Mortality Influenced by Sepsis Bundle Compliance and Initial Lactic Acid in Severe Sepsis and Septic Shock

Evelyn George
Belmont University

Follow this and additional works at: https://repository.belmont.edu/dnpscholarlyprojects
Part of the Bacterial Infections and Mycoses Commons, and the Nursing Commons

Recommended Citation
George, Evelyn, "Mortality Influenced by Sepsis Bundle Compliance and Initial Lactic Acid in Severe Sepsis and Septic Shock" (2019).
DNP Scholarly Projects. 15.
https://repository.belmont.edu/dnpscholarlyprojects/15

This Scholarly Project is brought to you for free and open access by the School of Nursing at Belmont Digital Repository. It has been accepted for inclusion in DNP Scholarly Projects by an authorized administrator of Belmont Digital Repository. For more information, please contact repository@belmont.edu.
Mortality Influenced by Sepsis Bundle Compliance and Initial Lactic Acid in Severe Sepsis and Septic Shock

Evelyn George

Scholarly Project Advisor: Dr. Linda Wofford
Scholarly Project Team Members: Dr. Erin Shankel, Dr. David Phillippi
Date of Submission: April 15, 2019
Table of Contents

Abstract 4

Introduction and Background 5

Problem Statement 6

Purpose 7

Review of Evidence 7
  Defining Sepsis, Severe Sepsis, Septic Shock 7
    Sepsis Bundle 8
    Sepsis Bundle Compliance Related to Mortality Rates 9
    Lactic Acid Related to Mortality Rates 9
    Age and Sepsis Bundle 11

Theoretical Model 12
  Structure 12
    Process 13
    Outcomes 13
    Application 13

Project Design 14
  Clinical Setting 14
    Project Population 16
    Sources of Data 16
    Data Collection Process 17
    Statistical Analysis 18

Results 18
  Sample Characteristics 18
  Overall Sepsis Bundle Compliance and Mortality 19
  Lactic Acid and Mortality 19
  Older Individuals and Mortality 19

Discussion 20

Conclusion 24
Abstract

Sepsis, a life-threatening infection killing 270,000 yearly, is a concern to health care providers, policy makers, and patients due to its high volume and increasing cost. Patients older than 64 years have a higher occurrence of sepsis and greater mortality risk. The Surviving Sepsis Guidelines (SSG) recommends the use of the three-hour bundle that standardizes care to decrease cost, morbidity, and mortality. The three-hour bundle includes two treatments, intravenous fluids and antibiotics, and two tests, blood cultures and lactic acid level. One bundle element, lactic acid level, is associated with higher mortality rates, although only a few studies exist. The project purpose was to compare the influence of the three-hour sepsis bundle completion and the initial lactic acid level on mortality rates in adults in an emergency department over a two-year period. The Donabedian quality of care framework guided the project related to structure, process, and outcome. Analysis of data from a retrospective chart review of 341 charts determined the association between three-hour sepsis bundle compliance and mortality rates. Individuals who received the three-hour bundle elements had lowered mortality rates and those with higher lactic acid had increased odds of mortality. There was no significance between mortality rates of older individuals who received the three-hour bundle elements and those who did not. The findings of this project confirm completing the three-hour bundle and improving current processes in a specific emergency room positively impact mortality rate.

Keywords: three-hour sepsis bundle, lactic acid, mortality rate, emergency department
Introduction and Background

According to Centers for Disease Control and Prevention (2018), sepsis affects 1.7 million adults annually in the United States and 270,000 die as a result of sepsis each year. Sepsis is defined as the body’s reaction to an infection. Sepsis can progress into organ dysfunction with a high risk of mortality leading to severe sepsis and septic shock (Rhodes et al., 2017; Shah, Sterk, & Rech, 2018). Although the immune system is equipped to fight infection in healthy individuals, treatments such as administration of intravenous fluids, antibiotics, and tests such as blood cultures and lactic acid levels, can improve survival rates.

Sepsis is a concern for health care providers, policy makers, and patients due to the high volume of cases and high cost. Sepsis prevalence is expected to increase in the coming years, with a projected incidence of 1 million cases by year 2020 (Bang & Doty, 2009). According to Agency for Healthcare Research and Quality (AHRQ), septicemia is the sixth most common reason for hospitalization in the United States, affecting one of every 23 hospitalized patients (AHRQ, 2012). Between 2005 and 2010, patients with a primary diagnosis of septicemia contributed to a 71% increase in hospitalizations (Sutton & Friedman, 2013). Because longer hospitalizations means higher cost, the projected cost of septicemia in the U.S healthcare system was $20.3 billion in 2011 and increased to $24.3 billion in 2013 in the most recently published data, which makes it the most expensive condition treated in the U.S hospitals (Torio & Andrews, 2013; Torio & Moore, 2016)

Sepsis mortality is a serious concern in addition to high volume and increasing cost. From 2009 to 2014, sepsis accounted for 6% of hospitalization, but 15% of hospital deaths (Rhee et al., 2017). A 2014 study, including 2.9 million patients from 409 hospitals diagnosed with sepsis, reported that 1.7 million hospitalizations in the U.S occurred due to sepsis with 270,000
sepsis related deaths (Rhee et al., 2017). Medicare patients and patients older than 65 diagnosed with sepsis have not only higher incidence, but also higher mortality risk when compared to a younger population (Starr & Saito, 2014; Sutton & Friedman, 2013). In order to decrease sepsis mortality, the Surviving Sepsis Campaign established Surviving Sepsis Guidelines (SSG) recommending the use of a three-hour bundle which includes two treatments, intravenous fluids and antibiotics, and two tests, blood cultures and lactic acid level (Rhodes et al., 2017; Society of Critical Care Medicine, 2015). Additionally, as a quality process measure to address sepsis cost, morbidity and mortality. The SSG facilitated timely standardized responses to sepsis patients to decrease cost, decrease morbidity, and decrease mortality through the use of sepsis bundle.

One of the bundle elements, lactic acid level, is related to higher mortality rates in patients admitted for sepsis and other critical illness (Park et al, 2018). Sinkovic, Markota, Fluher, and Rehar (2013) performed a retrospective cohort analysis of 102 patients admitted with sepsis and septic shock in medical ICU from 2008 – 2010 in which, increased levels of lactic acid reliably predicted patients at higher risk of dying from sepsis and septic shock. However, according to Liu et al (2013), sepsis patients with intermediate lactate values (less than four mmol/L) had increased hospital admissions and higher 30-day mortality. Although the three-hour sepsis bundle does have criteria to assess lactic acid level, the predictability of lactic acid level on mortality rate needs further study.

**Problem Statement**

Sepsis is an alarming issue for the healthcare community because of high volume, cost, morbidity, and mortality. Sepsis mortality rate can be positively influenced through compliance of the sepsis bundle. Meanwhile, there is a literature gap in the study of mortality rate when comparing three-hour sepsis bundle compliance and initial lactic acid level in sepsis patients.
Purpose

The purpose of this quality improvement project was to compare if the three-hour sepsis bundle compliance and initial lactic acid level influence mortality rate in adults diagnosed with severe sepsis and septic shock in one ED over a two-year period. Through this project, the results may reinforce the importance of sepsis bundle compliance in the ED and may highlight the significance of the initial lactic acid measurement. The project may support the need for standardized treatment in order to increase survival rates. The project findings will be generalizable to patients diagnosed with sepsis who arrive to an ED. The author hypothesizes:

(a) Individuals who receive the three-hour bundle elements will have lower rates of mortality compared to individuals who did not receive the three-hour bundle elements.

(b) Individuals with higher initial lactic acid level for diagnosis will have higher rates of mortality compared to individuals who have decreased initial lactic acid.

(c) Older individuals who receive all the three-hour elements will have lower mortality rates compared to who did not receive all of the three-hour bundle elements.

Review of Evidence

Defining Sepsis, Severe Sepsis, Septic Shock

Bone et al., (1992) conducted a landmark study that classified sepsis as the manifestation of the body’s response to an infection or lack of infection and named it systemic inflammatory response syndrome (SIRS). SIRS symptoms include temperature (greater than 38°C Celsius or 100.4°F Fahrenheit or less than 36°C degrees Celsius 96.8°F Fahrenheit), tachycardia (greater than 90 beats per minute), tachypnea, (greater than 20 breaths per minute), a change in white blood cell count (greater than 12,000/cu mm) and a neutrophil count (less than 4,000/cu mm or 10%
immature neutrophils). Any two SIRS symptoms in a patient result in a diagnosis of sepsis (Bone et al, 1992; Cawcutt & Peters, 2014).

Sepsis can progress into severe sepsis and septic shock. “Severe sepsis” is defined as an organ dysfunction and “septic shock” is defined as persistent induced hypotension despite fluid resuscitation (Dellinger et al., 2013; Rhodes et al., 2017; Singer et al., 2016). This definition had remained unchanged over two decades, until recently. In 2016, The Society of Critical Care Medicine (SSCM) and the European Society of Intensive Care Medicine (ESICM) revised definitions through supporting evidence and recommended elimination of the term “severe sepsis” (Singer et al., 2016). For the purposes of this project and due to prior literature that was published using prior definitions, “severe sepsis” and “septic shock” will be the terms used.

**Sepsis Bundle**

In 2002, the SSCM and the ESICM launched goals to increase septic awareness, improve diagnosis and treatment, educate health care providers, and develop management guidelines to reduce sepsis mortality (Makic & Bridges, 2018). In 2004, SSC partnered with the Institute of Healthcare Improvement (IHI) along with panel experts, to develop two practice bundles that included interventions in the first six hours, the resuscitation bundle, and, within 24 hours, the management bundle (Marshall, Dellinger & Levy, 2010). After 2004, the resuscitation bundle was renamed the three-hour bundle and the management bundle as the six-hour bundle (Society of Critical Care Medicine, 2015). The SSC guidelines are revised every four years and the latest revision was accomplished in 2016 (Makic & Bridges, 2018; Rhodes et al., 2017).

This project focused on the three-hour bundle elements. The three-hour bundle consists of two tests, a lactic acid level and blood cultures prior to administration of antibiotics, and two
treatments, administration of broad-spectrum antibiotics and intravenous fluids (Society of Critical Care Medicine, 2015).

**Sepsis Bundle Compliance Related to Mortality Rates**

Sepsis bundle compliance improves patient outcomes (Dellinger et al., 2013; Rhodes et al., 2017; Seymour et al., 2017). An all-or-none phenomenon is applied to the sepsis bundle which requires all elements of the bundle to be accomplished in order to achieve bundle compliance (Marshall et al., 2010). The largest study following the 2004 SSC guidelines examined the relationship between sepsis bundle compliance and mortality. Levy et al. (2015) conducted a 7.5 year study with 29,470 patients from 218 hospitals in the United States, Europe, and South America who met the criteria for severe sepsis and septic shock to determine the association between sepsis bundle compliance and mortality. Overall mortality was lowered at highly compliant sites (29.0%) compared to low compliance sites (38.6%); Overall hospital mortality rate dropped 0.7% for every three month participation (p <0.001) (Levy et al., 2015). Rhodes et al. (2015) also conducted another global study with 618 hospitals from 62 countries with patients presenting with severe sepsis and septic shock. The overall three-hour compliance was associated with lower hospital mortality than non-compliance along with 40% reduction in dying at the hospital when compliant with either three or six-hour bundle (Rhodes et al., 2015). Bundle compliance changes patients’ outcomes globally in populations from ED, medical surgical wards, and intensive care units (ICU) (Levy et al., 2015; Nguyen et al., 2011; Rhodes et al., 2015).

**Lactic Acid Related to Mortality Rates**

Measuring lactic acid levels is one of the four elements of the three-hour sepsis bundle. Lactic acid accumulates in the body due to an increase of lactic production, diminished use, and
SEPSIS BUNDLE AND LACTIC ACID

clearance of lactic or both which is a common cause for hyperlactemia in sepsis (Suetrong & Walley, 2016). Hyperlactemia, elevated lactic acid, four mmol/L or higher is one criterion to diagnose severe sepsis (Dellinger et al., 2013). Two-thirds of patients with severe sepsis or shock had elevated lactate concentrations from the findings of Surviving Sepsis Campaign Database (Casserly et al., 2015). There are ways to decrease initial lactic acid to decrease morality. In septic patients decreasing initial lactic acid with hemodynamic resuscitation strategies such as fluid administration is a successful strategy to impact mortality (Liu et al., 2013, Suetrong & Walley, 2016).

Mikkelsen et al. (2009) evaluated the association between initial serum lactate level and mortality rate in patients presenting to the ED with severe sepsis through a retrospective cohort of patients from January 2005 to December 2006. The study confirmed that lactic acid level is associated with mortality independent of organ dysfunction and shock in patients admitted to the ED (Mikkelsen et al., 2009). However, since this study was published, SSG has updated guidelines multiple times. The authors only focused on initial lactic acid levels and mortality rates and neglected compliance of sepsis bundle along with this finding. Though studies establish lactic acid levels and persistent hyperlactemia are associated with adverse outcomes in sepsis, evidence has failed to compare noncompliance sepsis bundle and lactic acid levels (Khosravani et al., 2009, Liu et al., 2013, Nguyen et al., 2011, Puskarich, Illich, & Jones, 2014, Puskarich et al., 2013, Song et al., 2012, Toraman et al., 2004). With updated guidelines, new studies need to compare the impact of three-hour sepsis bundle compliance and initial lactic acid levels on mortality.
Age and Sepsis Bundle

The aging population plays a significant role in the increasing rates of sepsis. In the last 10 years in the United States, the population aged 65 years and older increased from 37.2 million in 2006 to 49.2 million in 2016 (33% increase) and is anticipated to almost double to 98 million in 2060 (Administration of Aging, 2018). With increased age, the body’s immune response to infection is reduced and puts older individuals at higher risk for developing infection (Rowe & McKoy, 2017). Stoller et al. (2015) found sepsis prevalence increased from 346 per 100,000 persons in 2008 to 436 per 100,000 persons in 2012. The mean age of the patients was 69 years in 2008 and 68 years in 2012 (Stoller et al., 2015).

Older adults have increased risk factors for deterioration from sepsis than younger patients due to decrease in organ function, immune function, and other comorbidities (Girard, Opal & Ely, 2005). Over the past several decades, the sepsis bundle has provided standardized care in both young adults and elderly patients (Makic & Bridges, 2018; Rhodes et al., 2015; Rhodes et al., 2017). Negret-Delgado et al. (2016) determined the adherence of the sepsis bundle comparing groups over and under 65 years of age; the study learned decreased sepsis bundle compliance occurred in the group over 65 years of age compared to the other group which resulted in more negative patient outcomes. However, other studies report older individuals diagnosed with sepsis had lower mortality rate when treated with all of elements of sepsis bundle (El Solh, Akinnusi, Alsawalha & Pineda, 2008; Heppner et al., 2012; Nasa, Juneja & Singh, 2012). Although treating infection in adults older than 65 years is challenging, sepsis bundle compliance is an evidence-based strategy to mitigate the higher risk of sepsis mortality in the older population.
Theoretical Model

For the purposes of this project, the Donabedian quality of care framework was used to guide the scholarly project. Avedis Donabedian, a physician and professor of medical care organization, was commissioned by the Health Services Research Section of the U.S Public Health Service to evaluate research on quality assessment (Ayanian & Markel, 2016). From his findings, he developed a framework to evaluate quality (Donabedian, 1966; Hickey & Brosnan, 2017).

The three concepts of the Donabedian model are structure, process, and outcomes (Ayanian & Markel, 2016; Donabedian 1966; Hickey & Brosnan, 2017). This framework has been used in multiple settings to evaluate quality such as implementation of nurse led triage, an integrated trauma system, and providing care for pediatric patients in an ED (Abdelwahab, Yang, & Teka 2017; Moore, Lavoie, Bourgeois, Lapointe, 2015; Ohns, Oliver-McNeil, Nantais-Smith, & George, 2016). The important assumptions related to this model are that structure, processes, and outcomes are all related and the relationships between all three concepts are unidirectional (Donabedian, 1966). Figure 1 illustrates the organization of the specific scholarly project elements into the Donabedian framework.

Structure

Structure refers to the administrative support needed for quality care and the environment in which the health care occurs (Donabedian 1966; Hickey & Brosnan, 2017). The number of available supplies and health care providers, and types of equipment are examples of structural components (Donabedian 1966; Hickey & Brosnan, 2017). The structural components in the scholarly project include the emergency department, the electronic health record (EHR) and the
Sepsis Committee. The feature most important to the scholarly project was the retrieval of data from the EHR.

Process

Process consists of provider and patient relationship and the ability of the provider to develop therapeutic relationships with patients. The diagnostic tests, differential diagnoses, interpretation of the results, and prescribed treatments are all process components (Donabedian 1966; Hickey & Brosnan, 2017). The current practices include the provider use of sepsis bundle, the initial lactic acid level, and patients receiving the bundle elements. The data collection facilitated understanding of current process and practices of an emergency department (ED). The Sepsis Committee identified and shared barriers in the current process through an interview with the scholarly project leader.

Outcomes

Outcomes are measurable change seen in health status because of the delivered health care (Donabedian 1966; Hickey & Brosnan, 2017). Outcomes can be seen by both providers and patients and are standard across all settings (Hickey & Brosnan, 2017). Outcomes such as mortality and life expectancy reflect culture and values of family while specific disease outcomes are a better indicator of provided health care quality (Hickey & Brosnan, 2017). The mortality rate was the outcome measured in the scholarly project.

Application

The structure, process, and outcomes elements of the Donabedian quality of care framework constructed the underpinning and support of this project. These three elements are key factors in understanding this quality improvement project that assessed the association of the three-hour sepsis bundle compliance and initial lactic acid level on mortality rate in adults
diagnosed with sepsis in the ED. Donabedian (1966) reported that *structure, process, and outcomes* provide unique information individually, but together facilitate an improved understanding of the medical care process.

**Project Design**

The scholarly project used a retrospective chart review designed to evaluate the association of three-hour sepsis bundle compliance and initial lactic acid level on mortality rate in adults diagnosed with sepsis in the ED. The retrospective chart review obtained data about patients diagnosed with severe sepsis and septic shock in an ED located in the southern region of United States. The retrospective chart review captured data from January 1, 2016 to December 31, 2017. The scholarly project protocol, data collection, and design were approved by the Belmont University Institutional Review Board. Additionally, through the collaboration, the project was supported by the facility who granted access to the retrospective data.

**Clinical Setting**

Accessing the electronic health record (EHR) was accomplished at this facility. This facility has 657 beds with 27 beds dedicated to the 24 hour adult emergency department. The care of sepsis patients is a priority for this organization. The facility includes, *Sepsis Committee*, which meets monthly to address issues related to sepsis care. This committee consists of chief nursing officer (CNO), medical directors of ED and ICU, director of hospitalist service, sepsis coordinator, nursing director, manager of ED, nurse manager of medical intensive care unit (MICU), and a nurse from cardiovascular intensive care unit (CVICU). The committee reviews sepsis cases by analyzing the successes and failures of each case, as well as continuously seeks strategies to improve the process and outcome of caring for sepsis patients. This quality
SEPSIS BUNDLE AND LACTIC ACID

improvement project analyzed data, provided findings, and recommended interventions to the committee that may help decrease sepsis mortality.

The facility’s mortality target goals in 2016 were to lower severe sepsis mortality by 10% and lower septic shock mortality by 20%. The mortality target goals for 2017 for severe sepsis were to lower sepsis mortality by 10% and to lower septic shock mortality by 30%. In relation to sepsis diagnosis, providers, nurses, and paramedic technicians in the ED are aware of the importance of early diagnosis and treatment of patients who might present with sepsis. The triage process is crucial in alerting staff about possible sepsis patients.

When a patient arrives to the ED, a registered nurse (RN) or a paramedic triages the patient. If a patient meets SIRS criteria for sepsis, a provider is notified. Immediately after the patient is brought to an available room and a thorough history and physical obtained by the provider and/or nurse, the sepsis order set is initiated that contains the three-hour sepsis bundle elements. The RN completes the sepsis order set in a timely manner with the priority to obtain initial lactic acid level, obtain two sets of blood culture from two different sites, administer antibiotics after collecting two sets of blood cultures, and administering intravenous fluids. The provider and the RN communicate about any abnormal changes throughout patient’s care in the ED. Through the diagnostic testing, treatment, and evaluation of the patient’s overall response to the treatment, the provider determines if the patient is admitted to the hospital for further treatment or discharged home after ED treatment completion. Through the sepsis bundle initiation, the patient receives standard of care and their mortality rate risk can be reduced. The patient treatment and response data was captured from the EHR to analyze the processes and outcomes of patients diagnosed with sepsis.
SEPSIS BUNDLE AND LACTIC ACID

**Project Population**

The project population consisted of cases identified through the retrospective chart review of the EHR. A purposive sample was used through the use of ICD-10 and MS-DRG codes. The inclusion criteria included patients age 18 and older, present on arrival (POA) with a diagnosis of severe sepsis and septic shock in the ED, an ICD-10 diagnosis code R65.2 (severe sepsis), R65.21 (septic shock) and MS-DRG code 871 (severe sepsis without mechanical ventilation), and who met SIRS criteria during triage. The sample criteria were chosen because the specific ED treats a high volume of sepsis patients aged 18 and older and the criteria match the published evidence (Gaieski, Edwards, Kallan, & Carr, 2013; Seymour et al., 2017). Through this project design and data collection, the project leader did not engage with patients directly.

**Sources of Data**

The retrospective chart review analyzed cases from January 1, 2016 through December 31, 2017. Data was retrieved from the facility EHR system applying the established inclusion criteria. The independent variables are the three-hour sepsis bundle compliance and initial lactic acid measurement. The data acquired included patient demographic characteristics: such as, age and gender. Age was measured as a discrete ratio variable and gender measured as a dichotomous variable. Ages 65 and greater were considered older individuals. The three-hour sepsis bundle consists of four elements that included obtaining lactic acid level, obtaining blood cultures prior to administration of antibiotics, administering broad spectrum antibiotics, and administering intravenous fluids.

**Lactic acid.** When a patient meets SIRS criteria, lactic acid level is obtained. The normal value for lactic acid ranges from 0-1.9 mmol/L. A lactic acid level 2.0 mmol/L or greater is considered abnormal. In this project, the action of obtaining a lactic acid level was measured as a
dichotomous variable and the actual numerical measurement of lactic acid level was measured as a continuous ratio variable.

**Blood cultures.** Blood cultures were defined when one set of aerobic and one set of anaerobic cultures were obtained. In this project, two sets of blood cultures received by the laboratory prior to antibiotic administration were measured as a dichotomous variable.

**Antibiotics.** The administration of broad spectrum antibiotic therapy of one or more drugs to have activity against all organisms is part of the three-hour sepsis bundle. In this project, the administration of antibiotics was measured as a dichotomous variable.

**Fluid therapy.** The administration of 30ml/kg of crystalloid fluids in patients who presented with hypotension or blood lactate concentration 4 mmol/L or greater was part of the three-hour sepsis bundle. In this project, the administration of fluid therapy was considered a dichotomous variable.

The dependent variable was mortality rate. Mortality was defined as a patient’s death in the hospital. Mortality was measured as a dichotomous variable in this project. The Sepsis Committee was also asked open ended questions concerning the barriers to sepsis bundle implementation and ideas or changes that have been implemented to help decrease sepsis mortality rates.

**Data Collection Process**

The data collection process started in August 2018 at the facility. Cases that met the inclusion criteria were captured through the EHR and given to the project leader. The project leader went to the facility twice a week to transcribe data using the facility’s computer in a private office. The review of cases included ED providers’ notes, nurses’ notes, laboratory results, medication orders and administration logs, case managements’ notes, hospitalists’ notes
and discharge notes. Each case was searched by the medical record number (MRN) through the EHR and results of each variable were transcribed on the Microsoft Excel sheet. The project adhered to the regulations of the Health Insurance Portability and Protection Act (HIPPA) to protect the confidentiality and anonymity of all cases. Each case was de-identified, assigned a unique number, and recorded on the Excel sheet. Every 19th case, one case was chosen randomly to double check results of the variables transcribed on the Excel sheet. If during the double checking errors were found, every 5th case was randomly chosen to be double checked.

**Statistical Analysis**

Data was analyzed using IBM Statistical Package for Social Sciences (SPSS) 25.0 for Windows. The demographic characteristics such as age and gender of the participants were analyzed using descriptive statistics by using the mean and standard deviation. The first hypothesis used Pearson chi-square test to compare mortality rates in individuals who did and who did not receive three hour bundle elements. The second hypothesis used logistic regression model to compare mortality rates and lactic acid levels. The third hypothesis used Pearson chi-square test to compare mortality rates in older individuals who did and did not receive three hour bundle elements. A $p$-value of 0.05 was employed with a 95% confidence interval.

**Results**

A total of 350 charts were collected through the retrospective chart review process. Nine charts were not included because they failed to meet the SIRS criteria during triage process, one of the inclusion criteria.

**Sample Characteristics**

A total sample of 341 charts was used for data analysis. Table 1 summarizes the age, gender, and mortality rate characteristics. The individuals’ age ranged from 18 to 97 years old.
with an average age of 64.8 years ($SD = 15.3$) and a median age of 66 years. Forty seven percent were female ($n = 163$) and 52.2% were male ($n = 178$). In 2016, the mortality rate was 25% ($n = 124$) and in 2017, the mortality rate was 14.3% ($n = 217$).

**Overall Sepsis Bundle Compliance and Mortality**

Of 341 charts, 340 charts were analyzed for the first hypothesis and one chart was excluded due to missing data. Eighty one percent ($n = 277$) received three-hour bundle elements compared to 18.5% ($n = 63$) who did not receive the three-hour bundle elements. A chi-square test of independence (see Table 2) determined the relationships between individuals who received and did not receive the three-hour bundle elements and mortality rates were statistically significant ($\chi^2 = 3.93; p = 0.04$). Individuals who received the three-hour bundle elements had lower rates of mortality compared to individuals who did not receive the three-hour bundle elements.

**Lactic Acid and Mortality**

Of 341 charts, 317 charts were analyzed for the second hypothesis and 24 charts were excluded due to missing data. Lactic acid levels ranged from 0.3mmol/L to 18.0mmol/L with an average lactic acid level of 3.8mmol/L ($SD = 2.9$) and a median level of 2.9mmol/L. A logistic regression (see Table 3) was calculated to predict mortality rates based on lactic acid levels. Higher lactic acid was associated with increased odds of mortality rates (adjusted odds ratio, 0.84; 95% confidence interval [CI], 0.77 to 0.92). Results indicated that the variables were statistically significant ($p < 0.01$).

**Older Individuals and Mortality**

187 charts ($N = 341$) were individuals who were 65 years old and above. The mean age of the sub-group was 76.0 ($SD = 7.6$) and median age was 75 years old. A chi-square test of
independence (Table 4) determined the relationships between older individuals who received the three-hour bundle and mortality rates were not statistically significant, ($\chi^2 = 0.32, p = 0.56$). No statistically significant evidence was produced that older individuals who received all the three-hour elements had lower mortality rates compared to those who did not receive all the three-hour bundle elements.

**Discussion**

In this retrospective chart review, the Donabedian quality of care framework guided the scholarly project through the concepts *structure, process, and outcomes*. The most important structural feature of this study was the data collection obtained through EHR of individuals who presented through the ED. The *process* and the *outcomes* components were studied through the three hypotheses and their results.

**Process and Outcomes**

The use of sepsis bundle through the sepsis order set, the initial lactic acid level, patients receiving the bundle elements, and the *Sepsis Committee* are the process components of this project. The mortality rate was a measured outcome in all three hypotheses. The mortality rates decreased by 10.7% from 2016 to 2017. The change in mortality rates could be attributed to staff awareness about sepsis, educational programs by *Sepsis Committee* and possible updated changes in the EHR.

The results confirm the first hypothesis. Individuals who received the three-hour bundle elements did have lower rates of mortality compared to individuals who did not receive the three-hour bundle elements. Previous research has shown the effectiveness of the three-hour bundle compliance in increasing survival rates (Leisman et al., 2017; Lynn et al., 2018). The results show that at this facility, the current process use of sepsis order set initiated the three-hour
bundle elements to be carried out by staff which in turn facilitated lower mortality rates in the ED. Further research can be useful in comparing provider’s use of sepsis order set with staff driven sepsis protocols at other facilities.

The results for second hypothesis confirmed that individuals with higher initial lactic acid level had higher rates of mortality compared to individuals who had decreased initial lactic acid level. Gribben et al., (2016) conducted a study that showed that higher lactic acid in sepsis patients did have higher mortality rates. Moreover, Filho et al., (2016) studied 443 patients with severe sepsis and septic shock; patients with initial lactic acid levels greater than 2.5mmol/L had a mortality rate more than 3.2 times higher than patients with lower or equal to 2.5mmol/L. Further research can be useful in evaluating lactic acid level measurement as a sensitive marker for sepsis patients.

The third hypothesis was not supported by the results. No relationship was demonstrated between older individuals who received all the three-hour elements having lower mortality rates compared to older individuals who did not. Prior research did report an association between older adults and mortality rate when bundle compliant (El Solh, Akinnusi, Alsawalha & Pineda, 2008; Heppner et al., 2012; Nasa, Juneja & Singh, 2012). However, Rowe et al., (2016) conducted a study which compared adults greater than 60 years old admitted to ICU with an higher mortality when compared to those who did not receive all three-hour elements. This study did not study the association of mortality with three-hour bundle compliance but suggested that early use of antimicrobials and vasopressors may be associated with lowered in sepsis mortality (Rowe et al., 2016). It can be challenging to identify sepsis in older adults because temperature, heart rate, and white blood cell count may be diminished in older adults compared to younger adults (Umberger, Callen & Brown, 2015). Since the current population contains a large
proportion of older adults, early identification and prompt treatment is crucial in improving mortality rates. Further research is warranted in evaluating different ways sepsis can be identified in the older population.

The goal of the Sepsis Committee is to bring awareness to the hospital about sepsis, improve the treatment of sepsis patients, and decrease sepsis mortality rates. The Sepsis Committee identified the most important barrier of the current process in the ED and proposed an idea that can be implemented to help with decreasing mortality rates through bundle compliance. Most of the committee members agreed that a “check” box mentality can occur when the provider orders the sepsis bundle, staff administers the ordered tests and treatment, but the provider does not continue to monitor and treat the individual. An idea proposed by the project leader and Sepsis Committee to overcome this barrier is to incorporate educational programs every three months to increase provider and staff awareness of sepsis and to share results of sepsis bundle compliance efforts.

This quality improvement project’s findings support that sepsis bundle compliance leads to lower mortality rates. The project also supported that measurement of lactic acid is a vital part of the bundle and helps providers gauge sepsis severity. To further improve outcomes, the current processes can be improved. The project leader recommends education and training about sepsis for the ED staff every three months and as needed. Online modules that include a pretest, the clinical information, and a post test can be an effective approach. Sepsis reference pocket cards given to staff and posters about the three-hour bundle can be placed in the department to assist with staff awareness. Substantial evidence demonstrates the positive impact of sepsis educational programs (Delaney et al., 2015; Ferrer et al., 2008; Herran-Monge et al., 2016).
Implications for Practice

Since the initiation of the scholarly project started, there has been updates to the SSC guidelines. The new SSC guidelines were revised with a major change to combine the three-hour bundle and six-hour bundle into a single one-hour bundle (Levy, Evans, & Rhodes, 2018). This major change communicates a sense of urgency to providers that resuscitation and management of sepsis patients can be started immediately (Levy, Evans, & Rhodes, 2018). Early recognition and prompt resuscitation are important especially in the ED, but also in other settings. This should be addressed and studied in future projects to address the global burden of sepsis mortality.

The findings from this project support the importance of three-hour sepsis bundle compliance, initial lactic acid measurement and its relation to mortality rates. This scholarly project confirms the importance of using evidence-based guidelines such as the three-hour bundle to guide practice with sepsis patients. The project also highlights the value of the lactic acid level for sepsis patients and aggressive treatment in the early hours. Continued improvements in processes of care that enhance early recognition are necessary to further improve outcomes of sepsis.

Strengths and Limitations

This project had limitations. Firstly, this was not a randomized trial, so results may be biased by confounding factors. Secondly, although the data was from a single facility and, was collected over two years from a large study population, the results may have limited external validity. Thirdly, the project leader did not include any other variables in the logistic regression model other than lactic acid levels. As research has shown, many factors influence mortality rates (Rhee et al., 2019; Sanderson et al., 2018; Shen et al., 2012).
Conclusion

The ED has a responsibility to provide the best overall care because it is the primary gateway for many sepsis patients. While sepsis is recognized as hard to identify, the three-hour bundle can improve sepsis mortality rates. The study did not find a relationship between older individuals who received the three-hour elements and mortality rates. However, this project’s results support that three-hour sepsis bundle compliance is associated with lowered mortality rates and higher lactic acid level can assist in gauging risk of mortality.
References


doi:10.1097/shk.0000000000000667


doi:10.1097/shk.0000000000000555


Figure 1 – Donabedian Quality of Care Framework. The red colored blocks are the specific elements applied to the framework.
Table 1  
*Age, Gender, and Mortality Characteristics*

<table>
<thead>
<tr>
<th></th>
<th>Age in years (N = 341)</th>
<th>Gender (N = 341)</th>
<th>Mortality Rate in 2016 (n = 124)</th>
<th>Mortality Rate in 2017 (n = 217)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD)</td>
<td>64.89 (15.34)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>66</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>18 - 97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female (%)</td>
<td>163 (47.8%)</td>
<td></td>
<td>93 (75%)</td>
<td>186 (85.7%)</td>
</tr>
<tr>
<td>Male (%)</td>
<td>178 (52.2%)</td>
<td></td>
<td>31 (25%)</td>
<td>31 (14.3%)</td>
</tr>
</tbody>
</table>

Table 2  
*Chi Square Test for Overall Sepsis Bundle Compliance and Mortality*

<table>
<thead>
<tr>
<th></th>
<th>Overall Sepsis Bundle Compliance and Mortality</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Compliance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Mortality</td>
<td>D Count</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>L Count</td>
<td>57</td>
</tr>
<tr>
<td>Pearson Chi-Square</td>
<td>Value</td>
<td>df</td>
</tr>
<tr>
<td></td>
<td>3.936*</td>
<td>1</td>
</tr>
</tbody>
</table>

Note. df = degrees of freedom  
*0 cells have expected count less than 5. The minimum expected count is 11.49*

Table 3  
*Logistic Regression for Lactic Acid and Mortality*

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>p</th>
<th>Adjusted Odds Ratio</th>
<th>95% C.I.for EXP(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactic acid</td>
<td>-0.17</td>
<td>0.04</td>
<td>14.63</td>
<td>1</td>
<td>&lt;0.01</td>
<td>0.84</td>
<td>[0.77, 0.92]</td>
</tr>
</tbody>
</table>
Note. CI = confidence interval df = degrees of freedom SE = standard error

Table 4
Chi Square test for Older Adults and Mortality

<table>
<thead>
<tr>
<th>Compliance</th>
<th>N</th>
<th>D</th>
<th>L</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>31</td>
<td>124</td>
<td>155</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pearson Chi-square</th>
<th>Value</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>.327*</td>
<td>1</td>
<td>0.568</td>
</tr>
</tbody>
</table>

*0 cells have expected count less than 5. The minimum expected count is 6.16