes = 1)	Risk for Sepsis Score ≥ 10 & DI >60 (No = 0)	Sepsis Bundle Narrator Performed (Yes = 3)	Sepsis Bundle Narrator Not Performed (No = 4)	Code for Bedside RN

De-Identified Patient ID	Code for Bedside RN when BPA alert fired	Length of Stay (LOS) in # of days	Time taken until antibiotic administration