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Evaluation Outcomes of a Modified Early Warning System for Early Identification of Sepsis in the Adult Population Requiring Acute Care

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Final DNP Project Report

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Dedication

This work is dedicated to my parents, a hard working mother that cares for others more than herself and is always satisfied with less than she deserves. A father who has also worked hard and provided exposure to many talents that any son could only dream to be taught by their father. You both have sacrificed to provide me with more than I deserve, dedicating your life to my success. It is through this work that I thank you and hope to someday make an impact on this world as big as you have in my life.

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Abstract

Objectives: To examine the use of a Modified Early Warning System (MEWS) for sepsis identification and evaluate its effects on treatment and outcomes for those patients diagnosed with sepsis after admission, during their stay at an acute care facility.

Design: A retrospective chart audit was conducted on the electronic medical records (EMRs) of patients who developed, and were diagnosed with, sepsis post admission. Specifically, a retrospective separate sample pretest posttest design was used to examine the accuracy of the MEWS, differences in outcomes (ICU days, length of hospital stay, qSOFA Score and mortality rates), and treatment initiation time (fluid resuscitation, antibiotic therapy, and lactate levels) during 12-months pre- and 12-months post-MEWS initiation.

Setting: This study was conducted at Ephraim McDowell Regional Medical Center (EMRMC), a 222-bed non-profit regional hospital that serves more than 119,000 residents from six counties in central Kentucky.

Patients: Inclusion criteria for the study were adults greater than or equal to 18 years of age, and an ICD-9 or ICD -10 diagnosis of sepsis, severe sepsis or septic shock post admission. Exclusion criteria were a sepsis diagnosis on admission, and patients younger than 18 years of age.

Interventions: A retrospective chart audit was completed to compare pre- and post-initiation of a MEWS for the identification of sepsis and to evaluate differences in treatment initiation and patient outcomes.

Measurements and Main Results: There were no differences found in the demographic variables between the pre- and post-MEWS samples including age, gender, and ethnicity. The ability of the MEWS to identify possible sepsis, severe sepsis, and septic shock before diagnosis

was 92.3%. Compliance with treatment initiation was significantly increased with the ordering of lactates ($p<.001$), while marginally significant with antibiotic initiation ($p=.052$) as well as fluid resuscitation in septic shock ($p=.054$). No differences were found between ICU days or mortality rates. A significant 3.5 day decrease in length of stay was identified for the post-MEWS initiation sample, which resulted in an estimated $131,176 savings on room cost alone across the one year sample.

Conclusion: During the one year period post-initiation, the MEWS at EMRMC proved to be accurate at the identification of sepsis, severe sepsis, and septic shock before the diagnosis was made. In addition, compliance with treatment initiation and patient overall length of stay were positively affected and contributed to a significant cost savings. Adding the MEWS proved to be an accurate way to provide an increase in the quality of care while reducing healthcare costs.

Evaluation Outcomes of a Modified Early Warning System for Early Identification of Sepsis in the Adult Population Requiring Acute Care

Sepsis is a life threatening overwhelming response to infection by the body that could progress to tissue damage, multiple organ failure and death (Centers for Disease Control and Prevention [CDC], 2016). It contributes to an increase in both financial burden and mortality, as in 2011 the United States (U.S.) spent $20.3 billion on hospital care for sepsis, which is partially attributed to the average 75% increase in length of hospital stay that these patients endure (CDC, 2016). Due to these negative influences on patient outcomes, multiple approaches have been trialed to assist with early recognition and treatment of sepsis.

Research strongly suggests that early identification and initiation of treatment is crucial for decreasing the risk of mortality in patients with sepsis, and the use of early warning systems has the potential to enable prompt treatment (Birriel, B, 2013). A number of Modified Early Warning Systems (MEWS) have been created that slightly vary in parameters used for the monitoring of sepsis although the most effective of these systems has not yet been identified. Due to the various early warning systems that have been developed, this project employs further investigation needed on the effects of a MEWS used for sepsis identification. In this article, a retrospective chart audit was completed, specifically using a separate sample pretest posttest design, to examine changes in accuracy of the MEWS, differences in outcomes (Intensive Care Unit (ICU) days, length of hospital stay (LOS), quick Sequential Organ Failure Assessment (qSOFA) Score and mortality rates), and treatment initiation time (receive fluid resuscitation, antibiotic therapy, and lactate levels) during 12-months pre- and 12-months post-MEWS initiation.

Background

The Society of Critical Care Medicine (SCCM; 2016) identifies sepsis as a "dysregulated host response to infection involving life-threatening organ dysfunction." Like stroke, heart attack and major trauma, sepsis should be considered a medical emergency, as there is a small window for identification and initiation of appropriate treatment to ensure a positive patient outcome (Robson & Daniels, 2013). The mortality rate for severe sepsis is even higher than that of myocardial infarction, stroke, or traumatic injury, having fatal results in up to 50% of cases (Roney et al. 2015). In addition the negative impact on patient outcomes, every sepsis diagnosis drives up the cost of health care, creating a hospitalization up to 75% longer than other patients (CDC, 2016). Early identification through the use of MEWS for sepsis may improve patient outcomes and reduce costs.

Current research has focused on a variety of factors for the prevention of sepsis, including common infection sources, preventive measures such as immunizations, and early identification systems for the acute care setting. The most effective way to change the outcome of sepsis is through early initiation of appropriate treatment (Roney et al. 2015). The recommended time frame to administer antibiotics is within one hour of recognition of sepsis due to the increase in mortality rate that occurs every hour thereafter (Lee, 2015). This further strengthens the significant role that early identification plays in creating a positive outcome in patients with sepsis and reinforces the notion that time does matter. Multiple systems have been created to assist with its early recognition, such as MEWS. Research suggests that tool like MEWS enable nurses to identify patients with sepsis, order tests, and initiate treatment sooner, which can decrease mortality rates by up to a 50% (Lopez-Bushneil & Demaray, 2014).

Although there are studies that support the use of tools like the MEWS, there is not yet sufficient evidence to determine a gold standard protocol (Lee, 2015). There are some similarities among the tools that have been validated, such as known or suggested infection, systemic manifestations, and indications of new onset or worsening organ dysfunction (Birriel, 2013). The few studies that have evaluated these tools suggest that they have the potential to enable earlier identification and treatment of sepsis and improve patient outcomes (Lee, 2015 and Roney et al. 2015). Thus, evaluating the effectiveness of MEWS in the clinical setting can provide important direction for its integration it into practice.

This project can advance research by investigating the effectiveness of the MEWS initiated at Ephraim McDowell Regional Medical Center (EMRMC). Due to the various early warning systems supported by research, evaluating the MEWS in this Regional Medical Center would provide more information about the selected system. At a local level, information will be obtained from this study to allow for further development of the MEWS. At a national level, results for this project would provide additional information that could be used to further compare the MEWS used to those that have already been evaluated.

Purpose

The purpose of this project was to examine the MEWS that is currently in use for sepsis identification at EMRMC and its effects on treatment and outcomes for patients diagnosed with sepsis after admission to the acute care facility. The examination of patient outcomes was completed through a retrospective chart review. The outcomes of focus during this study included: accuracy of MEWS trigger related to patients diagnosed with sepsis, severe sepsis, or septic shock; difference in patient outcomes; and treatment initiation time.

Materials and Methods

Study Design

A retrospective chart audit was conducted of the electronic medical records (EMRs) of patients who developed and were diagnosed with sepsis post admission. Specifically, a retrospective separate sample pretest posttest design was used to examine the following aims:

Aim 1: To determine the accuracy of sepsis identification using the MEWS, in identified patients during the 12-months post-initiation time point.

Aim 2: To identify the differences in patient outcomes (ICU days, LOS, qSOFA Score and mortality rates) between identified patients in the 12-month pre-intervention and 12-months post-initiation time points.

Aim 3: To identify treatment initiation time (fluid resuscitation, antibiotic therapy, and lactate levels) between identified patients in the 12-months pre-intervention and 12-months post-initiation time points.

Setting

This study was conducted at EMRMC, a 222-bed non-profit regional hospital that serves more than 119,000 residents from six counties in central Kentucky. EMRMC is a level 3-trauma center that has chest pain accreditation with percutaneous coronary intervention (PCI), and a 12-bed critical care unit managed by a three-physician critical care medicine team.

Study Population

The sample for this study was obtained by accessing and reviewing the EMR of the patients meeting inclusion criteria for a 12-month pre- and 12-month post-implementation period of the MEWS. The 12-month pre-MEWS period began September 1, 2014 and went through August 31, 2015. The post-MEWS 12-month period began August 1, 2016 and went through July

31, 2017. Inclusion criteria for the study were adults greater than or equal to 18 years of age, and an ICD-9 or ICD-10 diagnosis of sepsis, severe sepsis or septic shock at any time post admission. Exclusion criteria were any sepsis diagnosis on admission, and patients younger than 18 years of age.

Instruments

The MEWS for sepsis chosen by EMRMC was used as the monitoring tool for sepsis in this study. MEWS values that trigger an alert and are considered out of range include the following parameters: 1) temperature: < 96.8 F or > 101 F; 2) heart rate: > 90; 3) respirations: > 20; 4) blood pressure: systolic blood pressure < 90 or mean arterial pressure < 65 (see Figure 1). When two or greater of the listed parameters were identified as out of range by the system, an alert was printed indicating the need for investigation for sepsis.

The qSOFA score was used as a tool to identify patients with suspected infection who were at greater risk for a poor outcome. It uses three criteria, assigning one point for low blood pressure (SBP≤100 mmHg), high respiratory rate (≥22 breaths per min), or altered mentation (Glasgow Coma Scale<15; see Figure 2). When any two of these criteria are met, the result is considered positive, indicating the patient is at greater risk for a poor outcome. In recent studies, the qSOFA score agreed reasonably well with the longer SOFA criteria and the predictive validity was good for in-hospital mortality (AUROC=0.81; CI, 0.80-0.82; Seymour et al, 2016). In addition, Seymour et al (2016) showed that 70% of decedents had at least 2 qSOFA points while 78% of survivors had less than 2 points.

The Glasgow Coma Scale was used to determine the presence of altered mental status as one of the criteria for the qSOFA. The scale measures eye opening response (1-4), best verbal response (1-5), and best motor response (1-6) with a total score of 15 possible (see Figure 3).

Any score below 15 was considered altered for this study in relation to measuring mental status changes for qSOFA. There are wide variations in the findings related to reliability of the Glasgow Coma Scale. Values are reported that range from 0.85 to 0.32 when expressed as Kappa statistic where 1= perfect agreement and 0 = agreement no better than expected by chance (Teasdale, 2014). Also, Teasdale (2014) has noted higher levels of training and experience on the part of the examiner correlates with an increase in reliability.

Data Collection

Before initiating data collection, Internal Review Board (IRB) approval was obtained from both EMRMC and the University of Kentucky. After approval was obtained, the initial collection periods were established for six month intervals where a limited number of patients were found meeting the inclusion criteria. For this reason, a modification request was presented to both EMRMC and the University of Kentucky IRB to extend the periods from six months to 12 months, while also including ICD-9 codes for sepsis, severe sepsis, and septic shock, as they were used to code the earlier dates. Once the modification was approved, a retrospective chart audit was conducted to obtain patient medical record numbers and information on patients that met inclusion criteria for the study. These medical record numbers represented patients who had an ICD-9 or ICD-10 diagnosis of sepsis, severe sepsis or septic shock post admission, and were gathered for a 12-month period pre-MEWS and 12-month period post-MEWS initiation. The 12-month pre-MEWS period began September 1, 2014 and went through August 31, 2015 while the 12-month post-MEWS period began August 1, 2016 and went through July 31, 2017. All patients who met the inclusion criteria during those time periods were included in the study. The records included in the study were then de-identified and assigned with a number that was used on all data

collection forms. All data, including data collection forms and master list, were kept secure on the H drive at EMRMC, which is both password and firewall protected.

Utilizing the list of patients meeting criteria, the data were then reviewed. The data were extracted and guided by the table of measures listed in Table 2, which was stored on EMRMC's H drive during the collection process. Demographic measures of all patients was collected that include: 1) gender; 2) ethnicity; and 3) age (see table 2). Other data collected included: 1) whether there was a MEWS alert for patients with an ICD diagnosis of sepsis, severe sepsis, or septic shock post-admission for the post-MEWS sample 2) ICU days; 3) LOS; 4) qSOFA score; 5) mortality rate; 6) fluid resuscitation; 7.) patients identified with septic shock; 8) antibiotic initiation; and 9) lactate level (see Table 2). The data were recorded on the data collection form in excel to be entered into statistical analysis software.

Data Analysis

For the demographic section, to assess differences in patient records pre- and post-MEWS implementation, gender was described using frequencies with percentages and Chi-square, ethnicity was described using frequencies with percentages and the Fisher's Exact Test, while age in years was described by means with standard deviation (SD) and independent sample t-tests. Specifically, for Aim 1, "Was there a MEWS alert for patients with an ICD diagnosis of sepsis post admission," frequencies with percentages were used to describe the proportion of patients with an ICD-10 diagnosis of sepsis, severe sepsis, or septic shock, which had a MEWS alert before diagnosis. For Aim 2, to identify differences in patient outcomes, ICU days and LOS (in days) were described using medians with interquartile rages, while differences were examined using the Mann-Whitney U test. The qSOFA score and mortality rate were analyzed using frequencies with percentages and Chi-square analyses. For Aim 3, identification of the

differences in treatment initiation time through antibiotic initiation, lactate levels, and fluid resuscitation, were examined and described in the table of study measures (Table 2). Antibiotic initiation and lactate levels were described using frequencies and percentages with the differences described using Chi-Square. With respect to fluid resuscitation, the patients were first identified as two groups defined as Sepsis (including sepsis and severe sepsis) and Shock (including septic shock). These groups were described using frequencies and percentages with differences by Chi-square. Fluid resuscitation was then described by frequencies and percentages in those with septic shock while the difference was identified by the Fisher's Exact Test. IBM SPSS, version 24, was used for the analysis of the data with an alpha level of .05 throughout.

Results

Sample Characteristics

A total of 62 patient charts were reviewed with 36 patients who met inclusion criteria for the pre-MEWS initiation period and 26 in the post period. The average age was 70.2 years (SD=11.1; see Table 3). Just over half of the total sample (51.6%) were male and the majority were Caucasian (90.3%). There was no statistical difference between pre- and post-MEWS initiation samples in relation to demographic variables, indicating similarities between the two groups.

Accuracy of Sepsis Identification

Between August 1, 2016 and July 31, 2017, 24 of the 26 patients were identified as possibly septic by the MEWS system pre-diagnosis. This resulted in 92.3% accuracy of the MEWS ability to detect sepsis during the post initiation sample.

Difference in Patient Outcomes

In comparing patient outcomes pre- and post-MEWS initiation, there was no difference in ICU days between groups (p=.80). There was a significant reduction in overall LOS: the median LOS was 9.5 days (IQR=6-12.3) for the post initiation group versus 13 days (IQR=9-17) during the pre-MEWS sample (p=.035; see Table 3). There were no difference in qSOFA scores or mortality rates between the pre- and post-MEWS groups.

Treatment Initiation Time

There was a significant increase in compliance when ordering lactates from the pre-MEWS sample (0% vs. 46.2%, p<.001, respectively). Antibiotic initiation showed a marginally significant difference between groups as they rose from 52.8% during the pre-MEWS sample to 76.9% post (p=.052). The pre and post-MEWS samples showed no difference between groups as almost half 48.4% (p=.77) of the total sample was diagnosed with septic shock. Of those diagnosed with septic shock, there was also a marginally significant difference between the pre- and post-MEWS sample with 0% of the pre-initiation group receiving the 30ml/kg bolus versus 25% in the post-MEWS sample (p=.054).

Discussion

This study aimed to evaluate differences between pre and post-MEWS initiation samples at Ephraim McDowell Regional Medical Center. Specifically, the study's initial focus was to determine the system's ability to properly identify patients with signs of sepsis, severe sepsis, or septic shock pre-diagnosis. In addition, the study investigated differences in patient outcomes as well as treatment initiation times. Striving to positively identify this patient population early is crucial to the provision of adequate care. This study shows the ability of the MEWS to assist

with identification, increasing compliance to treatment initiation while significantly reducing the patient's overall hospital length of stay.

Accuracy of Sepsis Identification

Overall, the accuracy of the MEWS system was high. Only two out of the 26 patients did not have a MEWS alert pre-diagnosis resulting in 92.3% accuracy. This could have been affected with medications that have an impact on the vital signs, such as sedatives, antipyretics, or those that cause an increase in blood pressure, as this could have prevented identification by the MEWS. Their use could have falsely lowered or raised values, where they remain in range in relation to the MEWS triggers, initiating a trigger by the system. Although professional clinical judgment cannot be completely replaced by electronic monitoring systems, this study supports the accuracy of this MEWS, and its ability to assist in positive identification of a condition that requires immediate treatment to improve the chance of a positive outcome.

Difference in Patient Outcomes

The positive findings associated to LOS implies added value in addition to assistance in early identification of sepsis, even ICU days showed no statistical difference between the two groups. Although the difference in mortality was not statistically significant, results showed that the percent of patients discharged "alive" fell from 72.2% in the pre-MEWS sample period to 53.8% post. It is notable that those with a positive qSOFA score increased from 44.4% in the pre-MEWS sample to 65.4% post-initiation ($p=.10$). This correlation could be due to risk factors such as comorbid conditions that were not considered, and could contribute to an increased risk for death, although not statistically significant in this study.

According to the CDC (2016), sepsis can increase hospital LOS by up to 75%, which can dramatically add to the cost of healthcare for this patient population. During this study, the

hospital LOS for the post-MEWS initiation group was decreased by 3.5 days (p=.035) from the pre-initiation group. While only considering room cost, that average between ICU and medical-surgical rooms at this regional facility is according hospital record is $1,441.50 per day. At this rate, this reduction translates to $131,176 in savings on room costs alone for the post-initiation sample, not to mention savings on treatment and services that would have been necessary on the additional 3.5 days. This further solidifies the need for the MEWS selected at EMRMC, as it significantly reduces LOS, and decreases overall healthcare costs.

Treatment Initiation Time

The study did show an overall improvement in compliance with treatment initiation. Compliance with collecting lactate levels proved to be significant, going from 0% in the pre-MEWS sample to 46.2% in the post (p<.001). It should be noted that during the 12 month post initiation group, a protocol change was made that allowed the nursing staff to enter lactates by a standing order for positive MEWS alerts, which could have contributed to the increased compliance for this group. Although this could have been a factor, positive identification by the MEWS would have occurred triggering the order, further validating the importance of the MEWS.

Compliance with antibiotic initiation for all subjects and fluid resuscitation for those with septic shock were both marginally significant. Those who were compliant in this study were the ones who received the antibiotic or fluid within the time specified in Table 2. Some of those who did not meet receiving antibiotics or fluids may have still received therapy, just not in the specified time period. For antibiotics, the order verification process for the facility could have played a role in late administration. The order is entered by the provider, where it waits to be verified by pharmacy before it can be administered by the floor nurse. A lag in verification

could result in delayed administration. Also, for fluid resuscitation, the patient was required to receive at least 30 ml/kg in total volume in three hours after diagnosis. Failure to receive the total volume specified would have also resulted in non-compliance for this study. A possible barrier for compliance with fluids is the inability to place one order for 30 ml/kg. Instead, the provider must order a saline bolus in a 500cc or 1000cc amount. This could have contributed to the lack of compliance in two ways, as there is the potential to order an amount that is not sufficient, as well as a delay in the infusion from multiple verifications by pharmacy, not meeting the three hour window.

Studies have shown that the most effective intervention related to improving mortality is the rapid delivery antibiotics and fluids within the hour (Daniels, Nutbeam, McNamara, et al. 2011). It should be noted that although this study showed a marginally significant increase in both antibiotic and fluid compliance, 23.1% in the post initiation group still did not receive antibiotic therapy on time. Also, the number of patients who were diagnosed with septic shock and should have received the fluid bolus was even smaller than that of each sample group. So, although fluid resuscitation increased by 25% in the post-MEWS sample ($p=0.54$) there were only nine patients in this group who would make small changes in compliance dramatically affect percentages. With room left for improvement, compliance with antibiotic initiation in the post sample was 76.9% and fluid resuscitation was 25% and this could have played a role in the lack of improvement in mortality rates between the two groups.

Limitations

There were several limitations identified while conducting this study. First, this was a single center study and this limits the generalizability of the data. Also, this was a retrospective chart audit and the accuracy of the data was dependent on those who entered it into the electronic

medical record. Any information that was entered incorrectly, such as coding for inclusion criteria, could have altered the outcomes of either group. In addition, the sample size for each group remained small even after increasing the pre and post-MEWS periods to 12 months from the six month periods originally planned. Because of the small sample size, small improvements in compliance may seem greater by percentages than if more patients had been included the study. In relation to qSOFA scores, there were a few patients who did not have a Glasgow Coma score completed which could have resulted in a false negative result. Modifications to protocols also occurred during the post-MEWS period such as standing orders for lactates that could have positively affected compliance. Although these protocols could have helped, MEWS identification was still a crucial part of identification that initiated this process.

Recommendations

Recommendations for future studies, particularly for EMRMC, include further investigation on individualized protocols in combination with this MEWS for sepsis, such as the one implemented for lactate ordering. Initiation of the standing order for lactates could have increased compliance with lactate ordering, which showed the biggest improvement in compliance between pre- and post-samples. An order set that identified that antibiotic initiation was indicated for sepsis, along with labeling the order as STAT, could help decrease a delay in verification by pharmacy and administration by the nurses, which could increase overall compliance. Also, creating an order calculating the recommended amount for fluid administration based on 30 ml/kg for septic shock could increase compliance to fluid resuscitation, compared to entering an individual amount of 500-1000 milliliter bolus at a time. Once these protocols are initiated, a follow up study comparing the current post MEWS data to the use of these protocols in addition to the current MEWS could prove or disprove their

assistance in compliance to treatment, and further investigate their effects on mortality if compliance significantly improves.

In general, a larger multi-facility study using this MEWS would be beneficial as it would increase the sample size as well as generalizability. This would allow for better data and comparison between the MEWS chosen by EMRMC, to those who have existing research available. Investigating factors affecting mortality, such as comorbid conditions that were not identified in this study, could be beneficial and provide a more accurate picture on the baseline health status of the patients included. This would allow us to better investigate those at higher risk for death and correlation between qSOFA and mortality rates.

Conclusion

The goal of this study was to assess the accuracy of the MEWS utilized by EMRMC while also investigating its effects on treatment initiation times and patient outcomes. During the one year period post initiation, the MEWS proved to be 92.3% accurate in identifying septic patients before diagnosis. Treatment compliance showed a statistically significant increase related to lactates with marginally significant improvement for antibiotic and fluid administration. The patients overall hospital length of stay was reduced by 3.5 days which led to a cost savings of $131,176 in room cost alone across the post-MEWS sample.

The ability to provide quality care while reducing cost is often a hard task to conquer. After the initiation of the MEWS at EMRMC improvements were seen across both clinical and financial outcomes, with evidence of possible improvements with future adjustments. This study demonstrates that the MEWS system utilized by EMRMC is accurate, financially justifiable, and an important part of providing quality care to those diagnosed with sepsis, severe sepsis, or septic shock.

References

Birriel, B. (2013). Rapid Identification of Sepsis – The Value of Screening Tools. Society of Critical Care Medicine. Retrieved from: http://www.sccm.org/Communications/Critical-Connections/Archives/Pages/Rapid-Identification-of-Sepsis---The-Value-of-Screening-Tools.aspx

Centers for Disease Control Prevention. (2016). Sepsis Questions and Answers. Retrieved from: https://www.cdc.gov/sepsis/basic/qa.html

Centers for Disease Control Prevention. (2016). The Cost of Sepsis. Retrieved from: https://blogs.cdc.gov/safehealthcare/the-cost-of-sepsis/

Daniels R, Nutbeam T, McNamara G, et al. (2011). The sepsis six and the severe sepsis resuscitation bundle: a prospective observational cohort study. Emergency Medicine Journal 2011;28:507-512.

Lopez-Bushneil, K., Demaray, W. S., & Jaco, C. (2014). Reducing Sepsis Mortality. *MEDSURG Nursing*, *23*(1), 9-14.

Lee, R. (2015). Time Frames for Sepsis Screening Criteria. *Critical Care Nurse*, *35*(3), 74-75. doi:10.4037/ccn2015989

Robson, W., & Daniels, R. (2013). Diagnosis and management of sepsis in adults. *Nurse Prescribing*, *11*(2), 76-82.

Roney, J. K., Whitley, B. E., Maples, J. C., Scarborough Futrell, L., Stunkard, K. A., & Long, J. D. (2015). Modified early warning scoring (MEWS): evaluating the evidence for tool inclusion of sepsis screening criteria and impact on mortality and failure to rescue. *Journal Of Clinical Nursing*, *24*(23/24), 3343-3354. doi:10.1111/jocn.12952

Seymour CW, Liu VX, Iwashyna TJ, Brunkhorst FM, Rea TD, Scherag A, Rubenfeld G, Kahn JM, Shankar-Hari M, Singer M, Deutschman CS, Escobar GJ, Angus DC. (2016). Assessment of Clinical Criteria for SepsisFor the Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3). *JAMA.* 2016;315(8):762–774. doi:10.1001/jama.2016.0288

Sir Graham Teasdale (2014). The Glasgow Structured Approach to Assessment of the Glasgow Coma Scale. *Frequently Asked Questions.* Retrieved from: http://www.glasgowcomascale.org/faq/

Society of Critical Care Medicine (2016). Sepsis Definitions. New Recommendations Aim to Redefine Definition and Enhance Diagnosis of Sepsis, Septic Shock. Retrieved from: http://www.sccm.org/Research/Quality/Pages/Sepsis-Definitions.aspx

Tables

Table 1. *Inclusion and Exclusion Criteria for Patient Enrollment*

Inclusion Criteria	**Exclusion Criteria**
Adults ≥ 18 years of age	Pediatric patients < 18 years of age
ICD-9 or ICD-10 diagnosis of sepsis, severe sepsis or septic shock post admission	ICD-9 or ICD-10 diagnosis of sepsis, severe sepsis or septic shock on admission

Table 2. *Table of Study Measures*

Measures	**Description**	**Level of Measurement**	**Analysis**	**Data Source**
Demographics				
Gender	Male vs Female	Nominal	Frequencies (%), Chi-square	Electronic Medical Record
Ethnicity	White, Black, Hispanic, Indian, Native American, Middle Eastern, Mixed Race, Asian, Other	Nominal	Frequencies (%), Chi-square	Electronic Medical Record
Age	Age in years	Interval/Ratio	Means (SD), independent sample t-tests	Electronic Medical Record
Outcomes				
Was there a MEWS alert for patients with an ICD diagnosis of sepsis post admission?	Yes or No	Nominal	Frequencies (%)	Electronic Medical Record
ICU Days	Number of days in ICU identified by location order	Interval/Ratio	Median (Interquartile Range) Mann Whitney U Test	Electronic Medical Record
Length of Hospital Stay	Length of stay in days, based on admission and discharge dates.	Interval/Ratio	Median (Interquartile Range) Mann Whitney U Test	Electronic Medical Record
qSOFA Score	Measured as positive or negative related to a scale of 2 or greater being positive on diagnosis of the following are at greater risk for poor outcomes: Respiratory rate ≥ 22/min	Nominal	Frequencies (%), Chi-square	Electronic Medical Record

	Glasgow Coma Scale < 15 Systolic Blood Pressure (SBP) ≤ 100 mm Hg			
Mortality Rate	Measured as alive or deceased at discharge post inpatient sepsis, severe sepsis or septic shock diagnosis.	Nominal	Frequencies (%), Chi-square	Electronic Medical Record
Antibiotic Initiation	Measured as percent of antibiotics administered within 90 minutes from the time a diagnosis was made by a provider documented by ICD code in EMR and/or Identification of MEWS of 2 s/s of sepsis plus a single lab value indicating end organ damage.	Nominal	Frequencies (%), Chi-square	Electronic Medical Record
Lactate Level	Measured as the percentage of patients that get lactates completed at suspicion of sepsis, three hours after the first, and six hours after the second lactate.	Nominal	Frequencies (%), Chi-square	Electronic Medical Record
Diagnosis	Identified as sepsis (includes sepsis or severe sepsis) or shock (includes septic shock) to differentiate groups for fluid resuscitation.	Nominal	Frequencies (%), Chi-square	Electronic Medical Record
Fluid Resuscitation	Measured as percentage of patients who receive fluid bolus of 30ml/kg with septic shock. Identified by recommended 30ml/kg bolus.	Nominal	Frequencies (%), Fishers Exact Test	Electronic Medical Record

Table 3. *Comparison of Study Variables Pre and Post MEWS Initiation (N=62)*

Characteristic	Total sample (N=62) Mean (SD), n (%) or median (IQR)	Pre-MEWS (n=36) Mean (SD), n (%) or median (IQR)	Post-MEWS (n=26) Mean (SD), n (%) or median (IQR)	p
Age	70.2 (11.1)	68.8 (10.4)	72.1 (12.0)	.26
Gender				
Male	32 (51.6%)	19 (52.8%)	13 (50%)	.83
Female	30 (48.4%)	17 (47.2%)	13 (50%)	
Ethnicity				
Caucasian	56 (90.3%)	33 (91.7%)	23 (88.5%)	.69
African American	6 (9.7%)	3 (8.3%)	3 (11.5%)	
MEWS Alert Present				
Post Initiation Group	NA	NA	24 (92.3%)	NA
Diagnosis				
Sepsis/Severe Sepsis	32 (51.6%)	18 (50%)	14 (53.8%)	.77
Septic shock	30 (48.4%)	18 (50%)	12 (46.2%)	
qSOFA				
Positive	33 (53.2%)	16 (44.4%)	17 (65.4%)	.10
Negative	29 (46.8%)	9 (34.6%)	9 (34.6%)	
Lactate Level				
Yes	12 (19.4%)	0 (0%)	12 (46.2%)	<.001
No	50 (80.6%)	36 (100%)	14 (53.8%)	
Antibiotic Initiation				
Yes	39 (62.9%)	19 (52.8%)	20 (76.9%)	.052
No	23 (37.1%)	17 (47.2%)	6 (23.1%)	
Fluid Resuscitation				
Yes	3 (10%)	0 (0%)	3 (25%)	.054
No	27 (90%)	18 (100%)	9 (75%)	
ICU Days	3.5 (0-8)	3.5 (0-8.8)	3.5 (0-8)	.80
Hospital LOS	11 (2-8)	13 (9-17)	9.5 (6-12.3)	.035
Mortality				
Alive	40 (64.5%)	26 (72.2%)	14 (53.8%)	.14
Dead	22 (35.5%)	10 (27.8%)	12 (46.2%)	

Figures

Figure 1: *Mews Values That trigger an Alert*

MEWS Values that Trigger an Alert
Temperature: < 96.8 or > 101F
Heart Rate: > 90
Respirations: > 20
Systolic Blood Pressure: < 90 or Mean Arterial Pressure: < 65

When two or greater of the listed parameters are identified as out of range by the system, an alert will be printed indicating the need for investigation for sepsis.

Figure 2: *qSOFA Inclusion Criteria*

qSOFA (Quick SOFA) Criteria	
Respiratory Rate	≥ 22 Breaths per Minute
Altered Mentation	Glasgow Coma Score of < 15
Systolic Blood Pressure	≤ 100 mm Hg

Each category represents 1 point. If the patient meets two or more of the criteria, the qSOFA score is then considered positive

Figure 3: *Glasgow Coma Scale*

Glasgow Coma Scale
Eye Opening Response 4 = Spontaneous 3 = To Speech 2 = To Pain 1 = None
Best Verbal Response 5 = Oriented x3 4 = Confused Conversation 3 = Inappropriate Words 2 = Incomprehensible Sounds 1 = None
Best Motor Response 6 = Obeys Verbal Commands 5 = Localizes to Pain 4 = Withdrawals to Pain 3 = Flexion to Pain 2 = Extension to Pain 1 = None