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Improved hospital mortality rates after the implementation of emergency department sepsis teams

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ABSTRACT

Introduction: Sepsis is a leading cause of mortality with more than 700,000 hospitalizations and 200,000 deaths annually in the United States. Early recognition of sepsis is critical for timely initiation of treatment and improved outcomes. We sought to evaluate.
in-hospital mortality rates of patients diagnosed with sepsis before and after implementation of emergency department (ED) sepsis teams.
Methods: This was a retrospective study of adult patients seen at a tertiary care ED diagnosed with sepsis and severe sepsis. Pre-implementation study time frame was 5/1/2018–4/30/2019 and post-implementation was 11/1/2019–9/30/2020. A six-month washout period was utilized after implementation of ED-based sepsis teams. Indications for sepsis team activation were: two systemic inflammatory response syndrome (SIRS) criteria with suspected infection or two SIRS with confirmed infection during workup. Categorical variables are presented as frequencies and percentages. Continuous variables are presented as mean and standard deviation or median and quartiles depending on distribution. Multiple logistic regression compared mortality rates pre- and post-implementation while controlling for Charlson comorbidity index. Secondary objectives included comparing time metrics pre- and post-implementation. Student *t*-tests compared normally distributed variables and Wilcoxon rank sum tests compared non-normally distributed variables.
Results: There were 1188 participants included in the study; 553 before implementation of sepsis teams and 635 after implementation. Mean age of participants was 64 years. Patients were 74.7% white and 22.6% black. Medicare was the most common health insurance (59%). Mortality rates were significantly lower post-implementation of sepsis teams compared to pre-implementation with an adjusted odds ratio of 0.472, (95% CI, 0.352–0.632). ED LOS (95%CI (−67.2–−11.3), hospital LOS (95%CI, −1.0–−0.002) and time to lactic acid (95%CI, −10.0- -3.0) and antibiotics (95%CI, −29.0–−11.0) were all significantly lower after implementation.
Conclusion: Implementation of ED sepsis teams decreased inpatient hospital mortality rates, ED length of stay and hospital length of stay.

1. Introduction

Sepsis is life-threatening organ dysfunction caused by a dysregulated host response to infection [1]. Septic shock is a progression of sepsis that leads to significant circulatory, cellular, and metabolic derangements, dramatically increasing the risk of mortality [1]. Sepsis is one of the leading causes of mortality with more than 700,000 hospitalizations and 200,000 deaths annually in the United States [2]. Despite medical, pharmacological, and technological advances over the years, patients continue to die of sepsis. In the emergency department (ED), sepsis accounted for 315 visits per 100,000 people in 2011 [3]. In one study hospital, mortality was found to be 17% for sepsis and 26% for severe sepsis [4].

Correctly identifying and treating sepsis can be challenging. In 2004, Surviving Sepsis Campaign (SSC) clinical management guides were published. These were evidence-based recommendations that were intended to provide guidance to clinicians caring for patients with

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sepsis, severe sepsis, or septic shock [5]. SSC guidelines have been revised in 2008, 2012, and 2016 [6-8]. The standard of care in these guidelines are: early recognition of septic shock, implementation of a treatment bundle that emphasizes optimizing perfusion, obtaining source control when possible, and delivery of appropriately dosed, broad-spectrum antibiotics within one hour of onset of shock [8]. The use of these guidelines has led to decreased mortality in septic patients. Implementation of a sepsis bundle as quality indicators helped modify physician behavior in the ED setting and was associated with decreased in-hospital mortality for septic patients [9]. Despite these guidelines, compliance has been low with 19% compliance of 3-h bundles in one study [10].

Early identification as well as appropriate and timely management of sepsis is key to improving outcomes. Studies have shown that patients who present with severe sepsis and septic shock should receive early and appropriate antibiotics [11,12]. Patients with septic shock who received appropriate antibiotic therapy within one hour of recognition had the greatest benefit in mortality [12]. Since the ED is where many septic patients are seen initially, it is imperative to identify and treat sepsis early. There may be barriers to timely treatment, which include inability to continuously monitor all patients, long wait times, and lack of resources [13]. The goal of implementing sepsis teams was to increase compliance of the sepsis bundle and therefore have better patient outcomes.

In our institution, sepsis teams are rapid response teams that provide immediate assessment and treatment, and also ensure compliance with bundled care. Previous studies have shown the implementation of sepsis teams increased surviving sepsis campaign compliance [14]. A sepsis team is a multidisciplinary team consisting of a physician, a resident or advanced practice provider [(APP) nurse practitioner or physician assistant], nurse, and pharmacist who come together simultaneously to care for a septic patient. Multiple studies have confirmed that increased compliance with a sepsis bundle order set leads to better outcomes. However, there has been limited data on mortality rates for patients with ED multidisciplinary teams focused on septic patients.

In this study, we sought to analyze in-hospital mortality rates of patients diagnosed with sepsis, severe sepsis, and septic shock before and after implementation of sepsis teams in the ED. Secondary objectives included overall ED length of stay (LOS), hospital LOS, time to antibiotics, intravenous fluids, blood cultures, lactate, and time to admission.

2. Methods

This was a retrospective study of patients admitted to an urban tertiary care hospital with the diagnosis of sepsis, severe sepsis, or septic shock. We allowed for a six-month washout period from the time sepsis teams were initiated until data was evaluated for efficacy. We collected data from 05/01/18–04/31/19 for pre-implementation period and 11/01/19–10/31/20 for post-implementation period. This study was approved by the institution IRB.

2.1. Selection of participants

Patients were included if they were at least 18 years of age and presented during the study timeframe and met a primary admission diagnosis from the ED of sepsis severe sepsis, or septic shock. No patients meeting these criteria were excluded. Charts were excluded if missing demographic or hospital course information.

Upon arrival to the ED, patients who met criteria for sepsis teams were identified. Sepsis teams can be called early in the ED course when there are two or more SIRS criteria and suspected infection or later in the ED course, after there is confirmed infection. A best practice alert within the EMR automatically populates when 2 systemic inflammatory response (SIRS) components are determined and requires providers to consider the possibility of sepsis utilizing a checkbox that either links or skips the sepsis care path with the 3-h bundle requirements. Sepsis team criteria included 2 SIRS components plus suspected infection after initial evaluation or confirmed infection diagnosed during the work up. Sepsis teams are available 24/7/365 and are comprised of caregivers already working in the ED. Once a sepsis team was called, the patient's responsible physician, resident or APP, nurse, and ED pharmacist huddled together to complete the sepsis checklist and establish time zero. A sepsis care path was initiated by the physician and implemented by the nurse utilizing the electronic medical record (EMR). A 3-h bundle was obtained which included: measure initial lactate level, blood cultures x 2 sets, administer intravenous fluids (IVF) of either normal saline or lactated ringers at 30 cc/kg if lactate was greater than or equal to 4 mmol/L or if systolic blood pressure was <90 or MAP<65 mmHg, and administration of broad-spectrum antibiotics (Fig. 1).

Barriers to care, such as lack of intravenous access, antibiotic allergies, or comorbidities that may affect fluid resuscitation were determined during the initial sepsis team huddle.

2.2. Data collection

Data was extracted from the EMR, Epic Verona WI ®. Diagnosis of sepsis, severe sepsis, and septic shock were extracted utilizing ICD-10 codes. Patient identification information included age, race, gender, insurance status, Charlson comorbidity index, chief complaint, time of arrival to the ED, time to triage, time of when sepsis was identified, time of lactate result, time to IV fluids, time to blood cultures, time of antibiotics, time to disposition, time to hospital admission, time to ED departure, ED LOS, hospital LOS, in-hospital mortality pre and post sepsis team implementation (after allowing for an initial six month wash out period for implementation of the sepsis teams) were all collected.

2.3. Analysis

Descriptive statistics were used to evaluate demographic variables. Categorical variables were described using frequencies and percentages and *p*-values obtained from Pearson Chi square or Fisher's exact tests where appropriate. Normally Distributed continuous variables were described using means and standard deviations and *p*-values obtained from student's *t*-tests. Non-normally distributed continuous variables were described using medians and interquartile range with p-values from Wilcoxon rank sum tests. A significance level of 0.05 was assumed for all tests. Analyses will be performed using SAS® Software (version 9.4; Cary, NC).

3. Results

There were 1188 participants included in the study. A total of 553 patients were included in the pre-implementation group and 635 patients were included in the post-implementation group. Study demographics are provided in Table 1. The mean age of participants was 64 years and the majority of participants were white (75%) and had Medicare (59%). There was no significant difference in Table 1 between demographics, illness severity or Charlson co-morbidity index the pre and post implementation groups.

Among those with a primary diagnosis of sepsis, the mortality rate was significantly lower post-implementation of sepsis teams as compared to pre-implementation of sepsis teams, AOR 0.44, 95% CI

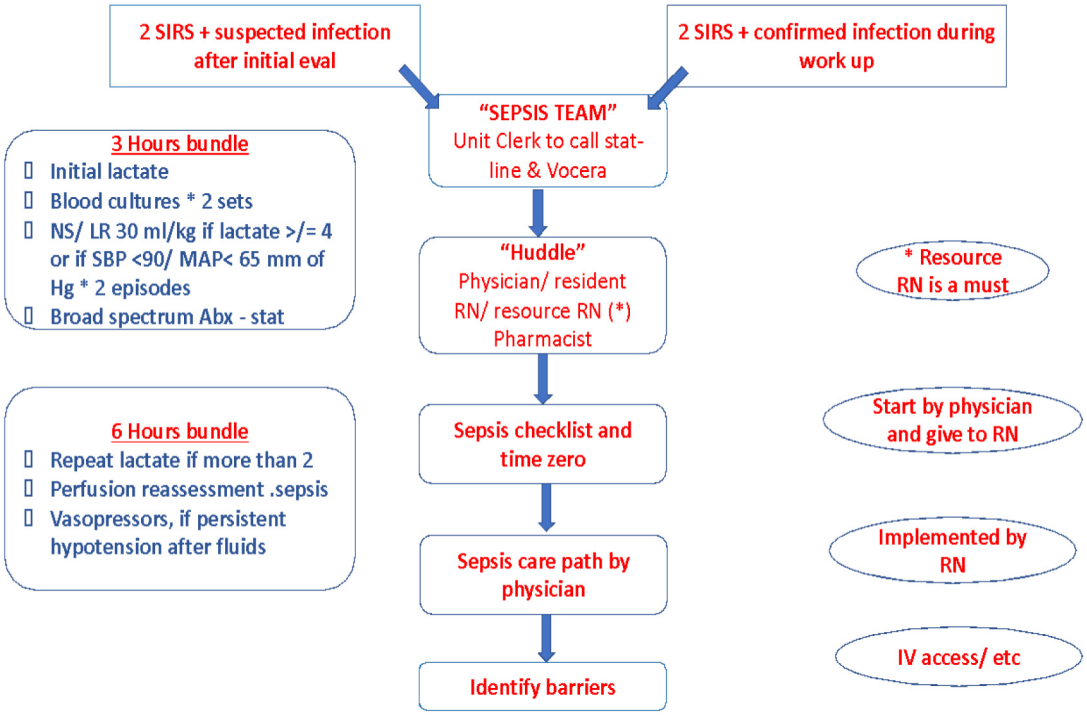

Fig. 1. Sepsis teams.

0.31–0.63, (Table 2b). Most time metrics were also significantly improved post implementation of sepsis teams among those with a primary diagnosis of sepsis, (Table 2a).

There were no significant differences in time metrics and mortality post and pre implementation of sepsis teams among those with a primary diagnosis of severe sepsis, (Tables 3a and 3b). Additionally, there were no significant differences in mortality and time metrics with the exception of time to admission among those with a primary diagnosis of septic shock, (Tables 4a and 4b).

Table 1
Demographics and other characteristics of all the participants, ($n = 1188$)

Variable	Overall	Pre ($n = 553$)	Post ($n = 635$)	p-value
Age	64.0(17.2)	63.7(17.8)	64.3(16.8)	0.5493
Gender				0.2848
Female	574(48.32)	258(46.65)	316(49.76)	
Male	614(51.68)	295(53.35)	319(50.24)	
Race				0.8672
Black	268(22.56)	124(22.42)	144(22.68)	
White	887(74.66)	414(74.86)	473(74.49)	
Other	15(1.26)	8(1.45)	7(1.10)	
Unknown	18(1.52)	7(1.27)	11(1.73)	
Ethnicity				1.0000
Not Hispanic	1138(95.79)	528(95.48)	610(96.06)	
Hispanic	3(0.25)	1(0.18)	2(0.31)	
Unknown	47(3.96)	24(4.340	23(3.62)	
Insurance				0.5298
Medicaid	203(17.09)	99(17.90)	104(16.38)	
Medicare	695(58.50)	325(58.77)	370(58.27)	
Private	241(20.29)	105(18.99)	136(21.42)	
Unknown	49(4.12)	24(4.34)	25(3.94)	
Comorbidity Index	4.7(3.7)	5.0(3.9)	4.5(3.6)	0.6589
Sepsis Severity				0.0646
Sepsis	863(72.64)	393(71.07)	470(74.02)	
Severe sepsis	154(12.96)	85(15.37)	69(10.87)	
Septic shock	171(14.39)	75(13.56)	96(15.12)	
Died				<0.0001
Yes	252(21.21)	156(28.21)	96(15.12)	
No	936(78.79)	397(71.79)	539(84.88)	

Statistics presented as mean (SD) or n (%).

4. Discussion

In this study, there was a 56% decrease for in-hospital mortality related to sepsis after the implementation of ED sepsis teams. There were also statistically significant improvements in time metrics for those in the sepsis cohort compared to severe sepsis and septic shock.

Sepsis teams can be called early in the ED course when there are two or more SIRS criteria and suspected infection or later in the ED course, after there is confirmed infection. Regardless of when the team is activated, it requires full participation from all individuals to meet timely requirements and care for the patient. Depending on the patient, there could be delays or interruptions in this process. This includes poor IV access, antibiotic allergies or resistance, or lack of nursing resources. Also, during periods of heavy ED volumes, patients may wait longer in triage before this process can be initiated. Therefore, our implementation of sepsis teams was meant to address some of these delays and interruptions as early on in the patient's course as possible and put together a core group of providers at the bedside to address these issues in order to expedite the patient sepsis care.

Interestingly, our study found that while our metrics statistically improved for sepsis, we didn't see much difference for severe sepsis and septic shock. This difference may exist because of disparities in early recognition of sepsis compared to severe sepsis and septic shock. Further studies will need to be completed to determine why our intervention did not have more effect on the sicker sepsis groups.

Although there are many studies that evaluate compliance and efficacy of performance bundles in the management of sepsis, there are few

Table 2a
Comparison of Time metrics pre- and post-implementation of sepsis teams, among those with sepsis ($n = 863$)

Subgroup results for Sepsis				
Variable	Overall	Pre ($n = 393$)	Post ($n = 470$)	IM(95% CI)
Time to triage	4(1–9)	3(1–7)	5(1−10)	0.5(0,1)
Time to lactate*	35(20–73)	41(23–83)	32(16–65)	-9(−13, −4)
Time to IV fluids	43(27–81)	46(28–91)	41(26–72)	−5(−9, 0)
Time to blood culture	47(24–104)	46(24–115)	49(24–100)	−1(−6, 4)
Time to antibiotics*	94(51–163)	107(62–173)	81(46–148)	−19(−29, −9)
Time to disposition*	276(197–362)	304(214–392)	252(191–331)	−45(−61, −28)
Time to admission*	430(326–559)	455(342–601)	403(317–527)	−48(−72, −24)
Time to departure*	408(306–557)	436(326–574)	382(294–522	−43(−67, −18)
ED LOS*	408(306–557)	436(326–574)	382(294–522)	−43(−67, −18)
Hospital LOS (Days)	6 (3–10.00)	6(3−10)	5(3–9)	−0.5(−1,0)

Times reported in minutes unless specified in the table. Statistics reported as median (Q1, Q3). IM = Confidence Interval Midpoint for the difference in time metrics between post and pre implementation of sepsis teams. CI = Confidence intervals.

Table 2b
Comparison of mortality rate before and after implementation of sepsis teams among those with a primary diagnosis of sepsis, ($n = 863$)

Subgroup results for Sepsis		
Effect	AOR	95% CI
Group: Post-implementation vs. Pre-implementation	0.44	0.31–0.63

AOR = Adjusted Odds Ratio, CI = Confidence Intervals. Variables controlled for include Comorbidity index and gender.

studies looking at the use of sepsis teams at the bedside [2]. One recent study evaluated the use of "code sepsis" teams on inpatient floors to quickly identify, manage, and treat sepsis. Results identified decreased mortality and improved compliance with bundled care [15]. The concepts of sepsis electronic alerts through the EMR and protocol-based bundled care implemented by a team of health care professionals at the bedside can be applied to the ED setting. Within the ED, patient flow, patient volume, and unexpected provider distractions can affect the ability for sepsis to be recognized and evaluated quickly. One strength of our sepsis team in the ED is that it activates all members from the patient's healthcare team in the ED to the bedside at the same time to assess and communicate the treatment plan to implement sepsis bundle requirements. Without overhead activation and an alert system, it may delay patient care as members of that patient's healthcare team could be preoccupied by other events in the ED during the time of the resuscitation,

Our sepsis team included a pharmacist, RN and physician and each of these brought a different skill to facilitate patient care. Team compositions may need to be institution specific to address site specific bottlenecks in patient care. Our study reflects the benefit of use of sepsis teams in the ED as they improve patient outcomes and reduce mortality.

4.1. Limitations

This study was limited by its retrospective nature and inherent biases utilizing this study design. SIRS criteria were utilized as the initial assessment for sepsis. Although SIRS criteria have been well studied, it has a low specificity and may have led to over or under identification of patients with sepsis, severe sepsis and septic shock which may have skewed results. In addition, patients with other medical conditions can frequently have two or more SIRS criteria, without being septic. This may have resulted in a more thorough workup than necessary. Our data only looked at those patients who had an ED diagnosis of sepsis, severe sepsis, and septic shock. Additionally, we relied on the clinician to initiate the sepsis teams based on information known at that time. We did not account for whether or not a provider placed a sepsis alert for each patient. Provider practice variation and incomplete information from patients and other providers may lead to delayed diagnosis. Lastly, there were multiple individuals involved in the timely response to the ED sepsis team. If there was a delay in care, such as timing to antibiotics, or establishing IV access, those challenges and their potential impact on patient outcomes were not accounted for in this study.

Table 3b
Comparison of mortality rate before and after implementation of sepsis teams among those with a primary diagnosis of Severe sepsis, (n = 154)

Effect	AOR	95% CI
Group: Post implementation vs. Pre-implementation	0.48	0.21–1.09

AOR = Adjusted Odds Ratio, CI = Confidence Intervals. Variables controlled for include Comorbidity index and gender.

Table 3a
Comparison of Time metrics pre and post implementation of sepsis teams, among those with severe sepsis ($n = 154$)

Subgroup results for Severe Sepsis				
Variable	Overall	Pre ($n = 85$)	Post ($n = 69$)	IM(95% CI)
Time to triage	4(1–10)	3(1–7)	6(2−11)	2(0, 4)
Time to lactate results	33(17–63)	33(18–56)	35(16–88)	4(−5, 13)
Time to IV fluids	37(23–69)	35(20–65)	45(27–76)	8(−2, 18)
Time to blood culture	45(23–114)	36(18–110)	53(25–114)	5(−8, 18)
Time to antibiotics	88(49–143)	93(49–149)	77(46–141)	−10(−31,11)
Time to disposition	291(211–371)	307(218–376)	273(201–348)	−28(−68, 12)
Time to admission	450(362–591)	452(370–585)	450(340–601)	−6(−62, 50)
Time to departure	413(320–574)	428(347–608)	396(311–525)	−34(−92, 24)
ED LOS	413(320–574)	428(347–608)	396(311–525)	−34(−92, 24)
Hospital LOS (Days)	6 (4–11)	6(4–11)	6(3−11)	−0.1(−2,1)

Times reported in minutes unless specified in the table. Statistics reported as median (Q1, Q3). IM = Confidence Interval Midpoint for the difference in time metrics between post and pre implementation of sepsis teams. CI = Confidence intervals.

Table 4a
Comparison of Time metrics pre- and post-implementation of sepsis teams, among those with septic shock ($n = 171$)

Subgroup results for Severe Sepsis				
Variable	Overall	Pre ($n = 75$)	Post ($n = 96$)	IM(95% CI)
Time to triage	3(1–9)	2(1–6)	4(1−12)	1(0,2)
Time to lactate result	28(16–54)	34(16–61)	25(16–44)	−7(−14, 1)
Time to IV fluids	34(20–69)	41(21–73)	33(20–67)	−3(−12, 6)
Time to blood culture	33(18–101)	31(17–99)	33(20−101)	1(−8, 10)
Time to antibiotics	100(47–161)	102(53–189)	98(41–149)	−10(−34, 14)
Time to disposition	281(211–355)	298(222–383)	252(202–348)	−24(−58, 11
Time to admission*	415(331–508)	452(362–562)	402(320–476)	−57(−102,−12)
Time to departure from the ED	417(340–564)	411(341–550)	421(329–567)	−3 (−54, 48)
ED LOS	417(340–564)	411(341–550)	421(329–567)	−3 (−54, 48)
Hospital LOS (Days)	6 (4–10)	6(3–10)	6(3–10)	−0.3(−2, 1)

Times reported in minutes unless specified in the table. Statistics reported as median (Q1, Q3). IM = Confidence Interval Midpoint for the difference in time metrics between post and pre implementation of sepsis teams. CI = Confidence intervals.

Table 4b
Comparison of mortality rate before and after implementation of sepsis teams among those with a primary diagnosis of Septic shock (n = 171)

Effect	AOR	95% CI
Group: Post implementation vs. Pre-implementation	0.60	0.29–1.24

AOR = Adjusted Odds Ratio, CI = Confidence Intervals. Variables controlled for include Comorbidity index and gender.

In conclusion, our study has demonstrated that implementation of sepsis teams in the ED leads to decreased in-hospital mortality rates in patient's diagnosed with sepsis.

Prior presentations

Society for Academic Emergency Medicine 2021 Virtual Meeting.

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None.

Author contribution statement

ELS conceived and designed the study. ELS, BF, and JK contributed to data collection. CM provided statistical advice on study design, analyzed the data. ELS, KM, LW and KT drafted the manuscript, and all authors contributed substantially to its revision. ELS takes responsibility for the paper as a whole.

Declaration of Competing Interest

None.

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