SEVERE SEPSIS AND SEPTIC SHOCK READMISSIONS IN OLDER ADULTS

Kimberly Sue Hodge

Submitted to the faculty of the University Graduate School
in partial fulfillment of the requirements
for the degree
Doctor of Philosophy
in the School of Nursing,
Indiana University

August 2020

Accepted by the Graduate Faculty of Indiana University, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Doctoral Committee

Janet Fulton, PhD, RN, ACNS-BC, FAAN, Chair

Patricia Ebright, PhD, CNS, RN, FAAN

June 11, 2020

Mary Lynn Davis-Ajami, PhD, MBA, MS, FNP-C, RN

Lesa Huber, PhD

DEDICATION

This work is dedicated to my husband, Larry, my children and their spouses (Mikkal, Jennifer, Kaycie, Cody, Gabrielle, Racheal, and Dillon) and my grandchildren (Maverick, Wyatt, Lily, Rhett, Elainea, Evaleigh, Braxten, Bailey, Easten, and Brynleigh). I love you!

ACKNOWLEDGEMENT

I offer a deep and heartfelt thanks to Dr. Patricia Ebright, Dr. Lesa Huber, and Dr. Janet Fulton. Each of you stuck with and supported me over many years through to my completion. I will be forever grateful.

Next, I would also like to extend a sincere thank you to my dissertation committee: Dr. Janet Fulton, Dr. Patricia Ebright, Dr. Mary Lynn Davis-Ajami, and Dr. Lesa Huber. I will be indebted to each of you for your constructive critique, encouragement, and grit.

I express a special thank you to my family, without whom completion of this program would not have been possible.

Finally, thank you to Jean Balagurus, my special friend. You never doubted that I would finish.

Kimberly Sue Hodge

SEVERE SEPSIS AND SEPTIC SHOCK READMISSIONS IN OLDER ADULTS

Hospital readmission is of growing importance in the healthcare industry because of associated patient and system costs, impact to the quality of patient care, and hospital Medicare payment penalties. The increasing interest in sepsis readmission prevention has highlighted the uniqueness of severe sepsis or septic shock survivors. The results of this study provide insight into the relationship between index hospital length of stay (LOS) and 30-day readmissions for older adults (> 65 years) who discharged home from an index hospital with a principle or secondary discharge diagnosis of severe sepsis or septic shock.

The purpose of this study was to investigate the relationship between index hospital LOS and 30-day readmissions in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock. Data used to answer the proposed research questions consisted of older adult discharge records from the 2014 Nationwide Readmissions Database (NRD), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality. Differences in 30-day readmissions between older adult age groups, gender, and older adult location were examined. The number of days to readmission since discharge was evaluated for the subset of older adults with a readmission.

Approximately 15.6% of older adults were readmitted within 30 days of their discharge. Readmissions were statistically different based on the older adult's age, gender, and LOS. Location did not have a significant effect on readmissions. Mean LOS

among readmitted older adults was 10.1 days. Analysis indicates that an older adult's LOS had a significant effect on readmissions, although models performed poorly. Findings suggest that there are certain factors that can predict older adults who are at risk for being readmitted after being discharged with a principle or secondary discharge diagnosis of severe sepsis or septic shock.

Janet Fulton, PhD, RN, ACNS-BC, FAAN, Chair

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACA	Affordable Care Act
AHRQ	Agency for Healthcare Research and Quality
AAT	Appropriate Antibiotic Therapy
CDC	Centers for Disease Control and Prevention
CHIP	Children's Health Insurance Program
CMS	Centers for Medicare & Medicaid Services
HCUP	Healthcare Cost and Utilization Project
HRRP	Hospital Readmissions Reduction Program
ICD-9-CM	International Classification of Diseases, Ninth Revision, Clinical Modification
IPPS	Inpatient Prospective Payment System
LOS	Length of Stay
NRD	Nationwide Readmissions Database
RDW	Red Cell Distribution Width
ROC	Receiving Operator Characteristic
SID	State Inpatient Databases

CHAPTER 1. INTRODUCTION

The American health care system is under intense scrutiny and has been the center of health care reform debate for years. In 2010, the Affordable Care Act (ACA) was enacted, a new era in health care began and preoccupation with testing service and payment models gained momentum. To support oversight of the new legislation, the ACA created and funded the Center for Medicare and Medicaid Innovation, more recently renamed the Centers for Medicare & Medicaid (CMS) Innovation Center. The CMS Innovation Center is responsible for the creation, implementation and oversight of innovative service delivery and payment models aimed at improving or maintaining quality care provision to individuals insured by Medicare, Medicaid, or the Children's Health Insurance Program (CHIP; "CMS Innovation Center Homepage | CMS Innovation Center," n.d.). The expected outcome of these legislative initiatives and resulting government health care programs is to improve quality of care, reduce costs and optimize the health of the population of interest ("CMS Innovation Center Homepage | CMS Innovation Center," n.d.).

Hospital 30-day readmissions are one outcome focus in the Medicare insurance program. Readmissions have demonstrated effects on quality, costs, and population health outcomes. A 30-day readmission is an unplanned admission to a hospital within 30 days of discharge from the same or another hospital, not including psychiatric, children's, or long-term care hospitals ("Hosp. Readmission Reduction | CMS," 2020). As a quality of care indicator, a 30-day readmission is linked to payment with penalties for hospitals incurring excessive readmissions for specific clinical conditions including acute myocardial infarction, heart failure, pneumonia, chronic obstructive pulmonary disease,

coronary artery bypass graft surgeries, and elective primary total hip and/or total knee arthroplasty ("Hosp. Readmission Reduction | CMS," 2020).

From 2009 to 2013, the rate of 30-day readmissions per 100 patient admissions for patients insured by Medicare was 18.1, 18.0, 18.1, 17.5, and 17.3, respectively, exceeding the rate for patients insured by Medicaid, uninsured and private pay (Barrett, Wier, Jiang, & Steiner, 2015). While the trend is moving favorably downward, there is ample room to further reduce 30-day readmissions in this population. In 2011, patients in the United States from all payer groups experienced around 3.3 million 30-day readmissions, which accounted for $41.3 billion of total hospital costs (Hines, Barrett, Jiang, & Steiner, 2014). The largest share of 30-day readmissions and hospital costs was incurred by those insured by Medicare, accounting for 55.9 % of readmissions and 58.2% or $24 billion of the costs (Hines et al., 2014).

Implementing targeted strategies to reduce 30-day readmissions is hypothesized to improve the quality of patient care, improve the patient experience with the health care system, decrease healthcare costs, reduce unnecessary use of health care resources, and position health care systems for success in value-based care (Scott, Shohag, & Ahmed, 2014). Hospital 30-day readmissions have been targeted as a key area for health care reform. At the same time that the ACA created the CMS Innovation Center, it also established the Hospital Readmissions Reduction Program (HRRP) and allowed CMS to reduce payments to hospitals participating in the Inpatient Prospective Payment System (IPPS) when 30-day readmissions exceeded a CMS-determined benchmark (Shen & Li, 2015).

The top three (3) most frequent 30-day readmission conditions for Medicare patients are congestive heart failure, septicemia, and pneumonia, respectively (Hines et al., 2014). Of the $24 billion in total costs for readmissions, these three (3) conditions accounted for $4.3 billion or 18% (Hines et al., 2014). Among the three conditions, septicemia, a bloodstream infection often referred to as sepsis, has national and international attention because sepsis affects millions of people worldwide, leads to millions of deaths annually, and its incidence continues to increase (World Health Organization, 2018).

Hospital length of stay (LOS) is another outcome of interest in determining quality and cost of healthcare. Hospital LOS is the amount of time the patient is hospitalized, usually reported in days, and calculated using day of admission and day of discharge. According to (Carey, 2015), hospitals could save money by keeping patients in the hospital longer and reducing 30-day readmissions. The total cost per patient is known to decrease with each additional day of staying in the hospital, thus increasing the LOS allows physicians and nurses to ensure that reasons for a patients' potential readmissions are identified and mitigated, provide and validate additional education, and monitor the patient's response to changes in treatment and medications (Dietz, Jones, Small, Gaieski, & Mikkelsen, 2017). Among the three top 30-day readmission conditions, studies have been conducted on congestive heart failure and pneumonia (Hines et al., 2014). Previous studies have not focused on the relationship of hospital LOS and 30-day readmissions in older adult severe sepsis or septic shock survivors (Rhee & Klompas, 2017). This study investigated the relationship between hospital LOS and 30-day readmissions in older adults with Medicare as their expected primary payer and who discharged home from the

hospital with a principle or secondary discharge diagnosis of severe sepsis or septic shock. In addition, this study investigated the relationship between the hospital LOS and the time to first readmit within 30 days of discharge among older adults with an expected primary payer of Medicare who discharged home with a principle or secondary discharge diagnosis of severe sepsis or septic shock. This chapter discusses the problem that was addressed in this study, including the purpose statement and the research questions that guided the study. It also provides an overview of the research methods that were used in the study and presents the significance of addressing the problem. Finally, the definition of key terms and a summary of key points is presented at the end of this chapter.

Problem Statement

Sepsis is a life-threatening disease caused by an infectious agent (microorganism) invading the bloodstream and usually affecting functioning of body organs (Shen & Li, 2015). The incidence and prevalence rates of sepsis in the United States have increased exponentially in the last four (4) decades and etiologies include an aging population, immunosuppression, and infectious agents that are multi-drug resistant (Kaukonen, Bailey, Suzuki, Pilcher, & Bellomo, 2014). Older adults account for a significant portion (60-85%) of sepsis episodes (Kaukonen et al., 2014) and incidence is higher in the winter months, often attributed to an increase in respiratory infections (Danai, Sinha, Moss, Haber, & Martin, 2007). When compared to unplanned 30-day readmissions related to pneumonia, chronic obstructive pulmonary disease, heart failure and acute myocardial infarction, the mean LOS of a readmission following index hospitalization with sepsis is found to be longer and the estimated mean cost per readmission is about $500 to $1500 or more for every readmission (F. Mayr, Balakumar, Talisa, Fine, & Yende, 2016).

Risk factors for sepsis 30-day readmissions include prior admission to an intensive care unit, bacteremia, age equal to or greater than 65, immunosuppression, having diabetes or cancer, contracting community acquired pneumonia after discharge, previous hospitalizations, and genetic factors (Prescott, Dickson, Rogers, Langa, & Iwashyna, 2015). The relationship between hospital LOS and 30-day readmissions and timing of first readmission in older adults with an expected payer of Medicare who discharged home with a principle or secondary diagnosis of severe sepsis and septic shock was not known. The increasing rate of sepsis in this population warranted exploration into 30-day readmissions and older adults discharging to home with a principle or secondary discharge diagnosis of severe sepsis or septic shock (Shankar-Hari & Rubenfeld, 2016). It was critical to explore the relationship of hospital LOS and 30-day readmissions to improve care quality and manage hospital costs for this population of older adults (Rhee & Klompas, 2017).

Purpose of the Study

The purpose of this study was to investigate the relationship between index hospital LOS and 30-day readmission rate in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock. The Centers for Disease Control and Prevention (CDC) International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) ("ICD - ICD-9-CM - International Classification of Diseases, Ninth Revision, Clinical Modification," n.d.) was used to identify a principle or secondary discharge diagnosis of severe sepsis (ICD-9-CM 995.92) or septic shock (ICD-9-CM 785.52). Differences in 30-day readmission rate between older adult age groups

(65-74, 75-84, and 85+), gender, and older adult location (urban-rural classification) were explored. Days to readmission since discharge was evaluated for the subset of older adults with a readmission.

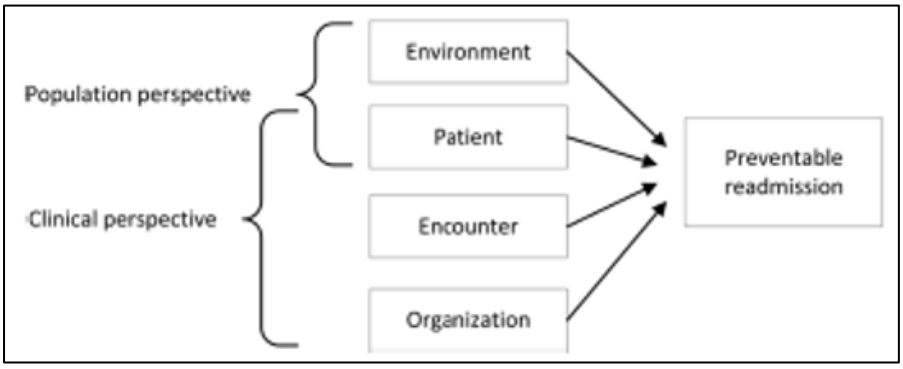
Conceptual Framework

The study was guided by the Conceptual Model of the Determinants of Preventable Readmissions (Vest, Gamm, Oxford, Gonzalez, & Slawson, 2010) (see Figure 1). The conceptual framework assists researchers to organize and evaluate factors associated with readmissions. An assumption of the framework is that healthcare exists where medical care and population health overlap. From a population health perspective, the patient-specific and environmental factors influence outcomes, such as readmissions. From a clinical perspective, process and structure elements of healthcare encounters influence outcomes, such as readmissions (Vest et al., 2010). From these perspectives, the researchers considered that avoidable readmissions operate within four (4) levels, including the patient, environment, organization, and healthcare encounter or encounters.

Patient level factors associated with readmissions include disease states, behaviors, socioeconomic standing, and demographics. Environmental factors associated with readmissions include anything external to both the patient and the healthcare provider or encounter. Organizational factors associated with readmissions include any factors within any healthcare encounter that apply to all encounters within a facility. Finally, healthcare encounter factors associated with readmissions include all activities and events that occur during the index hospitalization.

Figure 1

Conceptual Model of the Determinants of Preventable Readmissions



Operationalizing the Conceptual Framework

The Conceptual Model of the Determinants of Preventable Readmissions recognizes that the population and clinical perspectives converge around the patient. Addressing the interrelated factors that could lead to readmissions of older adults with severe sepsis or septic shock within 30 days of discharge, the following factors that were used in this study, based on the literature review, are organized according to the Conceptual Model of the Determinants of Preventable Readmissions at three of the four levels. Hospital encounter(s) level was not studied (see Table 1).

- Patient level variables
    - Age and age group (65-74 years, 75-84 years and 84+ years) – Older adults diagnosed with sepsis over the age of 80 years more often experienced readmittance within the 30-day period (Goodwin, Rice, Simpson, & Ford, 2015).
    - Gender – Older men more often reported nonadherence to healthy behaviors and poor dietary choices (Satariano, 2006).
- Environmental level variable

- Patient location (rural-urban classification)
- Organization level variable
    - LOS in hospital. There are different views regarding the benefits of longer hospital stay periods, this factor warranted further research (Goodwin et al., 2015).
- Outcome of interest
    - Readmission (yes/no)

Table 1

Linking Variables to the Conceptual Model (Determinants of Preventable Readmissions)

Variable	Linkage to Model
Age	Patient level variable
Age group	Patient level variable
Gender	Patient level variable
Patient location	Environmental level variable
Index hospital LOS	Organization level variable
Readmission	Outcome of interest

Assumptions

The assumptions of the study included the following:

1. The sample of older adults was representative of the population of older adults (> 65 years) who discharged from the index hospital with Medicare as the expected payer and a principle or secondary discharge diagnosis, coded using ICD-9-CM, of severe sepsis (ICD-9-CM 995.92) or severe sepsis with septic shock (ICD-9-CM 785.52).
2. The 30-day window for readmissions adequately represented the expected influence the index hospitalization LOS had on readmissions.

3. The data analysis chosen for each research question was grounded in sufficient evidence for each question and variable level of measurement.

Research Questions and Hypotheses

Based on the knowledge gap identified, the focus of this study was to investigate the relationship between index hospital LOS and 30-day readmissions in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock. Additionally, the association of 30-day readmission rates and older adult age groups (65-74, 75-84, and 85+), gender, and older adult's location (urban-rural classification) was examined. Days to readmission was evaluated for the subset of older adults who had a readmission. This study proposed to answer the following research questions.

Research question one: What percentage of older adults whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock had a 30-day readmission?

Research question two: Is the index hospital LOS associated with 30-day readmission rates in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock?

Research question three: Is age associated with 30-day readmission in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock? This was examined using age as continuous and as age groups (65-74, 75-84, 85+).

Research question four: Is gender associated with 30-day readmission rate in older adults whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock?

Research question five: Is associated with 30-day readmission rates for older adults whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock?

Research question six: What was the mean number of days to readmission after discharge for older adults who had a readmission?

Significance of the Study

Hospital readmission is of growing importance in the healthcare industry because of associated costs and impact to quality of patient care, specifically in cases of life-threatening diseases such as sepsis (Rhee & Klompas, 2017). The increasing interest in sepsis has highlighted the uniqueness in severe sepsis or septic shock survivors. This study explored the relationship between index hospital LOS and 30-day readmissions in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock. The results of this study will assist healthcare providers with decision-making related to the management of severe sepsis or septic shock survivors through 30-days after hospital discharge. The results of this study provide insight into the relationship between index hospital LOS and 30-day readmissions in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock and will add to the body of knowledge on hospital readmissions. Furthermore, the results of the study was an initial investigation to

exploring or developing healthcare management programs for older adults who survive severe sepsis or septic shock.

Nature of the Study

A retrospective cross-sectional research design was employed to examine the relationship between index hospital LOS and 30-day readmissions in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock. An observational study was used because archival data was used for the analysis. The data for the variables were previously collected and there was manipulation of variables after the data was collection, which was necessary for analysis (Parylo, 2012). A cross-sectional research design was appropriate because the focus of the study was to explore data collected at a point in time. The data for this study was collected during 2014.

The target population for this study was older adults (65+) whose expected primary payer at the time of the index discharge was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock. The older adults were 65 years old or above at the time that the data were collected. Publicly available data was used in the study. The data extracted for use in the study included demographic characteristics of older adults, age, the number of days to first readmission, gender, and location (urban-rural classification) as well as data on index hospital LOS, and 30-day readmissions.

Statistical analysis was performed using R package version 3.4.2 (The R Foundation, 2020). The NRD discharge weight variable was used to calculate national readmission estimates. Logistic regression was used to adjust for other factors and

examine the relationship between index hospital LOS and 30-day readmissions. Chi-square test of independence or Fisher's exact test was used to examine the associations between age groups, gender, and older adult location and 30-day readmission (yes/no) . Logistic regression models were used to examine these associations. Days to readmission since discharge was calculated for older adults with a readmission. Summary statistics were reported for days to readmission.

Definition of Terms

1. *30-day readmission*: An unplanned admission to a hospital within 30 days of discharge from the same or another hospital and does not include psychiatric, children's, or long-term care hospitals (Shankar-Hari & Rubenfeld, 2016).
2. *Hospital*: To be considered a hospital, an entity must be "primarily engaged in providing, by or under the supervision of a physician, to inpatients A) diagnostic services and therapeutic services for diagnosis, treatment, and care of injured, disabled, or sick persons or B) rehabilitation services for the rehabilitation of injured, disabled or sick persons." ("Hospitals | CMS," n.d.)
3. *LOS*: The number of days a patient spends in the hospital (Prescott et al., 2015).
4. *HRRP*: Federal program established as part of the ACA in 2010 that requires CMS to reduce payment to hospitals with excessive readmission rates for specified conditions (Prescott et al., 2015).
5. *Hospitalization*: Admission to a hospital (Prescott et al., 2015).
6. *Index hospital*: The hospital in which the principle or secondary diagnosis is the target diagnosis for the study, the patient is discharged alive, is not discharged against medical advice, and is not transferred out to another acute care hospital (Prescott et al., 2015).
7. *Older adults*: Individuals aged 65 years or older (Soto-Perez-de-Celis, Li, Yuan, Lau, & Hurria, 2018).
8. *Older adult groups*: Older adults 65-74 years, 75-84 years, and 85+ years (Prescott et al., 2015).

Summary

Hospital readmissions are a quality of care outcome and associated with payment penalties for hospitals who have excessive 30-day readmissions ("Hosp. Readmission Reduction | CMS," 2020). From 2009 to 2013, the rate of 30-day readmissions per 100 patient admissions for patients insured by Medicare was 18.1, 18.0, 18.1, 17.5, and 17.3,

respectively, exceeding Medicaid, uninsured, and private pay patients (Barrett et al., 2015). While the trend is moving favorably, there is ample room to further reduce readmissions in this population. Implementing targeted strategies to reduce readmissions is hypothesized to improve the quality of care provided to patients, improve the patient experience with the health care system, decrease healthcare costs, reduce unnecessary use of health care resources, and position health care systems for success in value-based care (Scott et al., 2014).

Hospital LOS is another outcome variable commonly investigated in healthcare. According to (Carey, 2015), hospitals could save money through keeping patients longer in the hospital to reduce readmissions. Increasing the LOS allows physicians and nurses to ensure that reasons for patients' potential readmissions are identified and mitigated, provide and validate additional education, and monitor the patient's response to changes in treatment and medications (Dietz et al., 2017). Specifically, this study focused on investigating the relationship between hospital LOS and 30-day readmission rates and days to first readmission in older adults (65+) whose primary expected insurance was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock. Sepsis is a life-threatening disease, which is caused by infection that invades the bloodstream and may affect the functioning of organs (Shankar-Hari & Rubenfeld, 2016). These diagnoses were specifically chosen for this study due to the associated mortality and morbidity as well as the need to further understand their discharge trajectory, especially with regard to readmission rate.

This chapter provided a discussion of the problem and the purpose statements. It included the research questions considered in this study. Additionally, this chapter

included an overview of the research methods and the significance of the study and it ended with the definition of terms and a summary of Chapter 1.

CHAPTER 2. LITERATURE REVIEW

Septicemia, a bloodstream infection often referred to as sepsis, has received national and international attention because it is one of the top three readmitting conditions for Medicare patients (Hines et al., 2014), it affects millions of people worldwide, killing millions diagnosed with it annually, and its incidence continues to increase (World Health Organization, 2018). Because a 30-day readmission is a quality of care outcome and associated with payment penalties for hospitals that have excessive readmissions ("Hosp. Readmission Reduction | CMS," 2020), reducing readmissions has become an important national issue. Implementing targeted strategies to reduce readmissions is hypothesized to improve the quality of care provided to patients, improve the patient experience with the health care system, decrease healthcare costs, reduce unnecessary use of health care resources, and position health care systems for success in value-based care (Scott et al., 2014). One way in which researchers have hypothesized to reduce readmission is to keep patients longer in the hospital (Carey, 2015) to allow physicians and nurses to observe the patients more and ensure that the potential reasons for readmission are managed accordingly (Dietz et al., 2017). The research gap that this study aimed to address was the lack of empirical evidence on the relationship between index hospital LOS and 30-day readmissions in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock (Rhee & Klompas, 2017).

The purpose of this study was to investigate the relationship between index hospital LOS and 30-day readmissions in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary

diagnosis of severe sepsis or septic shock. ICD-9-CM was used to identify a principle or secondary discharge diagnosis of severe sepsis (ICD-9-CM 995.92) or septic shock (ICD-9-CM 785.52). Differences in 30-day readmissions between older adult age groups (65-74, 75-84, and 85+), gender, and patient location (urban-rural classification) was explored. Readmission timing by day after discharge was evaluated for the sample.

Statistical analysis was performed using R package version 3.4.2 (The R Foundation, 2020). Logistic regression was used to control for confounders and examine the relationship between index hospital LOS and 30-day readmissions. Chi-square test of independence or Fisher's exact test was used to examine the differences in 30-day readmissions within age groups, gender, and patient location. Readmission timing by day of discharge was evaluated by calculating the number of days from discharge to readmission for all patients in the sample. Summary statistics was reported for readmission timing data.

This literature review provides scientific rationale for this study by examining knowledge uncovered by recent research studies regarding readmissions among sepsis survivors and its relation to their LOS in a hospital. The organization of this chapter is as follows: the first section of this literature review discusses the scientific rationale for this study. The second section provides a background on sepsis as a disease, including the circumstances that individuals afflicted with sepsis experience. The third section discusses hospital readmissions, particularly the norm of readmissions for sepsis patients and the various factors that are associated with readmission in the context of sepsis. The fourth section presents past research findings on the connection between hospital LOS

and readmission both in the general sense and among sepsis patients. The chapter ends with a summary of the literature review.

Older Adults

Older adults comprise a significant portion of the American population. According to Rafalimanana (2013), there is an expected global increase in the number of individuals 60 years and above. Trends show that the current 841 million will rise to more than two (2) billion by 2050 (Rafalimanana, 2013). There is also an expected increase in the United States (US), with 43.1 million individuals over 65 years of age in 2012 projected to become 83.7 million by 2050 (Ortman, Velkoff, & Hogan, 2014). Due to the large number of individuals from the generation of baby boomers, it is projected that more than one fifth of the American population will reach 65 years of age by 2030. Older adults were also found to be responsible for a significant portion of hospital visits. Albert, McCaig, and Ashman (2013) stated that 19 million visits to the United States' emergency departments, which comprises 15% of emergency department visits nationwide, were due to older adults. More than a third of these visits resulted in admission into a hospital for continued care. It is, in part, due to this that there is a need for hospital systems to continue with their advancement in healthcare practices and healthcare access.

Changes with Aging

There are various physiological and psychological changes that come with age. Essentially, the process of aging is characterized by a decline in efficiency on the body's efforts to maintain itself. This begins on the cellular level, wherein a slower and lower rate of repair, regeneration, and reproduction results in damaged or defective

biomolecules. Wohlgemuth, Calvani, and Marzetti (2014) suggested that this decline in cellular quality control significantly impacts negative changes in muscle composition and functional ability, mostly during the later parts of life.

Functional Ability and Overall Health

Aging is usually first manifested through changes in the musculoskeletal system, after which it also becomes evident through the decline in internal bodily functions such as respiration and digestion. Hamerman (1997) explained that individuals reach their peak in terms of bodily function shortly before 30 years of age, after which these functions gradually decline. Despite this, there is a significant number of functions that remain sufficient for everyday living. This is due to functional reserve, which pertains to the fact that most organs are designed to have a considerably higher capacity to function than is usually required by the body (Hamerman, 1997). Due to the inevitable decline in bodily functioning that comes with age, older adults become less likely to effectively handle stress. Some organs, such as the heart and blood vessels, the urinary organs, and the brain, are also likely to malfunction during stressful experiences at this stage in life. These stresses include pollution (Bentayeb et al., 2012), extreme temperature changes in the environment, and acquired chronic conditions (Zanobetti, O'Neill, Gronlund, & Schwartz, 2012). The associated reduction in older persons' tolerance to biological stress impacts their increased vulnerability to critical illnesses such as sepsis (Starr & Saito, 2014). In 2001 sepsis was identified as the tenth leading cause of death in persons older than 65 years (Starr & Saito, 2014).

Cognitive Impairment

With regard to the nervous system, a growing body of research has found a link between age-related loss of physical and cognitive function and the degeneration of cerebral structures and functions of the brain (Rosso, Taylor, Tabb, & Michael, 2013). For example, Hoffstaedter et al. (2015) found that cerebral gray matter, which is associated with mobility, undergoes atrophy as individuals age and results in movement deficits. Cognitive functions, including learning, memory, vocabulary, and comprehension, were also found to regress past the age of 70 (Woods, Cohen, & Pahor, 2013). Delirium is another factor that is increasingly common among older adults. Studies of Brummel et al. (2014) and of Woods et al. (2013) found that these transient episodes of cognitive regression are largely responsible for the decline in physical ability as well.

These physical and cognitive impairments that older adults experience also put them at risk of other health issues. Nazemi et al. (2015) found that impairments such as sensory loss, lack of appetite, mobility and muscle movement difficulties, cognitive deficits, and depressive symptoms contribute to older adults' greater susceptibility to experiencing malnutrition. While chronic and acute diseases and the use of various medications contribute to older adults' eating restrictions or lack of appetite, the resulting issue of malnutrition can also exacerbate already existing diseases in the individual, such as mental disorders or osteoporosis. The study also pointed out that malnutrition may also place them at higher risk of infection and dehydration (Nazemi et al., 2015). This factor is important in the current study as malnutrition could negatively impact on the patient's

ability to recover from sepsis. Impaired cognition or depression may be detrimental to adherence to the treatment regime.

Immunosenescence

Older adults also tend to experience gradual deterioration of the immune system brought on by natural age advancement, known as immunosenescence. This process reduces the immune system's ability to take the necessary actions against pathogens. Castelo-Branco & Soveral (2014) note that it is not caused by any single impairment; however, this ultimately lower's the body's defense system against infections. This is why it is not uncommon for elderly individuals to experience decreased effects from vaccines and increased vulnerability to infections. Starr and Saito (2014) pointed to the impaired ability of older adults who are diagnosed with sepsis to recover from this critical condition due to immunosenescence.

Related Variables Pertaining to Readmissions

Different correlational studies were found while reviewing the literature on hospital readmission of older adults. Other variables that could impact readmissions of older adults were noted. While determining the impact of older adults' perceptions of readiness to be discharged, Lau et al. (2016) conducted face-to-face interviews with those on the verge of being discharged. Lau et al. calculated a LACE index, together with other assessment scores, for individuals. The LACE index, a predictive score for 30-day readmissions after being discharged—consists of 25% of each of the following (i) LOS, (ii) acuteness of admission (direct admit vs emergency department admit), (iii) Charlson index, and (iv) the number of emergency department visits in the previous six (6) months. The participants had to indicate on a 10-point Likert scale whether they felt ready to be

discharged. The findings were inconclusive and no significant relationship between feeling ready to be discharged and 30-day readmissions was discovered.

A study on readmissions after coronary artery bypass surgery the following risk factor variables were identified: post-operative infection accounted for the highest number of readmissions (Hannan et al., 2011). This finding is of interest for this current study on the presence of severe sepsis and readmissions. In addition, increased risk of readmission was associated with growing older, gender (female), ethnicity of patients (African-American), being overweight, comorbidities such as renal failure, and being discharged to an institution/home without skilled nursing care (Hannan et al., 2011).

A study that focused on the correlation between LOS and 30-day readmission of patients with heart failure was determined to be of significance to this study. Khan et al. (2015) argued that a longer LOS is, from the onset, an indication of the severity of the patient's condition since it is only patients with more severe conditions who are kept in the hospital for longer. The study by Khan et al. included 4,020 patients from 20 hospitals across different countries which enabled them to compare regional information as well. The findings indicated that longer LOS could be linked with a higher probability of 30-day readmissions of all the conditions studies—cardiovascular disease and non-heart failure patients. In the case of patients with heart failure, there was a decreased risk of readmission within 30 days.

Longer LOS could be contraindicated due to risk factors associated with staying in the hospital longer. In a retrospective, cross-sectional study, Lee et al. (2018) pointed out that longer LOS was associated with a higher risk of infections and preventing other patients from being admitted to the hospital because of bed capacity. However,

preoperative conditions were found to be the main factors in determining the need for a longer hospital stay and were explained to be indicative of the patient already being sicker when arriving at the hospital to undergo the surgery. On the other hand, increased pre-operative quality of care decreased the need for prolonged LOS post operatively.

Older Adults' Susceptibility to Sepsis

Older adults are more susceptible than younger adults to experience sepsis. Among patients studied, correlational analyses found that, in general, individuals who are afflicted with severe sepsis tend to be in their seventh decade of life (with a median age of 68 years; Gaieski, Edwards, Kallan, & Carr, 2013; Stoller et al., 2016). Incidences of sepsis were found to increase significantly as one grows older. Angus and Van Der Poll (2013) uncovered that while sepsis occurs in only 0.2 of 1000 children, it occurs in 5.3 cases of 1000 adults from 60 to 64 years old, and 26.2 of 1000 adults 85 years and older. They added that the rate of mortality increases in a similar way. While there is a 10% mortality rate among children, it increases to 26% among individuals 60 to 64 years of age and 38% among those 85 years and older.

An impaired immune system is known to significantly contribute to the likelihood of developing severe sepsis in any population of patients (Johnston, McSorley, Anderton, Wigmore, & Maizels, 2014). This was found to be especially common among older adults, as changes arise in the structure and function of the components of the immune system with age, contributing to the susceptibility of older adults to infection. This dysfunction, or immunosenescence, is complex and includes a declining number of T cells and depressed T-cell response, which results in the decreased ability to respond to

new pathogens and predisposes older adults to more frequent and severe infections (Starr & Saito, 2014).

Similar results were found in Liang's study (2016), which added that this increased risk of developing sepsis and severity and mortality rates among older adults are partly due to the regression of the immune system with age. Specifically, "prolonged host inflammatory responses, a tendency toward coagulation activation and impaired fibrinolysis, and an increased susceptibility to microbial mediators including endotoxin leading to profound and persistent hypotension" were found to be associated with the older adult's greater susceptibility to sepsis (Liang, 2016). Liang's findings corroborated those of Turnbull et al. (2009). While it was commonly thought that the presence of defective T and B lymphocytes resulted in the older adult's weak defense system against pathogens, their analysis challenged this, concluding instead that the process of aging itself naturally affects individuals' innate immunity. Thus, the aging process compromises the functionality of the immune systems in the elderly population and contributes to increased incidence of sepsis and mortality related to sepsis (Turnbull et al., 2009). Meanwhile, other diseases that are significantly more prevalent among the elderly, such as diabetes, were also found to be some of the most common risk factors for sepsis (Lemay, Anzueto, Restrepo, & Mortensen, 2014).

The increased likelihood of older adults experiencing sepsis can be explained by the poor health status that is generally characteristic of older adults, as evidenced by higher likelihood of being afflicted with multiple clinically apparent and subclinical diseases. Because of this, it would follow that they are also at higher risk for developing an infection (Yende et al., 2013). For instance, adults between 65 and 70 years of age are

nearly five times as likely to be hospitalized for pneumonia than are those less than 50 years old (Yende et al., 2013).

Sepsis

Septicemia, or sepsis, is defined as "a serious systemic infection characterized by intense inflammation intertwined with profound alteration of vascular function, often followed by a state of relative immune paralysis" (Bernard & Bernard, 2012). In general, sepsis is a potentially fatal disease wherein the body has a systemic response to an infection, which can cause irreversible damage to the body's tissues and cells. This usually occurs as a result of the body's inability to successfully contain and clear an infection, or due to organ damage resulting from the invading host or the body's inability to maintain homeostasis resulting in alterations including acute respiratory distress / failure, severe acute pancreatitis, and heart and/or kidney failure. Sepsis most commonly affects the lungs, but it can also primarily occur as skin, abdominal, genitourinary, and catheter infections (Angus & Van Der Poll, 2013).

Research findings suggest that tachycardia, hypotension, hyperglycemia, hypo- or hyperthermia, tachypnea, edema, and an altered mental status are most often associated with a diagnosis of sepsis (Dellinger et al., 2013). Signs of abnormal white blood cell count and elevated plasma levels of C-reactive proteins can also indicate the occurrence of sepsis. Severe sepsis and septic shock may be identified when there is evidence of abnormal levels of organ dysfunction and arterial hypotension. Severe sepsis with organ failure comprises at least 60% of sepsis diagnoses (Lagu et al., 2012).

Severe sepsis occurs as a result of both community-acquired and healthcare–associated infections (Angus et al., 2001). About half of all sepsis cases were found to be

caused by pneumonia, followed by intra-abdominal and urinary tract infections. There are equal proportions of cases in which blood cultures are typically positive or negative in all sites (Linde-Zwirble & Angus, 2004). Survivors of sepsis are likely to experience various complications alongside sepsis, including muscle wasting, functional disability, and cognitive impairment for a period extending beyond several years after discharge (Desai et al., 2011; Iwashyna et al., 2012).

Due to the high frequency with which 30-day readmissions occur after sepsis, as well as the co-morbidities and mortality rates associated with sepsis, it has become an additional condition that warrants attention at the national level in the United States (Cooke & Iwashyna, 2014). Every year in the United States, there are approximately 700,000 cases of sepsis, which results in an economic burden of approximately $15–24 billion annually (Mayr, Yende, & Angus, 2014). Most patients who present with sepsis receive initial care in the emergency department and they generally have a 20% or more risk of short-term mortality (Angus & Van Der Poll, 2013).

A total of 6,067,789 discharges for severe sepsis were recorded from 2008 to 2012, as noted in a U.S. census that included 308,745,538 individuals. Over the study period, there were statistically significant increases in the annual incidence of discharges after severe sepsis, from 346/100,000 to 436/100,000 individuals each year. (Stoller et al., 2016). Meanwhile, a recent report by Liu et al. (2014) on sepsis in the U.S. national landscape found that sepsis contributed to 45% of in-hospital deaths. It is important to note that the current numbers recorded in studies are likely to underestimate the total impact of sepsis because of the possibility that many patients admitted with other common diagnoses either also have sepsis or develop sepsis during their hospital stay

(Cooke & Iwashyna, 2014). Because sepsis is now the most common non–pregnancy-related principle discharge diagnosis for Medicare and Medicaid and among the most common for private payers (Torio & Moore, 2016), the Agency for Healthcare and Research Quality recommended the addition of a specific focus on sepsis, so that CMS might achieve greater improvements in patient outcomes and advance the quality of hospital-based care.

Methods of effective sepsis care consist of a variety of complex means, from early recognition to aggressive treatment with intravenous fluids, antibiotics, and vasopressors, among other therapies and treatments (Prescott, Langa, Liu, Escobar, & Iwashyna, 2014). Growing evidence suggests that severe sepsis survivors are likely to suffer from additional complications in the long-term, post-sepsis. For instance, initial severe sepsis survivors have higher risks of death and cognitive dysfunction and exhibit a greater use of healthcare resources after hospital discharge (Liu et al., 2014; Prescott et al., 2014)

As discussed in the previously mentioned studies, sepsis and the outcomes following it can be thought of as results of a complex interplay between various baseline characteristics, such as pre-illness health status, risk factors for infection, dysregulated immune responses, health care setting, treatments provided, and the patient's response to treatments (Shankar-Hari & Rubenfeld, 2016).

Sepsis in Older Adults

Compared to the general population, there are no differences in the criteria for diagnosis of sepsis among older adults. Diagnosis includes evidence or a suspicion of an infection, along with a change in the patient's hemodynamic or hematological values, which consist of temperature, blood pressure, respiratory rate, and tachycardia (Sehgal,

Bajwa, Consalvo, & Bajaj, 2016). Additionally, sepsis can be suspected when there are signs of organ dysfunction, manifested as an increase in a lactic acid level or cardiac index and the presence of hyperbilirubinemia, hypoxia, and/or renal dysfunction (Sehgal et al., 2016).

Common contributing causes of sepsis in older adults include infections in the respiratory, cardiovascular, and genitourinary systems. Other infections, whether fungal or gram-negative infections in the context of pneumonia, were also found to more strongly contribute to the development of sepsis among older adults than among adults less than 65 years of age (Ginde, Moss, Shapiro, & Schwartz, 2013). The process of diagnosing sepsis among older adults may also be complicated by the presence of symptoms common to sepsis and other conditions that are observed in older adults (Wester, Dunlop, Melby, Dahle, & Wyller, 2013).

Physical Consequences of Sepsis in Older Adults

A variety of physical complications arise as a result of sepsis among older adults. For instance, a study by Iwashyna et al. (2012) on the effects of severe sepsis on elderly survivors found higher rates of low body mass index, even after controlling for the patients' health statuses pre-sepsis and projected comorbid geriatric conditions. This finding suggests that severe sepsis significantly increases loss of skeletal muscle tissue more than the loss of muscle tissue that naturally occurs with aging.

Sepsis also increases the risk of stroke for as long as 365 days after a discharge following admission for sepsis. The risk of stroke was documented to be highest within 15 days after discharge with sepsis and decreases the longer it has been since the sepsis event (Boehme, Ranawat, Luna, Kamel, & Elkind, 2017). The risk of having an ischemic

stroke within 180 days of hospitalization for sepsis varied significantly with age with individuals younger than 45 years at most risk of having a stroke due to sepsis, followed by similar risk profiles for those aged 45 to 65, and older than 65 (Boehme et al., 2017). These findings are similar to the findings of Lee et al. (2014), but a notable difference was that this association between sepsis and stroke only occurs with age and ischemic stroke, not with hemorrhagic stroke. Altogether, these findings suggest that even when sepsis patients survive their sepsis hospitalization, the battle is only half-won. They are at increased risk of cardiovascular disease and stroke, and subsequent mortality. It remains unclear whether the increased risk of stroke after sepsis is because of the shared risk factors and comorbid conditions that can place a patient at risk for both sepsis and stroke at similar times, or whether sepsis is independently associated with risk of stroke.

Mortality is also a common consequence of sepsis among individuals with ages on the extreme ends of the developmental spectrum. Infants and older adults have a higher risk of mortality than persons in other age demographics because of the weak immunity that is characteristic of these developmental stages (Gentile et al., 2014).

Functional Consequences of Sepsis in Older Adults

When examining the health consequences among older adult patients, it is important to include their functional status. According to Elsawy & Higgins (2011), there are two dimensions of functional ability that must be considered. First are the activities of daily living, which pertain to the patient's ability to perform self-care activities such as bathing and toileting. Second are the instrumental activities of daily living, which pertains to the patient's ability to perform activities that are needed in order to live independently, such as preparing meals and cleaning their homes. Additional evidence of

this was reported by Nasa, Juneja, & Singh (2012), which stated that assessing elderly patients' functional status is a significant predictor of the clinical outcomes.

Researchers have shown that older adults who survive sepsis have altered impairment, particularly in terms of function and cognition as well as a decrease in overall quality of life. A study by Iwashyna, Netzer, Langa, and Cigolle (2012) on older adult sepsis survivors demonstrated that they experienced significant changes in cognition and functional ability. Specifically, they reported a significant relationship between severe sepsis and a three-fold rate of progression from mild to severe cognitive impairment, and the patients in their cohorts were found to have regressed in their frequency and ability to perform instrumental activities of daily living. As noted in the work by Wester et al. (2013), unspecific functional deterioration, such as reduced ability to complete daily tasks, may be the only symptom of sepsis after discharge.

Such changes in brain function and body composition contribute to frailty, increasing an older adult's need for assistance with activities of daily living, instrumental activities of daily living, both of which can compromise their independence. Survivors of severe sepsis and other critical illnesses often require significant additional healthcare compared to their pre-sepsis state, frequently in inpatient settings such as long-term acute care hospitals, inpatient rehabilitation facilities, and skilled nursing facilities (Prescott et al., 2014).

Burden of Sepsis on Family and Caregivers

Every year, approximately 65 million people in the United States (29% to 39% of the population) act as caregivers for a chronically ill, disabled, or older family member or friend. They look after them in terms of medical care as well as ensure that their basic life

functions are properly managed as well. Due to the presence of these caregivers, people who need assistance are better able to maintain their health and function adequately in their home settings (Sarkar & Bates, 2014). According to Coleman (2003), one of the major functions that these caregivers do is to serve as communication conduits with the hospital system and health care providers, discussing issues related to the patient that may require joint decision-making and assisting with the direct handling of the patient. Likely caregivers of older adults include spouses, children, friends, relatives, or hired individuals (Coleman, 2003).

Sepsis among older adults was found to place extra burden on the adult's primary caregiver. While researchers have acknowledged that the mortality rates associated with sepsis have decreased in the last ten years, having sepsis has exacerbated consequences for older adults, which significantly increases their reliance on their caregivers (Rowe & McKoy, 2017). These consequences include decreased quality of life, increased functional impairments, and higher rates of rehospitalization. As severe sepsis was found to significantly contribute to long-term functional disability and cognitive impairment among older patients, sepsis survivors have an increased need for skilled nursing care/skilled nurses and other caregivers outside the health care system after acute hospitalization (Iwashyna, Netzer, Langa, & Cigolle, 2012). Similar findings were reported in Liang's (2016) study. From initial diagnosis of sepsis among older adults, to treatment and monitoring of the disease, caregivers are given additional responsibilities and burdens. Particularly due to the high mortality and morbidity likelihood that is characteristic of sepsis among older adults, caregivers must be involved in all discussions

related to patient preferences and expected clinical outcomes, contributing to increased caregiver burden and stress (Liang, 2016).

Burden of Sepsis on The Health Care System

A substantial amount of financial, human, and health care resources are used in treating complications in the terminal stages of a patient's life, even if the treatment modalities do not have effective clinical outcomes. The majority of patients who consume health care resources and account for dollars spent are from the older adult population with most treated outside of the intensive care unit (Stiermaier et al., 2013).

Researchers have concluded in recent literature that sepsis is the most expensive condition to manage in hospitals throughout the United States. Not only is a 30-day readmission more likely in this population, but it is also two to three times costlier than a readmission due to other medical conditions, such as heart failure and pneumonia (Mayr et al., 2016). Overall, the Agency for Healthcare Research and Quality (AHRQ) revealed that recent annual costs of sepsis management averaged $30 billion, more than half of which was allocated for the treatment and care of individuals aged 65 years and above (Torio & Moore, 2016). Between 1998 to 2004, a total spending of $261 billion was used in the hospitalization of older adults in the United States, with nearly 60% spent on sepsis and pneumonia. The hospitalization rates, along with the expenses, for these two conditions have increased since 2000, particularly among patients older than 85 years (Stiermaier et al., 2013). Among older adult patients, who make up more than half of all intensive care unit admissions due to sepsis, more than 75% of those who survived the disease were more likely to either be rehospitalized or placed in skilled nursing facilities after initial discharge (Starr & Saito, 2014).

Despite the large amount of expenses that hospitals spend to take care of people who have been diagnosed with sepsis, Sehgal et al. (2016) report that the current protocols and guidelines, in the context of older adults with severe sepsis and septic shock, are still vague. Given the increasing fragility of an older adult's body systems as they age, it is important that factors and procedures that complicate the clinical treatment of older adult patients who develop sepsis have careful consideration prior to implementation to provide the best possible quality of health care and its associated outcomes while also reducing unnecessary and excessive expenses (Sehgal et al., 2016).

Hospital Length of Stay

Severe sepsis had relevant trends among their targets from the years 2008 to 2012, as found from an analysis of the HCUP National Inpatient Sample (Stoller et al., 2016). As the number of sepsis cases increased, LOS and hospital charges also increased at a statistically significant rate (Stoller et al., 2016). A review of Medicare beneficiaries between 2012 and 2018 supported other's work and indicated that sepsis is costly, both in terms of mortality and costs (Buchman et al., 2020).

Patients with severe sepsis, even those who do not require intensive care unit admission, often need prolonged and recurrent health care from hospitals and other inpatient facilities after hospital discharge. A study by Prescott et al. (2014) comparing 1,083 sepsis patients with a mean age of 78.5 to 1,083 non-sepsis patients showed that the rate of inpatient healthcare use and hospital stay increased from 24.2 days per patient-year pre-severe sepsis to 47.9 days per patient-year post-severe sepsis. A study by Liu et al. (2014) echoed these findings, demonstrating that the proportion of days sepsis

survivors spend alive admitted to a healthcare facility increases by nearly three times in the year after sepsis hospitalization compared with the year before.

Hospital Readmission of Patients with Sepsis

It was widely found that alongside experiencing increased healthcare usage in the year following their admission, sepsis survivors are also susceptible to increased 30-day readmission rates. Compared to non-sepsis patients who were admitted to hospitals, sepsis survivors are at a greater risk of rehospitalization (Prescott et al., 2015; Sun et al., 2016). Donnelly, Hohmann, and Wang's (2015) study using more than 216,000 patients admitted with severe sepsis found that one (1) in 20 were unplanned readmissions within seven (7) days after hospital discharge and that one (1) in five (5) were readmitted within 30 days after hospital discharge (Donnelly, Hohmann, & Wang, 2015). This rate is echoed by Liu et al. (2014) population-based study in a community healthcare system, where one (1) in every six (6) sepsis survivors were readmitted within 30 days of hospital discharge. Three (3) of every six (6) were readmitted within one (1) year of hospital discharge. Fewer than half of rehospitalizations were due to sepsis and were instead due to other complications. Patients had a three-fold increase in the percentage of living days spent in hospitals or care facilities after sepsis hospitalization These results indicates that the impact of sepsis on the individual extends well beyond the initial hospitalization (Liu et al., 2014).

Compared to patients' usual, pre-sepsis healthcare utilization, a nationally representative cohort of older adult adults with severe sepsis were found to have a significantly greater use of inpatient facilities after hospital discharge. In terms of LOS, patients are likely to spend a mean of 25% of their remaining days alive following an

index admission in an inpatient healthcare facility (Prescott et al., 2014). Most patients were rehospitalized, many more than once. Among those who have not been rehospitalized, only one (1) in five (5) severe sepsis survivors remained alive for a full year (Prescott et al., 2014).

Increased healthcare utilization and rehospitalization rates reinforce previous findings that the effects of critical illness reach far beyond the hospital discharge. Significant burden may be placed on patients and their families and/or caregivers after the initial discharge. Caregivers, in particular, were found to experience depression and lifestyle or employment disruption due to the difficulties they experience in caring for sepsis survivors (Desai, Law, & Needham, 2011).

A significant number of older adults diagnosed with sepsis who get discharged from the hospital tend to disposition to a post-acute care facility, such as long-term care hospital, inpatient rehabilitation facility, or skilled nursing facility, rather than to home. According to Martin, Mannino, and Moss (2006), only 54% of older patients return home after acute hospitalization, compared to 75% of younger patients. In recent years, admission rates of older adults diagnosed with sepsis into a post-acute care facility after hospitalization have been consistent, as evidenced by a 44.9% rate in 2008 compared to a 42.6% rate in 2012 (Stoller et al., 2016). Several studies have examined readmission following sepsis, particularly the burden that sepsis readmission places on the patient and family in terms of cost, mortality, and healthcare resource utilization. Researchers have consistently suggested that health care utilization increases after sepsis (Liu et al., 2014; Prescott et al., 2014; Ortego et al., 2015).

Evidence suggests that readmission after hospitalization with severe sepsis is common and associated with significant mortality, cost, and an increase in health care utilization after discharge. Goodwin et al. (2015) reported that almost half of all severe sepsis survivors require readmission within six months of discharge and the majority of readmissions occurred within the first 30 days. If these results were generalized to the entire United States population, over 91,300 readmissions would occur annually within 30 days of hospital discharge and over 171,300 readmissions within 6 months of discharge. Financially, this would result in 14,200 and 30,100 in-hospital deaths and $3 billion and $9 billion in cost, respectively (Goodwin et al., 2015).

Readmissions due to Additional Complications

Most readmissions among sepsis survivors were not due to sepsis, but for other infectious diagnoses or other conditions/complications (Liu et al., 2014). Donnelly, Hohmann, and Wang (2015) found that 41.3% of the diagnoses for 7-day readmissions were related to sepsis and 40.3% for 30-day readmissions were due to sepsis. The majority of the readmissions following severe sepsis were due to a diagnosis of infection (68.3% and 66.9%, respectively). Another study reported that when readmissions occur following sepsis, nearly 30% were due to another episode of sepsis and 60% were due to infections (Chang, Tseng, & Shapiro, 2015).

This pattern in sepsis was found to be similar to that seen in other common and costly hospital conditions. In particular, among Medicare patients hospitalized for heart failure, acute myocardial infarction, or pneumonia, between 18% and 25% were rehospitalized within 30 days of acute care discharge, with fewer than one third of the readmissions due to the same diagnosis (Dharmarajan et al., 2013).

Studies on sepsis mortality indicate that sepsis patients are at increased risk of mortality post-sepsis; additionally, 70% of the deaths were due to cardiovascular or pulmonary comorbidities (Wang et al., 2014). Sepsis was found to be independently associated with increased risk of mortality even after hospital treatment. Compared with individuals who did not develop sepsis, rates of death among individuals experiencing sepsis were twice as high for up to five years following the sepsis event (Wang et al., 2014). The study did not discuss whether increased sepsis mortality reflects the increased susceptibility of those with heightened comorbid burden or whether sepsis triggers an independent pathophysiological process leading to early death.

The inpatient mortality rate of severe sepsis patients had a consistent decline between 2008-2012, going from 22.2% to 17.3%, respectively (Stoller et al., 2016). Iwashyna and Angus (2014) and Kaukonen et al. (2014) also found decreasing mortality rates for severe sepsis. Over the past decade, there has been significant emphasis on early identification and treatment for sepsis, possibly contributing to the decreases in mortality noted despite the increased incidence of sepsis diagnosis.

Risk Factors of Readmission

Multiple studies have attempted to define the factors that are associated with general hospital readmission. Jones et al. (2015) identified various factors that independently place patients at risk for hospital readmission within 30 days of discharge. Individuals who are older, with a higher number of hospitalizations in the year prior to the index hospitalization, a non-elective index admission type, one or more procedures during the index hospitalization, and low hemoglobin and high red cell distribution width (RDW) at discharge are more likely than others to be readmitted within 30 days. These

findings were supported by Schneider et al. (2013) who found that patients who are older and African-American are more likely to be readmitted. Having comorbidities, emergent surgery, transfusion requirements, and discharge to a skilled nursing facility also makes a patient more likely to readmit within 30 days.

One researcher emphasized that severe sepsis survivors are less likely to be readmitted if they are older than 80 years (Goodwin et al., 2015). Tangeman, Rudra, Kerr, and Grant (2014) attempts to explain this finding, suggesting that as individuals become frailer as they age, there is increased likelihood for palliative care discussion and decisions resulting in subsequent readmission avoidance. Another study reported that the increased readmission risk after sepsis was not confined to older adults or to those with the more severe cases of comorbid conditions. Younger people, as well as those who were previously healthy, were found to be at a higher risk for readmission after a hospitalization with sepsis (Jones et al., 2015). After controlling for a history of malignancy and pre-sepsis health care utilization, the relationship between sepsis and readmission in younger people was weakened. These findings supported recent studies that revealed a history of malignancy and pre-sepsis health care utilization to be risk factors associated with increased health care utilization after sepsis (Jones et al., 2015).

The dominant factors contributing to a person's health journey after discharge with severe sepsis or septic shock were conditions that were present prior to admission (Wang et al., 2014). Severity of illness and the need for intensive care were both predictive of the need for early readmission following sepsis. The researchers discuss that inadequate measurement of pre-sepsis level of function and utilization can result in an overestimation of the impact of sepsis on post-discharge health care and utilization.

These findings might suggest that an optimal approach to post-hospital care in sepsis should focus on treatment approaches that address disease-specific problems within the much larger context of common hospital risks.

Length of Hospital Stay and Readmission

Improving care transitions and reducing 30-day hospital readmissions have become a national priority in the United States (Mechanic, 2014). This is largely because utilization of post-acute care, which consists of services and placement upon discharge, is increasing in cost. Together with 30-day readmissions, the total cost may end up rivaling, and possibly even topping, the cost of the index hospitalization. Due to this, an incentive to integrate acute and post-acute care, especially for high-risk conditions, is highlighted among researchers (Mechanic, 2014).

The urgency of the necessity of reducing hospital readmissions stems from the recent improvement of short-term mortality among sepsis survivors (Stevenson, Rubenstein, Radin, Wiener, & Walkey, 2014). Globally, this epidemiology pattern has been studied to gain approximately 14 million additional sepsis survivors and the number is increasing yearly. While this is good news, it also implies a growing demand, and therefore cost, for ongoing health care needs (Fleischmann et al., 2016). Decreasing rates of hospital readmissions has emerged as an important approach to improving the quality and efficiency of overall healthcare delivery (Kripalani, Theobald, Anctil, & Vasilevskis, 2014).

CMS determined that 30 days after discharge is appropriate to identify readmissions that are attributable to an index admission. According to CMS, 30 days is ample and yet concise enough to reflect the quality of hospital-delivered care and

transitions to the outpatient setting. It also allows for additional analysis to be made by hospitals and their communities to find ways to reduce readmissions (Office of Minority Health & at The University of Chicago, n.d.). Regarding the foundation of a 30-day monitoring time, some researchers have argued that the readmission time of 30 days has little scientific basis (Dharmarajan et al., 2013). Others have argued that 30 days is too long a time frame to base hospital care upon, as outcomes may largely be influenced by the quality of outpatient care or the development of new problems outside the hospital's field of responsibility (Joynt & Jha, 2013). This is supported by various researchers, who have found that approximately one-third of 30-day readmissions occur within the first seen (7) days, while more than half (55.7%) occur within the first 14 days (Dharmarajan et al., 2013; Vashi et al., 2013; Kripalani et al., 2014). As an alternative, these shorter time frames were suggested by the researchers as more appropriate for hospital accountability.

A link between hospital LOS and readmissions is proposed by researchers (Kaboli et al., 2012), who suggested that LOS influences certain outcomes that in turn influence readmission rates. For instance, additional but unnecessary days in the hospital would potentially expose patients to other infections and diseases in the hospital, which could increase readmission rates. It was then suggested that reducing hospital LOS would improve the efficiency of hospital care, thus lessen readmission rates among patients. However, there is emerging concern that excessive LOS reduction may be harmful because discharging before medically stable may result in increased hospital readmission or use of emergency department services (Kaboli et al., 2012). Thus, the question still appears to be a contested one.

Length of Stay and Hospital Use

LOS in the intensive care unit is one factor that researchers have linked to readmission rates, particularly because it has been used as a direct measure of hospital resource utilization and it is surprisingly consistent among most diagnoses (Hunter, Johnson, & Coustasse, 2014). New and improved healthcare procedures, such as the National Institute of Health and Care Excellence guidance for management of early onset sepsis that aims to provide welcome consistency, may require increased health investigations and can thus result increased length of hospital stay (Mukherjee, Davidson, Anguvaa, Duffy, & Kennea, 2015).

Severe sepsis was found to worsen cognitive and physical impairments and increase the severity of chronic diseases, such as chronic kidney disease and cardiovascular disease. These changes may extend past several years after the first episode of severe sepsis (Pandharipande et al., 2013). This finding was consistent even after accounting for poor pre-infection health status (Yende, Iwashyna, & Angus, 2014). When it happens, patients are more likely to utilize more of the hospital's resources, and longer LOS is likely to occur.

Comparisons between severe sepsis survivors and survivors of non-sepsis hospitalizations have shown that both cohorts exhibit similar increases in use of hospital facilities and resources. The differences with survivors of severe sepsis include a greater mortality, a steeper decline in days spent at home, and a more significant increase in the proportion of days alive spent in an inpatient healthcare facility (Prescott et al., 2014). The gravity of this difference is evidenced in the numbers; from a 24.2 days per patient in

the year before severe sepsis, patients spend a mean of 47.9 days in the hospital after severe sepsis (Prescott et al., 2014).

Increased LOS may not always be a result of good quality health care. A research study done among patients hospitalized for heart failure found that longer length of initial stay in the hospital was related to a higher risk of hospital readmission within 30 days. With a large sample size of nearly 20,000 patients and comprehensive data of co-morbidities among the patients, the findings suggested that LOS may be a useful indication not only for quality health care, but for the severity of the complication and the patients' status of co-morbidities (Reynolds et al., 2015).

Cases of higher hospital-level sepsis and sepsis mortality rates were found to be associated with a longer LOS, which was also associated with the need for readmission (Goodwin et al., 2015). Notably, patients who were hospitalized with sepsis were also more likely to have comorbidities. Likely comorbidities, including dementia and malignancy, require additional interventions such as improvement in medical management and patient-centered discussions on aggressive care. One such option of intensive care comes in the form of increased LOS and rehospitalization (Chang et al., 2015). These researchers suggested that it is important for patients and their families to be knowledgeable of both the high morbidity in sepsis and the likely range of outcomes among survivors, including the high probability of extended morbidity that may result in longer stay in the hospital, and even rehospitalization (Chang et al., 2015).

Researchers found that patients with only one complication were more likely to be readmitted after longer lengths of stay, while patients with multiple complications were more likely to be readmitted after shorter lengths of stay (Kohlnhofer, Tevis, Weber, &

Kennedy, 2014). That patients with multiple complications are discharged before the average LOS required is an issue that must be solved, as 41% of these patients were subsequently readmitted. This suggest that there was inadequate diagnosis or untimely follow-up.

The finding that comorbidity is a significant determinant for hospital readmission compared with index admissions is widely supported. Goodwin et al. (2015) reported that it is common for severe sepsis patients to have substantial comorbidity burdens, which are associated with readmission and more frequent hospitalizations. Damrauer, Gaffey, Debord Smith, Fairman, and Nguyen (2015) investigated the role of post-care complications and comorbidities in affecting hospital LOS, and they found that stroke and pneumonia were associated with increased LOS. It is for this reason that a number of patients must remain in the hospital; to treat specific conditions that arose as comorbidities of healthcare procedures rather than as a result of underlying illness or overall health status. Along with the study's findings, the researchers proposed that streamlining healthcare strategies and preventing complications is an important aspect to focus on in the attempt to reduce LOS among patients (Damrauer et al., 2015).

These findings are especially relevant among individuals with poor health and chronic health conditions, as sepsis has long been observed to occur more frequently in these individuals, and that a single episode of sepsis worsens chronic health conditions (Shah et al., 2013a). Small subclinical changes in cognition over time increased the risk of pneumonia and sepsis re-hospitalization. The association found between cognition and pneumonia and sepsis were independent of demographic characteristics, health behaviors,

education, income, and detailed measures of chronic diseases and physical function (Shah et al., 2013b).

The implications of the severity of patients' diagnosis extend to hospital resource utilization. de Groot et al. (2015) found that a reduction in time to antibiotics was not significantly associated with an improvement of relevant clinical outcomes or LOS in the hospital among emergency department patients with mild to severe stages of sepsis. Likewise, they found an association between delayed administration of antibiotics with shorter hospital stay. These findings were accounted for by the knowledge that administration of antibiotics was more often delayed for patients with less severe infections, while more severely ill patients were administered antibiotics within a shorter period of time after admission to the emergency department (de Groot et al., 2015).

In another case, LOS may even be attributed to shortcomings in hospital treatment. Zhang, Micek, and Kollef (2015) found direct significant association between delays in the administration of appropriate antibiotic therapy (AAT) and hospital LOS. On average, patients who experienced a 24-hour delay in the administration of AAT were found to have intensive care unit and hospital LOS increased by 2.3 days and 3.2 days, respectively. Given that AAT is an independent determinant of intensive care unit and hospital LOS in blood culture positive patients with severe sepsis and septic shock, this was a significant finding (Zhang, Micek, & Kollef, 2015).

Researchers also identified another potential factor of increased LOS and increased preventable readmission risk to be complications gained from care provisions from the hospital (e.g., catheter-associated infections, transfusions). Patients with prolonged initial admission due to sepsis are at risk of developing a hospital-associated

infection; if they do catch a hospital-associated infection, they are at a nearly four-fold higher risk of an unplanned hospital readmission as compared to patients who were admitted due to a non-sepsis diagnosis. These unplanned readmissions are likely to occur within 30 days of discharge (Sun et al., 2016).

Antibiotics in particular were associated with infection-related unplanned readmission, and researchers have highlighted that future studies will need to further investigate whether this would pose a generalized readmission risk for patients or an infectious-specific readmission risk (Prescott et al., 2015). Rohde et al. (2014) found that transfusion strategies yielded similar infection risks among patients. Because of this, it is important to adhere to a strict transfusion strategy for hospitalized patients and make specific hemoglobin-based recommendations for different patient populations.

Quality of Healthcare in Different Areas

Health care access and quality especially affects low-income and middle-income populations. In high-income populations, survivors of long-term sepsis have experienced sustained decline in mortality in recent years, albeit have more often experienced long-term cognitive and functional decline (Shankar-Hari & Rubenfeld, 2016). On the other hand, in low-income and middle-income populations, growing research evidence about sepsis is less optimistic. Machado et al. (2017) studied sepsis cases in Brazil and reported that sepsis still has an ominous prognosis in patients admitted to various intensive care units, with hospital mortality rates of 55%. Across hospitals, there is inconsistent availability even for basic therapies such as antimicrobials. Even so, many hospitals that do provide these therapies have suboptimal provision, which contributes to an increase in readmission rates (Machado et al., 2017).

Fortunately, sustained efforts to implement best practices alongside increased sepsis awareness in Brazilian intensive care unit settings, where good standards of care are provided, are associated with decreased mortality rates and costs (Machado et al., 2017b; Noritomi et al., 2014). While some hospitals serving in low-income and middle-income populations provide good quality health care, most still frequently provide poorer quality care. Large urban populations, in particular, usually have unsatisfactory primary care and have poor access to acute care despite the existence of a similar average number of intensive care unit beds per person as in more developed areas (Austin et al., 2014). Intensive care units serving in low-income and middle-income populations are also likely to provide suboptimal infection control procedures. Soares et al. (2015) study involving 59,693 patients in a large sample of Brazilian intensive care units found that if they had better staffing levels and implementation of protocols, they would exhibit better clinical outcomes (Soares et al., 2015).

There is an interesting scenario for hospital quality improvement initiatives in certain areas with socio-economically challenged populations. While there are roughly enough resources, there is still limitation in access to care both in private and public health systems (Phua, Lim, Tay, & Aung, 2013). Particularly, there are still restrictions and shortcomings in the efficiency of sepsis awareness among lay people, which contributes to a delay in searching for care. A frequent challenge in developed countries, and even more so in socio-economically challenged settings, is the gap between scientific research and practice in the bedside (Phua et al., 2013). According to Miller et al. (2013), this gap is mainly explained by a lack of adequate workflow prioritizing timely access of

care for the severe sepsis patients inside the hospitals, as well as staff's lack of knowledge, and a resistance to follow guidelines.

Taken together, these results emphasize the importance of risk stratification of readmission data to account for the role that comorbidities and baseline patient health plays in post-acute care readmission. Additionally, it is suggested that flawless attention to a patient's overall health status in the post-discharge setting may help to prevent post-acute care readmission.

Reduced Length of Stay and Readmission due to Quality Improvements in Healthcare

There are researchers who did not find that a reduction in LOS was correlated to an increase in readmissions. Kaboli et al. (2013) analyzed 14 years of data from 129 hospitals and more than four (4) million admissions and found that although LOS decreased by 27% (1.46 days), there was no increase in readmissions. In fact, adjusted relative readmission rates actually decreased by 16% over the same period. These findings held across the five (5) individual diagnoses evaluated (Kaboli et al., 2013). An explanation for this finding was that improvements in terms of hospital discharge procedures, increased access to post-discharge care, and improvements in hospital technology and preventive measures had contributed to these results.

With the increasing consideration of readmissions as a measure of quality and expense in healthcare systems, severe sepsis may be an important opportunity for targeted interventions. The rate of repeat hospitalization observed among sepsis patients exceeds the average readmission rate for Medicare beneficiaries (Jencks, Williams, & Coleman, 2009), as well as the rehospitalization rates observed among non-sepsis

patients in their study. This finding suggests that severe sepsis survivors in particular may benefit from improvements in acute and post-discharge care management. This might include improved coordination of care, more frequent geriatric medicine involvement to aid in newly acquired disabilities and functional limitations, support for caretakers (Davydow, Hough, Langa, & Iwashyna, 2012), or an increased focus on in-hospital development of the ability to live independently.

Improvements in Index Admission

A longer hospital LOS is more likely among patients with severe community-acquired pneumonia and sepsis when AAT was not prescribed in the optimal time frame (Muszynski et al., 2011). In contrast, Geerlings, Hulscher, and Prins (2014) demonstrated that the timely and knowledgeable use of AAT in patients with sepsis was associated with shorter hospital LOS in a multicenter study from the Netherlands. Walker, Mayo, Camire, and Kearney (2013) evaluated 201 patients classified into two (2) groups, a control group consisting of 109 patients who did not receive palliative care consultation despite meeting criteria as per their screening results, and a treatment group of 92 patients who met criteria, had a palliative care consultation, and a palliative team present during rounds and found that the LOS at the intensive care unit was greater than that of the treatment group by a mean of 4 days (11 days compared to 7 days in the treatment group). In turn, the intensive care unit costs were also reduced by $2,760 (United States denomination) in the treatment group (Walker et al., 2013).

Intensive care units and hospital LOS could potentially be reduced if improvements in the delivery of the appropriate treatment procedures are strictly followed. Leisman et al. (2016) found a significant relationship between adhering to a

requirement to initiate intravenous fluid resuscitation within 30 minutes of severe sepsis or septic shock identification and decreased in-hospital mortality and hospital LOS in a sample of 1,866 patients. These data suggest that reductions in intensive care unit and hospital LOS, along with improvements in clinical outcomes, can be used as economic justifications for the development of new therapeutics and diagnostics for the management of sepsis.

In order to ensure that the improvement of health care quality for sepsis is heading in the right direction, the issue of frequent underdiagnosis of sepsis should be addressed. High-quality and precision metrics for acute myocardial infarction, congestive heart failure, and pneumonia already exist due to a high volume of previous decades' work to make accurate recognition of those conditions nearly universal. However, researchers found that research work on sepsis diagnosis is falling short (Iwashyna et al., 2014). Focus on the improvement of diagnostic accuracy for sepsis could improve the diagnosis of non-sepsis patients, as well as reduce the occurrence of diagnostic ambiguity and inadequacy (Iwashyna et al., 2014).

Another important aspect of sepsis mandates is the catalyzing and aggregation of local efforts for hospital quality improvement. Recent research suggests that current public reporting and pay-for-performance methods are insufficient tools to fully improve care (Berenson, Pronovost, & Krumholz, 2013). Alternatively, researchers have suggested that CMS should increase collaboration and sharing of best practices so that knowledge and understanding on how to improve the quality of healthcare can be fostered. In doing so, understanding and awareness of how to better care for patients may be spread beyond hospital boundaries to the public (Berenson et al., 2013).

Financial penalties still exist that create incentives to withhold reports of delayed diagnosis of sepsis instead of addressing the problem in a timely manner. As there is growing concern for the timely recognition and needs assessment of individuals with sepsis, an improvement in the quality of healthcare is needed (Centers for Medicare & Medicaid Services, 2019).

It would be beneficial for sepsis mandates to be highly responsive to new evidence. One National Quality Forum sepsis measure provides an optimistic example of such responsiveness: The ProCESS trial demonstrated that focus on recognition, early antibiotics, and fluid resuscitation may achieve equivalent positive sepsis outcomes as would be the case if more complicated protocols were used (Yealy et al., 2014). This finding shows that when there are new discoveries of more efficient healthcare methods, quality measurement should improve in tandem.

Improvements in Post-Acute Discharge Care

At discharge, post–acute care use was more common after sepsis compared to most other diagnoses, and highest after cases of severe sepsis (Jones et al., 2015). As a way to improve effective strategies for care transitions, it would be beneficial for hospitals to recognize that post–acute care facilities are being utilized at an increasing rate, especially among sepsis patients. In 2010, the proportion of hospitalizations resulting in discharges to post-acute care facilities increased from 9.2% in 1996 to 13.7% in 2010 (a 49.0% relative increase), while the proportion of discharges going home decreased from 90.8% to 86.3% (a 5.0% relative decrease). The study recorded an absolute increase of 1.67 million discharges to post-acute care facilities in 2010 (Burke et al., 2015a). The reasons for this increase are unknown but would be beneficial to

evaluate. Because admissions to post-acute care facilities are starting to rival those of direct discharges home, expenditures on post-acute care facilities is now also the fastest growing area of Medicare costs (> $62 billion in 2012; Ackerly & Grabowski, 2014; Chandra, Dalton, & Holmes, 2013).

Post-acute care rehabilitation after sepsis was also found to have the potential to improve long-term mortality, and possibly even decrease readmission rates (Chao et al., 2014). This finding is consistent across various cardiac and pulmonary diseases. A study by Carey and Lin (2014) found evidence among 19,811 people that health maintenance organizations may significantly improve patient management through post-acute care in the 30 day period following discharge, which is likely to result in fewer readmissions.

The result of an increase in the discharge of patients to post-acute care facilities is a decrease in hospital LOS, which was found to extend across payers, patient demographics, and several diagnosis groups (Burke et al., 2015b). These results are especially relevant to this study as more than half of all the post-acute care facility discharges were found to consist of patients more than 80 years of age, and because more than 40% of hospitalizations in this age group end with a post-acute care facility stay (Burke et al., 2015b). This is an alternative that is worth exploring, especially when considering that after discharge, sepsis survivors were significantly more likely than non-survivors to be rehospitalized; the 30-day readmission rates observed after sepsis rivaled rates associated with known CMS high-risk conditions (Dharmarajan et al., 2013).

Carey (2015) articulated an important aspect of the subject matter that most research studies tend to overlook when analyzing the relationship between LOS and readmission rates. On the data side, hospital administrative discharge data, while very

good for measuring LOS and time to readmission, contains incomplete information on patient clinical condition and quality of healthcare given to the patient. No information was available on quality of discharge planning and coordination, or on the amount of follow-up care administered during the post-discharge period. Additionally, it is difficult to differentiate between planned and unplanned readmissions. Nevertheless, the results from these studies suggest that adoption of best practices are an efficient and practical means of improving outcomes and prevent further readmissions.

Summary

In summary, there has been no conflict identified in recent literature regarding sepsis and the health implications for people, especially older adults, who are diagnosed with severe sepsis or septic shock. Sepsis, a systemic infection, can be acquired through spread within a community (e.g., community-acquired pneumonia) as a result of poor healthcare (Bernard & Bernard, 2012; Linde-Zwirble & Angus, 2004). It is found to be associated with multiple potential complications, ranging from muscular to cognitive impairment, and even stroke, and can affect people for years following an episode of sepsis (Boehme et al., 2017; Desai, Law, & Needham, 2011; Iwashyna et al., 2010). For this reason, hospitalization due to sepsis is an occurrence that has been given a lot of attention, as individuals suffering from sepsis are in dire need of timely and professional healthcare.

Recent records of hospitalizations due to sepsis found that the numbers have increased over the years (Cooke & Iwashyna, 2014; Stoller et al., 2016). This surge in sepsis cases have been found to place a heavy economic burden every year due to the subsequent rise in demand for treatment procedures and healthcare resources (Prescott et

al., 2014) not only for sepsis, but also because patients who are admitted for sepsis usually turn out to have comorbid diseases and complications (Liu et al., 2014; Prescott et al., 2014). It was found that a significant number of individuals with sepsis are older adults, thus increasing the risk of additional infections alongside sepsis as well as hospitalization for those complications (Gaieski et al., 2013; Yende et al., 2013).

A particularly concerning issue for both sepsis survivors and hospitals is the inevitable post-acute care requirements and readmissions that may occur among sepsis patients. Sepsis readmissions usually occur within 30 days after discharge, with a fewer portion occur within seven (7) days (Donnelly, Hohmann, & Wang, 2015; Liu et al., 2014). Interestingly, research studies have noted the sharp increase in hospital resource utilization, which contributed to an increase in the number of days individuals with sepsis spend in the hospital and a subsequent increase in the number of readmissions per patient (Ortego et al., 2015; Prescott et al., 2014). This is alarming, especially since researchers have found that a large portion of these readmissions are not due to sepsis itself, but due to other diagnoses, particularly new or recurring infections, that either stem from or become a comorbidity with sepsis (Chang, Tseng, & Shapiro, 2015; Dharmarajan et al., 2013). These findings paint a picture of the implications of having sepsis and indicate the importance of providing optimal care to these individuals by making available treatment approaches that address various diseases as opposed to just sepsis.

Because of the aforementioned increase in hospital resource utilization, LOS, and subsequent readmission, researchers and institutions are concentrating on how to improve these three aspects of healthcare in the United States (Kripalani et al., 2014; Mechanic, 2014), now more than ever due to number of individuals diagnosed with sepsis, which is

rising every year (Fleischmann et al., 2016). While it is generally agreed upon that a change in LOS would contribute to a reduction in readmission rates (Kaboli et al., 2012), this review of the literature has found differing points of view regarding whether an increase or a decrease in LOS would be a bigger help.

Researchers initially proposed a positive correlation between LOS and hospital resource utilization, suggesting that a longer stay at the hospital directly corresponds to better health outcomes because comprehensive treatment procedures are provided to the patient and because their health may be carefully monitored for a longer period of time (Hunter, Johnson, & Coustasse, 2014; Mukherjee et al., 2015). Because of the common possibility of a multiple-diagnosis case, it was hypothesized that a longer amount of time would be needed to treat all health issues (Pandharipande et al., 2013; Yende, Iwashyna, & Angus, 2014). Although this position is plausible, there is evidence of its shortcomings. Researchers have found evidence that poor healthcare may also contribute to longer hospitalizations. One common example is the delay in hospital treatment procedures and therapies, which further complicates the patient's health issues (Zhang et al., 2015). It is also possible for patients to at increased risk of getting a nosocomial infection because they spent a longer time confined in the hospital (Sun et al., 2016). Certain treatment procedures that have not been properly screened and tested for health hazards are another cause for longer hospitalizations (Rohde et al., 2014). These issues are especially common in hospitals in middle-income and low-income areas in the United States, which still have limitations in their standards of care (Austin et al., 2014; Machado et al., 2017; Noritomi et al., 2014; Soares et al., 2015).

On the other end of the spectrum, a growing body of research does not support the view that a reduction in hospital LOS would lead to an increase in readmissions. In contrast, it may possibly lead to a reduction in readmissions, given that there is an improvement in the quality of healthcare that is provided to sepsis survivors (Davydow et al., 2012). This can be done mainly in two ways. First, improvements in index admission, in the form of more accurate diagnosis, responsive care teams, timelier prescription and delivery of treatments, and a stronger connection between medical research and medical practice, will allow for earlier addressing of the main issues at hand in a shorter period of time (Geerlings, Hulscher, & Prins, 2014; Iwashyna et al., 2014; Walker et al., 2013; Yealy, Kellum, & Huang, 2014). Second, there should be increased awareness and increased utilization of post-acute care facilities, which aid in the continuation of health monitoring and care outside the hospital (Burke et al., 2015; Chao et al., 2014). This was found by researchers to reduce the chances of readmissions (Carey & Lin, 2014).

Given the information that was found in recent literature, it should be noted that not all reviewed studies were done on patients with sepsis. What this study hoped to achieve, then, is to expand the empirical literature on the association between hospital LOS and 30-day readmissions among older adults whose primary payer was expected to be Medicare and who discharged home with a discharge diagnosis of severe sepsis or septic shock.

CHAPTER 3. METHODS

The purpose of this study was to investigate the relationship between index hospital LOS and 30-day readmission rates in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock. ICD-9-CM was used to identify a principle or secondary discharge diagnosis of severe sepsis (ICD-9-CM 995.92) or septic shock (ICD-9-CM 785.52). Associations between 30-day readmission rate and factors of age (groups of 65-74, 75-84, and 85+), gender, and patient location (urban-rural classification) were examined. Days to readmission was evaluated for the subset of older adults who had a readmission.

This study proposed to answer the following research questions.

Research question one: What percentage of older adults whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock had a 30-day readmission?

Research question two: Is index hospital LOS associated with 30-day readmission rate in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock?

Research question three: Is age associated with 30-day readmission in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock? This was assessed using age as continuous and as age groups (65-74, 75-84, 85+).

Research question four: Is gender associated with 30-day readmission rate in older adults whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock?

Research question five: Is location associated with 30-day readmission rate for older adults whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock?

Research question six: What is the mean number of days to readmission after discharge for older adults who had a readmission?

This chapter includes a discussion of the research design and its appropriateness. This chapter provides a discussion of the target population and sample considered in the study, as well as details of data collection and analysis. Finally, this chapter ends with a summary of the key points of the research methodology that was used in the study.

Study Design

A retrospective cross-sectional research design was used to investigate the association between index hospital LOS and 30-day readmission rates in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock. Associations between 30-day readmission rate and age (groups of 65-74, 75-84, and 85+), gender, and older adult location (urban-rural classification) were also evaluated by means of logistic regression models. Data for the variables have been previously collected from State Inpatient Databases (SID), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality and consumed into the 2014 Nationwide Readmissions

Database (NRD), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality.

Setting and Participants

The setting for the participants included in the study include all inpatients with an index hospital discharge and one or more 30-day readmissions during 2014 from the State Inpatient Databases (SID), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality used to populate the 2014 Nationwide Readmissions Database (NRD), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality. The Table 2 below contains inclusion and exclusion criteria that was used for the sample participants.

Table 2

Variables, Including Inclusion and Exclusion Criteria

Inclusion	Exclusion
Admission: any day of week	Discharge disposition, uniform coding: 1) transfer to short term hospital, 2) other transfers, including skilled nursing facility, intermediate care, and another type of facility, 3) home health care, 4) against medical advice, 5) died in hospital, and 6) discharged alive, destination unknown
Died during hospitalization: no	Died during hospitalization: yes
Age $\geq$ 65	Age < 65
Discharge disposition, uniform coding: routine	Service line: maternal, neonatal, mental health, substance abuse, injury, or surgical
Service line: medical	Expected primary payer: Medicaid, private insurance, self-pay, no charge, other
Expected primary payer: Medicare	Rehabilitation transfer
Discharge year : 2014	Discharge year : not 2014

Data Sources, Variables, and Measurement

Data used in this study was from the 2014 Nationwide Readmissions Database (NRD), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality. NRD data was from the State Inpatient Databases (SID), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality. The NRD is a database built to support various types of analyses for readmissions of all patients. The NRD includes data on patient discharges with or without a 30-day readmission, all ages, and all expected payers for the identified year. The database was developed to address the gap in health care data which lacks information on hospital readmissions for all ages. The 2014 database was chosen because it includes the number of chronic conditions, a potential confounder. The most recent, 2016 NRD, did not yet include the number of chronic conditions. The NRD was used and the sample for analysis only included older adults who discharged with Medicare as the expected primary payer, were 65 years and older), who had a routine (home without home health services) discharge from the index hospital, and with a principle or secondary discharge diagnosis of severe sepsis or septic shock using the ICD-9-CM.

Independent variables included in this study were age, age groups, gender, older adult location, and hospital LOS. The dependent variable was readmission. Table 3 includes pertinent research questions, variables, level of measurement, and linkage to conceptual framework.

Table 3

Study Variables

Research Question	Variable	Level of Measurement	Linkage to Framework
3	Age (years)	Numeric	Patient level
3	Age group (65-74, 75-84, 85+)	Ordinal	Patient level
4	Gender (male or female)	Dichotomous	Patient level
5	Older Adult location (rural-urban classification)	Nominal	Environmental level
2	Hospital LOS (days)	Numeric	Organization level
1, 2, 3, 4, 5, 6	Readmission	Dichotomous	Outcome

Study Size

The sample size needed to consist of 10-15 observations (older adults) per independent variable in the smaller of the readmission/ no readmission groups. With four (4) independent variables, at least 40 observations in the smaller group were needed. Assuming the readmission rate was 13% (Yende et al., 2013), then complete data on at least 235 older adults was needed. All requirements were met.

Statistical Methods

Statistical analysis was performed using R package version 3.4.2 (The R Foundation, 2020). Chi-square test of independence was used to test whether proportions were the same or different for 30-day readmissions within older adult age groups, gender groups, and older adult designation groups. Logistic regression models were used to estimate the associations between readmission with LOS, age, gender, and location. Logistic regression was used to estimate the association between index hospital LOS and 30-day readmissions adjusted for age, gender and location.

Cases with missing data were disregarded in the study. The variables including age group, gender, and designation were considered nominal data and were analyzed

using frequencies and percentages. Descriptive statistics (mean, standard deviation, and range) were used to present the hospital LOS variable. The dichotomous readmission variable was the outcome and all other variables were summarized by readmission (yes/no).

To address research question one, a percentage was calculated with the numerator representing the number of older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock who had a 30-day readmission and the denominator representing the number of older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock. This value was multiplied by 100 to convert to a percentage. For research question two, the researcher used bivariate and logistic regression to evaluate the associations between the independent variables and the dependent variable, which was dichotomous. Through this, the researcher determined whether there was a statistically significant positive or negative association between the variables (Saks & Allsop, 2012).

For research question three, research question four, and research question five, a Chi-square test was conducted to determine whether 30-day readmission rates in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock was different between older adult age groups, between males and females, and between designation (rural-urban classification). A significance level of .05 was used for all analyses. For research question six, the first index days to readmission was plotted for older adults (> 65 years) whose expected primary payer was Medicare and who

discharged home with a principle or secondary diagnosis of severe sepsis or septic shock to allow for exploration of first readmission timing following index hospital discharge.

Institutional Review Board

Indiana University-Purdue University Indianapolis Institutional Review Board determined this study to be "Review Not Required".

Summary

In this study, the researcher employed a retrospective cross-sectional study design to investigate the relationship between index hospital LOS and 30-day readmission rates in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock. Differences in 30-day readmission rates between older adult age groups (65-74, 75-84, and 85+), gender, and location (urban-rural classification) and readmission timing by day after discharge were evaluated.

CHAPTER 4. RESULTS

Summary

The objective of this study was to analyze 30-day readmission rates for older adults (> 65) whose expected payer was Medicare who discharged with principle or secondary discharge diagnosis of severe sepsis or septic shock and to observe the effects that demographics have on these rates and LOS. Data used to answer the proposed research questions consisted of discharge records from the 2014 Nationwide Readmissions Database (NRD), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality. Only older adults (> 65) whose expected payer was Medicare who discharged with principle or secondary discharge diagnosis of severe sepsis or septic shock were included in statistical analyses. Most research questions pertain to older adults with a principle or secondary discharge diagnosis of severe sepsis or septic shock, a serious and rather uncommon condition among discharged older adults, greatly reducing the data available for the proposed statistical methods. Data was also restricted to older adults who discharged between January 2014 and November 2014 to allow a 30-day period for possible readmission at the end of the year to run-out.

Research Questions and Hypotheses

Six research questions were proposed, and statistical hypotheses were developed to evaluate each individual question.

Research question one: What percentage of older adults whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock had a 30-day readmission?

Research question two: Is index hospital LOS associated with 30-day readmission rate in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock?

Research question three: Is age associated with 30-day readmission in older adults (> 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock? This will be assessed using age as continuous and as age groups (65-74, 75-84, 85+).

Research question four: Is gender associated with 30-day readmission rate in older adults whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock?

Research question five: Is location associated with 30-day readmission rate for older adults whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock?

Research question six: What is the mean number of days to readmission after discharge for older adults who had a readmission?

Research question one and research question six do not require statistical testing and descriptive statistics describing the population of interest were used to answer them. Research questions comparing 30-day readmission rates between two or more groups of older adults were first assessed using chi-square tests to evaluate for existing correlation the variable of interest (e.g., gender) and readmission among older adults. Questions were further evaluated using logistic regression to explore differences in readmission probability between groups, often accounting for confounding variables. Finally,

questions comparing readmission rates based on a continuous variable (e.g., LOS) were assessed directly using logistic regression, controlling for confounding variables.

The population of interest was older adults (> 65) whose expected payer was Medicare who discharged with principle or secondary discharge diagnosis of severe sepsis or septic shock. These older adults were identified from the list of hospital discharges. An indicator variable was created identifying older adults that were readmitted within a 30-day period. Additional variables necessary for statistical analysis (e.g., age categories, etc.) were also created.

Older Adult Population

Data consisted of nearly 15 million discharge records from 2014. Of these, 5,673,818 records were from older adults who were 65 or older at the time of their hospital discharge. The mean age of older adults included in analysis was 77.3 years with a standard deviation of 7.9 years. The oldest adults included in this study were 90 years old. Nearly 10% of the population (n = 554,917; 9.78%) were recorded as 90 years old, indicating possible truncation of age. Younger older adults also accounted for a disproportionally large subset of the population with nearly 10% between 65 and 66 years of age (n = 502,537; 8.85%).

Data from the population of interest (65+ years old, expected primary payer was Medicare, and a principle or secondary discharge diagnosis of severe sepsis or septic shock) included 15,193 discharge records from 14,857 unique older adults. Of these older adults, 2,374 were readmitted within a 30-day period. The mean age of older adults within the population of interest was 78.4 years with a standard deviation of 7.9 years. The number of adults in the eldest age group (89-90) were disproportionally larger than

younger ages. However, the number of adults at younger ages (65-66) was far lower compared to the full population of discharges. Older adult's gender was divided almost equally between male and females with males representing 7,544 (49.7%) discharges and females representing 7,649 (50.3%). The numbers and percentages of older adult's demographics from the population of interest is shown in Table 4. Figure 2 contains the age distribution for these older adults.

Table 4

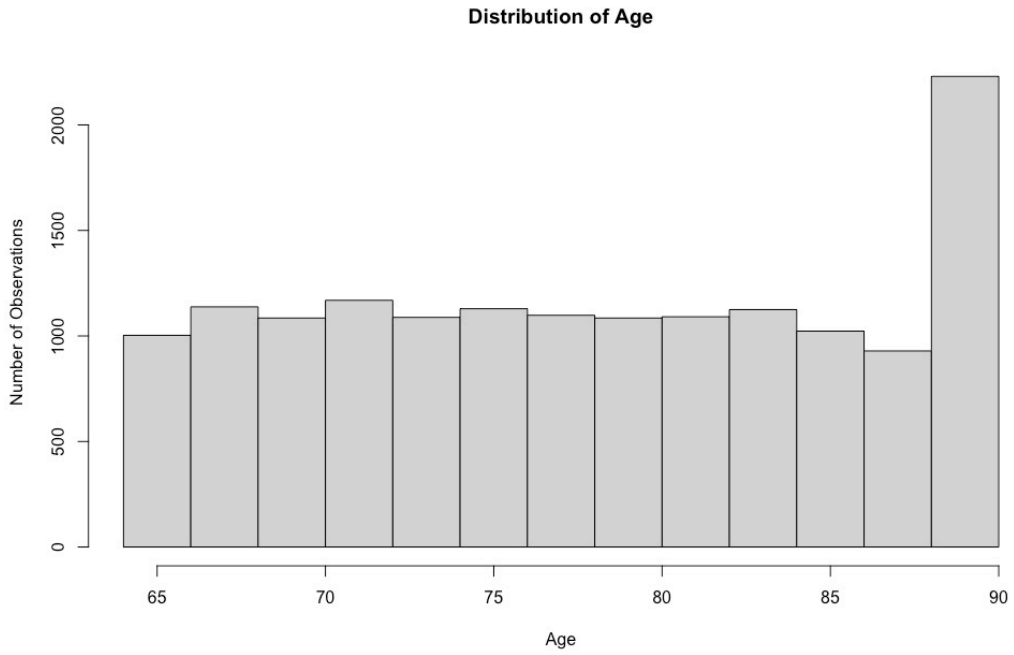
Observed Counts and Percentages for Older Adult Demographics

Characteristic	Number Total (%)	Number Readmitted (%)
All Older Adults (Encounters)	15193	2374 (15.6%)
Male	7544 (49.7%)	1230 (8.1%)
Female	7649 (50.3%)	1144 (7.5%)
Age		
65 - 74	5483 (36.1%)	1001 (6.6%)
75 - 84	5528 (36.4%)	873 (5.7%)
85 +	4182 (27.5%)	500 (3.3%)
Location		
Metro (> 1M)	5186 (34.1%)	839 (5.5%)
Fringe Metro (> 1M	3598 (23.7%)	567 (3.7%)
Metro (.25M – 1M)	3111 (20.5%)	474 (3.1%)
Metro (0.05M – 0.25M)	1362 (8.9%)	217 (1.4%)
Micropolitan	1116 (7.4%)	150 (1.0%)
Not Micropolitan or Metropolitan	790 (5.2%)	121 (0.8%)
Unknown	30 (0.2%)	6 (<0.01%)

Note. All percentages recorded as percentages of all observations from the population of interest.

Figure 2

Distribution of Age Among Older Adults in the Population of Interest



The distribution of LOS was also assessed. The mean LOS in the population of interest was 10.1 days with a standard deviation of 13.5 days. LOS contained some extreme observations with LOS exceeding expected values from the distribution. There were 31 observations with a recorded LOS greater than 100 days and as extreme as 365 days. Table 5 contains summary statistics for age and LOS. Figure 3 shows the distribution of LOS for older adults with LOS less than 100 days.

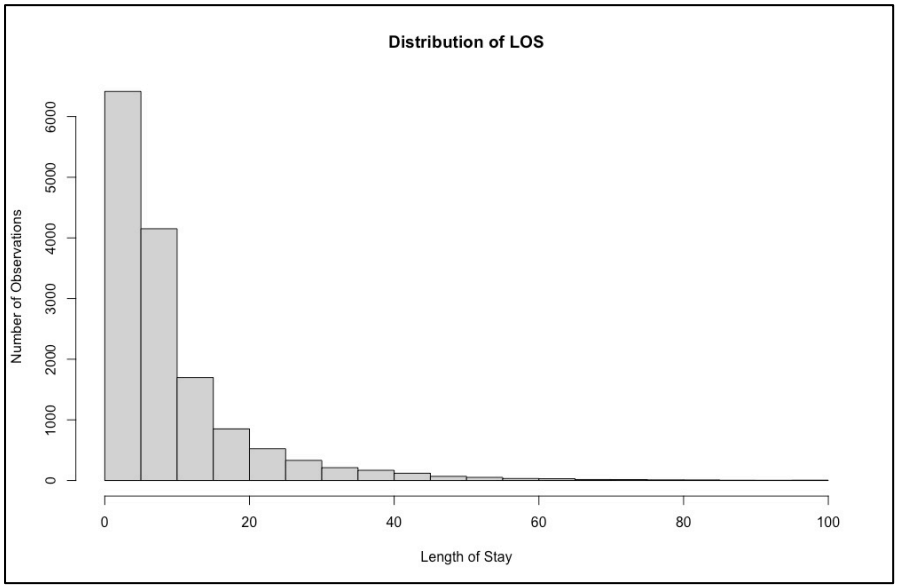
Table 5

Summary Statistics for Continuous Variables of Interest

Variable	Mean	Median	Standard Deviation	Min	Max
Age	78.4	78	7.9	65	90
LOS	10.1	6	13.5	1	365

Figure 3

Distribution of LOS in Days among Older Adults in Population of Interest. Plotted Data is Restricted to Older Adults with LOS Less than 100 Days.



Statistical Assumptions

A combination of descriptive statistics, non-parametric statistical tests and logistic regression modeling were used to assess each research question. Few assumptions were required to perform these methods. For non-parametric tests, groups had to be independent of one another and the counts in each cell were considered randomly sampled and independent older adults from the population of interest. This meant that admission rates from one older adult should not affect those of other older adults. Minimum cell counts were required for accurate inference from chi-square tests. In the event that cell counts in any cell were fewer than five observations, Fisher's exact tests were used to correct *p*-values for small sample sizes.

Assumptions necessary for logistic regression were relaxed compared to other statistical methods, provided the sample size was large enough. The dependent variable in

this study related to 30-day readmission of an older adult and could be formulated as a binary variable (1 if readmitted within 30 days; 0 otherwise). Models in this research required few independent variables and were focused on quantifying the relationship between a single independent variable and readmission rates, controlling for demographics. Thus, multicollinearity among independent variables was not a concern. Similar to chi-square tests, logistic regression models required all older adult to act independently of one another. Finally, it was assumed that any relationship between a continuous independent variable and the log-odds ratio of the dependent variable were linear. Higher order models were considered to account for possible quadratic relationships. To this author's knowledge, all assumptions necessary for the proposed methodology were met.

In addition to assumptions required for the statistical methodology, regression diagnostics were used to identify outliers or observations that highly influenced the model fit. If outliers or influential observations were detected, the observations were removed, and models were refit with the remaining data.

Research Question One

The overall 30-day readmission rate among older adults ($\geq$ 65) with an expected primary payer of Medicare and with a principle or secondary discharge diagnosis of severe sepsis or septic shock was 15.6% (Table 4). This accounted for 2,374 older adults out of 15,193 older adults discharged with these diagnoses. These rates varied based on older adult gender, age, and other criteria. Readmission rates within these demographics can be found in the tables that follow.

Research Question Two

Research question two focused on whether 30-day readmission rates among the population of interest were associated with LOS. It was possible that increased LOS indicated older adults who were in a more critical condition and that higher rates of readmission would be observed among those with a longer LOS. Contrarily, older adults with shorter LOS may have received less adequate care and be more likely to be readmitted within 30 days.

Logistic regression was used to model older adult's 30-day readmission rates using LOS as an independent variable. Older adult gender and age were controlled for during modeling. Data that contained extreme values for LOS, outliers and influential points were examined to determine if they should be removed during modeling. Table 6 contains the parameter estimates, odds ratio, and *p*-values associated with each coefficient.

Table 6

Parameter Estimates, Odds Ratios, and P-Values for the Logistic Regression Model Incorporating Older Adult LOS

Variable	Estimate	Odds Ratio	*p*-value
Age (75-84)	-0.155	0.856	0.0023
(85 +)	-0.447	0.639	< 0.0001
Gender	-0.054	0.948	0.2353
LOS	0.011	1.011	< 0.0001

Note. Age and gender are controlled for.

The fitted model resulted age and LOS as statistically significant predictors for readmission rates among this older adult population. The parameter estimate for LOS was 0.011, indicating that increased LOS is associated with higher 30-day readmission rates.

The *p*-value associated with this estimate was < 0.0001, which indicated LOS as a predictor of readmission at a 0.05 significance level. Other covariates used to control for gender and age resulted in age categories being a significant covariate. In this case, older adults were less likely to be readmitted within 30 days.

No outliers or influential points were detected based on observations using Cook's Distance. Models fit with a quadratic effect for LOS resulted in this additional parameter being significant. However, the pseudo-R^2 and area under the receiving operator characteristic (ROC) curve were not greatly improved by using a quadratic trend and a linear fit was kept improving interpretability of the results. The area under the ROC curve was 0.589 indicating that the model's precision was poor. The pseudo-R^2 for the model was 0.01 also indicative of poor relationships between the predictors and readmission rates. LOS had a statistically significant effect on older adult's 30-day readmission rates and older adults in the population of interest with longer LOS were more likely to be readmitted.

Research Question Three

Research question three focused on the relationship between age and 30-day readmission rates among older adults ($\geq$ 65) with an expected payer of Medicare and a principle or secondary discharge diagnosis of severe sepsis or septic shock. Data includes older adult's age at the time of discharge. These were categorized into three age categories (65 – 74, 75 – 84, and 85+). Analyses were conducted for both categorical and continuous values of age.

Chi square tests and logistic regression models were used assess the association between age and 30-day readmission rates. Chi-square tests evaluated whether the

frequency of readmission rates was dependent on age category. Logistic regression models allowed quantification of these relationships, as well as the ability to model readmission rates using age as a continuous variable. Gender was controlled for during modeling. Age contained no outliers, although there was a higher frequency of older adults in older age categories, which may indicate that age was truncated at 90 years. Table 7 contains the counts and frequencies of the population of interest who either admitted or did not admitted within 30-days for each age category.

Table 7

Frequency Table Comparing Readmitted Older Adults and Non-Readmitted Older Adults Among Age Groups

	30-day Readmitted	
Age	No	Yes
65 - 74	4482	1001
75 - 84	4655	873
85 +	3682	500
Total	12819	2374

Older adults within the age range of 65 to 74 years old were readmitted in 1,001 out of 5,483 (18.3%) of cases. Older adults between 75 and 84 years of age were readmitted 873 out of 5,528 (15.8%) of cases. Out of the 4,182 encounters with older adults greater than 84 years, 500 (12.0%) were readmitted within 30-days. Chi-square tests using all three categories reported statistically significant differences between the frequencies of readmission among age categories as compared to expectations if the true readmission rate was the same across all categories. The chi-square statistic was 71.615 with a *p*-value less than 0.0001, demonstrating a statistically significant relationship between readmission rates and age categories at a 0.05 significance level. A difference in frequency was identified among the oldest age category, where readmission occurred less

frequently. Removing this category and performing a chi-square test to detect differences in the youngest two older adult age groups led to a chi-square statistic of 3.276 with a *p*-value of 0.0703. The dependency between age and admission rates for the age categories 65-74 and 75-84 was not statistically significant at a 0.05 significance level.

A logistic regression model was fit using these age categories as the independent variable to quantify the effect that these categories have on 30-day readmission rates. Gender was included in the model to control for gender differences. Table 8 contains the parameter estimates, odds ratio, and *p*-values associated with the model coefficients.

Table 8

Parameter Estimates, Odds Ratios, and P-Values for the Logistic Regression Model Using Age (Categorical)

Variable	Estimate	Odds Ratio	*p*-value
Age (75-84)	-0.173	0.841	0.0006
(85 +)	-0.490	0.613	< 0.0001
Gender (F)	-0.069	0.933	0.1231

Note. Gender is controlled for.

Both age categories were statistically significant predictors of readmission probabilities at a 0.05 significance level. The odds ratios for age categories 75-84 and 85+ were 0.841 and 0.613 respectively, indicating that older adults in the 65-74 range had the highest probabilities of readmission and the odds of readmission were reduced with each increasing age group. Older adult gender was not a significant covariate in the model and had little effect on readmission rates. The area under the ROC curve for the fit model was 0.554 indicating poor model performance from these predictors.

A second logistic regression model was fit using the older adult's true age as an independent variable to quantify the effect that each year has on the probability of

readmission within 30 days. Models were fit using linear and quadratic trends between readmission rate and age. Model results are shown in Table 9.

Table 9

Parameter Estimates, Odds Ratios, and P-Values for the Logistic Regression Model Using Age (Categorical) and True Age

		Linear Fit			Quadratic Fit	
Variable	Estimate	Odds Ratio	p-value	Estimate	Odds Ratio	*p*-value
Age	-0.170	0.977	<0.0001	0.171	1.186	0.0040
Age^2	NA	NA	NA	-0.001	0.999	0.0093
Gender (F)	-0.073	0.930	0.1070	-0.066	0.936	0.1399

Note. Older adult gender is controlled for. Linear and quadratic effects for age are modeled and shown separately.

Age was a statistically significant predictor of readmission rates at a 0.05 significance level. The quadratic trend was also statistically significant, although prediction from the model was scarcely improved by the more complex model. The effect that age has on readmission rate is interpreted differently if the quadratic trend is used. Using a linear trend, the odds ratio for age is 0.977 indicating that with each additional year, the odds of being readmitted within 30 days decreases. When a quadratic trend is used, the odds ratio of the linear trend is 1.186 and the quadratic trend 0.999, which indicates that readmission probability increases by year until a certain age and then begins to decrease for older adults. In either case, age is a significant variable in determining readmission rates, although prediction ability from the fitted models is poor.

Research Question Four

Readmission rates among discharged older adults ($\geq$ 65) with an expected payer of Medicare and with a principle or secondary discharge diagnosis of severe sepsis or

septic shock were compared between men and women. Similar to associations between ages, chi-square tests and logistic regression models were used assess the association between older adult gender and 30-day readmission rates among the population.

Table 10 contains counts for older adults readmitted and not readmitted within 30 days of their discharge for each gender. Males accounted for 7,544 (49.65%) of discharges and had a 30-day readmission rate of 16.30 %. Out of the 7,649 female older adults, 14.95% were readmitted within 30 days. The chi-square statistic comparing admission rates between males and females was 5.134 with a *p*-value of 0.0235. There is evidence that readmission rates are dependent on an older adult's gender at a 0.05 significance level.

Table 10

Frequency Table Comparing Readmitted Older Adults and Non-Readmitted Older Adults by Gender

	30-day Readmitted	
Gender	No	Yes
Male	6314	1230
Female	6505	1144
Total	12819	2374

In addition to chi-square tests, readmission rates were modeled using logistic regression to quantify the difference in odds of readmission between males and females. In this case, gender was used as an independent variable to model the log-odds of the probability of readmission within 30 days. No other variables were included in the model. The *p*-value for an indicator variable identifying female older adults was 0.022 (see Table 11), significant at a 0.05 significance level. The odds ratio for female older adults was 0.903 compared to male older adults indicating that females had a slightly lower

probability of being readmitted. The area under the ROC curve was only 0.513 demonstrating that knowing the gender of the older adult provided very little information to predict readmission. While there is a statistically significant difference in readmission rates between men and women, the true difference in these rates is very small.

Table 11

Parameter Estimates, Odds Ratios, and P-Values for the Logistic Regression Model Using Gender

Variable	Estimate	Odds Ratio	*p*-value
Gender (Female)	-0.102	0.903	0.0222

Research Question Five

Research question five focused on identifying differences in 30-day readmission rates among older adults ($\geq$ 65) whose expected insurance was Medicare who had a principle or secondary discharge diagnosis of severe sepsis or septic shock from different locations relative to urban areas. Location information was based on the older adult's rural-urban classification and was divided into six (6) groups. These represent classification of United States counties as (1) Central counties of metropolitan areas with at least one (1) million population, (2) Fringe counties of metropolitan areas with at least one (1) million population, (3) Counties in metropolitan areas of 250,000-999,999 population, (4) Counties in metropolitan areas of 50,000-249,999 population, (5) Micropolitan counties, (6) Not metropolitan or micropolitan counties ("THE HCUP NATIONWIDE READMISSIONS DATABASE (NRD), 2014," n.d.). Chi-square tests and logistic regression models were used assess the association between an older adult's location category and 30-day readmission rates.

Table 12 contains counts for older adults who either readmitted or did not readmit from each location category. Thirty older adults recorded an unknown location category and were removed from the analysis.

Table 12

Frequency Table Comparing Readmitted Older Adults and Non-Readmitted Older Adults Among Location Based on Rural-Urban County Classification

	30-day Readmitted	
Location	No	Yes
1	4347	839
2	3031	567
3	2637	474
4	1145	217
5	966	150
6	669	121
Total	12795	2368

Thirty-day readmission rates for the six rural-urban classifications were 16.2%, 15.8%, 15.2%, 15.9%, 13.4%, and 15.3%, respectively from the most urban classification (1) to the most rural (6). A chi-square test compared the proportion of readmissions from each location category to the counts that were expected if the true readmission rate was equal among each category. The chi-square statistic for tests comparing all categories was 6.237 with a *p*-value of 0.397, which indicated that there is was no statistically significant deviation between location categories compared to the total readmission rate across all categories.

Logistic regression modeling was used to predict 30-day readmission rates and further quantify differences between older adults from different location categories. No additional variables were used during modeling. Table 13 shows coefficient estimates, odds ratios and *p*-values associated with location categories. The odds ratio of all groups

were less than one (1), as compared to locations category one (1), indicating all other groups have a lower probability of readmission. Only category five (5), representing micropolitan counties, had a statistically significant effect on 30-day readmission rates at a 0.05 significance level. In general, the model explained very little deviance compared to an intercept-only model. This suggests that location based on rural-urban classification has little effect on an older adult's likelihood to be readmitted. While one category is statistically significant, adjusting results to account for simultaneous testing would likely result in non-significant results for all location classifications.

Table 13

Parameter Estimates, Odds Ratios, and P-Values for the Logistic Regression Model Using Location Based and a County's Rural-Urban Classification

Variable	Estimate	Odds Ratio	*p*-value
2	-0.031	0.969	0.5981
3	-0.071	0.931	0.2552
4	-0.018	0.982	0.8263
5	-0.217	0.805	0.0228
6	-0.065	0.937	0.5390

Research Question Six

Research question six related to the number of days after discharge until an older adult (≥ 65) whose expected insurance was Medicare who had a principle or secondary discharge diagnosis of severe sepsis or septic shock is among readmitted older adults (≥ 65). The distribution of number of days from discharge until readmission was determined for all older adults (≥ 65), all older adults (≥ 65) readmitted within 30 days, older adults (≥ 65) discharged with severe sepsis or septic shock, and older adults (≥ 65) discharged with severe sepsis or septic shock and readmitted within 30 days.

The mean number of days between discharge and readmission among older adults considered during the rest of this research (65 years or older, expected insurance was Medicare, discharged with principle or secondary diagnosis of severe sepsis or septic shock) was 13.5 days. This was slightly higher than the median of 12 days. If discharge diagnoses are ignored, the number of 30-day readmissions is 910,081. The mean number of discharges is 14.1, slightly higher than older adults with severe sepsis or septic shock. Among older adults diagnosed with severe sepsis or septic shock but readmitted anytime within the same year, the mean number of days between discharge and readmission was 85 days with a standard deviation of 78.3. Finally, among all 3,167,055 older adults that were discharged and readmitted within the same year, the mean number of days was 92, with a standard deviation of 80.3. Table 14 shows summary statistics from these four (4) groups of older adults. Figure 4 contains frequency plots for the number of days between discharge and readmission for each group of older adults.

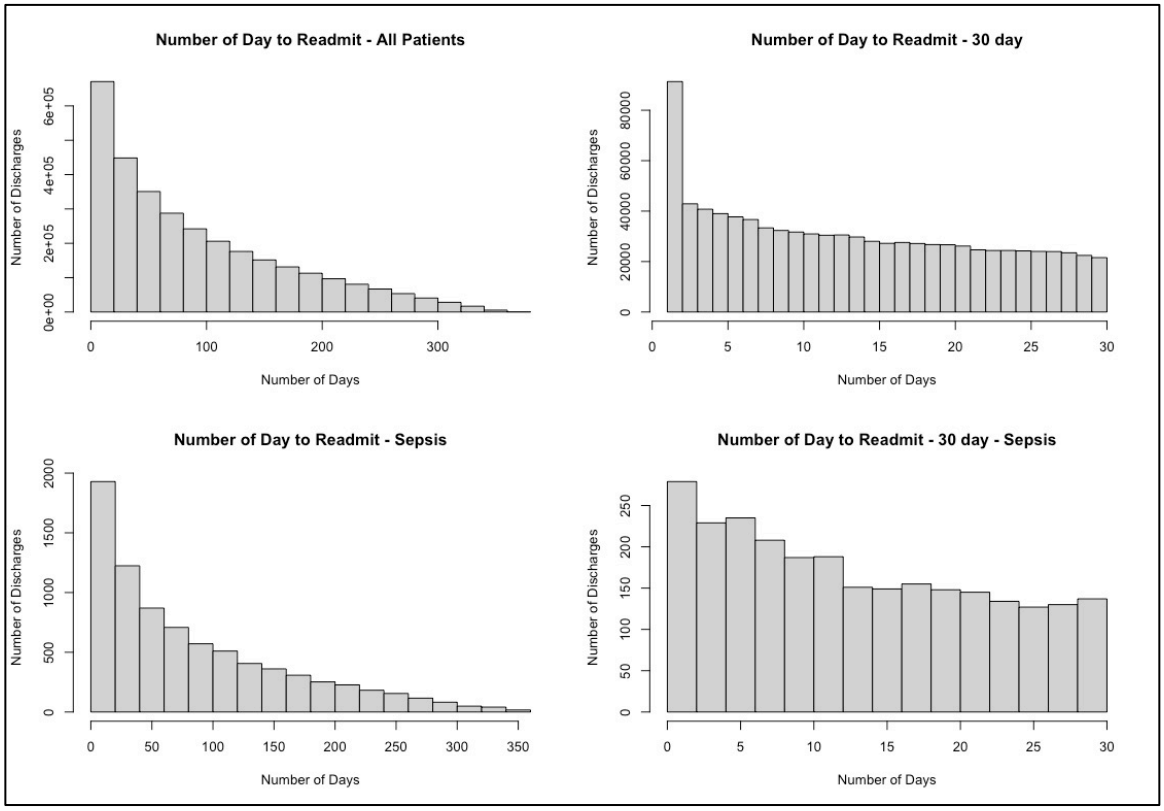
Table 14

Summary Statistics of Number of Days Between Discharge and Readmission

Variable	N	Mean	Median	Standard Deviation	Min	Max
All Readmits	3167055	92.00	68	80.25	1	363
30-day Readmits	910081	14.11	13	8.81	1	30
Sepsis / Shock	8008	85.04	60	78.28	1	365
30-day Readmits – Sepsis / Shock	2374	13.51	12	8.74	1	30

Figure 4

Frequency Plots of Number of Days Between Discharge and Readmission



Summary

Statistical tests and modeling were used to explore 2014 30-day readmission rates and LOS for older adults (≥ 65) whose expected payer was Medicare, and who discharged with a principle or secondary discharge diagnosis of severe sepsis or septic shock. The relationship between readmission rates and demographic, geographic, and other variables were explored. Approximately 15.6% of older adult's whose principle or secondary discharge diagnosis was severe sepsis or septic shock were readmitted within 30 days of their discharge. The rates of readmission were statistically different based on the older adult's age, gender, and LOS. Reported results indicated that older adults (85+) and females were less likely to be readmitted than other older adults. Location based on

rural-urban county classification did not have a significant effect on readmission rates among the older adult population of interest. Mean LOS among readmitted older adults was 10.1 days. Reported results indicate that an older adult's LOS had a significant effect on readmission rates, although models predicting these rates performed poorly. Discussion of these results are provided in the following chapter.

CHAPTER 5. DISCUSSION

Conclusions and Recommendations

The objective of this quantitative research study was to analyze 30-day readmission rates for older adults (≥ 65) whose expected payer was Medicare and who discharged with a principle or secondary discharge diagnosis of severe sepsis or septic shock and to observe the effects that older adult demographics have on these rates and LOS. Data used to answer the proposed research questions consisted of older adult discharge records from the 2014 Nationwide Readmissions Database (NRD), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality. Only adults who were 65 and older with an expected payer of Medicare and who discharged home with a principle or secondary discharge diagnosis of severe sepsis or septic shock were included for statistical analyses. Research questions pertained to this population. Severe sepsis and septic shock, serious and rather uncommon conditions among discharged older adults, reduced the data available for the proposed statistical methods and subsequent analysis. Data were also restricted to initially discharged older adults between January 2014 and November 2014 to allow a 30-day run-out period for a possible readmission to occur.

A summary of the research findings indicated that 15.6% older adults (≥ 65) with an expected payer of Medicare who discharged with a principle or secondary discharge diagnosis of severe sepsis or septic shock were readmitted within 30 days of their discharge. The rates of readmission were statistically different based on the older adult's age, gender, and LOS. Results indicated that older adults (80+) and females were less likely to be readmitted than other older adults. The older adult's location, based on rural-

urban county classification, did not have a significant effect on readmission rates among the population of interest. Mean LOS among readmitted older adults was ten (10) days. The results of the analysis showed that older adult's LOS had a significant effect on readmission rates, although models predicting these rates performed poorly. The interpretation and implications of these research findings are discussed in this chapter.

Interpretation of the Findings

In this section, the findings from the previous chapter will be interpreted based on whether they have confirmed, disconfirmed, or extended knowledge in the discipline by comparing them to what has been reported in existing literature on readmission rates for older adults with an expected payer of Medicare and who discharged home with principle or secondary discharge diagnosis of severe sepsis or septic shock. The discussion was made in the context of the theoretical framework. Finally, the interpretation of the findings is organized based on the six (6) study research questions.

Research question one: What percentage of older adults ($\geq$ 65) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock had a 30-day readmission?

The overall 30-day readmission rate among older adults ($\geq$ 65) whose expected primary payer was Medicare and who discharged home with a principle or secondary discharge diagnosis of severe sepsis or septic shock was 15.6%. This readmission rate was consistent with previous studies on the readmission rate of patients diagnosed with sepsis among older adults, indicating that older adults are at risk for being re-admitted from sepsis-related hospitalization (Gadre, Shah, Mireles-Cabodevila, Patel, & Duggal, 2019; Hatfield et al., 2018). The contribution of this study is that the readmission rate

findings were specified by the study population to include only older adults (≥ 65) whose expected primary payer was Medicare and who discharged home with a principle or secondary discharge diagnosis of severe sepsis or septic shock.

Research question two**:** Is index hospital LOS associated with 30-day readmission rate in older adults (≥ 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock?

LOS was a significant predictor for readmission rates among this older adult population, indicating that increased LOS was associated with higher 30-day readmission rates. Previous studies have not focused on the relationship of hospital LOS and 30-day readmissions in older adult severe sepsis or septic shock survivors (Rhee & Klompas, 2017). The current findings provide empirical support that as the LOS increases, the more likely that older adults who have been discharged with a principle or secondary discharge diagnosis of severe sepsis or septic shock will be re-admitted within 30-days of index hospital discharge.

Given that age was also found to be a covariate of LOS and readmission rate among the older adults, the same finding was found after age was controlled. Older adults (80+) were less likely to be readmitted within 30 days. This is consistent with Goodwin et al.'s (2015), who found that severe sepsis survivors are less likely to be readmitted if they are older than 80 years. Given that LOS continues to be a significant predictor of readmission after age has been controlled, the current findings provide further empirical support that as the LOS increases, the more likely that older adults who have been discharged with a principle or secondary discharge diagnosis of severe sepsis or septic shock will be re-admitted within 30 days.

Research question three: Is age associated with 30-day readmission in older adults (≥ 65 years) whose expected primary payer was Medicare and who discharged home with a principle or secondary diagnosis of severe sepsis or septic shock?

The findings indicated that age was a statistically significant predictor of readmission rates among older adults whose expected primary payer was Medicare and who were discharged home with a principle or secondary diagnosis of severe sepsis or septic shock. More specifically, as age increases, the likelihood for readmission decreases. This is generally not consistent with previous studies indicating that older age is a risk factor for hospital readmission (Jones et al., 2015; Schneider et al., 2013). These previous studies, however, did not involve older adults who had been discharged with a principle or secondary discharge diagnosis of severe sepsis or septic shock. The current research study provides support that age negatively predicts readmission among older adults who were discharged with a principle or secondary diagnosis of severe sepsis or septic shock.

More sophisticated analyses showed that with each additional year of age, the odds of being readmitted within 30 days decreases. This indicates that readmission probability likely increases by year until a certain age and then begins to decrease for older adults. This pattern of readmission rate was also observed in a previous study conducted by Goodwin et al. (2015) who found that severe sepsis survivors are less likely to be readmitted if they are older than 80 years. In order to explain why the likelihood of being readmitted within 30 days decreases for each additional year of age, Tangeman et al. (2014) suggested that as individuals become frailer as they age, there is increased

likelihood for palliative care discussion and decisions resulting in subsequent readmission avoidance.

Research question four: Is gender associated with 30-day readmission rate in older adults (≥ 65) whose expected primary payer was Medicare and who discharged home with a principle or secondary discharge diagnosis of severe sepsis or septic shock?

The research findings showed that females had a lower probability of being readmitted. Even though there is a statistically significant difference in readmission rates between men and women, the true difference in these rates was small. These findings are inconsistent with previous research such as the one conducted by Khera et al. (2017), who both found that gender, specifically women, is a risk factor for being readmitted after having been discharged after surviving severe sepsis.

One possible explanation for the inconsistency of the current findings with the existing literature was provided in one previous study, wherein older men were found to be more often nonadherent to healthy behaviors and have poor dietary choices (Satariano, 2006). This suggests that the current findings that females had a lower probability of being readmitted compared to males is because females are more likely to have healthier behaviors and adherence to medical recommendations, putting them at less at risk for readmission. However, given the small statistical differences between the readmission rate between men and women from the findings, these assertions cannot be confidently made.

Research question five: Is older adult location associated with 30-day readmission rate for older adults (≥ 65) whose expected primary payer was Medicare and who

discharged home with a principle or secondary discharge diagnosis of severe sepsis or septic shock?

In general, the findings showed that older adult location based on rural-urban classification has little effect on an older adult's likelihood to be readmitted after discharging with a principle or secondary discharge diagnosis of severe sepsis or septic shock. The current literature on the role of location in the readmission from sepsis is inconsistent. Goodwin et al. (2015) found that there is no significant relationship between location and readmission from sepsis. This is inconsistent with previous findings indicating that living in urban locations is considered a risk factor for 30-day readmission from sepsis (Chang et al., 2015). Hatfeld et al. (2018) also found that the place where health care was provided could impact the prognosis of sepsis patients, suggesting the possible differences in health outcomes among rural and urban older adults. The current research study was consistent with the findings of Goodwin et al. (2015), providing additional empirical support for the lack of effect of the rural-urban classification in an older adult's likelihood to be readmitted after discharging with a principle or secondary discharge diagnosis of severe sepsis or septic shock within the 30-day time frame.

Research question six: What is the mean number of days to readmission after discharge for older adults who had a readmission?

The mean number of days between discharge and readmission among older adults considered in this research (65 years or older, expected payer was Medicare, discharged with a principle or secondary discharge diagnosis of severe sepsis or septic shock) was 13.5 days. The contribution of this study is that information was uncovered about the critical point wherein readmission is likely to occur in this population. This projection

accounts for the inclusion of several interrelated characteristics such as older adults were 65 and older, Medicare was the expected payer, and who had discharged with a principle or secondary discharge diagnosis of severe sepsis or septic shock.

Another contribution of this research study findings was that several permutations were tested in order to determine the typical number of days where readmission is likely to occur. For example, if discharge diagnoses are ignored, the mean number of days between discharge and readmission was 14.1, slightly higher than older adults with severe sepsis or septic shock. Among older adults diagnosed with severe sepsis or septic shock but readmitted anytime within the same year, the mean number of days between discharge and readmission was 85 days. Finally, among all older adults who were discharged and readmitted within the same year, the mean number of days between discharge and readmission was 92 days.

Limitations of the Study

One limitation of this study is the generalizability of the findings. The research was delimited to older adults ($\geq$ 65) whose expected insurance was Medicare and who discharged with a principle or secondary discharge diagnosis of severe sepsis or septic shock. These findings do not apply to all categories of patients diagnosed with sepsis and to other age levels. Generalizations should match the characteristics of the sample for this study in order to arrive at relatively accurate conclusions and interpretations.

Another limitation of this research study involves the retrospective nature and the cross-sectional design of the study. For instance, data that were used to operationalize the variables of the study have been previously collected from State Inpatient Databases (SID), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research

and Quality and consumed into the 2014 Nationwide Readmissions Database (NRD), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research. The use of secondary or archival data meant that this researcher had no control of the contents and the accuracy of the data and the possibility of bias in terms of representativeness.

Another limitation involves the statistical significance of some of the findings that were generated. For instance, the finding that females had a slightly lower probability of being readmitted compared to males cannot be taken confidently given that only a small statistical difference was found between the readmission rate between men and women who had severe sepsis or septic shock. These research findings need further verification in future research studies in order to fully establish the clarity of the relationship of the variables.

Recommendations

Based on the findings of this study regarding the relationship between gender and the 30-day readmission rate among older adults with severe sepsis, more research should be explored to understand its inconsistency with previous research indicating that women are more at risk for being readmitted after having been previously admitted from severe sepsis (Wilcox, Donnelly, & Lone, 2020). Future research should explore the possible interaction effects of gender on other covariates in order to fully understand the role of gender in the 30-day readmission of older adults who had been previously admitted for sepsis.

Another recommendation for future research is to further expand the knowledge by exploring possible moderators that enhance the specificity of the relationship of the variables. Given that all of the variables in the study were non-psychological constructs

such as gender, age, and LOS, future researchers should explore the role of psychological constructs as possible moderators or mediators. Some examples of psychological constructs that could be explored include self-efficacy, personality traits, activation, and optimism.

Implications

The implications of the findings for positive social change is enhanced through a deeper understanding the risks factors associated with the 30-day readmission of older adults (≥ 65) whose expected primary insurance was Medicare and who were discharged with a principle or secondary discharge diagnosis of severe sepsis or septic shock. At the society and policy levels, the findings can be used to identify vulnerable sub-populations so that more specialized care can be provided in order to minimize readmission. Hospitals could save money by keeping patients in the hospital longer in order for physicians and nurses to ensure that reasons for a patients' potential readmissions are identified and mitigated, provide and validate additional education, and monitor the patient's response to changes in treatment and medications (Dietz et al., 2017). The total cost per patient is known to decrease as a result of reduction in the 30-day readmissions. Hence, a deeper understanding of the different risk factors associated with the readmission of older adults (≥ 65) whose expected primary insurance was Medicare and who were discharged with a principle or secondary discharge diagnosis of severe sepsis or septic shock can be helpful in mitigating the economic and social burden of re-hospitalization.

Older adults (≥ 65) whose expected primary insurance was Medicare and who were discharged with a principle or secondary discharge diagnosis of severe sepsis or septic shock are at risk for a 30-day readmission, underscoring the importance of

evidence-based knowledge that can influence health care policies to limit readmission (Gadre, Shah, Mireles-Cabodevila, Patel, & Duggal, 2019). Previous studies on the readmission of sepsis patients who are older have been less grounded on existing theoretical models. The theoretical implication of this study is that research on readmission among older adults who had been previously hospitalized for sepsis had not been sufficiently framed by theories. Based on the research findings, there appears to be a need to conceptualize the readmission of older adults who discharged with a sepsis-related diagnosis based on existing body of evidence-based knowledge, including the contributions of this current research study.

Conclusion

Research findings indicated that approximately 15.6% of older adults (≥ 65) whose expected primary insurance was Medicare and who were discharged with a principle or secondary discharge diagnosis of severe sepsis or septic shock were readmitted within 30 days of their discharge. The rates of readmission were statistically different based on the older adult's age, gender, and LOS. Results show that older adults (80+) and females were slightly less likely to be readmitted than other older adults. Location, in terms of the rural-urban county classification, did not have a statistically significant effect on the readmission rates among the older adult population of interest. Mean LOS among readmitted older adults was 10.1 days. Finally, the results of the analysis also showed that older adult's LOS had a statistically significant effect on readmission rates, although models predicting these rates performed poorly.

Readmission of older adults is a significant economic burden for health care institutions and payers, including Medicare (Strom et al., 2017). These findings suggest

that there are certain factors that can predict older adults who are at risk for being readmitted after being discharged with a principle or secondary discharge diagnosis of severe sepsis or septic shock. Through the identification of certain combinations of risk factors, health care professionals may be able to identify vulnerable groups that could inform their provision of care. Health care professionals could have a deeper understanding of the complexity of interrelated factors in determining the risk of readmission among older adults ($\geq$ 65) whose expected primary insurance was Medicare and who were discharged with a principle or secondary discharge diagnosis of severe sepsis or septic shock. Lastly, there is an impetus for healthcare providers to provide initial and continued education for older adults to increase self-awareness and acquisition of self-management skills, including the adoption of healthier lifestyles and behaviors.

REFERENCES

Albert, M., McCaig, L. F., & Ashman, J. J. (2013). Emergency department visits by persons aged 65 and over: United States, 2009-2010. *NCHS Data Brief*.

Angus, D. C., Linde-Zwirble, W. T., Lidicker, J., Clermont, G., Carcillo, J., & Pinsky, M. R. (2001). Epidemiology of severe sepsis in the United States: Analysis of incidence, outcome, and associated costs of care. *Critical Care Medicine*. https://doi.org/10.1097/00003246-200107000-00002

Angus, D. C., & Van Der Poll, T. (2013). Severe sepsis and septic shock. *New England Journal of Medicine*. https://doi.org/10.1056/NEJMra1208623

Austin, S., Murthy, S., Wunsch, H., Adhikari, N. K. J., Karir, V., Rowan, K., … Angus, D. C. (2014). Access to urban acute care services in high- vs. middle-income countries: An analysis of seven cities. *Intensive Care Medicine*. https://doi.org/10.1007/s00134-013-3174-7

Barrett, M. L., Wier, L. M., Jiang, J., & Steiner, C. A. (2015). *All-Cause Readmissions by Payer and Age, 2009-2013: Table 2*. *HCUP Statistical Brief #199*. https://doi.org/NBK343800 [bookaccession]

Bentayeb, M., Simoni, M., Baiz, N., Norback, D., Baldacci, S., Maio, S., … Annesi-Maesano, I. (2012). Adverse respiratory effects of outdoor air pollution in the elderly. *International Journal of Tuberculosis and Lung Disease*. https://doi.org/10.5588/ijtld.11.0666

Berenson, R. A., Pronovost, P. J., & Krumholz, H. M. (2013). Achieving the Potential of Health Care Performance Measures. *Timely Analysis of Immediate Health Policy Issues*.

Bernard, A. M., & Bernard, G. R. (2012). The immune response: Targets for the treatment of severe sepsis. *International Journal of Inflammation*. https://doi.org/10.1155/2012/697592

Boehme, A. K., Ranawat, P., Luna, J., Kamel, H., & Elkind, M. S. V. (2017). Risk of Acute Stroke after Hospitalization for Sepsis: A Case-Crossover Study. *Stroke*. https://doi.org/10.1161/STROKEAHA.116.016162

Brummel, N. E., Jackson, J. C., Pandharipande, P. P., Thompson, J. L., Shintani, A. K., Dittus, R. S., … Girard, T. D. (2014). Delirium in the ICU and subsequent long-term disability among survivors of mechanical ventilation. In *Critical Care Medicine*. https://doi.org/10.1097/CCM.0b013e3182a645bd

Buchman, T. G., Simpson, S. Q., Sciarretta, K. L., Finne, K. P., Sowers, N., Collier, M., … Kelman, J. A. (2020). Sepsis Among Medicare Beneficiaries. *Critical Care Medicine*, *48*(3), 276–288. https://doi.org/10.1097/CCM.0000000000004224

Burke, R. E., Juarez-Colunga, E., Levy, C., Prochazka, A. V., Coleman, E. A., & Ginde, A. A. (2015a). Patient and hospitalization characteristics associated with increased postacute care facility discharges from US hospitals. *Medical Care*. https://doi.org/10.1097/MLR.0000000000000359

Burke, R. E., Juarez-Colunga, E., Levy, C., Prochazka, A. V., Coleman, E. A., & Ginde, A. A. (2015b). Rise of post-acute care facilities as a discharge destination of us hospitalizations. *JAMA Internal Medicine*. https://doi.org/10.1001/jamainternmed.2014.6383

Carey, K. (2015). Measuring the hospital length of stay/readmission cost trade-off under a bundled payment mechanism. *Health Economics (United Kingdom)*, *24*(7), 790–802. https://doi.org/10.1002/hec.3061

Carey, K., & Lin, M.-Y. (2014). Hospital length of stay and readmission: an early investigation. *Medical Care Research and Review : MCRR*, *71*(1), 99–111. https://doi.org/10.1177/1077558713504998

Castelo-Branco, C., & Soveral, I. (2014). The immune system and aging: A review. *Gynecological Endocrinology*, *30*(1), 16–22. https://doi.org/10.3109/09513590.2013.852531

Centers for Medicare & Medicaid Services. (2019). Measure Details. Retrieved July 9, 2020, from https://cmit.cms.gov/CMIT_public/ViewMeasure?MeasureId=1017

Chang, D. W., Tseng, C. H., & Shapiro, M. F. (2015). Rehospitalizations following sepsis: Common and costly. *Critical Care Medicine*, *43*(10), 2085–2093. https://doi.org/10.1097/CCM.0000000000001159

Chao, P. W., Shih, C. J., Lee, Y. J., Tseng, C. M., Kuo, S. C., Shih, Y. N., … Chen, Y. T. (2014). Association of postdischarge rehabilitation with mortality in intensive care unit survivors of sepsis. *American Journal of Respiratory and Critical Care Medicine*, *190*(9), 1003–1011. https://doi.org/10.1164/rccm.201406-1170OC

CMS Innovation Center Homepage | CMS Innovation Center. (n.d.). Retrieved July 9, 2020, from https://innovation.cms.gov/

Coleman, E. A. (2003). Falling through the cracks: Challenges and opportunities for improving transitional care for persons with continuous complex care needs. *Journal of the American Geriatrics Society*, *51*(4), 549–555. https://doi.org/10.1046/j.1532-5415.2003.51185.x

Cooke, C. R., & Iwashyna, T. J. (2014). Sepsis mandates: Improving inpatient care while advancing quality improvement. *JAMA - Journal of the American Medical Association*, *312*(14), 1397–1398. https://doi.org/10.1001/jama.2014.11350

Damrauer, S. M., Gaffey, A. C., Debord Smith, A., Fairman, R. M., & Nguyen, L. L. (2015). Comparison of risk factors for length of stay and readmission following lower extremity bypass surgery Presented at the 2014 Joint Annual Meeting of the New England Society for Vascular Surgery and Eastern Vascular Society, Boston, Mass, September 11-14, . *Journal of Vascular Surgery*, *62*(5), 1192-1200.e1. https://doi.org/10.1016/j.jvs.2015.06.213

Danai, P. A., Sinha, S., Moss, M., Haber, M. J., & Martin, G. S. (2007). Seasonal variation in the epidemiology of sepsis. *Critical Care Medicine*, *35*(2), 410–415. https://doi.org/10.1097/01.CCM.0000253405.17038.43

Davydow, D. S., Hough, C. L., Langa, K. M., & Iwashyna, T. J. (2012). Depressive symptoms in spouses of older patients with severe sepsis. *Critical Care Medicine*, *40*(8), 2335–2341. https://doi.org/10.1097/CCM.0b013e3182536a81

de Groot, B., Ansems, A., Gerling, D. H., Rijpsma, D., van Amstel, P., Linzel, D., … de Jonge, E. (2015). The association between time to antibiotics and relevant clinical outcomes in emergency department patients with various stages of sepsis: A prospective multi-center study. *Critical Care*, *19*(1). https://doi.org/10.1186/s13054-015-0936-3

Dellinger, R. P., Levy, M. M., Rhodes, A., Annane, D., Gerlach, H., Opal, S. M., … Moreno, R. (2013). Surviving Sepsis Campaign. *Critical Care Medicine*, *41*(2), 580–637. https://doi.org/10.1097/CCM.0b013e31827e83af

Desai, S. V., Law, T. J., & Needham, D. M. (2011). Long-term complications of critical care. *Critical Care Medicine*, *39*(2), 371–379. https://doi.org/10.1097/CCM.0b013e3181fd66e5

Dharmarajan, K., Hsieh, A. F., Lin, Z., Bueno, H., Ross, J. S., Horwitz, L. I., … Krumholz, H. M. (2013). Diagnoses and timing of 30-day readmissions after hospitalization for heart failure, acute myocardial infarction, or pneumonia. *JAMA - Journal of the American Medical Association*, *309*(4), 355–363. https://doi.org/10.1001/jama.2012.216476

Dietz, B. W., Jones, T. K., Small, D. S., Gaieski, D. F., & Mikkelsen, M. E. (2017). The Relationship Between Index Hospitalizations, Sepsis, and Death or Transition to Hospice Care During 30-Day Hospital Readmissions. *Medical Care*, *55*(4), 362–370. https://doi.org/10.1097/MLR.0000000000000669

Donnelly, J. P., Hohmann, S. F., & Wang, H. E. (2015). Unplanned Readmissions after Hospitalization for Severe Sepsis at Academic Medical Center-Affiliated Hospitals. *Critical Care Medicine*, *43*(9), 1916–1927. https://doi.org/10.1097/CCM.0000000000001147

Elsawy, B., & Higgins, K. E. (2011). The Geriatric Assessment. *American Family Physician Www.Aafp.Org/Afp*, *83*(1).

Fleischmann, C., Scherag, A., Adhikari, N. K. J., Hartog, C. S., Tsaganos, T., Schlattmann, P., … Reinhart, K. (2016). Assessment of global incidence and mortality of hospital-treated sepsis current estimates and limitations. *American Journal of Respiratory and Critical Care Medicine*, *193*(3), 259–272. https://doi.org/10.1164/rccm.201504-0781OC

Gadre, S. K., Shah, M., Mireles-Cabodevila, E., Patel, B., & Duggal, A. (2019). Epidemiology and Predictors of 30-Day Readmission in Patients With Sepsis. *Chest*, *155*(3), 483–490. https://doi.org/10.1016/j.chest.2018.12.008

Geerlings, S. E., Hulscher, M. E. J. L., & Prins, J. M. (2014). [Appropriate use of antibiotics shortens length of hospital stay]. *Nederlands Tijdschrift Voor Geneeskunde*, *158*, A7288.

Gentile, L. F., Nacionales, D. C., Lopez, M. C., Vanzant, E., Cuenca, A., Cuenca, A. G., … Efron, P. A. (2014). Protective Immunity and Defects in the Neonatal and Elderly

Immune Response to Sepsis. *The Journal of Immunology*, *192*(7), 3156–3165. https://doi.org/10.4049/jimmunol.1301726

Ginde, A. A., Moss, M., Shapiro, N. I., & Schwartz, R. S. (2013). Impact of older age and nursing home residence on clinical outcomes of US emergency department visits for severe sepsis. *Journal of Critical Care*, *28*(5), 606–611. https://doi.org/10.1016/j.jcrc.2013.03.018

Goodwin, A. J., Rice, D. A., Simpson, K. N., & Ford, D. W. (2015). Frequency, cost, and risk factors of readmissions among severe sepsis survivors. *Critical Care Medicine*, *43*(4), 738–746. https://doi.org/10.1097/CCM.0000000000000859

Hamerman, D. (1997). Aging and the musculoskeletal system. *Annals of the Rheumatic Diseases*, *56*(10), 578–585. https://doi.org/10.1136/ard.56.10.578

Hannan, E. L., Zhong, Y., Lahey, S. J., Culliford, A. T., Gold, J. P., Smith, C. R., … Wechsler, A. (2011). 30-Day readmissions after coronary artery bypass graft surgery in New York State. *JACC: Cardiovascular Interventions*, *4*(5), 569–576. https://doi.org/10.1016/j.jcin.2011.01.010

Hatfeld, K. M., Dantes, R. B., Baggs, J., Sapiano, M. R. P., Fiore, A. E., Jernigan, J. A., & Epstein, L. (2018). Assessing variability in hospital-level mortality among U.S. Medicare benefciaries with hospitalizations for severe sepsis and septic shock. *Critical Care Medicine*, *46*(11), 1753–1760. https://doi.org/10.1097/CCM.0000000000003324

Hines, A. L., Barrett, M. L., Jiang, H. J., & Steiner, C. A. (2014). *Conditions With the Largest Number of Adult Hospital Readmissions by Payer, 2011*.

Hoffstaedter, F., Grefkes, C., Roski, C., Caspers, S., Zilles, K., & Eickhoff, S. B. (2015). Age-related decrease of functional connectivity additional to gray matter atrophy in a network for movement initiation. *Brain Structure and Function*, *220*(2), 999–1012. https://doi.org/10.1007/s00429-013-0696-2

Hosp. Readmission Reduction | CMS. (2020). Retrieved July 8, 2020, from https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/Value-Based-Programs/HRRP/Hospital-Readmission-Reduction-Program

Hospitals | CMS. (n.d.). Retrieved July 9, 2020, from https://www.cms.gov/Medicare/Provider-Enrollment-and-Certification/CertificationandComplianc/Hospitals

Hunter, A., Johnson, L., & Coustasse, A. (2014). Reduction of intensive care unit length of stay: The case of early mobilization. *Health Care Manager*, *33*(2), 128–135. https://doi.org/10.1097/HCM.0000000000000006

ICD - ICD-9-CM - International Classification of Diseases, Ninth Revision, Clinical Modification. (n.d.). Retrieved July 9, 2020, from https://www.cdc.gov/nchs/icd/icd9cm.htm

Iwashyna, T. J., & Angus, D. C. (2014). Declining case fatality rates for severe sepsis: Good data bring good news with ambiguous implications. *JAMA - Journal of the*

American Medical Association, *311*(13), 1295–1297. https://doi.org/10.1001/jama.2014.2639

Iwashyna, T. J., Netzer, G., Langa, K. M., & Cigolle, C. (2012). Spurious inferences about long-term outcomes: The case of severe sepsis and geriatric conditions. *American Journal of Respiratory and Critical Care Medicine*, *185*(8), 835–841. https://doi.org/10.1164/rccm.201109-1660OC

Iwashyna, T. J., Odden, A., Rohde, J., Bonham, C., Kuhn, L., Malani, P., … Flanders, S. (2014). Identifying patients with severe sepsis using administrative claims: Patient-level validation of the angus implementation of the international consensus conference definition of severe sepsis. *Medical Care*, *52*(6). https://doi.org/10.1097/MLR.0b013e318268ac86

Jencks, S. F., Williams, M. V., & Coleman, E. A. (2009). Rehospitalizations among patients in the medicare fee-for-service program. *New England Journal of Medicine*, *360*(14), 1418–1428. https://doi.org/10.1056/NEJMsa0803563

Johnston, C. J. C., McSorley, H. J., Anderton, S. M., Wigmore, S. J., & Maizels, R. M. (2014). Helminths and immunological tolerance. *Transplantation*, *97*(2), 127–132. https://doi.org/10.1097/TP.0b013e3182a53f59

Jones, T. K., Fuchs, B. D., Small, D. S., Halpern, S. D., Hanish, A., Umscheid, C. A., … Mikkelsen, M. E. (2015). Post-acute care use and hospital readmission after sepsis. *Annals of the American Thoracic Society*, *12*(6), 904–913. https://doi.org/10.1513/AnnalsATS.201411-504OC

Joynt, K. E., & Jha, A. K. (2013). Characteristics of hospitals receiving penalties under the hospital readmissions reduction program. *JAMA - Journal of the American Medical Association*, *309*(4), 342–343. https://doi.org/10.1001/jama.2012.94856

Kaboli, P. J., Go, O. T., Hockenberry, J., Glasgow, J. M., Johnson, S. R., Rosenthal, G. E., … Vaughan-Sarrazin, M. (2012). Associations between reduced hospital length of stay and 30-day readmission rate and mortality: 14-year experience in 129 veterans affairs hospitals. *Annals of Internal Medicine*, *157*(12), 837–845. https://doi.org/10.7326/0003-4819-157-12-201212180-00003

Kaukonen, K. M., Bailey, M., Suzuki, S., Pilcher, D., & Bellomo, R. (2014). Mortality related to severe sepsis and septic shock among critically ill patients in Australia and New Zealand, 2000-2012. *JAMA - Journal of the American Medical Association*, *311*(13), 1308–1316. https://doi.org/10.1001/jama.2014.2637

Khan, H., Greene, S. J., Fonarow, G. C., Kalogeropoulos, A. P., Ambrosy, A. P., Maggioni, A. P., … Butler, J. (2015). Length of hospital stay and 30-day readmission following heart failure hospitalization: Insights from the EVEREST trial. *European Journal of Heart Failure*, *17*(10), 1022–1031. https://doi.org/10.1002/ejhf.282

Khera, R., Jain, S., Pandey, A., Agusala, V., Kumbhani, D. J., Das, S. R., … Girotra, S. (2017). Comparison of Readmission Rates After Acute Myocardial Infarction in 3 Patient Age Groups (18 to 44, 45 to 64, and ≥65 Years) in the United States. *American Journal of Cardiology*, *120*(10), 1761–1767. https://doi.org/10.1016/j.amjcard.2017.07.081

Kohlnhofer, B. M., Tevis, S. E., Weber, S. M., & Kennedy, G. D. (2014). Multiple complications and short length of stay are associated with postoperative readmissions. *American Journal of Surgery*, *207*(4), 449–456. https://doi.org/10.1016/j.amjsurg.2013.10.022

Kripalani, S., Theobald, C. N., Anctil, B., & Vasilevskis, E. E. (2014). Reducing Hospital Readmission Rates: Current Strategies and Future Directions. *Annual Review of Medicine*, *65*(1), 471–485. https://doi.org/10.1146/annurev-med-022613-090415

Lagu, T., Rothberg, M. B., Shieh, M. S., Pekow, P. S., Steingrub, J. S., & Lindenauer, P. K. (2012). Hospitalizations, costs, and outcomes of severe sepsis in the United States 2003 to 2007. *Critical Care Medicine*, *40*(3), 754–761. https://doi.org/10.1097/CCM.0b013e318232db65

Lau, D., Padwal, R. S., Majumdar, S. R., Pederson, J. L., Belga, S., Kahlon, S., … McAlister, F. A. (2016). Patient-Reported Discharge Readiness and 30-Day Risk of Readmission or Death: A Prospective Cohort Study. *American Journal of Medicine*, *129*(1), 89–95. https://doi.org/10.1016/j.amjmed.2015.08.018

Lee, S. Y., Lee, S. H., Tan, J. H. H., Foo, H. S. L., Phan, P. H., Kow, A. W. C., … Mordiffi, S. Z. (2018). Factors associated with prolonged length of stay for elective hepatobiliary and neurosurgery patients: a retrospective medical record review. *BMC Health Services Research*, *18*(1), 5. https://doi.org/10.1186/s12913-017-2817-8

Leisman, D., Wie, B., Doerfler, M., Bianculli, A., Ward, M. F., Akerman, M., … Zemmel D'Amore, J. A. (2016). Association of Fluid Resuscitation Initiation Within 30 Minutes of Severe Sepsis and Septic Shock Recognition With Reduced Mortality and Length of Stay. *Annals of Emergency Medicine*, *68*(3), 298–311. https://doi.org/10.1016/j.annemergmed.2016.02.044

Lemay, A. C., Anzueto, A., Restrepo, M. I., & Mortensen, E. M. (2014). Predictors of long-term mortality after severe sepsis in the elderly. *American Journal of the Medical Sciences*, *347*(4), 282–288. https://doi.org/10.1097/MAJ.0b013e318295a147

Liang, S. Y. (2016). Sepsis and Other Infectious Disease Emergencies in the Elderly. *Emergency Medicine Clinics of North America*, *34*(3), 501–522. https://doi.org/10.1016/j.emc.2016.04.005

Linde-Zwirble, W. T., & Angus, D. C. (2004). Severe sepsis epidemiology: Sampling, selection, and society. *Critical Care*, *8*(4), 222–226. https://doi.org/10.1186/cc2917

Liu, V., Lei, X., Prescott, H. C., Kipnis, P., Iwashyna, T. J., & Escobar, G. J. (2014). Hospital readmission and healthcare utilization following sepsis in community settings. *Journal of Hospital Medicine*, *9*(8), 502–507. https://doi.org/10.1002/jhm.2197

Machado, F. R., Cavalcanti, A. B., Bozza, F. A., Ferreira, E. M., Angotti Carrara, F. S., Sousa, J. L., … Lippi, M. M. (2017). The epidemiology of sepsis in Brazilian intensive care units (the Sepsis PREvalence Assessment Database, SPREAD): An observational study. *The Lancet Infectious Diseases*, *17*(11), 1180–1189. https://doi.org/10.1016/S1473-3099(17)30322-5

Martin, G. S., Mannino, D. M., & Moss, M. (2006). The effect of age on the development and outcome of adult sepsis. *Critical Care Medicine*. https://doi.org/10.1097/01.CCM.0000194535.82812.BA

Mayr, F. B., Yende, S., & Angus, D. C. (2014). Epidemiology of severe sepsis. *Virulence*, *5*(1), 4–11. https://doi.org/10.4161/viru.27372

Mayr, F., Balakumar, V., Talisa, V., Fine, M., & Yende, S. (2016). 1336: Understanding the Burden of Unplanned Sepsis Readmissions. *Critical Care Medicine*, *44*(12), 409. https://doi.org/10.1097/01.ccm.0000510010.72169.93

Mechanic, R. (2014). Post-acute care - The next frontier for controlling medicare spending. *New England Journal of Medicine*, *370*(8), 692–694. https://doi.org/10.1056/NEJMp1315607

Miller, R. R., Dong, L., Nelson, N. C., Brown, S. M., Kuttler, K. G., Probst, D. R., … Clemmer, T. P. (2013). Multicenter implementation of a severe sepsis and septic shock treatment bundle. *American Journal of Respiratory and Critical Care Medicine*, *188*(1), 77–82. https://doi.org/10.1164/rccm.201212-2199OC

Mukherjee, A., Davidson, L., Anguvaa, L., Duffy, D. A., & Kennea, N. (2015). NICE neonatal early onset sepsis guidance:Greater consistency, but more investigations, and greater length of stay. *Archives of Disease in Childhood: Fetal and Neonatal Edition*, *100*(3), F248–F249. https://doi.org/10.1136/archdischild-2014-306349

Muszynski, J. A., Knatz, N. L., Sargel, C. L., Fernandez, S. A., Marquardt, D. J., & Hall, M. W. (2011). Timing of Correct Parenteral Antibiotic Initiation and Outcomes From Severe Bacterial Community-acquired Pneumonia in Children. *The Pediatric Infectious Disease Journal*, *30*(4), 295–301. https://doi.org/10.1097/INF.0b013e3181ff64ec

Nasa, P., Juneja, D., & Singh, O. (2012). Severe sepsis and septic shock in the elderly: An overview. *World Journal of Critical Care Medicine*, *1*(1), 23–30. https://doi.org/10.5492/wjccm.v1.i1.23

Nazemi, L., Skoog, I., Karlsson, I., Hosseini, S., Mohammadi, M. H. R., Hosseini, M., … Baikpour, M. (2015). Malnutrition, prevalence and relation to some risk factors among elderly residents of nursing homes in Tehran, Iran. *Iranian Journal of Public Health*, *44*(2), 218–227.

Office of Minority Health, C., & at The University of Chicago, N. (n.d.). *Guide to Reducing Disparities in Readmissions Guide to Reducing Disparities in Readmissions Acknowledgments*.

Ortman, J. M., Velkoff, V. A., & Hogan, H. (2014). *An Aging Nation: The Older Population in the United States Population Estimates and Projections Current Population Reports*.

Pandharipande, P. P., Girard, T. D., Jackson, J. C., Morandi, A., Thompson, J. L., Pun, B. T., … Ely, E. W. (2013). Long-Term Cognitive Impairment after Critical Illness. *New England Journal of Medicine*, *369*(14), 1306–1316. https://doi.org/10.1056/NEJMoa1301372

Parylo, O. (2012). Qualitative, quantitative, or mixed methods: An analysis of research design in articles on principal professional development (1998-2008). *International Journal of Multiple Research Approaches*, *6*(3), 297–313. https://doi.org/10.5172/mra.2012.6.3.297

Phua, J., Lim, H. F., Tay, C. K., & Aung, N. W. (2013). Public awareness of sepsis and stroke in singapore:A population-based survey. *Annals of the Academy of Medicine Singapore*.

Prescott, H. C., Dickson, R. P., Rogers, M. A. M., Langa, K. M., & Iwashyna, T. J. (2015). Hospitalization type and subsequent severe sepsis. *American Journal of Respiratory and Critical Care Medicine*. https://doi.org/10.1164/rccm.201503-0483OC

Prescott, H. C., Langa, K. M., Liu, V., Escobar, G. J., & Iwashyna, T. J. (2014). Increased 1-year healthcare use in survivors of severe sepsis. *American Journal of Respiratory and Critical Care Medicine*. https://doi.org/10.1164/rccm.201403-0471OC

Rafalimanana, H. (2013). *World Population Ageing*. *Economic and Social Affairs United Nations*.

Reynolds, K., Butler, M. G., Kimes, T. M., Rosales, A. G., Chan, W., & Nichols, G. A. (2015). Relation of Acute Heart Failure Hospital Length of Stay to Subsequent Readmission and All-Cause Mortality. *American Journal of Cardiology*. https://doi.org/10.1016/j.amjcard.2015.04.052

Rhee, C., & Klompas, M. (2017). New Sepsis and Septic Shock Definitions: Clinical Implications and Controversies. *Infectious Disease Clinics of North America*. https://doi.org/10.1016/j.idc.2017.05.001

Rohde, J. M., Dimcheff, D. E., Blumberg, N., Saint, S., Langa, K. M., Kuhn, L., … Rogers, M. A. M. (2014). Health care-associated infection after red blood cell transfusion: A systematic review and meta-analysis. *JAMA - Journal of the American Medical Association*. https://doi.org/10.1001/jama.2014.2726

Rosso, A. L., Taylor, J. A., Tabb, L. P., & Michael, Y. L. (2013). Mobility, disability, and social engagement in older adults. *Journal of Aging and Health*, *25*(4), 617–637. https://doi.org/10.1177/0898264313482489

Rowe, T. A., & McKoy, J. M. (2017). Sepsis in Older Adults. *Infectious Disease Clinics of North America*, *31*(4), 731–742. https://doi.org/10.1016/j.idc.2017.07.010

Saks, M., & Allsop, J. (2012). *Researching Health: Qualitative, Quantitative and Mixed Methods*. (A. Poyner, Ed.) (2nd ed.). Los Angeles: Sage Publications.

Sarkar, U., & Bates, D. W. (2014). Care partners and online patient portals. *JAMA - Journal of the American Medical Association*, *311*(4), 357–358. https://doi.org/10.1001/jama.2013.285825

Satariano, W. a. (2006). Aging, Health, and the Environment: An Ecological Model. *Epidemiology of Aging*, 39–84.

Schneider, E. B., Haider, A. H., Hyder, O., Efron, J. E., Lidor, A. O., & Pawlik, T. M. (2013). Assessing short- and long-term outcomes among black vs white Medicare

patients undergoing resection of colorectal cancer. *American Journal of Surgery*, *205*(4), 402–408. https://doi.org/10.1016/j.amjsurg.2012.08.005

Scott, I. A., Shohag, H., & Ahmed, M. (2014). Quality of care factors associated with unplanned readmissions of older medical patients: A case-control study. *Internal Medicine Journal*. https://doi.org/10.1111/imj.12334

Sehgal, V., Bajwa, S. J. S., Consalvo, J. A., & Bajaj, A. (2016). Clinical conundrums in management of sepsis in the elderly. *Journal of Translational Internal Medicine*, *3*(3), 106–112. https://doi.org/10.1515/jtim-2015-0010

Shah, F. A., Pike, F., Alvarez, K., Angus, D., Newman, A. B., Lopez, O., … Yende, S. (2013a). Bidirectional relationship between cognitive function and pneumonia. *American Journal of Respiratory and Critical Care Medicine*. https://doi.org/10.1164/rccm.201212-2154OC

Shah, F. A., Pike, F., Alvarez, K., Angus, D., Newman, A. B., Lopez, O., … Yende, S. (2013b). Bidirectional relationship between cognitive function and pneumonia. *American Journal of Respiratory and Critical Care Medicine*, *188*(5), 586–592. https://doi.org/10.1164/rccm.201212-2154OC

Shankar-Hari, M., & Rubenfeld, G. D. (2016). Understanding Long-Term Outcomes Following Sepsis: Implications and Challenges. *Current Infectious Disease Reports*. https://doi.org/10.1007/s11908-016-0544-7

Shen, H.-N., & Li, C.-Y. (2015). Risk Factors of Readmissions Among Severe Sepsis Survivors. *Critical Care Medicine*, *43*(10), e461. https://doi.org/10.1097/CCM.0000000000001125

Soares, M., Bozza, F. A., Angus, D. C., Japiassú, A. M., Viana, W. N., Costa, R., … Salluh, J. I. F. (2015). Organizational characteristics, outcomes, and resource use in 78 Brazilian intensive care units: the ORCHESTRA study. *Intensive Care Medicine*. https://doi.org/10.1007/s00134-015-4076-7

Soto-Perez-de-Celis, E., Li, D., Yuan, Y., Lau, Y. M., & Hurria, A. (2018). Functional versus chronological age: geriatric assessments to guide decision making in older patients with cancer. *The Lancet Oncology*, *19*(6), e305–e316. https://doi.org/10.1016/S1470-2045(18)30348-6

Starr, M. E., & Saito, H. (2014). Sepsis in old age: Review of human and animal studies. *Aging and Disease*, *5*(2), 126–136. https://doi.org/10.14336/AD.2014.0500126

Stevenson, E. K., Rubenstein, A. R., Radin, G. T., Wiener, R. S., & Walkey, A. J. (2014). Two decades of mortality trends among patients with severe sepsis: A comparative meta-Analysis. *Critical Care Medicine*. https://doi.org/10.1097/CCM.0000000000000026

Stiermaier, T., Herkner, H., Tobudic, S., Burgmann, K., Staudinger, T., Schellongowski, P., & Burgmann, H. (2013). Incidence and long-term outcome of sepsis on general wards and in an ICU at the General Hospital of Vienna: An observational cohort study. *Wiener Klinische Wochenschrift*, *125*(11–12), 302–308. https://doi.org/10.1007/s00508-013-0351-1

Stoller, J., Halpin, L., Weis, M., Aplin, B., Qu, W., Georgescu, C., & Nazzal, M. (2016). Epidemiology of severe sepsis: 2008-2012. *Journal of Critical Care*, *31*(1), 58–62. https://doi.org/10.1016/j.jcrc.2015.09.034

Strom, J. B., Kramer, D. B., Wang, Y., Shen, C., Wasfy, J. H., Landon, B. E., … Yeh, R. W. (2017). Short-term rehospitalization across the spectrum of age and insurance types in the United States. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0180767

Sun, A., Netzer, G., Small, D. S., Hanish, A., Fuchs, B. D., Gaieski, D. F., & Mikkelsen, M. E. (2016). Association between Index Hospitalization and Hospital Readmission in Sepsis Survivors. *Critical Care Medicine*. https://doi.org/10.1097/CCM.0000000000001464

Tangeman, J. C., Rudra, C. B., Kerr, C. W., & Grant, P. C. (2014). A hospice-hospital partnership: Reducing hospitalization costs and 30-day readmissions among seriously ill adults. *Journal of Palliative Medicine*. https://doi.org/10.1089/jpm.2013.0612

THE HCUP NATIONWIDE READMISSIONS DATABASE (NRD), 2014. (n.d.). Retrieved July 9, 2020, from https://www.hcup-us.ahrq.gov/db/nation/nrd/NRD_Introduction_2010-2014.jsp

The R Foundation. (2020). R: The R Project for Statistical Computing. Retrieved July 9, 2020, from https://www.r-project.org/

Torio, C. M., & Moore, B. J. (2016). *National Inpatient Hospital Costs: The Most Expensive Conditions by Payer, 2013 #204*. Rockville.

Turnbull, I. R., Clark, A. T., Stromberg, P. E., Dixon, D. J., Woolsey, C. A., Davis, C. G., … Coopersmith, C. M. (2009). Effects of aging on the immunopathological response to sepsis. *Crit Care Med*, *37*(3), 1018–1023. https://doi.org/10.1097/CCM.0b013e3181968f3a

Vest, J. R., Gamm, L. D., Oxford, B. A., Gonzalez, M. I., & Slawson, K. M. (2010). Determinants of preventable readmissions in the United States: A systematic review. *Implementation Science*. https://doi.org/10.1186/1748-5908-5-88

Walker, K. A., Mayo, R. L., Camire, L. M., & Kearney, C. D. (2013). Effectiveness of integration of palliative medicine specialist services into the intensive care unit of a community teaching hospital. *Journal of Palliative Medicine*. https://doi.org/10.1089/jpm.2013.0052

Wang, H. E., Szychowski, J. M., Griffin, R., Safford, M. M., Shapiro, N. I., & Howard, G. (2014). Long-term mortality after communityacquired sepsis: A longitudinal population-based cohort study. *BMJ Open*. https://doi.org/10.1136/bmjopen-2013-004283

Wester, A. L., Dunlop, O., Melby, K. K., Dahle, U. R., & Wyller, T. B. (2013). Age-related differences in symptoms, diagnosis and prognosis of bacteremia. *BMC Infectious Diseases*, *13*(1), 346. https://doi.org/10.1186/1471-2334-13-346

Wilcox, E. M., Donnelly, J. P., & Lone, N. I. (2020). Understanding gender disparities in outcomes after sepsis. *Intensive Care Medicine*, *46*(4), 796–798. https://doi.org/10.1007/s00134-020-05961-3

Wohlgemuth, S. E., Calvani, R., & Marzetti, E. (2014). The interplay between autophagy and mitochondrial dysfunction in oxidative stress-induced cardiac aging and pathology. *Journal of Molecular and Cellular Cardiology*, *71*, 62–70. https://doi.org/10.1016/j.yjmcc.2014.03.007

Woods, A. J., Cohen, R. A., & Pahor, M. (2013). Cognitive frailty: Frontiers and challenges. *Journal of Nutrition, Health and Aging*, *17*(9), 741–743. https://doi.org/10.1007/s12603-013-0398-8

World Health Organization. (2018). Sepsis. Retrieved July 8, 2020, from https://www.who.int/news-room/fact-sheets/detail/sepsis

Yealy, D. M., Kellum, J. A., Huang, D. T., Barnato, A. E., Weissfeld, L. A., Pike, F., … Angus, D. C. (2014). A randomized trial of protocol-based care for early septic shock. *New England Journal of Medicine*. https://doi.org/10.1056/NEJMoa1401602

Yende, S., Alvarez, K., Loehr, L., Folsom, A. R., Newman, A. B., Weissfeld, L. A., … Angus, D. C. (2013). Epidemiology and long-term clinical and biologic risk factors for pneumonia in community-dwelling older Americans analysis of three cohorts. *Chest*. https://doi.org/10.1378/chest.12-2818

Yende, S., Iwashyna, T. J., & Angus, D. C. (2014). Interplay between sepsis and chronic health. *Trends in Molecular Medicine*. https://doi.org/10.1016/j.molmed.2014.02.005

Zanobetti, A., O'Neill, M. S., Gronlund, C. J., & Schwartz, J. D. (2012). Summer temperature variability and long-term survival among elderly people with chronic disease. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(17), 6608–6613. https://doi.org/10.1073/pnas.1113070109

Zhang, D., Micek, S. T., & Kollef, M. H. (2015). Time to appropriate antibiotic therapy is an independent determinant of postinfection ICU and hospital lengths of stay in patients with sepsis. *Critical Care Medicine*. https://doi.org/10.1097/CCM.0000000000001140

CURRICULUM VITAE

Kimberly Sue Hodge

Education

Doctor of Philosophy — August 2020
Indiana University, Indianapolis, IN
Major: Nursing
Minor: Educational Psychology

Master of Science in Nursing — May 2008
Indiana University, Indianapolis, IN
Major: Adult Health Clinical Nurse Specialist
Concentration: Adult Critical Care

Associate of Science in Nursing — May 1985
Indiana University, Indianapolis, IN

Professional Experience

Aledade, Inc., Product Director, Transitions of Care — 2019-Present

Primaria Health, LLC, Senior Director, Care Navigation — 2018-2019

naviHealth, Inc., Director, Bundled Payment for Care Improvement — 2016-2019

Franciscan Alliance
- Director, Case Management — 2012-2016
- Critical Care/Cardiac Clinical Nurse Specialist — 2008-2012

Indiana Wesleyan University, Adjunct Faculty — 2008-2011

St. Vincent Seton Specialty Hospital, Clinical Nurse Specialist — 2008-2008

Indiana University School of Nursing
- Research Assistant for Dr. Wendy Miller — 2012-2013
- Adjunct Faculty — 2011-2016
- Research Assistant for Dr. Janice Fulton — 2010-2012
- Research Assistant for Dr. Janice Buelow — 2007-2008
- Associate Instructor in Nursing, Adult Online Critical Care Course — 2006-2011
- Teaching Assistant, Adult Online Critical Care Course — 2005-2006
- Guest Expert, Adult Online Critical Care Course — 2001-2011

IU Health (formerly Clarian Health)
- Critical Care Staff Registered Nurse 1998-2002
- Critical Care and Emergency Response Clinical Educator 2002-2008

Rush Memorial Hospital, Registered Nurse 2001-2002
- Hospital Supervisor
- Nurse Educator
- ACLS Course Director

Eskenazi Health (formerly Wishard Hospital), Registered Nurse
- Trauma Critical Care Staff Registered Nurse 1997-1998
- Critical Care Team Leader/Shift Coordinator 1998-1998

Kindred Hospital (formerly Vencor) 1994-1997
- Special Care Unit Staff Registered Nurse
- Hospital Supervisor

Franciscan Health Indianapolis (formerly St. Francis Hospital) 1993-1993
- Cardiac Surgery Intensive Care Unit Staff Registered Nurse

IU Health (formerly Indiana University Hospital), Registered Nurse 1991-1993

The Jewish Hospital, Registered Nurse / Assistant Head Nurse 1990-1990

Hewlett-Packard, Registered Nurse 1989-1989
- Sales Support/Education Consultant

Mercy Hospital-Hamilton, Registered Nurse
- Critical Care Staff Registered Nurse 1988-1989
- Clinical Nursing Supervisor 1989-1990

American Mobile Nursing, Critical Care Registered Nurse 1987-1988

Community Hospital South (formerly University Heights) 1987-1987
- Critical Care Charge Registered Nurse

IU Health (formerly Indiana University Hospital)
- Critical Care Staff Registered Nurse 1986-1987
- Critical Care Student Nurse 1984-1986

Schneck Medical Center, Nursing Assistant 1981-1984

Columbus Regional Health, Student Nursing Assistant 1980-1981

Professional Organizations and Activities

Alpha Chapter, Sigma Theta Tau International	2008-Present
American Association of Critical-Care Nurses	1998-Present
Central Indiana Chapter of the American Association of Critical-Care Nurses	2003-Present
Central Indiana Organization of Clinical Nurse Specialists	2005-Present
National Association of Clinical Nurse Specialists	2005-Present
Coalition of Advance Practice Nurses in Indiana	2012-2020
Indiana Hoosier South Central Chapter of the American Association of Critical-Care Nurses	2001-2004
Indiana State Nurse Association	2001-Present

Licenses and Certifications

Registered Nurse	1986-Present
Basic Life Support	1980-Present
Advanced Cardiac Life Support	1988-Present
Adult Health Clinical Nurse Specialist (ACNS-BC)	2011-Present
CCRN® (Adult)	1996-Present

Publications

Dirkes S. **Hodge** K. Continuous renal replacement therapy in the adult intensive care unit: history and current trends. Critical Care Nurse. 27(2):61-6, 68-72, 74-80; quiz 81, 2007 Apr.

Hodge, K. Content Editor: Cardiovascular nursing: A comprehensive overview (2nd Ed). (2011). Western Schools *(*www.westernschools.com*)*.

Hodge, K. Content Editor: Cardiovascular Disease and Women. (2011). Western Schools *(*www.westernschools.com*)*.

Hodge, K. & Fulton, J. (2010). Technology: Friend or foe? Clinical Nurse Specialist. 24(5).

Hodge, K., Federspiel, C. & Fulton, J. (2014). Accountable care organizations – New horizons for clinical nurse specialist practice, In Fulton, J., Lyon, B. & Goudreau, K. (Eds), Foundations of clinical nurse specialist practice. New York: Springer Publishing Company.

Poster Presentations

Hodge, K. & Hughes, S. Developing a Combined CRRT Program (Poster Presentation, 2004 CRRT International Conference)

Hodge, K. & Hughes, S. Keys to a Successful CRRT Educational Program (Poster Presentation, 2004 CRRT International Conference)

Hodge, K. & Hughes, S. Keys to a Successful CRRT Educational Program (Poster Presentation, 2005 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K. & Peavy, K. What is a CAT (Chapter Advisory Team)? (Poster Presentation, 2006 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K. & Peavy, K. What is a CAT (Chapter Advisory Team)? (Poster Presentation, 2007 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K. & Lowder, M. Using a Critical Care Bowl to Encourage Chapter Membership (Poster Presentation, 2006 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K. Reducing the Use of Unnecessary Urinary Catheters (Poster Presentation, 2009 SSFHS Leadership Meeting)

Hodge, K. Reducing the Use of Unnecessary Urinary Catheters (Poster Presentation, 2009 Institute for Healthcare Improvement 21st Annual National Forum)

Hodge, K. & Lowder, M. Volume Resuscitation in Sepsis: Using Stroke Volume Optimization to get it "Just Right" (Poster Presentation, 2012 National Association of Clinical Nurse Specialists Conference)

Hodge, K. & Lowder, M. Nursing Research Committee (Poster Presentation, 2012 National Association of Clinical Nurse Specialists Conference)

Conference Presentations

Hodge, K. Navigating the Chapter Website (2005 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K. Navigating the Chapter Website (2006 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K. Dysproteinemia and the Kidney (2006 Intravenous Nurse's Society Annual Conference)

Hodge, K. Silence and Patient Outcomes (2006 Clarian Health, Topics in Critical Care Conference)

Hodge, K. & Peavy, K. Taking Care of Business: Chapter and Region Strategic Planning (2007 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K. Therapeutic Hypothermia after Cardiac Arrest (2007 Clarian Health, Topics in Critical Care Conference)

Hodge, K. & Peavy, K. Chapter Strategic Planning (2008 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K. & Peavy, K. Chapter Strategic Planning (2009 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K. & Peavy, K. Chapter Strategic Planning (2010 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K. & Peavy, K. Chapter Strategic Planning (2012 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K., Peavy, K. & Brinker, D. Chapter Leader Feedback – Growing Yourself Forward (2008 American Association of Critical-Care Nurses National Teaching Institute)

Bixby, M. & **Hodge, K.** Continuous Renal Replacement Therapy: Life Support for the Kidneys (2009 American Association of Critical-Care Nurses National Teaching Institute)

Bixby, M. & **Hodge, K.** Continuous Renal Replacement Therapy: Life Support for the Kidneys (2012 American Association of Critical-Care Nurses National Teaching Institute)

Bixby, M. & **Hodge, K.** Continuous Renal Replacement Therapy: Life Support for the Kidneys (2013 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K. Reducing the Use of Unnecessary Urinary Catheters (2009 Indiana Hospital Association Annual Meeting)

Hodge, K. Reducing the Use of Unnecessary Urinary Catheters (2009 St. Francis Hardwiring University)

Hodge, K. CCRN and PCCN Review (2010 Wabash Valley Chapter of the American Association of Critical-Care Nurses)

Hodge, K. e-Learning and the NxStage CRRT Machine (2010 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K. CRRT Bedside Management and Panelist for CRRT Case Studies (2010 CRRTeams Conference)

Hodge, K. External Consulting: Idea to Reality (2010 Central Indiana Organization of Clinical Nurse Specialists Conference, Tools for Success: Advancing CNR Practice at all Levels)

Hodge, K. & Peavy, K. Back to the Future: Chapter Succession Planning (2011 American Association of Critical-Care Nurses National Teaching Institute)

Peavy, K. & Hodge, K. Back to the Future: Chapter Succession Planning (2012 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K. & Lowder, M. Rescue Me! Preventing Failure to Rescue (2011 Barbra Cunningham Nursing Practice Showcase)

Hodge, K. & Lowder, M. Volume Resuscitation in Sepsis: Using Stroke Volume Optimization to get it "Just Right" (2011 Barbra Cunningham Nursing Practice Showcase)

Hodge, K. & Lowder, M. Volume Resuscitation in Sepsis: Using Stroke Volume Optimization to get it "Just Right" (2011 Indiana Hospital Association Annual Meeting)

Hodge, K., Lowder, M. & Ahrens, T. Volume Resuscitation in Sepsis: Using Stroke Volume Optimization to get it "Just Right" (2012 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K. Authentic Leadership (2011 Stand Tall for a Healthy Work Environment sponsored by Alpha Chapter of Sigma Theta Tau, International and Central Indiana Chapter of the American Association of Critical-Care Nurses)

Hodge, K. Creating a Legacy (2012 Indiana University School of Nursing Student Induction Ceremony)

Hodge, K. Creating a Legacy (2013 Indiana University School of Nursing Student Induction Ceremony)

Hodge, K. Failure to Rescue: Nursing Sensitive Indicator (2012 AACN Progressive Care Pathways)

Hodge, K. SIRS, Sepsis, Severe Sepsis, and Septic Shock: The Continuum (2012 AACN Progressive Care Pathways)

Hodge, K. Accountable Care Organizations (2012 Central Indiana Organization of Clinical Nurse Specialists Conference, The Changing Landscape and CNS Work)

Hodge, K. Using Stroke Volume Optimization to Prevent Failure to Rescue in Sepsis (2013 University of Michigan SICU Conference - Leaping Forward: Stitching Evidence into Practice)

Hodge, K. Creating a Seamless Continuum: Clinical Team Member Integration (2013 the Centers for Medicare & Medicaid Services Post-Acute Care Learning Series)

Hodge, K. Creating and Sustaining a Post-Acute Care Continuing Care Network for ACO Beneficiaries (Practice Exemplar) (2013 Indiana University School of Nursing, Impacts of Accountable Care - Transforming Nursing Practice, Improving Quality of Care Conference)

Hodge, K. Post-Acute Care Continuing Care Network: Provider Agreements, Quality Metrics, Scripting, Communication, and Transparency (2013 the Centers for Medicare & Medicaid Services Post-Acute Care Learning Series)

Hodge, K. CNS Role in ACO & Transitions of Care (2013 Central Indiana Organization of Clinical Nurse Specialists Conference, The Changing Landscape and CNS Work)

Hodge, K. Healthy Work Environment Overview (2014 Healthy Work Environment Seminar, Franciscan St. Francis Health)

Hodge, K. Healthy Work Environments: Skilled Communication and Accountability (2014 6 West Team Retreat, Franciscan St. Francis Health)

Hodge, K. Getting Better Post-Hospital Care: Why You Need a Continuing Care Network (2014 Health Dimensions Group: National Summit – Integrating Care Across the Continuum)

Hodge, K. Accountable Care Organizations: Importance to Acute and Critical Care Nurses (2014 Central Indiana Chapter of the American Association of Critical Care Nurses)

Hodge, K. Why ACOs are Good for Your Patients (2014 Leading Age PEAK Leadership Summit)

Hodge, K. Medicare Accountable Care Organizations: Redesigning Healthcare for the Future (2014 Healthy Lung Expo)

Hodge, K. Post-Acute Care: A CNS Playground (2014 Central Indiana Organization of Clinical Nurse Specialists Meeting)

Hodge, K. What is an ACO? (2014 Franciscan St. Francis Health Nurses' Day Seminar)

Hodge, K., & Balagurus, J. Accountable Care Organizations: Importance to Acute and Critical Care Nurses (2014 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K., & Balagurus, J. Accountable Care: Acute and Critical Care Nurses' Contribution (2014 American Association of Critical-Care Nurses National Teaching Institute)

Hodge, K. Post-Acute Continuing Care Networks: Building and Sustaining Partnerships (2014 ACO and Payer Leadership Summit)

Hodge, K. Accountable Care Organizations (2014 Kelly School of Business, Indiana University)

Hodge, K. ACO Care Management: Successes and Challenges (2015 Franciscan Alliance ACO Summit)

Hodge, K. ACO Care Management: Programs (2015 Franciscan Alliance ACO Summit)

Hodge, K. Accountable Care Organizations (2015 Indiana University Purdue University at Indianapolis Public Health Graduate Student Seminar)

Hodge, K. Emerging Strategies for Post-Acute and Hospital Partnerships (2015 Bridging the Continuum of Care: Hospital & Post-Acute Care Integration Conference)

Hodge, K. Panel Discussion (participant): Why Post-Acute Care Must Have a Seat at the Risk Table (2015 2nd Annual World Congress ACO Strategy Meeting)

Hodge, K. Panel Discussion (participant): Why Post-Acute Care Must Have a Seat at the Risk Table (2015 2nd Annual World Congress ACO Strategy Meeting)

Hodge, K. Intersection and Influence: The CNS and Population Health Initiatives (2016 Central Indiana Organization of Clinical Nurse Specialists Conference)

Hodge, K. Root Cause Analysis and the 5 Why's (2017 Dignity Health System Post-Acute Care Seminar)

Hodge, K. Skills, Technologies & Attributes Case Managers Need to Succeed in Value-Based Care (2018 CMCC New World Symposium)

Hodge, K. Readmission Prevention in Post-Acute Care (2018 Dignity Health System Post-Acute Care Seminar)

Webinars and Podcasts

Hodge, K. Keeping the CRRT Machine Running (A.K.A. Troubleshooting) (2008 Webinar hosted by NxStage Medical, Inc.)

Hodge, K. Pioneer ACO Model: Post-Acute Care (PAC) Measures – Best Practices and Lessons Learned (2014 Webinar hosted by the Centers for Medicare & Medicaid Services)

Hodge, K. Acute & Post-Acute Perspectives on Partnering (2014 Webinar hosted by the American Hospital Association)
Fuller, B. & **Hodge, K.** Advanced Bundled Payments for Care Improvement (BPCI) is Coming: Are you ready? (2018 Hosted by naviHealth and Health Forum)

Fuller, B. & **Hodge, K.** Thriving in BPCI (2018 Hosted by naviHealth and Health Forum)

Hodge, K. & Altman, C. Transitional Care Management Billing Training (2020 Webinar hosted by Aledade)

Olexa-Meadors, C., Mostrom, K. & **Hodge, K.** Grand Rounds: Emergency Department Visit Reduction through Telehealth (2020 Webinar hosted by Aledade)

DuBard, A, **Hodge, K.**, Slaga, M., Israel, J. & Magnuson, C. Grand Rounds: COVID-19 Stay Well at Home Initiative (2020 Webinar hosted by Aledade)

Hodge, K., Altman, C. & Koziel, S. Community Health Center (CHC) Rounds: Billing and Coding Support During COVID-19 (2020 Webinar hosted by Aledade)

Hodge, K., Altman, C. & Torontow, J. Practice Manager Rounds: Billing and Coding Support During COVID-19: Stay Well at Home and Advance Care Planning (2020 Webinar hosted by Aledade)

Hodge, K., Posner, H., & Gonzalez, V. Grand Rounds: Transitions of Care (2020 Webinar hosted by Aledade)

Hodge, K. The ACO Show Podcast: Transitions of Care (2020 Podcast hosted by Aledade, Inc.)

Hodge, K., Altman, C., Koziel, S. & Torontow, J. Practice Manager Rounds: Transitional Care Management Billing Training (2020 Webinar hosted by Aledade)

Hodge, K., Altman, C., & Torontow, J. Care Management: CCM and PC (2020 Webinar hosted by Aledade)