Burn Injury and Diabetes: Description, Trends and Resource Utilization Using the National Burn Repository Data from 2002-2011

Dissertation

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy
In the Graduate School of The Ohio State University

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2016

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Abstract

Diabetes is an increasing chronic health problem in the United States with projections that by 2050, 15 out of every 1,000 people will have diabetes. Costs are high with an estimated 1 in every 5 health care dollars spent on care. Diabetes complications including peripheral neuropathy, retinopathy, and gait instability put this population at higher risk for burn injury. It’s estimated that 10% of all burn patients have diabetes and incidence increases with age. The presence of diabetes in burn patients has profound effects on treatment, resource utilization, and outcomes. Treatment is complicated by the micro-vascular complications associated with diabetes and the hypermetabolic response associated with burn injuries. The relationship between glycemic control and the stress response on wound healing, predisposes burn patients with diabetes to more infections, more surgeries, and longer lengths of hospital stay, thus more resource utilization. Conceptual frameworks, such as the Andersen and Aday Behavioral Model of Health Services Utilization contribute to a greater understanding of throughput in relation to health outcomes and resource utilization. The purpose of this study was to gain an understanding of the impact the comorbidity of diabetes patients in the United States adult burn patients. Greater knowledge about the trends, burn type, severity, and outcomes in this population is needed to develop care strategies to improve outcomes and reduce or control resource utilization. This descriptive cross sectional design used the National Burn Repository 2012 data to identify the trend, describe the differences in burn
patients with and without diabetes, and to compare resource utilization between the groups. This sample of 58,707 adult burn patients included patients from 91 of the 127 burn centers in the United States over a 9.5-year period. Findings included a significant increasing trend for burn patients to experience a comorbidity of diabetes so that in 2002, 4.8% of burn patients also had diabetes increasing to 16.68% in 2011. In all age groups, patients with diabetes were significantly older (\( p < .0001 \)), had higher percent of full thickness burns (\( p < .0001 \)), and had higher rates of inhalation injury (\( p < .0001 \)).

Patients with diabetes had significantly higher mortality rates in all age groups when compared to their counterparts without diabetes (\( p < 0.0001 \)). Burn patients with diabetes had significantly longer hospital days [12.99 vs. 10.52 days (\( p < .0001 \))], more intensive care unit days [7.30 vs. 5.59 days (\( p < .0001 \))], more ventilator days [3.49 vs. 3.04 days (\( p = 0.0475 \))], and higher adjusted charges [$136,849 vs. $101,318 (\( p < 0.0001 \))] . There were no significant differences in total body surface areas burned (\( p = 0.1395 \)) or percent partial thickness area between the two groups (\( p = 0.8980 \)). This study provides evidence that the incidence of diabetes in burn patients is on the rise and overall these patients are older, have more severe burns, have poorer outcomes, and use more health care resources. There are many opportunities for improvement and future research in the areas of burn prevention, treatment, and early identification of these high risk patients.
Dedication

This dissertation is dedicated to my family. To my wonderful husband and best friend Doug, for supporting me in this journey, never allowing me to give up, and believing in me even when I did not. Without his love and support, I could never have finished writing this dissertation. To my children, Sarah and Adam and daughter-in-law Lanie, thank you for your patience and understanding, love and encouragement during this journey. Thank you to my mother. Despite the progression of her Alzheimer’s disease during this process, she still encouraged me in her clear moments. Finally, to baby Lincoln, who has provided much joy and laughter during this past year with his beautiful smile. I love you all and appreciate the sacrifices you have made during this dissertation so that I could complete this journey.
Acknowledgments

I would like to express my deepest gratitude to my advisor, Dr. Pamela Salsberry. You have provided so much support and encouragement throughout this process, always available to help find a solution to a difficult problem, and challenging me to analyze the data in a different way. You have been invaluable as a mentor to me and have helped me to conceptualize my work in a way that is truly enlightening. Without your guidance and support, this dissertation would not have been possible.

I would like to thank my dissertation committee, Dr. Jodi Ford and Dr. Loraine Smith. Your expertise, time, energy, and thoughtful comments were much appreciated.

Dr. Rodney Sturdivant, thank you for your support and for making yourself available to help with statistical analyses. No question went unanswered, and your feedback was always insightful. I would not have made it through survival analysis without your guidance.

Last, but certainly not least, I would like to thank my candidacy committee: Dr. Alfred Dembe, Dr. Linda Chlan, and Dr. Karen Ahijevych, for their valuable suggestions along the way. Your feedback helped to make this study possible.
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Table of Contents

Abstract.................................................................................................................................................. ii

Dedication ................................................................................................................................................. iv

Acknowledgments...................................................................................................................................... v

Vita........................................................................................................................................................... vi

List of Tables ............................................................................................................................................. x

List of Figures ........................................................................................................................................... xii

Chapter 1: Introduction ............................................................................................................................. 1

Chapter 2: Trends in Adult Burn Injury Patients with Diabetes in the United States 2002-2011 Using the National Burn Repository ...................................................................................... 17

Chapter 3: Description of the Characteristics of Burn Patients With Diabetes Using the NBR Data Set 2002-2011 ............................................................................................................. 39

Chapter 4: Resource Utilization and Outcomes in Burn Patients With and Without Diabetes Using NBR Data 2002-2011 ......................................................................................................... 83

Chapter 5: Discussion and Conclusions .................................................................................................. 117

References................................................................................................................................................ 135

Appendix A: Permission for Use of the Andersen and Aday Model....................................................... 145

Appendix B: Permission for Use of the National Burn Repository Data .............................................. 147

Appendix C: Summary of Key Findings ................................................................................................. 149
List of Tables

Chapter 2: Trends in Adult Burn Injury Patients with Diabetes in the United States 2002-2011 Using the National Burn Repository

Table 2.1. Hospitals and States Contributing Data to the NBR ........................................... 23
Table 2.2. Comparison of Those With and Without Comorbid Conditions in the NBR Data Base Continuous Variables .................................................................................................................. 27
Table 2.3. Comparison of Those With and Without Comorbid Conditions in the NBR Data Base Categorical Variables .................................................................................................................. 28
Table 2.4. Comparison of Burn Patients With Diabetes By Age Group and Year .... 33

Chapter 3: Description of the Characteristics of Burn Patients With Diabetes Using the NBR Data Set 2002-2011

Table 3.1. Patient Demographics for Entire Sample, Under 65 Years of Age and 65 years of Age and Older .......................................................................................................................... 50
Table 3.2. Patient Demographics for <65 Years of Age Stratified to 18-< 40 and 40-< 65 Years of Age ................................................................................................................................. 52
Table 3.3. Comparison of Severity of Illness for Those With and Without Diabetes ................................................................................................................................. 61
Table 3.4. Severity of Illness Patient Under 65 Stratified to 18-< 40 Years of Age and 40-< 65 Years of Age .......................................................................................................................... 61
Table 3.5. Logistic Regression Analysis of Mortality With Burn Injury and Diabetes ................................................................................................................................. 62
Table 3.6. Logistic Regression Analysis of Mortality With Burn Injury and Diabetes Under 65 Years of Age .......................................................................................................................... 63
Table 3.7. Logistic Regression Analysis of Mortality in Those With Burn Injury and Diabetes < 40 Years of Age .................................................................................................................. 63
Table 3.8. Logistic Regression Analysis of Mortality in Those With Burn Injury and Diabetes >40 and <65 Years of Age .................................................. 63

Table 3.9. Logistic Regression Analysis of Mortality in Those With Burn Injury and Diabetes 65 Years of Age and Older.................................................. 64

Chapter 4: Resource Utilization and Outcomes in Burn Patients With and Without Diabetes Using NBR Data 2002-2011

Table 4.1. Mean Unadjusted and Adjusted Hospital Charges ......................... 93
Table 4.2. Resource Utilization in Burn Patients.............................................. 95
Table 4.3. Resource Utilization for Under 65 Years of Age Stratified By Age ...... 96
Table 4.4. Forward Stepwise Sequence of Chi-Squares for the Log-Rank Test ..... 105
List of Figures

Figure 1.1. Schematic representation of the Model of Health Care Utilization ............... 8

Figure 1.2. Andersen and Aday Model of Health Care Utilization: Burn Injury and Diabetes................................................................. 14

Chapter 2: Trends in Adult Burn Injury Patients with Diabetes in the United States 2002-2011 Using the National Burn Repository

Figure 2.1. Schematic representation of the flow to arrive at analytic sample......... 25

Figure 2.2. Percent of adult burn patients with and without diabetes by year for the entire sample................................................................. 30

Figure 2.3. Percent of adult burn patient with and without diabetes by year in those 65 years of age or older ......................................................... 31

Figure 2.4. Percent of adult burn patient with and without diabetes by year in those under 65 years of age........................................................................ 32

Figure 2.5. Percent of patients with diabetes in all age groups by year.............. 33

Chapter 3: Description of the Characteristics of Burn Patients With Diabetes Using the NBR Data Set 2002-2011

Figure 3.1. Percent of burn patients with diabetes by year........................................ 48

Figure 3.2. Etiology of burns for patients with and without diabetes for the entire sample ................................................................................. 53

Figure 3.3. Etiology of burns for patients with and without diabetes under age 65 ......................................................................................... 54

Figure 3.4. Etiology of subjects between 18 and < 40 years of age ...................... 55

Figure 3.5. Etiology of subjects 40-< 65 years of age .......................................... 55

Figure 3.6. Etiology of burns for patients with and without diabetes age 65 and older ......................................................................................... 56
Figure 3.7. Health behaviors for analytic sample for burn patients with and without diabetes .......................................................... 57

Figure 3.8. Health behaviors for burn patients less than 65 with and without diabetes ........................................................................................................ 57

Figure 3.9. Health behaviors for burn patients 65 and older with and without diabetes ........................................................................................................ 58

Figure 3.10. Health behaviors for burn patients 18-< 40 years of age .................. 58

Figure 3.11. Health behaviors for burn patients 40-< 65 years of age .................. 59

Figure 3.12. Discharge destination comparing those with and without diabetes in the entire sample ........................................................................................................ 65

Figure 3.13. Discharge destination comparing those with and without diabetes less than 65 years of age ................................................................................. 66

Figure 3.14. Discharge destination comparing those with and without diabetes less than 40 years of age ................................................................................. 67

Figure 3.15. Discharge destination comparing those with and without diabetes greater than 40 and less than 65 years of age ........................................................................ 68

Figure 3.16. Discharge destination comparing those with and without diabetes 65 years of age and older ................................................................................. 69

Chapter 4: Resource Utilization and Outcomes in Burn Patients With and Without Diabetes Using NBR Data 2002-2011

Figure 4.1. Yearly mean adjusted charges for the entire sample ......................... 97

Figure 4.2. Yearly mean adjusted charges by year for elderly patients ................ 97

Figure 4.3. Yearly mean adjusted charges for patients less than 65 years of age ..... 98

Figure 4.4. Yearly mean adjusted charges for patients < 40 years of age ............ 98

Figure 4.5. Yearly mean adjusted charges for patients 40 to < 65 years of age ...... 99

Figure 4.6. Kaplan-Meier Curve. Burns with and without diabetes for time to discharge censoring death entire sample .............................................. 100
Figure 4.7. Kaplan-Meier Curve. Burns with and without diabetes for time to discharge censoring death < 65 years of age ................................................................. 101

Figure 4.8. Kaplan-Meier Curve. Burns with and without diabetes for time to discharge censoring death < 40 years of age ................................................................. 102

Figure 4.9. Kaplan-Meier Curve. Burns with and without diabetes for time to discharge censoring death 40 to < 65 years of age ................................................................. 103

Figure 4.10. Kaplan-Meier Curve. Burns with and without diabetes for time to discharge censoring death ≥ 65 years of age ................................................................. 104
Chapter 1: Introduction

Diabetes is a major chronic disease in the United States and the numbers of persons with diabetes is increasing. If current trends continue, it is estimated that by the year 2050, 15 out of 1,000 people in the United States will have diabetes. Diabetes is often complicated by the development of peripheral neuropathy and retinopathy thus increasing the risk for burn injury, especially in those over 65 years of age. The growing rates of persons with diabetes who have an increased risk for burn injury will continue to strain our health care system as more health care resources are used (Boyle, Thompson, Gregg, Barker, & Williamson, 2010). A general estimate of yearly burn injuries in the United States is 486,000 (includes those admitted to hospitals or treated in emergency rooms; American Burn Association [ABA], n.d.). Greater knowledge about the prevalence of burn patients with diabetes, including burn type, severity, and outcomes is needed to better inform care strategies for this high risk population. This study is being undertaken to understand and describe the influences of the comorbidity of diabetes on the outcomes of adult burn injured persons in the United States.

Diabetes

It is estimated that the current prevalence rate of diabetes in the United States is 9.3% of the population. Of the 29.1 million people that have diabetes in the United States, 8.1 million are undiagnosed and 21 million people are diagnosed. In 2012, about 86 million people in the United States over age 20 had prediabetes, and 17 million new
cases of diabetes were diagnosed in this age group. By the year 2050, it is predicted that the number of people with diabetes will triple in the United States. In persons over the age of 20, the proportion of men to women with diabetes is approximately equal, 11.8% of men and 10.8% of women. Prevalence by race/ethnicity was 7.6% of non-Hispanic Whites, 9.0% of Asian Americans, 12.8% of non-Hispanic Blacks and 12.8% of Hispanics. In the elderly, 65 years or older 25.9% of all people have diabetes. In 2010, diabetes contributed to 234,051 deaths; however, this number may be low based on the number of persons with undiagnosed or prediabetes in the United States. Currently diabetes is the seventh leading cause of death in the United States. Complications from this chronic disease include heart disease (death rates are 2 to 4 times higher in adults with diabetes), stroke (risk 1.5 times higher in people with diabetes), hypertension (71% of people with diabetes), and the leading cause of blindness in person ages 20-74 is diabetic retinopathy (4.2 million people). Approximately 60% of people with diabetes have mild to severe neuropathy predisposing them to injuries such as burns. In 2012, the cost of diabetes care in the United States was $245 billion with $176 billion related to medical cost and the remainder accounted for by lost productivity (American Diabetes Association [ADA], 2015). It is estimated that about 1 out of every 5 health care dollars in the United States is spent for the care of a person with diabetes. Furthermore, about 1 in every 10 health care dollars is linked to diabetes (Centers for Disease Control and Prevention [CDC], 2015).

**Burn Injury**

The American Burn Association’s 2015 fact sheet states that the estimated number of people receiving treatment for burn injuries is about 486,000 per year (ABA,
n.d.). This includes visits to emergency departments and admissions to the hospital. This number may be higher because those treated in primary care offices and urgent care centers are not captured in the reporting. Around 40,000 of these patients are admitted to the hospital each year, with over 75% being admitted to one of the 127 burn centers in the United States. Of the 127 recognized burn centers (both verified and unverified), the average number of annual admissions per institution is over 200 patients. All other hospitals that admit burn patients average fewer than three admissions per year (ABA, n.d.). Burn injuries are consistently in the top ten causes of death for children under the age of 5 and adults over the age of 34 (L. Edelman, 2007). It has been demonstrated that best outcomes for the burn patient are obtained when patients are cared for in specialized burn centers and the percentage of patients admitted to verified burn centers has steadily increased in recent years (ABA, n.d.). The survival rate for victims admitted to burn centers is 96.7% compared to admissions to hospitals without burn centers (ABA, n.d.).

Burn care is costly, with the average cost of a hospital stay of $97,000 (Mandal, 2007). In the 2015 National Burn Repository report, the average total charges for burns of all TBSA; $ = 80,357 data from 2005-2014) was $93,893, with a range of $45,777 to $856,635 (ABA, 2014). Daily room rates, dressing change costs, operating room costs, laboratory costs, imaging costs, and consultants’ charges all contribute to the high cost of care for this patient population. Furthermore, the costs associated with outpatient care, care giving, labor and social costs all contribute to the high cost of burn care long after hospital discharge. The lifetime costs for burn deaths are almost four times higher than for cancer and six times higher than those for heart disease. In the United States it has been estimated that the government--federal, state,
and local—provide 28% of the costs related to burn care (L. Edelman, 2007). Finally, comorbid conditions, such as diabetes that effect wound healing, the burn injury stress responses, and additional complications, all contribute to the high cost of burn care. In order for hospitals that care for burn patients to stay viable, they need to provide cost effective quality care, demonstrate the best outcomes, and maximize reimbursement for the services provided (Sanchez, Perperez, Bastida, & Martinez, 2007).

**Burn Injury and Diabetes**

Patients with diabetes are at higher risk for burn injuries resulting from scald and contact with hot objects (Herndon, 2012; Maghsoudi, Aghamohammadzadeh, & Khalil, 2008). The neuropathy that develops as a result of uncontrolled or poorly controlled diabetes contributes to the increased risk for these injuries. Because neuropathy results in the loss of or alteration in feeling, the person with diabetes may not perceive that the water is hot or feel the pain from contact with the hot object. The lack of the pain sensation associated with neuropathy contributes to deeper burns and delays in seeking treatment for the injury (Herndon, 2012). A 2002 study (McCampbell et al., 2002) of burn patients with and without diabetes found that scald injuries were more likely to occur from the shower or tub and not hot liquid spills (33% with diabetes vs. 15% without diabetes \( P < 0.01 \)). They also found that persons with diabetes had a delayed presentation for care 45% of the time \( (P = 0.00001) \).

In 2012, it was estimated that 43.1 million people in the United States were age 65 or older, with this number projected to rise to 83.7 million by 2050 (Ortman, Velkoff, & Hogan, 2014). In the elderly, 65 years or older 25.9% of all people have diabetes (CDC, 2015). Given the increasing aging population in the United States complicated
with a rise in diabetes prevalence, we are likely to see an increasing number of burn injuries over the next decade in this population. Little has been done to examine the severity of illness, the resource use and the outcomes of this high risk population of burn patients.

A 2007 study of 31,000 adult admissions to 70 burn centers found that burn patients with preexisting conditions had longer lengths of stay and higher risk for mortality (Thombs, Singh, Halonen, Diallo, & Milner, 2007). Despite only 27% of this sample having comorbid conditions listed, Thombs et al. (2007) found that the addition of diabetes predicted a 26% longer length of stay (LOS), but did not predict mortality. A retrospective comparison of clinical outcomes of 181 burn patients with diabetes and 190 burn patients without diabetes found that the length of hospital stay was longer for the patients with diabetes (23 vs. 12 days; \( P = 0.0001 \)) despite no significant differences in total burn size (McCampbell et al., 2002). This sample of adult patients with diabetes had a higher rate of full thickness burn injuries than those without diabetes (McCampbell et al., 2002). Both studies demonstrated that LOS is longer in the person with diabetes and burn injury; however, with the rising rates of diabetes in the general population and the rising cost of burn care this relationship needs to be reexamined. The Yang, Wei, Yuan, and Schoung (2010) study of 1,080 hospitalized burn patients described the value of predicting the LOS data as an important outcome measure. They argued that LOS can be used to plan services, resources, outpatient follow up, family, and patient counseling and can also predict cost.
Overview of the Behavioral Model of Health Services Utilization

The Andersen and Aday Behavioral Model of Health Services Utilization (A&A) was developed to study access to care and throughput in relation to health outcomes and resource utilization. The environment and health care system interact to influence the population characteristics, health beliefs, resource utilization, and outcomes (Andersen, 1995). This model has been used to predict health care utilization and patient outcomes based on environmental variables, patient variables, and health behaviors (Aday, Begley, Lairson, & Slater, 1993). The model has two units of analysis: the macro level, which encompasses the health care system or community, and the micro level that includes the patient, provider, or institution. This study focused on the micro level to explain the relationships that exist between the burn patient with and without diabetes and their resource utilization and outcomes using data from a national data base.

The A&A model was first developed in 1968 to understand why families use health services and to define and measure access to care (Andersen, 1995). Aday and Andersen (1974) stated that the two main themes in the literature related to access to care were characteristics of the population (income, insurance coverage, and attitudes toward care) and how the health care is delivered (Aday & Andersen, 1974). The original framework focused on explaining the equity of accessing care and was used to identify variables that facilitate or impede the utilization of services (Aday & Andersen, 1974). Measures of access include outcomes and use of services (Institute of Medicine, 1993). The model has evolved to explain the use of formal health services, the important interactions between the patient and the health care system, and the relationship of these interactions with patient outcomes (Andersen, 1995). The current model has four major
constructs: the environment, population characteristics, health behaviors, and outcomes. It has the additional benefit of the ability to describe the interactions among the environment, the population characteristics, health behaviors, and outcomes. The outcomes of the health care delivery system are related to the equity, efficiency and effectiveness of the system (Andersen, 1995). This provides the opportunity to improve health care policy and improve efficiency of throughput in the system. The Andersen and Aday Model is shown in Figure 1.1.

**External Environment**

The environment includes the health care system and the external environment (Andersen, 1995). In the context of this study the history of the modern burn center is important in understanding the eternal environment and how it has influenced the current treatment of burn injuries and the organization and delivery of burn care. Historical developments in the external environment have shaped the philosophical bases for the modern burn unit and burn care. In 1916 Sir Harold Gillies stated that for burn care to be successful the institution needs to be committed to provide this care. In 1939, McIndoes established the burn unit for the Royal Air Force in the United Kingdom, and his work highlighted the important concepts related to the organization and delivery of burn care used today. They are: (a) the importance of the commitment of the institution to care of the burn patient, (b) a scientific approach to care is needed, (c) specialized training for personnel and competency must be maintained, and (d) psychosocial needs of the patient cannot be ignored (Cancio & Wolf, 2012).
Population Characteristics

The second major construct of the A&A model are the population characteristics. These include predisposing factors, enabling resources, individual and provider characteristics, community characteristics, and need for care. Predisposing factors are factors that the individual has prior to the onset of the burn injury, including their demographics, previous health status, social structure, and health beliefs. Demographic characteristics include age, gender, race, and comorbid conditions and represent the biological aspects of the likelihood of seeking care and resource utilization (Andersen, 1995; Andersen & Newman, 1973). In relationship to the burn patient, it is known that those patients with advancing age, female patients, African-American or Hispanic patients, and patients with more comorbid conditions will have longer lengths of stay, more resource utilization, and higher mortality rates (Attia, Reda, Mandil, Arafa, & Massoud, 2000; Thombs et al., 2007). A second predisposing characteristic is the social structure that determines the person’s place in his/her community and includes education, ethnicity, and income (Andersen, 1995). L. Edelman (2007) identified socioeconomic (SES) factors associated with increased incidence of burn injury and included: ethnicity, substandard living conditions, low income, large families, single parents, illiteracy, maternal education, unemployment, job loss, not owning a home, not having a telephone, and crowding (p. 958). Social structure variables are not available in the National Burn Repository (NBR) data base and therefore will not be used in this study.

Health beliefs are the attitudes, values, and knowledge that people have about health and services (Andersen, 1995). In relation to this population, relevant health beliefs include burn prevention knowledge, and the knowledge and use of health services
related to comorbid conditions. These variables are not available in the NBR data base and will not be included in this study.

Enabling resources are the resources that the person has access to which allow access to health care services. This includes resources such as health care facilities, and the types of services provided. Enabling resources important for pre burn injury treatment of diabetes and glycemic control would include insurance status and income however pre burn treatment of diabetes is not included in the data base. Personal resources include income, health insurance, and their ability to use care (Andersen, 1995). Past studies have demonstrated that patients without health insurance are unable to receive care, have higher mortality rates, and are unable to receive services needed for best outcomes and management of their chronic diseases (Sacks, Hill, & Rodgers Jr., 2011). In a 2011 retrospective study of trauma patients, uninsured patients had the highest odds of being discharged to home without additional services, compared to their cohorts with private or government insurance (Sacks et al., 2011).

The third population characteristic is need and is defined by Andersen and Newman (1973) as the level of the illness that causes the individual to seek care. This is divided into perceived needs and clinically-evaluated needs (Andersen, 1995). Perceived needs would be the burn injury and the severity of the injury from the individual’s perspective. The clinically evaluated needs would include meeting ABA transfer criteria and severity of injury. Severity of illness and need is assessed in burn injury by considering TBSA burn, % partial thickness burn, % full thickness burn, inhalation injury, body part burned, etiology of the burn, and comorbid conditions. (Herndon, 2012).
**Health Behaviors**

The third major construct in this model are health behaviors. Andersen (1995) stated that the individual’s health behaviors influence their use of the health care system and their outcomes. Health behaviors include risk-taking behaviors such as drug and alcohol use, the use of smoke detectors, and temperatures of hot water tanks in the home. It has been estimated that upwards of 50% of adult burn patients have significant levels of alcohol in their blood at the time of burn injury, and alcohol and drug ingestion prior to injury is a risk factor for higher morbidity and mortality (Silver et al., 2008). Hot tap water accounts for about 17% of all scald injuries and those at higher risk for scald injuries are the elderly and young children (Herndon, 2012). The CDC (2013) stated that mortality from fire injury is the third most common cause of unintentional death in the home. Properly working smoke detectors have been shown to decrease mortality rates. Other health behaviors that may negatively influence resource utilization and outcomes in the burn population include undiagnosed, poorly controlled or untreated comorbid conditions, such as psychiatric illness, diabetes, pain, and heart disease, and self pay or underinsured patients (L. Edelman, 2007; Hussain & Dunn, 2013; Thombs et al., 2007).

**Outcomes**

Outcomes of care are a reflection of health care system structure and process and utilization of this system. Outcomes in the A&A model include perceived health status, evaluated health status, and consumer satisfaction. Burn patients have many long-term, life-changing consequences from their injuries, both physical (including scarring, contractures, and loss of function) and psychological (depression and post-traumatic stress disorder). These physical and psychological complications are part of both their
perceived health status and clinically-evaluated health status. Transitioning from burn victim to burn survivor, return to work, and quality of life measures have been used as outcome measures for burn patients. The Burn Specific Health Scale (BSHS) has been validated for use in the burn population and has provided rich data on prediction of emotional distress at 6 months and 12 months post burn injury (Andel et al., 2007). Functional outcome scales, community re-entry, and return to work are other measures of quality of life post-burn, as well as measures of perceived and evaluated health status (Cromes, Halavanahalli, Kowalske, & Helm, 2002). Finally, the long term financial impact from ongoing medical bills and loss of wages can have devastating long term effects on the burn patient and his or her family (Pavoni, Gianesello, Paparella, Buenseqni, & Barbon, 2010). Financial impact measures include changes in the household income, wages and socioeconomic status. These measures are not available in the data base used for this study.

Other patient outcome measures that are frequently used are hospital mortality, and discharge destination. Measures used to reflect resource utilization during the hospital stay include length of hospital stay, ventilator days, and hospital charges. A review of the literature identified variables that impact the outcomes of LOS, mortality and discharge destination for burn patients. These include insurance or lack thereof, the timing of discharge, organizational determinants such as the delivery of care and practice patterns, the linkage of longer LOSs to iatrogenic complications, patient characteristics, including comorbid conditions, procedure utilization, family and social factors, technology, the health care environment, and patient resources (Ho, Ying, & Chan, 2001;
Discharge disposition such as home with home care, skilled nursing facility, or acute inpatient rehabilitation centers all influence the utilization of health care services. Patients with comorbid conditions, advancing age, physical limitations, and lack of family and community support will have longer LOSs and utilize more health care services at discharge such as home health care, skilled nursing facilities or acute inpatient rehabilitation centers (Hussain & Dunn, 2013). Based on the literature and the effects of comorbid conditions on resource utilization burn patients with diabetes will use more health resources. This would include more operations, more non operative procedures, more infections, longer LOS (both hospital and ICU), and more ventilator days (L. Edelman, 2007; Thombs et al., 2007). To date no theoretical models have been used in previous studies of hospital outcomes and resource utilization for burn patients and their resource utilization. Figure 1.2 demonstrates how the Andersen and Aday model will be used in this study.

**Summary**

It is well established that burn injury treatment is different from other types of traumatic injuries. Burn treatment requires more materials and personnel because of the wounds and metabolic derangements occurring post burn injury (Taylor, Lawless, Sen, Greenhalgh, & Palmieri, 2014). Likewise, patients with the chronic disease of diabetes have a multitude of health care expenditures over the course of the disease. These health care costs estimated at 174 billion dollars, include pain and suffering, care provided by care givers, and care for those with uncontrolled or undiagnosed diabetes (ADA, 2008).
Figure 1.2. Andersen and Aday Model of Health Care Utilization: Burn Injury and Diabetes. Adapted from “Revisiting the Behavioral Model and Access to Medical Care: Does It Matter?” By R. M. Andersen, (1995), Journal of Health and Social Behavior, 36, 1-10. Copyright 1995 by American Sociological Association. Used with permission (see Appendix A).
Better prevention and treatment options are needed to improve long term outcomes. The intersection of a diabetes epidemic with an aging population almost certainly means that persons with burns complicated by diabetes are likely to increase dramatically in the future. Thus an understanding of the impact on the health care system of adult patients with burn injury and diabetes is necessary. Greater knowledge about the burn type, severity, and outcomes in this high risk population is needed to better inform prevention campaigns and develop care strategies to improve outcomes and resource utilization.

This study will:

1. Determine if the comorbidity of diabetes in adult burn patients is occurring with greater frequency over the past decade (2002 to 2011) using the NBR data.
   
   Hypothesis 1: There will be a significant and increasing trend in burn cases complicated with a diagnosis of diabetes.

2. Examine the differences in demographics, health behaviors, mortality and burn characteristics between burn patients with and without diabetes and test for differences by age and diabetes status.
   
   Hypothesis 2: Burn patients with diabetes will be older, have more scald and contact burns, engage in less risk taking behaviors, and will have deeper burns.

3. To examine the effect diabetes has on resource utilization in adult burn patients measured by hospital LOS and charges and test for differences by age and diabetes status.
   
   Hypothesis 3: Adult burn patients with diabetes will have greater resource use evidenced by longer LOSs and higher hospital charges.
Note: Chapters 2, 3 and 4 are manuscripts based on the findings in this dissertation. I recognize there may be some redundancy from the manuscript format.
Chapter 2: Trends in Adult Burn Injury Patients with Diabetes in the United States 2002-2011 Using the National Burn Repository
Abstract

Objective: The purpose of this study was to examine the prevalence and trends over time (2002-2011) of diabetes in adult burn patient in the United States stratified by age.

Research Design and Methods: This study used the National Burn Repository Data from 2002-2011. Only data for burn patients in the United States for this period were used. Subjects were included if they were 18 years of age or older, had comorbidity data; only the initial burn admission was included in these analyses. Patients were excluded if they had no cutaneous burn injury or were reconstructive patients. Subjects were identified by diabetes status for trend analysis. Subjects were analyzed using the entire sample and then further stratified by age groups ≥ 65, 18-< 65, 18-< 40, and 40 < 65.

Results: The prevalence of diabetes in 2002 in adult burn patients was 4.85% of the patients with a study rise to 16.68% in 2011. In patients over 65 years of age the prevalence of diabetes in 2002 was 12.29% increasing to 30.27% in 2011. This represents a 2.5-fold increase in this age group. In those under 65 years of age, a 3.9-fold increase in the prevalence of diabetes was found from 3.44% in 2002 to 13.12% in 2011. Significant increasing trends over time were found for the entire sample (p < .0001), those under 18-< 40 years of age (p < .0001), those 40-< 65 years of age (p < .0001), and those 65 years of age and older (p < .0001).

Conclusions: The number of adult burn patients with the comorbid condition of diabetes in the United States has increased significantly over the past 9.5 years. The continued aging population and rise in diabetes rates in the United States will likely increase the number of burn injuries in persons with diabetes.
Introduction

In the United States, 29.1 million people have a current diagnosis of diabetes (CDC, 2015). If trends continue, it is estimated that this number will rise to one in three by the year 2050 (ADA, 2015). Persons suffering from diabetes have about 3, and 1.5, times the risk of heart disease and stroke respectively. In persons with diabetes 71% have hypertension. Further, approximately 60% of people with diabetes have mild to severe neuropathy and 4.2 million have diabetic retinopathy, predisposing them to injuries such as burns. In 2012, the cost of diabetes care in the United States was $245 billion, with $176 billion related to medical cost and the remainder accounted for by lost productivity (ADA, 2015). It is estimated that about one out of every five health care dollars in the United States is spent for the care of a person with diabetes (CDC, 2015). The growing rates of persons with diabetes who have an increased risk for burn injury will continue to strain our healthcare system (Boyle et al., 2010; CDC, 2015).

A general estimate of yearly burn injuries in the United States is 486,000 (ABA, n.d.). This number may be higher because those treated in primary care offices and urgent care centers are not captured in this reporting mechanism. Around 40,000 of these patients are admitted to the hospital each year. The 127 burn centers in the United States are responsible for treating over 75% of these patients (ABA, n.d.). Best outcomes for burn patients are obtained when patients are cared for in specialized burn centers (ABA, n.d.). Indeed, the survival rate for victims admitted to burn centers is 96.7% (ABA, n.d.). Burn care is costly, with the average cost of a hospital stay of $97,000 (Mandal, 2007). In the 2015 National Burn Repository report, the unadjusted average total charges for all TBSA was $93,893 with a range of $45,777 to $856,635 (ABA, 2015). Daily room rates,
dressing change costs, operating room costs, laboratory costs, imaging costs, and consultants’ charges all contribute to the high cost of care for this patient population. Furthermore, the costs associated with outpatient care, care giving, labor and social costs all contribute to the high cost of burn care long after hospital discharge. The lifetime costs for burn deaths are almost four times higher than for cancer and six times higher than those for heart disease. In the United States, it has been estimated that the government--federal, state and local--provide 28% of the costs related to burn care (L. Edelman, 2007).

In 2012, it was estimated that 43.1 million people in the United States were age 65 or older, with this number projected to rise to 83.7 million by 2050 (Ortman et al., 2014). Of those 65 years or older, 25.9% have diabetes (CDC, 2015). Given the increasing aging population in the United States complicated with a rise in diabetes prevalence, we are likely to see an increasing number of burn injuries over the next decade in the aging population along with increasing costs to the healthcare system.

A 2007 study (Thombs et al.) of 31,000 adult admissions to 70 burn centers found that burn patients with preexisting conditions had longer lengths of stay and higher risk for mortality. Despite only 27% of this sample having comorbid conditions listed, they found that the addition of diabetes predicted a 26% longer length of stay but did not predict mortality (Thombs et al., 2007). A retrospective comparison of clinical outcomes of 181 burn patients with diabetes and 190 burn patients without diabetes found that the length of hospital stay was longer for the patients with diabetes (23 vs. 12 days; $P = 0.0001$) despite no significant differences in total burn size. Both studies demonstrate that length of stay is longer in the person with diabetes and burn injury, however with the
rising rates of diabetes in the general population and the rising cost of burn care the trend of adult burn patients with diabetes needs to be examined.

It is well established that burn injury treatment is different from other types of traumatic injuries. Burn treatment requires more materials and personnel because of the wounds and metabolic derangements occurring post burn injury (Taylor, Lawless, et al., 2014). Likewise, patients with the chronic disease of diabetes have a multitude of health care expenditures over the course of the disease. These health care costs estimated at $174 billion dollars, include pain and suffering, care provided by caregivers, and care for those with uncontrolled or undiagnosed diabetes (ADA, 2008). The intersection of the diabetes epidemic with the growing demographic of those over 65 years suggests that there will be increasing numbers of burn injuries complicated by diabetes. This is a major concern, not the least in that these individuals are likely to be sicker and require increased resources to return to independent functioning. The purpose of this study is to examine the trend in the number of burn injuries complicated by diabetes over the last decade, using a national U.S. sample.

**Research Design and Methods**

**Overall Study Design**

A retrospective design using 9.5 years of cross sectional data from NBR database release 2012 was done to explore the trend for burn injury complicated by diabetes. This is a secondary data analysis using a large national sample; all persons are de-identified. This was submitted to the Institutional Review Board, and permission was not needed for this study because this is a study using a de-identified national data base. Permission was obtained from the American Burn Association for use of the data base (see Appendix B).
Data Set Description

The NBR is the central repository where burn centers voluntarily contribute a minimal data set regarding their burn admission. Data was obtained by each individual institution using clinical record review. Cases from the United States and from three international sites are included in the data set however only data from the United States was used. Data is submitted annually and the central repository examines the quality of the data, summarizes and compares cases, and generates an annual report. The current study used the data from the 2012 reporting period, which reflects burn cases submitted to the NBR from January 1, 2002 through June 30, 2011 and includes both pediatric and adult burn admissions. Data in this data set is data from the United States only (ABA, 2012).

In the 2012 report, 91 of the burn centers in the United States submitted data representing 35 states and the District of Columbia. Table 2.1 illustrates the numbers of burn centers and states contributing data to the NBR since the first report in 2002. States that did not contribute data were not identified in the 2012 report. All verified burn centers in the United States must contribute data to maintain their verified status. The minimal data elements were determined by the ABA burn registry and NBR committees. Custom data points can be collected by each individual burn center and used for research and quality improvement activities at their institution. Cases are accepted into the NBR with missing data only if they include values for age, sex, a diagnosis, and outcome. States that do not have burn centers include Alaska, Idaho, Montana, Wyoming, North Dakota, Mississippi, Delaware, and New Hampshire. States that have burn centers but did not contribute data to the NBR include Hawaii, South Dakota, Kentucky, West
Virginia, Maine, and Vermont (Bessey et al., 2014). All 62 verified burn centers in the United States contributed data to the NBR (Bessey et al., 2014).

Table 2.1

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of hospitals contributing data to the NBR</th>
<th>Number of states contributing to the NBR</th>
<th>Reporting period January - June 30 of the previous year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>46</td>
<td></td>
<td>1974-2002</td>
</tr>
<tr>
<td>2003*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>70</td>
<td>30 states and the District of Columbia</td>
<td>1995-2005</td>
</tr>
<tr>
<td>2006</td>
<td>70</td>
<td>30 states and the District of Columbia</td>
<td>1996-2006</td>
</tr>
<tr>
<td>2007</td>
<td>70</td>
<td>33 states and the District of Columbia</td>
<td>1997-2007</td>
</tr>
<tr>
<td>2008*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>79</td>
<td>33 states and the District of Columbia</td>
<td>1999-2008</td>
</tr>
<tr>
<td>2010</td>
<td>83</td>
<td>33 states and the District of Columbia</td>
<td>2000-2009</td>
</tr>
<tr>
<td>2011</td>
<td>91</td>
<td>35 states and the District of Columbia</td>
<td>2001 -2010</td>
</tr>
<tr>
<td>2012</td>
<td>91</td>
<td>35 states and the District of Columbia</td>
<td>2002 -2011</td>
</tr>
</tbody>
</table>

*No reports were found for these years

Included in the minimum data set are the following data elements: reporting hospital number, number of operating room visits, the number of procedures performed, gender, cause of death, state where injury occurred, age, year of injury, year of arrival at reporting hospital, description of event, etiology of the injury, site where the injury occurred, body surface area burned--Lund Browder chart, total deep burn, inhalation injury, ICD-9 diagnosis codes related to burn injury and complications, DRG code, total
hospital days, total ICU days, hospital disposition, primary payer source, and MS-DRG code. Other data that hospitals collect but that are not part of the minimal data set include occupation, comorbid conditions, alcohol or drug use, complications, and intensive care length of stay (ABA, 2012).

**Sample Description**

In the January 1, 2002-June 30, 2011 data period, there were a total of 172,640 records in the data set. Only adult burn patients (those patients 18 years of age and older) from United States hospitals with burn injuries are included in this study because the relationship being studied is between adult patients with diabetes and burn injury. Subjects had to have comorbidity data to be included in the analytic sample. Exclusion criteria include subjects < 18 and those with an etiology in the “other” category, which is the category for non-burn conditions such as abrasions/friction/degloving injuries, acute soft tissue infections (necrotizing fasciitis, Fournier’s gangrene), chronic non-healing wounds, and intravenous infiltrations, purpura fulminans, scalded skin syndrome, and toxic epidermal necrolysis/Steven Johnson Syndrome. Only first admissions were included because the outcomes of interest were related to the initial injury only. Readmissions may be planned for grafting procedures and reconstruction or unplanned for infections or pain control; however, reasons for readmission are not always reported in the data base and not all centers contributing data for this report report readmissions. Subjects with no cutaneous injury (for example patients with inhalation injury) will be excluded because they will have no wounds and will not have the same physiologic response as those patients with burn wounds. After exclusions, an eligible sample of 111,210 adult burn patients remained. Figure 2.1 is the flow diagram for the analytic
Figure 2.1. Schematic representation of the flow to arrive at analytic sample.
sample. Further analysis found that of the 111,210 adult burn patients meeting inclusion criteria 52,503 had no comorbidity data reported in this NBR data set leaving an analytic sample of 58,707 subjects. The cases in this data set represent all the burn cases in the burn registry from 2002-2011 who received specialized burn care and had comorbid data.

Table 2.2 compares patients in the eligible sample with and without comorbid data on age, burn severity and outcomes. Patients in the analytic sample were significantly older ($p < .0001$) and had significantly lower partial thickness burns ($p < .0001$). There were no differences in the percent full thickness injury ($p = 0.8955$) and total body surface area burns ($p = 0.0829$) between those with and without comorbid data. Patients in the analytic sample had significantly longer lengths of hospital stay ($p < .0001$), ICU days ($p < .0001$), ventilator days ($p < .0001$) and significantly higher hospital charges ($p < .0001$). Table 2.3 demonstrates the differences in mortality, gender, insurance status and race between those patients with and without comorbid conditions. Patients with comorbid conditions had significantly higher mortality rates ($p < .0001$) and were significantly more female ($p < .0001$). Patients without comorbid conditions were more likely to be Caucasian (67.36% vs. 59.92%) or African American (19.62% vs. 14.67%) when compared to the patients without comorbid conditions. Insurance status was also significantly different between the groups with those with comorbid conditions having more Medicaid (13.96% vs. 9.02%) and higher rates of Medicare (26.12% vs. 7.67%) than those without comorbid condition. Subjects without comorbidity data had more self pay listed for insurance (19.01% vs. 12.86%) than subjects with comorbid conditions.
Table 2.2

Comparison of Those With and Without Comorbid Conditions in the NBR Data Base
Continuous Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sample without comorbid conditions (n = 52,503)</th>
<th>Sample with comorbid conditions (n = 58,707)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Median (range)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Age</td>
<td>40.38 (15.98)</td>
<td>38.4 (18-96.93)</td>
<td>46.16 (17.67)</td>
</tr>
<tr>
<td>TNSA</td>
<td>8.3 (12.93)</td>
<td>4 (0-100)</td>
<td>8.17 (13.30)</td>
</tr>
<tr>
<td>% FT</td>
<td>3.57 (10.84)</td>
<td>0 (0-100)</td>
<td>3.58 (10.75)</td>
</tr>
<tr>
<td>% PT</td>
<td>5.46 (7.97)</td>
<td>3 (0-100)</td>
<td>5.10 (8.25)</td>
</tr>
<tr>
<td>Hosp days</td>
<td>9.38 (18.25)</td>
<td>3 (0-712)</td>
<td>12.29 (19.93)</td>
</tr>
<tr>
<td>ICU days</td>
<td>4.57 (14.30)</td>
<td>0 (0-450)</td>
<td>7.07 (16.31)</td>
</tr>
<tr>
<td>Vent days</td>
<td>2.65 (18.77)</td>
<td>0 (0-700)</td>
<td>3.52 (13.14)</td>
</tr>
<tr>
<td>Charges</td>
<td>$73,721 ($233,888)</td>
<td>$13,953 (0-5,618,542)</td>
<td>$125,974 ($120,085)</td>
</tr>
</tbody>
</table>
Table 2.3

*Comparison of Those With and Without Comorbid Conditions in the NBR Data Base Categorical Variables*

<table>
<thead>
<tr>
<th>Variable</th>
<th>With comorbid conditions</th>
<th>Without comorbid conditions</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>6.93%</td>
<td>4.46%</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Gender</td>
<td>34% female</td>
<td>23% female</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>59.92%</td>
<td>67.36%</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>14.67%</td>
<td>19.62%</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>14.38%</td>
<td>5.76%</td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>2.45%</td>
<td>2.03%</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>American Indian</td>
<td>2.10%</td>
<td>0.15%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0.55%</td>
<td>0.53%</td>
<td></td>
</tr>
<tr>
<td>Insurance status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicaid</td>
<td>13.96%</td>
<td>9.02%</td>
<td></td>
</tr>
<tr>
<td>Medicare</td>
<td>26.12%</td>
<td>7.67%</td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>32.18%</td>
<td>31.34%</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>BWC</td>
<td>7.41%</td>
<td>15.08%</td>
<td></td>
</tr>
<tr>
<td>Self Pay</td>
<td>12.86%</td>
<td>19.01%</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>7.64%</td>
<td>17.12%</td>
<td></td>
</tr>
</tbody>
</table>

**Measures**

Elderly is defined as patients 65 years or older, which is consistent with the definition of “older adult” by the U.S. Census Bureau (1995).

Diabetes is extracted from the past medical history by each registrar at the institution. This is a self-reported diagnosis and no confirmatory testing is included in the data base such as admission glucose level or hemoglobin A1c.

**Data Analysis**

The measures included in this study are population characteristics of age and the comorbid condition of diabetes, and the number of burn patients with diabetes. All
variable definitions are from the National TRACS Version 5.0 User’s Manual and include the definitions used by each registrar to enter data into the data base. The reporting of data as percentages was done because the number of burn centers and the number of subjects in the data base vary by year from 70 hospitals contributing data from 30 states and the District of Columbia to 91 hospitals contributing data from 35 states and the District of Columbia.

This study used secondary data from January 2002 through June 30, 2011. The overall statistical approach included various methods. Means and percentages were used to examine the yearly prevalence of burn patients with diabetes. Cochran- Armitage Trend test was used to test the trend over time. Subjects were analyzed by the entire sample and by age stratifications < 65, ≥ 65, 18-39, and 40-64 years of age.

Results

In the sample of 58,707 there were a total of 6,370 patients with burn injury and diabetes and 52,337 without. The mean age of those with diabetes was 57.22 with a range 18-90. Those without diabetes had a mean age of 44.81 with a range of 18-98. Those with diabetes were significantly older than those without ($p < 0.001$). In those patients under 65 years of age the mean age of those with diabetes was 49.15 with a range 18-64.99. Those without diabetes had a mean age of 39.71 with a range of 18-64.99. Those with diabetes were significantly older than those without ($p < 0.001$) in the under 65 years old age group. In those patients 65 years of age and older the mean age of those with diabetes was 74.11 with a range 65-90. Those without diabetes had a mean age of 75.87 with a range of 65-98. Those without diabetes were significantly older than those with ($p < 0.001$) in the 65 years of age and older group.
Figure 2.2 shows the overall rise in the comorbid condition of diabetes in burn patients over a 9.5-year period. In 2002, 4.84% of the sample had the comorbid condition of diabetes while in 2011, 16.68% of the sample had the comorbid condition of diabetes. The Cochran Armitage trend test was significant for an increasing trend in diabetes in the burn patient for all ages 18-98 \((p > .0001)\).

\[\text{Figure 2.2. Percent of adult burn patients with and without diabetes by year for the entire sample.}\]

**Age-Specific Patterns**

In those over 65 years of age with burn injury the incidence of those with diabetes has increased. Figure 2.3 illustrates the number of elderly patients with burn injury and diabetes by year. The rate of patients 65 years of age and older with the comorbid condition of diabetes in 2002 was 12.29% and increased to 30.27% by 2011. Cochran
Armitage trend test was significant for an increasing trend in diabetes in the burn patient for those 65 years of age and older \( (p > .0001) \).

![Figure 2.3](image)

**Figure 2.3.** Percent of adult burn patient with and without diabetes by year in those 65 years of age or older.

In those less than 65 years of age with burn injury the incidence of those with diabetes has increased. Figure 2.4 demonstrates that the number of patients less than 65 years of age with burn injury and diabetes is increasing over time. The rate of those < 65 years of age with the comorbid condition of diabetes is 3.44% of the burn population with a rising trend over the 9.5 year period to 13.12%. The Cochran Armitage trend test was significant for an increasing trend in diabetes in the burn patient less than 65 years of age \( (p > .0001) \).

Subjects less than 65 years of age were divided into two groups for further analysis. Subjects 18-< 40 years of age the prevalence of diabetes in burn injury has increased from 1.48% in 2002 to 4.94% in 2011. This represents a 3.3 times increase in
diabetes prevalence. In subjects 40 to 64 years of age the prevalence of diabetes in burn injury has increased from 5.98% in 2002 to 18.95% in 2011. This represents a 3.2 times increase in diabetes prevalence for this age group. The Cochran Armitage trend test was significant for an increasing trend in diabetes in the burn patient 18-< 40 ($p < .0001$) and for patients 40 to < 65 ($p < .0001$).

**Figure 2.4.** Percent of adult burn patient with and without diabetes by year in those under 65 years of age.

In Figure 2.5 and Table 2.4, the comparison of the entire sample, subjects 18-< 40 years of age, subjects 40 to < 65 years of age and subjects > 65 years of age is demonstrated. This demonstrates a significant rising trend in all age stratifications for this sample. Of note the subjects in the 18-< 40 age group had a 3.3 times increase in
Figure 2.5. Percent of patients with diabetes in all age groups by year. (Note the increasing trend in all age groups.)

<table>
<thead>
<tr>
<th>Year</th>
<th>Burns with diabetes analytic sample</th>
<th>N</th>
<th>Burns with diabetes under age 40</th>
<th>N</th>
<th>Burns with diabetes age 40-&lt;65</th>
<th>N</th>
<th>Burns with diabetes age 65&amp; older</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>4.84%</td>
<td>58,707</td>
<td>1.48%</td>
<td>23,143</td>
<td>5.95%</td>
<td>26,344</td>
<td>12.29%</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>6.29%</td>
<td>4.84%</td>
<td>58,707</td>
<td>1.48%</td>
<td>23,143</td>
<td>5.95%</td>
<td>26,344</td>
<td>12.29%</td>
</tr>
<tr>
<td>2004</td>
<td>7.41%</td>
<td>58,707</td>
<td>1.48%</td>
<td>23,143</td>
<td>5.95%</td>
<td>26,344</td>
<td>12.29%</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>8.82%</td>
<td>58,707</td>
<td>1.48%</td>
<td>23,143</td>
<td>5.95%</td>
<td>26,344</td>
<td>12.29%</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>11.12%</td>
<td>58,707</td>
<td>1.48%</td>
<td>23,143</td>
<td>5.95%</td>
<td>26,344</td>
<td>12.29%</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>10.77%</td>
<td>58,707</td>
<td>1.48%</td>
<td>23,143</td>
<td>5.95%</td>
<td>26,344</td>
<td>12.29%</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>11.43%</td>
<td>58,707</td>
<td>1.48%</td>
<td>23,143</td>
<td>5.95%</td>
<td>26,344</td>
<td>12.29%</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>13.60%</td>
<td>58,707</td>
<td>1.48%</td>
<td>23,143</td>
<td>5.95%</td>
<td>26,344</td>
<td>12.29%</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>16.07%</td>
<td>58,707</td>
<td>1.48%</td>
<td>23,143</td>
<td>5.95%</td>
<td>26,344</td>
<td>12.29%</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>16.68%</td>
<td>58,707</td>
<td>1.48%</td>
<td>23,143</td>
<td>5.95%</td>
<td>26,344</td>
<td>12.29%</td>
<td></td>
</tr>
</tbody>
</table>
diabetes prevalence followed by the 40-64 year olds at 3.2 times increase with the elderly having a 2.6 times increase in prevalence.

Conclusions

This is the first analysis of burn injured patients with diabetes using the large national sample of burn patients in the NBR data base. This demonstrates that the incidence of burn injuries with the comorbid condition of diabetes is on the rise. This has clear implications for the health care system such as increases in resource utilization and poorer outcomes. Like the national statistics the rise in persons with diabetes in the adult population with burn injury is also rising. It has been estimated that 10% of all burn patients have diabetes, and the incidence increases as patients’ age. This does not account for those with undiagnosed or pre diabetes. A 2004 retrospective study of burn patients found that in burn patients ages 15-54, 6% had the comorbid condition of diabetes and in those ≥ age 55, 32% had diabetes (Memmel, Kowal-Vern, & Latenser, 2004). We found that the rise over time from a prevalence in 2002 of 4.84% of the sample to 2011, with 16.68% of the sample having the comorbid condition of diabetes representing a 3.9-fold increase in the number of burn patients with diabetes. The increase is present in all age groups, 18-< 40, 40-< 65, and the elderly with the largest increase in subjects < 65 years of age overall. In subjects 18-< 40, a 3.3 times increase in diabetes prevalence was seen followed by the 40-64 year olds with 3.2 times increase, the elderly ≥ 65 having a 2.6 times increase in prevalence. If this significant rising trend continues at the same rate over the next 10 years, burn patients with diabetes may be as high as 50% of the adult burn population. Since the majority of the burn injuries area preventable injuries in this population the need to develop burn prevention programs
aimed at patients with diabetes in the community is essential. Target prevention should begin with patients less than 65 years of age since this is where the greatest rise in prevalence is occurring.

Patients with diabetes are at higher risk for burn injuries resulting from scald and contact with hot objects (Herndon, 2012; Maghsoudi, Aghamohammadzadeh, & Nasim, 2008). The neuropathy that develops as a result of uncontrolled or poorly controlled diabetes contributes to the increased risk for these injuries. Because neuropathy results in the loss of or alteration in feeling, the person with diabetes may not perceive that the water is hot or feel the pain from contact with the hot object. The lack of the pain sensation associated with neuropathy contributes to deeper burns and delays in seeking treatment for the injury (Barker, Rosson, Dellon, 2006; Herndon, 2012; Loh & Tan, 2014; Thombs, Singh, Halonen, Diallo, & Milner, 2007). A 2002 study of burn patients with and without diabetes found that scald injuries were more likely to occur from the shower or tub and not hot liquid spills (33% with diabetes vs. 15% without diabetes $P < 0.01$). They also found that persons with diabetes had a delayed presentation for care 45% of the time ($P = 0.00001$; McCampbell et al., 2002). The identification of this increasing trend in burn injury puts patients with diabetes at high risk for preventable injury. This demonstrates the need for targeting prevention efforts at scald and contact injuries.

To date no study has looked at increasing age, and the comorbid condition of diabetes coupled with burn injury. As the population ages, we hypothesize that this trend of increasing elderly burn patients with the comorbid condition of diabetes will continue. It is speculated that these patients will be at high risk for preventable burn injury and will
impact the already strained health care system. There was a significant rising trend over time in those with diabetes and burn injury over the age of 65 in the years 2002-2011, and by 2011, 32% of all those over the age of 65 had diabetes. Rao, Ali, and Moiemen (2006) studied 63 elderly patients and found a positive correlation between the number of comorbid conditions and mortality but did not examine specific comorbid conditions such as diabetes (Rao et al., 2006). Keck, Lumenta, Andel, Kamolz, & Frey (2009) found the incidence of premorbid conditions in burn patients over the age of 65 to be as high as 85%. In a study to examine the effect of diabetes on outcomes in adult civilian patients admitted to the burn ICU, 57 persons with diabetes were compared to 405 persons without diabetes. Patients with diabetes were older (mean age 60±15), had higher admission glucose (196±81) and higher mean glucose (147±37), more glucose variability, and longer ICU stays (Dahagam, Mora, Wolf, & Wade, 2011).

Our study is the first to use the national data base to examine the trends in the incidence of diabetes and burn injury in the United States. There have been national studies using the NBR to look at the impact of comorbid conditions on burn injury but to date no study has looked at the national trend of diabetes coupled with burn injury to identify the scope of the problem (Barsun, Sen, Palmieri, & Greenhalgh, 2013: Thombs et al., 2007). There have also been studies using NBR data that examine the effects age on outcomes but none relating to diabetes and age (Pham, et al., 2009). A population based study from Ontario Canada found that overall there was a 31% rise over 6 years in persons over 20 years of age with diabetes (Lipscombe & Hux, 2007) suggested that this may not only be a crisis in the United States but other countries as well. The evidence supports that there is an increase in burn patients with the comorbid condition of diabetes
and the rate of rise is highest in patients < 65 years of age, therefore a better understanding of this relationship is needed to develop prevention programs in the community for this high risk population.

This is a multi-year cross sectional study with a sample collected over 9.5 years from burn centers in the United States with 91 of the 127 burn centers in the United States contributed data providing a good representation of the population. Despite this data not being primary data, data quality control measures to ensure completeness and accuracy of the data are completed at each institution. A validity review of the NBR 2009 release found data inconsistencies and missing data as well as duplicate records however vast improvements have been made in the 2012 release (Taylor et al., 2013). Sample bias may also be present because those without comorbid conditions were not included in the analytic sample. Comparisons of the eligible sample were completed. Burn patients with comorbid conditions were significantly older, had more full thickness injury, and used more resources when compared to burns without comorbid data. Diabetes is self-reported by the patient and placed in the medical record and this diagnosis may be over or under represented. Additionally, there is no data to validate the diagnosis of diabetes (such as admission HbA1c) for patients. The diagnosis of diabetes is dependent on the ability of the registrar at each facility to extrapolate the diagnosis from the chart however self-reported comorbidities have been shown to be accurate (Harvey, Craney, & Kelly, 2002; Mukerji et al., 2007).

**Implications**

Increasing rates of burn injuries with the comorbid condition of diabetes over the last decade highlight the need for the development of prevention programs. The
inclusion of comorbid data in the NBR data is needed to identify those burn patients with comorbid conditions such as diabetes so that they impact of this disease on burn injury can be studied further. Studies need to be done to examine how the comorbid condition of diabetes with burn injury impact resource utilization and outcomes. This information is important to identify burn prevention strategies in this high risk population.
Chapter 3: Description of the Characteristics of Burn Patients With Diabetes Using the NBR Data Set 2002-2011
Abstract

Introduction: Diabetes is a growing problem in this country and because of the micro and macro vascular changes that occur as a result of the progression of the disease persons with diabetes are at greater risk for experiencing burns. This risk in conjunction with an increasing aging population in the United States suggests that there may be an increase in the number of burn patients with the comorbid condition of diabetes in the future. If this occurs, the impact on patients as well as the health care system is potentially great. However, we have limited knowledge about the characteristics of the burn patient with diabetes, including demographics, behaviors, burn severity and type, and effects on mortality. This study will begin to fill in these gaps by examining the characteristics of the burn patient with diabetes to better understand the epidemiology in this high risk population.

Methods: The NBR was used to examine adults with diabetes in the United States. Records were included if they were 18 years of age or older, were first admissions for burn injury, and had comorbidity data in the NBR. Records were excluded if they had no cutaneous burn injury. Comparisons were made between subjects with and subjects without diabetes. The sample was stratified into age groups, < 65 years of age and ≥ 65 year of age. Subjects in the < 65 age category were further stratified to 18 to < 40 and 40 to < 65 years of age. Baseline patient characteristics, severity of illness, health behaviors and mortality were compared between subjects with and without diabetes using \( \chi^2 \) or student t-test. Multivariate logistic regression was conducted to assess the effects of diabetes on mortality.
**Results:** A total of 111,210 adult burn in the 2002 to 2011 data base were eligible for this study, of which 58,705 (52.8%) met inclusion criteria. Patients with diabetes were significantly older ($p < .0001$), females ($p < 0.001$), had higher likelihood of full thickness burns ($p < .0001$), more inhalation injuries ($p = 0.0049$), more scald and contact burns ($p < 0.001$), more likely to be African Americans ($p < 0.0001$), and had higher rates of Medicare insurance ($p < 0.001$). There were no significant differences in TBSA ($p = 0.1395$) or the percent of partial thickness area between the two groups ($p = 0.8980$). Diabetes did not significantly impact mortality when controlling for age, TBSA, or full thickness burns ($p = 0.2119$).

**Conclusions:** This analysis describes the epidemiology of the burn patient with the comorbid condition of diabetes. Understanding the epidemiology will aid in developing target interventions to better manage the care of the burn patient with diabetes.
Introduction

In 2014, 29.1 million people in the United States were diagnosed with diabetes and accounted for 9.3% of the population. Of these, 18.8 million were diagnosed and 7 million were undiagnosed. An additional 79 million American adults (20 years or older) met criteria for prediabetes (ADA, 2014). The CDC has predicted that if the obesity epidemic continues to progress at the current rate, as many as one in three Americans will develop diabetes. Along with obesity, other factors contributing to the predicted increasing rates of diabetes include: the aging population, the increase in the minority populations at high risk for diabetes with African Americans having 2 times the risk of Caucasians, and that people with diabetes are living longer with increasing rates as people age (ADA, 2011; CDC, 2013; Sladek et al., 2007). Projections show that the number of persons with diabetes in the United States will increase to 48.3 million by the year 2050 (Narayan, Boyle, Geiss, Saaddine, & Thompson, 2006).

Many complications of diabetes, such as peripheral neuropathy, retinopathy, and gait, instability put this population at higher risk for burn injury. Neuropathies associated with diabetes contribute to the higher incidence of burns related to scalds and contact with hot objects. The presence of neuropathy contributes to the delay in seeking care for burn injury because of the altered pain response (Barker et al., 2006; Herndon, 2012; Loh & Tan, 2014). It has been estimated that 10% of all burn patients have diabetes, and the incidence increases as patients’ age. This does not account for those with undiagnosed or pre diabetes. A 2004 study from one burn center found that in burn patients older than 65, 85% had the comorbid condition of diabetes whereas the incidence of diabetes in the general population over 65 was 18% (Memmel et al., 2004).
The presence of diabetes in patients with burn injury has profound effects on the treatment and outcomes. Treatment is complicated because of the micro-vascular complications associated with the progression and control of the disease and in large burns the marked and sustained hypermetabolic response (Jeschke et al., 2011). Because of the relationship between glycemic control, the stress response, and wound healing, burn patients with diabetes may be predisposed to more infections, more surgeries and longer lengths of hospital stay (Memmel et al., 2004). A prospective study by Schwartz and colleagues (2011) found that patients with diabetes and burn injury have significant delays in burn wound healing and therefore use more health care resources. The implications for practice are many, including development of prevention programs geared toward burn injury, identifying the best evidence and practice for those with burn injury and diabetes and the evaluation of outcomes in this population.

Given the expected rise in diabetes prevalence over the next decade, and the increasing older population, the risk for burn injury in persons with diabetes is likely that there will be both an increase in the overall number of burn injuries in persons with diabetes and that a higher proportion of these burn injuries will be in older adults. To date, no study has used the NBR data set to examine and describe the population of adult burn patients with diabetes. The purpose of this study was to examine the differences in demographics, health behaviors, the severity of burn injury, and mortality between adult burn patients with diabetes and those without diabetes. This will provide essential knowledge for anticipating the needs of this growing subset of burn patients and for designing systems of care to address their needs.
Methods

This study was a cross sectional non experimental descriptive design using a large national sample of burn patients. The NBR data from January 1, 2002 through June 30, 2011 release provided a sample of adult burn patients large enough to describe the characteristics of the adult burn patient with diabetes. This is a secondary data analysis using this large national sample; all persons are de-identified. Submission to the Institutional Review Board for permission was done but not needed for this study. Permission was obtained from the American Burn Association for use of the data base (see Appendix B).

Sample

A total of 111,210 total records were eligible for this study, of which 58,707 (52.8%) had comorbid data. Since this is a study of adult burn patients with first admission for burn, records were included if they were 18 years of age or older, and were first admissions for burn injury. Records were excluded if they had no cutaneous burn injury, had no comorbid data or if they were a duplicate record. Figure 2.1 in Chapter 2 is the consort diagram delineating how the analytical sample was derived.

Definition of Terms

Diabetes is extracted from the past medical history by each registrar at the institution. This is a self-reported diagnosis and no confirmatory testing is included in the data base such as admission glucose level or hemoglobin A1c.

Elderly is defined as patients 65 years or older, which is consistent with the definition of “older adult” by the U.S. Census Bureau (1995).
Etiologies were grouped with fire/flame/conflagration and thermal injury, scalds, contact with hot objects, electrical, chemical, and other which included unknown, other mechanisms and not specified. The categories are consistent with those definitions in the NBR code book (ABA, 2007).

Insurance status includes Medicaid, Medicare, private which includes commercial insurance, veterans insurance and military/government insurance, workers compensation, self pay which includes charity and uninsured, and missing. The categories are consistent with those definitions in the NBR code book (ABA, 2007).

Race was categorized according to the NBR code book description of race and includes White, Black, Hispanic, Asian, American Indian, or unknown or missing (ABA, 2007).

**Data Analysis**

Data from the NBR was placed in a study specific data base and variables were created to identify each different comorbid condition using the NBR categories. Results were analyzed using SAS 9.4). Because not all data was present for every variable, sample size may vary for results, $P < 0.05$ was considered significant.

The analytic sample was compared with the sample without comorbid data to identify if differences were present. Comparisons were made between subjects with and without diabetes for the entire sample and stratified by age. Age groups were < 65 years of age and 65 years of age and older. Those less than 65 were stratified to young adults 18-< 40 and middle age adults 40-< 65 to compare those with and without diabetes. Variables included to describe the population were age, gender, race, insurance status, etiology, health risk behaviors, comorbid condition of diabetes, and mortality. Patients
with diabetes in all age groups were also analyzed for the presence of other comorbid conditions that are typically present with diabetes including cardiovascular disease, stroke, and hypertension.

The overall statistical approach includes various methods. For univariate analysis, continuous data will be reported as the mean and standard deviation. The student’s $t$-test will be used or continuous data to compare differences in burns with and without diabetes. Categorical data will be expressed as frequency distribution and the Chi-square test will be used to determine if differences existed between burn patients with diabetes and burn patients without diabetes.

Multivariate logistic regression was done with mortality as the dependent variable. Age, total body surface area, and percent full thickness were added to the regression model based on the literature.

**Age**

Age has been found to be the strongest independent risk factor for mortality in numerous studies of burn patients. It is well established in the burn literature that advancing age increases mortality with smaller percentage body burn. Although mortality rates of patients 65 years and older have improved due to advances in burn resuscitation, critical care, treatment of infections and wound care, higher mortality rates persist (American Burn Association, 2012; Chang, Edelman, Morris, & Saffle, 2005; Herndon, 2012; Lundgren et al., 2009; Pham et al., 2009; Rao et al., 2006). Lundgren et al. (2009), examined 325 elderly patients and found that in patients over 75 years of age, one year mortality rates following a burn injury were significantly correlated with the number of co-morbid conditions such as diabetes (Lundgren et al., 2009).
Total Body Surface Area

Past studies have found that the greatest predictor of survival was the TBSA burned. A study of burn patients older than 80 years old found that the higher the TBS, the higher the mortality rate. Additionally, no patients in this age group survived a burn with 60% or greater TBSA (Pomahac et al., 2006). Previous studies have demonstrated that the TBSA and percentage full thickness may predict outcomes such as mortality.

Full Thickness Area

Full thickness injuries contribute to the severity of illness because surgical interventions (i.e., skin grafting) must be done in order for the wound to heal. Higher percentage TBSA and percentage full thickness burn contribute to longer lengths of stay, increased resource utilization, and mortality (Herndon, 2012).

The entire sample was analyzed as well as those patients under 65 and those elderly burn patients 65 years of age and older to describe the differences in patients with and without diabetes. SAS 9.4 was used for analysis.

Results

In Figure 3.1, the rise in the number of patients with diabetes is shown by year. The prevalence of diabetes is trending upward in the total analytic sample, those less than 65 and those 65 and older with the most dramatic rise being seen in those 65 and older. In 2002 4.85% of the patients had diabetes in 2002 with a study rise to 16.68% in 2011. The rate of those < 65 years of age with the comorbid condition of diabetes is 8.84% of the burn population with a rising trend over the 9.5 year period to 13.12%. Patients 65 years of age and with the comorbid condition of diabetes in 2002 were 12.29% and increased to 30.27% by 2011.
In the analytic sample, only 178 patients with diabetes had the comorbid condition of coronary artery diseases (CAD). This represents only 2% of the patients with diabetes and is most certainly under represented. Patients with CAD and diabetes were significantly older ($p < .0001$) however there were no significant differences in TBSA, PT, FT, hospital length of stay, ICU days, ventilator days or charges. Mortality was significantly higher in patients with CAD and diabetes ($p < .0001$). Seventy one percent of the sample had diabetes and hypertension (HTN). Patients were significantly older if they had diabetes and HTN ($p < .0001$), but there were no significant differences in TBSA, PT, FT, hospital length of stay, ICU days, ventilator days, charges, or mortality. Four percent of patients with diabetes also had history of stroke and again may be under represented in this sample. These patients were significantly older ($p < .0001$), had significantly more partial thickness injury ($p = 0.0035$) had significantly longer
lengths of stay \( (p = 0.0035) \), higher charges \( (p = 0.0124) \) and higher rates of mortality \( (p < .0001) \). There were no significant differences in ICU days or ventilator days.

**Patient Characteristic**

Table 3.1 describes the differences in patient characteristics for the analytic sample, those patients under 65 years of age and those 65 years of age and older based on diabetes status. Patient characteristics included age, gender, race and insurance status. In the overall sample, adult burn patients with diabetes were more likely to be older (7.23 vs. 43.31 years; \( p < .0001 \)) female (32.87%; \( p < .00001 \)) African American than White (21.36% vs. 16.56%), and have Medicare (34.13% vs. 14.52%) when compared to those without diabetes.

Patients under 65 years of age with diabetes were significantly older (49.15 vs. 39.71 years; \( p < .0001 \)), were significantly more female (29.85% vs. 26%; \( p < .0001 \)), African Americans (22.71% vs. 16.40%) and have Medicare (16.60% vs. 6.98%) and Medicaid (17.15% vs. 12.68%) when compared to those without diabetes.

Table 3.2 demonstrates the demographic characteristics of patients in the < 65 year old age group further stratifying patients to < 40 and 40 to < 65. Patients 18-< 40 years of age with diabetes were older (31.48 vs. 28.62 years \[ p < .0001 \]), female (32.73% vs. 2404% \[ p < .0001 \]), had more African Americans (23.20% vs. 15.17%) and had higher rates of Medicaid (20.46% vs. 12.46%) when compared to those without diabetes. Patients 40 < 65 years of age with diabetes were older (53.09 vs. 50.46 years \[ p < .0001 \]), had more African Americans (21.95% vs. 18.36%) and higher rates of Medicaid
Table 3.1

**Patient Demographics for Entire Sample, Under 65 Years of Age and 65 years of Age and Older**

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>With diabetes</th>
<th>Without diabetes</th>
<th>$P^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entire sample</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>46.16 Mean</td>
<td>57.23 Mean</td>
<td>44.87 Mean</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td></td>
<td>17.67 (SD)</td>
<td>15.09 (SD)</td>
<td>17.48 (SD)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>28.73% female</td>
<td>32.87% female</td>
<td>28.23% female</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>61.45%</td>
<td>62.34%</td>
<td>63.68%</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>17.08%</td>
<td>21.36%</td>
<td>16.56%</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>10.19%</td>
<td>8.37%</td>
<td>10.41%</td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>1.64%</td>
<td>1.57%</td>
<td>1.65%</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>American Indian</td>
<td>0.54%</td>
<td>0.79%</td>
<td>0.51%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2.25%</td>
<td>2.55%</td>
<td>2.21%</td>
<td></td>
</tr>
<tr>
<td>Insurance status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicaid</td>
<td>11.42%</td>
<td>12.56%</td>
<td>11.29%</td>
<td></td>
</tr>
<tr>
<td>Medicare</td>
<td>16.65%</td>
<td>34.13%</td>
<td>14.25%</td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>31.53%</td>
<td>31.09%</td>
<td>31.58%</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>BWC</td>
<td>11.34%</td>
<td>6.45%</td>
<td>11.94%</td>
<td></td>
</tr>
<tr>
<td>Self pay</td>
<td>16.55%</td>
<td>9.74%</td>
<td>17.38%</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>12.50%</td>
<td>6.04%</td>
<td>13.29%</td>
<td></td>
</tr>
<tr>
<td><strong>Under 65</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>40.53 Mean</td>
<td>49.15 Mean</td>
<td>39.71 Mean</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td></td>
<td>12.85 (SD)</td>
<td>10.64 (SD)</td>
<td>12.74 (SD)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>26.34% female</td>
<td>29.85% female</td>
<td>26.00% female</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>62.17%</td>
<td>59.66%</td>
<td>62.40%</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>17.25%</td>
<td>22.71%</td>
<td>16.40%</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>11.18%</td>
<td>10.28%</td>
<td>11.27%</td>
<td>&lt; .0001</td>
</tr>
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<td>Asian</td>
<td>1.56%</td>
<td>2.62%</td>
<td>1.59</td>
<td></td>
</tr>
<tr>
<td>American Indian</td>
<td>0.58%</td>
<td>.94%</td>
<td>0.54%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2.27%</td>
<td>2.62%</td>
<td>2.24%</td>
<td></td>
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<tr>
<td>Insurance status</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Medicaid</td>
<td>13.07%</td>
<td>17.15%</td>
<td>12.68%</td>
<td></td>
</tr>
<tr>
<td>Medicare</td>
<td>7.36%</td>
<td>16.60%</td>
<td>6.48%</td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>34.59%</td>
<td>37.58%</td>
<td>34.30%</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>BWC</td>
<td>13.28%</td>
<td>9.10%</td>
<td>13.68%</td>
<td></td>
</tr>
<tr>
<td>Self pay</td>
<td>19.31%</td>
<td>13.86%</td>
<td>19.38%</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>12.39%</td>
<td>5.71%</td>
<td>13.04%</td>
<td></td>
</tr>
</tbody>
</table>

Continued
(18.86% vs. 9.98%) when compared to those without diabetes. There were no differences in female gender in this age group in patients with and without diabetes.

Patients over 65 years of age with diabetes were significantly younger (74.11 vs. 75.87 years; \( p < .0001 \)), female (39.20%; \( p < .0001 \)), and African Americans (19.65% vs. 15.20%) when compared to those without diabetes. Insurance status was predominately Medicare for both groups 70.76% for those with diabetes and 63.44% for those without. Subjects without diabetes had significantly higher rates of self pay status (14.82%) than those with diabetes (6.74%) in this age group.
Table 3.2

*Patient Demographics for <65 Years of Age Stratified to 18-< 40 and 40-< 65 Years of Age.*

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>With diabetes</th>
<th>Without diabetes</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>18 - &lt; 40</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>28.71 Mean 6.42 (SD)</td>
<td>31.48 Mean 6.09 (SD)</td>
<td>28.62 Mean 6.41(SD)</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Gender</td>
<td>24.3% female</td>
<td>32.73% female</td>
<td>24.04% female</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>59.67%</td>
<td>56.31%</td>
<td>59.79%</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>15.44%</td>
<td>23.20%</td>
<td>15.17%</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>14.68%</td>
<td>12.50%</td>
<td>14.76%</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Asian</td>
<td>1.68%</td>
<td>1.29%</td>
<td>1.69%</td>
<td></td>
</tr>
<tr>
<td>American Indian</td>
<td>0.61%</td>
<td>1.29%</td>
<td>0.59%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2.38%</td>
<td>2.19%</td>
<td>2.38%</td>
<td></td>
</tr>
<tr>
<td>Insurance status</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Medicaid</td>
<td>13.13%</td>
<td>20.46%</td>
<td>12.46%</td>
<td></td>
</tr>
<tr>
<td>Medicare</td>
<td>2.99%</td>
<td>6.48%</td>
<td>2.87%</td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>32.34%</td>
<td>38.63%</td>
<td>32.12%</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>BWC</td>
<td>15.03%</td>
<td>9.02%</td>
<td>15.25%</td>
<td></td>
</tr>
<tr>
<td>Self Pay</td>
<td>23.29%</td>
<td>20.06%</td>
<td>23.41%</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>13.22%</td>
<td>5.34%</td>
<td>13.50%</td>
<td></td>
</tr>
<tr>
<td><strong>40-&lt; 65</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>50.81 Mean 6.77(SD)</td>
<td>53.09 Mean 6.69(SD)</td>
<td>50.46 Mean 6.71(SD)</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Gender</td>
<td>28.08% female</td>
<td>29.21% female</td>
<td>27.91% female</td>
<td>0.1094</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>64.34%</td>
<td>60.40%</td>
<td>64.94%</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>18.83%</td>
<td>21.95%</td>
<td>18.35%</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>8.14%</td>
<td>9.79%</td>
<td>7.88%</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Asian</td>
<td>1.45%</td>
<td>1.26%</td>
<td>1.48%</td>
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<tr>
<td>American Indian</td>
<td>0.55%</td>
<td>0.86%</td>
<td>0.50%</td>
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</tr>
<tr>
<td>Other</td>
<td>2.18%</td>
<td>2.72%</td>
<td>2.10%</td>
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</tr>
<tr>
<td>Insurance Status</td>
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<td></td>
</tr>
<tr>
<td>Medicaid</td>
<td>13.01%</td>
<td>16.42%</td>
<td>12.49%</td>
<td></td>
</tr>
<tr>
<td>Medicare</td>
<td>11.17%</td>
<td>18.86%</td>
<td>9.98%</td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>36.54%</td>
<td>37.35%</td>
<td>36.42%</td>
<td></td>
</tr>
<tr>
<td>BWC</td>
<td>11.76%</td>
<td>9.12%</td>
<td>12.16%</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Self Pay</td>
<td>15.84%</td>
<td>12.47%</td>
<td>16.36%</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>11.68%</td>
<td>5.79%</td>
<td>12.59%</td>
<td></td>
</tr>
</tbody>
</table>
Etiology of Injury

In Figure 3.2, burn patients with diabetes were significantly different in the etiology of injury ($p < 0.0001$) with higher rates of scald (26.44% vs. 20.62%) and contact burns (8.67% vs. 4.8%). Figure 3.3 displays the differences in etiology of burn in patients less than 65 years of age. Burn patients with diabetes were significantly different in their etiology of injury ($p < 0.0001$) with higher rates of scald (27.30% vs. 20.85%) and contact burns (8.98% vs. 4.76%) in those with diabetes compared to those without.

![Figure 3.2](image)

*Figure 3.2.* Etiology of burns for patients with and without diabetes for the entire sample.
Figure 3.3. Etiology of burns for patients with and without diabetes under age 65.

Figures 3.4 and 3.5 illustrate the differences in etiology for burn patients 18 - < 40 and 40 to < 65 years of age. Subjects < 40 years of age had significant differences in their etiology of injury having more contact injuries (9.02% vs. 4.61%) and scald burns (28.08% vs. 21.04%) in the diabetes group. Subjects 40 -< 65 years of age had significant differences in their etiology of injury having more contact injuries (8.97% vs. 5.54%) and scald burns (27.12% vs. 21.15%) in the diabetes group.

Figure 3.6 illustrates the differences in etiology of injury for burn patient 65 years of age and older. Patients with diabetes were significantly different in their etiology of injury ($p < 0.0001$) with lower rates of scald burns (14.31% vs. 19.21%) and higher rates of contact burns (8.0% vs. 5.03%) when compared with patients without diabetes. Those 65 years of age and older with and without diabetes had higher flame/thermal burn injuries than persons without.
Figure 3.4. Etiology of subjects between 18 and < 40 years of age.

Figure 3.5. Etiology of subjects 40-< 65 years of age.
Health Behaviors

Health behaviors examined were smoking, the use of alcohol, and illicit drugs. Comparisons of health behaviors between patients with and without diabetes are illustrated in Figures 3.7, 3.8, 3.9, 3.10, and 3.11. In the entire sample those without diabetes smoked significantly more ($p = 0.0019$) use more alcohol ($p < 0.0001$) and used more illicit drugs ($p < 0.0001$) than patients with diabetes. In those under 65 years of age subjects without diabetes smoked significantly more ($p = 0.0293$), used more alcohol ($p < 0.0001$), and used more illicit drugs ($p < 0.0001$). Subjects < 40 years of age and without diabetes smoked significantly more ($p = 0.0278$) and used more illicit drugs ($p = 0.0033$) than subjects with diabetes. There were no significant differences in the groups in use of alcohol ($p = 0.0967$). Subjects > 40 and < 65 years of age without diabetes used significantly more alcohol ($p < .0001$) and used more illicit drugs ($p < .0001$) than subjects with diabetes. There were no significant differences in the groups in smoking.

Figure 3.6. Etiology of burns for patients with and without diabetes age 65 and older.
behaviors \( (p = 0.4545) \). In those 65 years of age and older subjects without diabetes had no significant differences in health behaviors smoking \( (p = 0.1830) \), alcohol \( (p = 0.0683) \), and illicit drugs \( (p < 0.4616) \) when compared to those without diabetes.

**Figure 3.7.** Health behaviors for analytic sample for burn patients with and without diabetes.

**Figure 3.8.** Health behaviors for burn patients less than 65 with and without diabetes.
Figure 3.9. Health behaviors for burn patients 65 and older with and without diabetes.

Figure 3.10. Health behaviors for patients 18-< 40 years of age.
Figure 3.11. Health behaviors for patient 40-< 65 years of age.

Severity of Illness

Severity of illness included total burn surface area, total area of full thickness, total area of partial thickness and inhalation injury. Table 3.3 shows the differences in the severity of illness for burn patients with and without diabetes. Overall, patients with diabetes had significantly higher percent of full thickness burns (4.27 vs. 3.51; \( p < .0001 \)) and higher incidence of inhalation injury (\( p = < .0001 \)). There were no significant differences in the percent total area burned (8.41 vs. 8.17; \( p = 0.1395 \)) or the percent of partial thickness area burned (5.11 vs. 5.10; \( p = 0.8980 \)). Patients under 65 years of age with diabetes had significantly higher percent of full thickness burns (3.76 vs. 3.20; \( p = 0.0027 \)). There were no significant differences in the percent total area burned (8.07 vs. 7.89; \( p = 0.4123 \)), the percent of partial thickness area burned (5.25 vs. 5.11; \( p = .3148 \)), or the presence of inhalation injury (3.68\% vs. 4.45\%; \( p = 0.0552 \)). For patients 65 years of age and older there were no difference in total body surface area burn.
(p = 0.1266), area of full thickness burn (p = 0.8332), or area of partial thickness burn (p = 0.3652). Inhalation injury was significantly higher in those without diabetes (p < .0001).

Table 3.4 demonstrates the differences in severity of illness in subjects < 40 years of age and subjects 40 -< 65 years of age. Patients < 40 years of age with diabetes had a significant difference in TBSA (p = 0.0404) and percent partial thickness injury (p = 0.0126) compared to patients without diabetes. There were no significant differences between the groups in percent full thickness (p = 0.0502), mortality (p = 0.6421) or inhalation injury (p = 0.7097). Patients > 40 and < 65 years of age with diabetes had a significant difference in the presence of inhalation injury (p = 0.0177). There were no significant differences between the groups in TBSA (p = 0.1736), percent partial thickness injury (p = 0.5904), percent full thickness (p = 0.4393), mortality (p = 0.6809).

Mortality

The mortality rate for the entire sample was 5.66%. In Table 3.3 patients with diabetes had significantly higher mortality rates than those without diabetes (7.35% vs. 4.80%; p < 0.0001). Patients less than 65 years of age with diabetes had mortality rates significantly higher than those without diabetes (4.50% vs. 3.60%; p = 0.0026). In elderly patients 65 years of age and older with diabetes, the mortality rate was significantly lower than those without diabetes (13.28% vs. 16.74%; p = 0.0002).
Table 3.3

Comparison of Severity of Illness for Those With and Without Diabetes

<table>
<thead>
<tr>
<th></th>
<th>With diabetes</th>
<th>Without diabetes</th>
<th>( P^a )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean, range</td>
<td>Mean, range</td>
<td></td>
</tr>
<tr>
<td><strong>Entire sample, ( N = 58,707 )</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TBSA</td>
<td>8.41%, 0-100%</td>
<td>8.17%, 0-100%</td>
<td>0.1395</td>
</tr>
<tr>
<td>% FT</td>
<td>4.27%, 0-100%</td>
<td>3.51%, 0-100%</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>% PT</td>
<td>5.11%, 0-100%</td>
<td>5.10%, 0-100%</td>
<td>0.8980</td>
</tr>
<tr>
<td>Mortality</td>
<td>7.35%</td>
<td>4.80%</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Inhalation injury</td>
<td>3.85%</td>
<td>4.80%</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td><strong>Less than 65, ( N = 49,254 )</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TBSA</td>
<td>8.07%, 0-100%</td>
<td>7.89%, 0-100%</td>
<td>0.4123</td>
</tr>
<tr>
<td>% FT</td>
<td>3.76%, 0-100%</td>
<td>3.20%, 0-100%</td>
<td>0.0027</td>
</tr>
<tr>
<td>% PT</td>
<td>5.25%, 0-100%</td>
<td>5.11%, 0-100%</td>
<td>0.3148</td>
</tr>
<tr>
<td>Mortality</td>
<td>4.50%</td>
<td>3.60%</td>
<td>0.0026</td>
</tr>
<tr>
<td>Inhalation injury</td>
<td>3.68%</td>
<td>4.45%</td>
<td>0.0552</td>
</tr>
<tr>
<td><strong>65 and older, ( N = 9,453 )</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TBSA</td>
<td>9.12%, 0-100%</td>
<td>9.67%, 0-100%</td>
<td>0.1266</td>
</tr>
<tr>
<td>% FT</td>
<td>5.30%, 0-100%</td>
<td>5.37%, 0-100%</td>
<td>0.8332</td>
</tr>
<tr>
<td>% PT</td>
<td>4.84%, 0-100%</td>
<td>5.03%, 0-100%</td>
<td>0.3652</td>
</tr>
<tr>
<td>Mortality</td>
<td>13.28%</td>
<td>16.74%</td>
<td>0.0002</td>
</tr>
<tr>
<td>Inhalation injury</td>
<td>4.13%</td>
<td>7.04%</td>
<td>&lt; .0001</td>
</tr>
</tbody>
</table>

\( a \) Comparison test are between those with and without diabetes.

Table 3.4

Severity of Illness Patient Under 65 Stratified to 18-< 40 Years of Age and 40-< 65 Years of Age

<table>
<thead>
<tr>
<th></th>
<th>With diabetes</th>
<th>Without diabetes</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean, Range</td>
<td>Mean, Range</td>
<td></td>
</tr>
<tr>
<td><strong>18-&lt; 40</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( N = 22,910 )</td>
<td>8.42%, 0-2.5%</td>
<td>7.45%, 0-100%</td>
<td>0.0404</td>
</tr>
<tr>
<td>% FT</td>
<td>3.55%, 0-80%</td>
<td>2.76%, 0-100%</td>
<td>0.0502</td>
</tr>
<tr>
<td>% PT</td>
<td>5.77%, 0-72%</td>
<td>5.0%, 0-99.8%</td>
<td>0.0126</td>
</tr>
<tr>
<td>Mortality</td>
<td>2.67%</td>
<td>2.41%</td>
<td>0.6421</td>
</tr>
<tr>
<td>Inhalation injury</td>
<td>0.11%</td>
<td>4.16%</td>
<td>0.7097</td>
</tr>
<tr>
<td><strong>40 &lt; 65</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( N = 26,344 )</td>
<td>7.99%, 0-100%</td>
<td>8.32%, 0-100%</td>
<td>0.1736</td>
</tr>
<tr>
<td>% FT</td>
<td>3.80%, 0-100%</td>
<td>3.63%, 0-100%</td>
<td>0.4393</td>
</tr>
<tr>
<td>% PT</td>
<td>5.13%, 0-78%</td>
<td>5.21%, 0-100%</td>
<td>0.5904</td>
</tr>
<tr>
<td>Mortality</td>
<td>0.66%</td>
<td>4.12%</td>
<td>0.6809</td>
</tr>
<tr>
<td>Inhalation Injury</td>
<td>0.44%</td>
<td>4.19%</td>
<td>0.0177</td>
</tr>
</tbody>
</table>
Tables 3.5, 3.6, 3.7, and 3.8 display the results of the multivariate regression with the dependent variable of mortality. This was completed to analyze the association of age, total body surface area, area full thickness and the comorbid condition of diabetes on mortality. The variables were added to the model based on the literature and if they were significant at the .05 level. In the entire sample, the adjusted OR for mortality is 0.923 (95% CI 0.814, 1.046) for the adult burn patient with diabetes compared to those without diabetes. Patients < 65 years of age, the adjusted OR was 1.080 (95% CI 0.896, 1.301) for the adult burn patient with diabetes compared to those without diabetes. Patients 18-< 40 years of age, the adjusted OR was 1.050 (95% CI 0.855, 1.301) for the adult burn patient with diabetes compared to those without diabetes. Patients > 40 and < 65 years of age the adjusted OR was 1.194 (95% CI 0.727, 1.962) for the adult burn patient with diabetes compared to those without diabetes. Patients 65 years of age and older, the adjusted OR was 0.827 (95% CI 0.729, 1.043) for the adult burn patient with diabetes compared to those without diabetes.

Table 3.5

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>β</th>
<th>SE</th>
<th>Wald’s Chi Square</th>
<th>P</th>
<th>Odds ratio</th>
<th>Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-6.7537</td>
<td>0.08770</td>
<td>5927.8327</td>
<td>&lt; .0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.0551</td>
<td>0.00129</td>
<td>1837.6866</td>
<td>&lt; .0001</td>
<td>1.057</td>
<td>1.054-1.059</td>
</tr>
<tr>
<td>Area total</td>
<td>0.0584</td>
<td>0.00177</td>
<td>1092.8775</td>
<td>&lt; .0001</td>
<td>1.060</td>
<td>1.057-1.064</td>
</tr>
<tr>
<td>Area full</td>
<td>0.0247</td>
<td>0.00212</td>
<td>135.3873</td>
<td>&lt; .0001</td>
<td>1.025</td>
<td>1.021-1.029</td>
</tr>
<tr>
<td>Diabetes</td>
<td>-0.0803</td>
<td>0.06430</td>
<td>1.5582</td>
<td>0.2119</td>
<td>0.923</td>
<td>0.814-1.047</td>
</tr>
</tbody>
</table>
### Table 3.6

*Logistic Regression Analysis of Mortality in Those With Burn Injury and Diabetes Under 65 Years of Age*

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>$\beta$</th>
<th>SE</th>
<th>Wald’s Chi Square</th>
<th>$P$</th>
<th>Odds ratio</th>
<th>Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-5.9267</td>
<td>0.1207</td>
<td>2411.0886</td>
<td>&lt; .0001</td>
<td>1.039</td>
<td>1.034-1.044</td>
</tr>
<tr>
<td>Age</td>
<td>0.0382</td>
<td>0.00245</td>
<td>244.0422</td>
<td>&lt; .0001</td>
<td>1.039</td>
<td>1.034-1.044</td>
</tr>
<tr>
<td>Area full</td>
<td>0.0274</td>
<td>0.00239</td>
<td>130.5648</td>
<td>&lt; .0001</td>
<td>1.028</td>
<td>1.0231-1.033</td>
</tr>
<tr>
<td>Diabetes</td>
<td>0.0766</td>
<td>0.09500</td>
<td>6506.0199</td>
<td>0.4199</td>
<td>1.080</td>
<td>0.8961-1.301</td>
</tr>
</tbody>
</table>

### Table 3.7

*Logistic Regression Analysis of Mortality in Those With Burn Injury and Diabetes < 40 Years of Age*

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>$\beta$</th>
<th>SE</th>
<th>Wald’s Chi Square</th>
<th>$P$</th>
<th>Odds ratio</th>
<th>Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-7.0015</td>
<td>0.28870</td>
<td>588.3276</td>
<td>&lt; .0001</td>
<td>1.058</td>
<td>1.047-1.069</td>
</tr>
<tr>
<td>Age</td>
<td>0.0562</td>
<td>0.00532</td>
<td>111.3668</td>
<td>&lt; .0001</td>
<td>1.058</td>
<td>1.047-1.069</td>
</tr>
<tr>
<td>Area total</td>
<td>0.0567</td>
<td>0.00261</td>
<td>470.1293</td>
<td>&lt; .0001</td>
<td>1.031</td>
<td>1.024-1.037</td>
</tr>
<tr>
<td>Area full</td>
<td>0.0303</td>
<td>0.00318</td>
<td>90.6020</td>
<td>&lt; .0001</td>
<td>1.058</td>
<td>1.053-1.064</td>
</tr>
<tr>
<td>Diabetes</td>
<td>0.0488</td>
<td>0.10470</td>
<td>217.2172</td>
<td>0.6412</td>
<td>1.050</td>
<td>0.8551-1.289</td>
</tr>
</tbody>
</table>

### Table 3.8

*Logistic Regression Analysis of Mortality in Those With Burn Injury and Diabetes >40 and <65 Years of Age*

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>$\beta$</th>
<th>SE</th>
<th>Wald’s Chi Square</th>
<th>$P$</th>
<th>Odds ratio</th>
<th>Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>4.85610</td>
<td>0.23760</td>
<td>417.8516</td>
<td>&lt; .0001</td>
<td>1.010</td>
<td>1.025</td>
</tr>
<tr>
<td>Age</td>
<td>0.00954</td>
<td>0.00781</td>
<td>1.4909</td>
<td>0.2221</td>
<td>1.010</td>
<td>1.025</td>
</tr>
<tr>
<td>Area total</td>
<td>0.04540</td>
<td>0.00327</td>
<td>193.1251</td>
<td>&lt; .0001</td>
<td>1.046</td>
<td>1.049-1.053</td>
</tr>
<tr>
<td>Area full</td>
<td>0.02490</td>
<td>0.00377</td>
<td>43.5557</td>
<td>&lt; .0001</td>
<td>1.025</td>
<td>1.018-1.033</td>
</tr>
<tr>
<td>Diabetes</td>
<td>0.17740</td>
<td>0.25350</td>
<td>4.899</td>
<td>0.4840</td>
<td>1.194</td>
<td>0.727-1.962</td>
</tr>
</tbody>
</table>
### Table 3.9

**Logistic Regression Analysis of Mortality in Those With Burn Injury and Diabetes 65 Years of Age and Older**

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>β</th>
<th>SE</th>
<th>Wald’s Chi Square</th>
<th>P</th>
<th>Odds ratio</th>
<th>Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-8.4099</td>
<td>0.39400</td>
<td>455.6402</td>
<td>&lt; .0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.0742</td>
<td>0.00491</td>
<td>288.0490</td>
<td>&lt; .0001</td>
<td>1.077</td>
<td>1.067-1.087</td>
</tr>
<tr>
<td>Area total</td>
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<td>0.00593</td>
<td>412.3797</td>
<td>&lt; .0001</td>
<td>1.086</td>
<td>1.077-1.096</td>
</tr>
<tr>
<td>Area full</td>
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<td>0.00407</td>
<td>9.8409</td>
<td>0.0017</td>
<td>1.016</td>
<td>1.006-1.025</td>
</tr>
<tr>
<td>Diabetes</td>
<td>-0.1370</td>
<td>0.09130</td>
<td>2.2563</td>
<td>0.1331</td>
<td>0.821</td>
<td>0.729-1.043</td>
</tr>
</tbody>
</table>

### Discharge Destination

Figures 3.12, 3.13, 3.14, 3.15, and 3.16 illustrate the differences in discharge destination for the entire sample, and by age stratification. Burn patients with diabetes were discharged to home with home care (8.27%) at higher rates than those without diabetes (6.71%) in the entire sample. They were also transferred to other services more often (12.37%) than patients without diabetes. In those less than 65 years of age, 8.22% of those with diabetes were discharged home with home care while only 6.56% of patients without diabetes received home care at discharge. Transfers to other services were higher in those with diabetes in this age group (8.75%) compared to those without (5.56%). Patients < 40 years of age (8.32%) were discharged home with home care compared to those without (7.32%). Transfers to other services were higher in those with diabetes in this age group (9.71%) compared to those without (6.93%). Patients > 40 and < 65 years of age (7.75%) were discharged home with home care compared to those without (5.77%). Transfers to other services were higher in those with diabetes in this age group (4.45%) compared to those without (3.85%). In the elderly (65 and older) burn patients with diabetes were discharged to home with home care (8.39%) at higher rates.
than those without diabetes (7.66%). Elderly patients with and without diabetes were discharged to home at lower rates (46.89% with diabetes, 46.94% without diabetes) than patients under 65 years of age (72.17% with diabetes, 77.97% without diabetes). In all age groups and the entire sample those without diabetes were discharged to home without services more often than patients with diabetes.

Figure 3.12. Discharge destination comparing those with and without diabetes in the entire sample.
Figure 3.13. Discharge destination comparing those with and without diabetes less than 65 years of age.
Figure 3.14. Discharge destination comparing those with and without diabetes in less than 40 years of age.
Figure 3.15. Discharge destination comparing those with and without diabetes in greater than 40 and less than 65 years of age.
Figure 3.16. Discharge destination comparing those with and without diabetes 65 years of age and older.
Discussion

The NBR data set provides a large sample of injury data that is accessible for use in analysis. This represents 9.5 years of cumulative data from burn centers across the United States and is a cost effective way to study epidemiology and the characteristics of burn patients. Subsets of injuries such as patients with diabetes may have a sample size large enough to draw conclusions about the population (ABA, 2014). In relationship to the burn patient, it is known that those patients with advancing age, female patients, African-American or Hispanic patients, and patients with more comorbid conditions will have longer lengths of stay, more resource utilization, and higher mortality rates however to date no studies using the NBR have described the epidemiology of the burn patient with the comorbid condition of diabetes (Attia et al., 2000; Thombs et al., 2007).

Patient Characteristics

In general, various comorbid conditions have been studied in relationship to the burn patient but the majorities have examined the effect of the presence and numbers of comorbid conditions. Only one study in one center examined critically ill burn patients with diabetes ($n = 57$) patients and without diabetes ($n = 405$) finding that the patients with diabetes were older (mean age 60±15), had higher admission glucose (196±81) and higher mean glucose (147±37), more glucose variability, and longer ICU stays, thus more resource utilization than those without diabetes (Dahagam et al., 2011). Keck et al. (2009) found the incidence of pre morbid conditions in burn patients over the age of 65 to be as high as 85% but not specifically diabetes.

The finding of patients with diabetes being significantly older in the entire sample is consistent with the literature. The incidence of diabetes is increasing in the older
population with an estimated 10.9 million people 65 years or older having diabetes. Our sample demonstrated that there is an increasing trend of patients over age 65 with diabetes and over 30% of the elderly in 2011 were found to have the comorbid condition of diabetes. This is consistent with the national statistics that thirty percent of those 75 years of age or older having diabetes (CDC, 2013). Cognitive decline, physical disabilities (such as retinopathy and neuropathy) associated with diabetes, and the risk of polypharmacy increase the risk in the elderly for burn injury in the home (Gregg, Engelgau, & Narayan, 2002; Hornick & Aron, 2008; Keck et al., 2009). As people age, they have a decrease in their ability to heal wounds because of alterations in the immune response and an increase in the inflammatory response. Decreased ability to heal the burn wounds makes patients more vulnerable to opportunistic infections which in turn can increase length of hospital stay (Kerby et al., 2006). The combination of the comorbid condition of diabetes and advancing age may compound the effects on wound healing. Thus it is important to understand the effect of those with diabetes and age on burn injury in order to provide evidence based care in this population.

The current rate reported in the literature is that the burn population is seventy percent male and our sample was 71.27% male (ABA, 2015). In those patients with diabetes the number of females with diabetes was significantly higher in all age groups. Two studies have demonstrated that despite the higher incidence of males sustaining burn injury, females in some age categories had higher mortality rates (McGwin Jr et al., 2002; O’Keefe, Hunt, & Purdue, 2001; Pham et al., 2009). In a study of 23,180 patients age 55 or older, men were more likely to be burned overall (1.4:1), but women outnumbered men in the 75 years and older category (Pham et al., 2009). Female patients were older,
of the Black race, and in poorer health on admission than their male counterparts (McGwin Jr. et al., 2002). In the Chang et al. (2005) study of burn patients aged 65 years or older, females had longer lengths of stay and were less likely to be discharged to home. Using the NBR data from 1991-2001 to compare gender differences in clinical outcomes demonstrated that females had increased odds of death (OR 1.5 95% CI 1.3-1.6) when compared to men. When adjustments were made for age, race, TBSA and inhalation injury, the OR was 1.3 (95% CI 1.2-1.5), and this higher odds of death in females was attributed to the differences in immune responses to burn injury between men and women (Kerby et al., 2006). Identification of significantly higher rates of female patients in those with diabetes and burn injury may impact prevention efforts and treatment.

Currently the population in the United States is 67% non-Hispanic White, 12% Black, 14% Hispanic, 1% Native American, and 4% Asian (DeNavas-Walt, Proctor, & Smith, 2011). Prevalence of diabetes by race/ethnicity was 7.1% of non-Hispanic Whites, 8.4% of Asia Americans, 12.6% of non-Hispanic Blacks, and 11.8% of Hispanics (CDC, 2013). In our study, persons with diabetes and burn injury differed from the general population with diabetes in that there was a higher prevalence of Non-Hispanic Whites (62.34%) and of non-Hispanic Blacks (21.6%). This may be explained by the fact that the overall incidence of burn injury is higher in non-Hispanic whites than any other category (ABA, 2014). A Canadian study of 4,297 burn patients’ ages infant to 99 over a 30 year time span found that Caucasians were the largest group of burn patients (79%) with a mortality rate of 6.6% compared to all ethnic groups (4.1%; p < 0.006). In relation to mechanism of injury and ethnicity flame injury has been found to be highest...
(51.6%) followed by scald (22.8%) in all age and ethnic groups (Papp & Haythornthwaite, 2014). In a literature review by L. Edelman (2007), six of the seven studies reviewed found that non-whites were at higher risk for burn injury, and had higher mortality rates (L. Edelman, 2007). Therefore, ethnic disparities are important to consider when describing the population and planning interventions and prevention programs.

Patients with diabetes had higher rates of Medicare insurance in all age groups. Those with diabetes and burn injury had lower rates of no insurance coverage than those without diabetes. This may be explained by the fact that those with diabetes are older and are more likely to apply for insurance benefits to cover their ongoing diabetes care. Insurance status has been shown to be a predictor of discharge placement in the burn and trauma patient. In a 2011 retrospective study of trauma patients, uninsured patient had the highest odds of being discharged to home without additional services, compared to their cohorts with private or government insurance. Past studies have demonstrated that patients without health insurance are unable to receive care, have higher mortality rates, and are unable to receive the services needed for best outcomes and management of their chronic diseases making them even more vulnerable to injury (Sacks et al., 2011). A 1997 retrospective study (Rhee et al., 1997) examined data from 3,141 trauma patients admitted to Level One trauma centers. After controlling for gender, age, race, and the injury severity score, the payer status was not significantly correlated with mortality, discharge disposition, total hospital charges, total hospital LOS, or the total ICU LOS. The only significant difference in hospital LOS were in those patients with non-
commercial insurance who required transfer to long term care facilities (Rhee et al., 1997).

Subjects with diabetes were more likely to experience flame/fire injuries followed by scalds and contact injuries. Cognitive declines and decreased mobility associated with neuropathy may predispose the patient with diabetes to fire and flame injuries as well as scald and contact burns. Scald injuries were higher in those with diabetes in the entire sample and those under 65 years of age while those over 65 years of age scald injuries were higher in those without diabetes. This may be attributed to the physical changes in mobility and sensation associated with normal aging. Contact injuries were higher in the subjects with diabetes than those without in all age groups. Physical disabilities such as the neuropathy and retinopathy associated with diabetes can lead to larger TBSAs, deeper burns, an overall and more inhalation injuries with flame injuries (Ho et al., 2001; Keck et al., 2009). In general, patients with diabetes are at higher risk for sustaining scald burns or contact burns than those without diabetes and because of the neuropathies care may be delayed (Herndon, 2012). In a Pham et al. 2009 study of older adults using the NBR data, flame injuries were the most common injury in elderly patients, followed by scalds; 55.6% of the injuries occurred in the home. Other sources conclude that flame and scald injuries, or scalds alone, are the most common cause of burns in those 65 years of age or older. Most of these injuries occur in the home and involve cooking or bathing. Normal changes associated with aging may put this age group at higher risk, in addition to physical disabilities such as those that may occur with diabetes.
Health Behaviors

Health behaviors included in this study were risk-taking behaviors such as smoking, illicit drug use and alcohol use. Smoking behavior was significantly higher in those with diabetes in our sample however in those 65 years of age and older smoking was not significantly different between the groups. In the past, smoking has been implicated in the risk for burn injury, fire-related deaths, and poor wound healing. Smoking is the leading cause of fire related deaths (Ahrens, 2003). Wound healing is delayed in patients who smoke because the nicotine causes vasoconstriction of the vessels, which decreases the oxygenation to the wound. Smoking also delays wound healing because it decreases the collagen synthesis and combined with the effects of diabetes, wound healing can be further delayed (Guo & DiPietro, 2010).

Alcohol use was documented in 10.24% of our sample and was not significantly different in those with and without diabetes in the elderly burn patient. In patients with diabetes, the use of alcohol was significantly less in the entire sample and those under 65 years of age. Past studies have found that upwards of 50% of adult burn patients have significant levels of alcohol in their blood at the time of burn injury, and alcohol and drug ingestion prior to injury is a risk factor for higher morbidity and mortality (Silver et al., 2008). Other estimates find that alcohol use is implicated in approximately 64% of burn and fire injuries in adults, and that about 25% of admitted burn patients have a history of alcohol abuse. Many studies have documented that alcohol abuse in patients is correlated with longer lengths of stay, poorer outcomes, higher resource utilization including more procedures, and higher health care cost. In the burn patient, the odds of mortality are 2 times higher in patients with alcohol abuse and patients have 2-5 times higher rates of
complications. Alcohol use/abuse can delay definitive burn treatment because skin grafting surgery may need to be delayed to treat the underlying alcohol use (Coffey, Kulisek, Tanda, & Chipps, 2011; Coffey & Murphy, 2012). Our current study found lower rates of alcohol use however our population was older and included only those with comorbid conditions therefore the use of alcohol may be underrepresented.

We found no significant difference in those with and without diabetes and use of illicit drugs however it is important to identify patients with illicit drug use because of the impact on severity of illness. The impairments to judgment associated with use of illicit drugs and alcohol use increase the risk for burn injury. Studies have found that younger males have greater risk taking behaviors. The literature abounds with studies that have found that males are more likely to engage in risk taking behavior than females and that these behaviors decrease with aging (Byrnes, Miller, & Schafer, 1999; Harris, Jenkins, & Glaser, 2006; Rolison, Hanoch, Wood, & Liu, 2013). Danks et al. (2004) found that subjects who were burned in the production of drugs had more flame injuries, producing full thickness injuries and more inhalation injuries. A 1995 study by McGill, Kowal-Vern, Fisher, Kahn, and Gamelli examined 161 burn patients with positive drug screens for ethanol, cannabinoids, cocaine metabolites, amphetamines, phencyclidine or benzodiazepines, patients had greater TBSA burns, higher incidence of inhalation injury, and higher mortality rates than non-substance abusers. Patients in this study who had higher rates of drug and alcohol use were younger, male, and did not have diabetes.

**Severity of Illness**

Total body surface area (TBSA) has long been used to measure the severity of burns and predictor of survival. Larger TBSAs result in more severe injuries and more
significant physiologic response. This response may be amplified in patients with diabetes. Full thickness injuries contribute to the severity of illness because surgical interventions (i.e., skin grafting) must be done in order for the wound to heal. Higher percentage TBSA and percentage full thickness burn contribute to longer lengths of stay, increased resource utilization, and mortality (Herndon, 2012). This study found that there were no significant difference in total TBSA in patients with diabetes or percent full thickness injury however the area of partial thickness injury was significantly higher in the group with diabetes for the entire sample. In those under 65, diabetes was significantly associated with percent full thickness injury as McCampbell and colleagues (2002) found that in subjects 18-65 years old, those with diabetes had significantly higher rates of full thickness burns when compared to patient without diabetes ($p = 0.025$). It is thought that this may a result of the neuropathy associated with diabetes (McCampbell et al., 2002). Patients 65 years and older had no significant differences in severity of illness between those with and without diabetes. This may be a result of thinner skin in this age group skin therefore the risk of sustaining deeper burns with less thermal or chemical contract is the same for those with and without diabetes. The preexisting physical decline and cognitive decline in the elderly may also contribute to this finding (Herndon, 2012; Kerby et al., 2006).

Many complications of diabetes such as peripheral neuropathy, retinopathy and gait instability put this population at higher risk for burn injury. Neuropathies associated with diabetes contribute to the higher incidence of burns related to scalds and contact with hot objects. The presence of neuropathy contributes to the delay in seeking care for burn injury because of the altered pain response (Barker et al., 2006; Herndon, 2012; Loh
It has been estimated that 10% of all burn patients have diabetes, and the incidence increases as patients’ age. This does not account for those with undiagnosed or pre diabetes. The presence of diabetes in patients with burn injury has profound effects on the treatment and outcomes. Treatment is complicated because of the micro-vascular complications associated with the progression and control of the disease and in large burns the marked and sustained hypermetabolic response (Jeschke et al., 2011). Because of the relationship between glycemic control, the stress response, and wound healing, burn patients with diabetes may be predisposed to more infections, more surgeries and longer lengths of hospital stay (Memmel et al., 2004). A prospective study by Schwartz and colleagues (2011) found that patients with diabetes and burn injury have significant delays in burn wound healing and therefore use more health care resources. Therefore, the understanding of the epidemiology of this high risk group of burn patients has implications for practice, including development of prevention programs, identifying the best evidence and practice for those with burn injury and diabetes and the evaluation of outcomes in this population.

Severity of injury is also measured by the presence of inhalation injury and many of the validated burn specific severity of injury scales include inhalation injury (El-Helbawy & Ghareeb, 2011). The presence of inhalation injury was significantly higher in the subjects without diabetes and this is the group that is younger and has significantly higher smoking behaviors. Inhalation injury has been found to be a predictor of mortality in the burn patient. A study comparing burn patients with inhalation injury and those without found that patients with inhalation injury had an overall mortality rate of 16% ($P < 0.001$) and 10% of those deaths occurred within the first 48 hours post burn. In patients
with smaller burns (< 10% TBSA burned), there was no significant difference in mortality or length of stay for patients with the smaller burns and inhalation injury and those patients with inhalation injury only (D. Edelman, White, Tyburski, & Wilson, 2006). A systematic review of 13 articles examining the prognostic factors and inhalation injury in burn patients, found that higher TBSA, age, and the presence of inhalation injury were predictors of mortality (Colohan, 2010). Our study is the first step in identifying those with inhalation injury, burn injury and diabetes and further studies need to be done to fully understand the effect of this combination on treatment and outcomes.

Mortality

Burn injuries are consistently in the top 10 causes of death for children under the age of 5 and adults over the age of 34 (L. Edelman, 2007). The current survival rate for persons with burn injuries is 97.3% (ABA, 2015). Mortality rates increased with higher TBSA, advancing age, and with the presence of inhalation injury. Pham et al. (2009) concluded that advancing age has consistently been the most significant independent predictor of mortality in the burn injured patient. Increased mortality in the elderly has been attributed to decreased wound healing ability, their decrease in physiologic reserves, poor nutritional status pre injury, and increasing medical comorbidities associated with age including diabetes. Studies have found that elderly burn patients with a higher number of comorbidities had significantly higher mortality rates (Rani & Schwacha, 2012; Wibbenmeyer et al., 2001). It is well established in the burn literature that advancing age increases mortality with smaller percentage body burn. Although mortality rates of patients 65 years and older have improved due to advances in burn
resuscitation, critical care, treatment of infections and wound care, higher mortality rates persist (ABA, 2015; Chang et al., 2005; Gore et al., 2001; Herndon, 2012; Lundgren et al., 2009; Pham et al., 2009; Rao et al., 2006). Age has been found to be the strongest independent risk factor for mortality in numerous studies of burn patients. One study (Pham et al., 2009) of 23,180 patients age 55 or older divided patients into three groups based on age: 55-64, 65-74, and 75 and older examined outcomes after burn injury. The mean burn size and inhalation injury did not differ significantly by age group. The odds ratio for mortality in the 65-74 age group was 2.3 (95% CI 2.1-2.7) and 5.4 (95% CI 4.8-6.1) in the 75 and older age group. McGwin Jr. and colleagues (2002) found that females up to age sixty with burn injuries had a mortality rate 2.3 times higher than men of the same age (OR 2.3, 95% CI 1.4-3.8). No differences in mortality were found after age 60 (OR 0.9, 95% CI 0.5-1.6; McGwin Jr., George, Cross, & Rue, 2008). When we controlled for age, there were no differences in those 65 years or older. This suggests that the burden of the contribution to mortality is in those less than 65 years of age with diabetes. In patients 65 years of age and older the mortality rate was higher in those without diabetes, suggesting that the burden of the physiologic effects of the aging process coupled with the physiologic effects of the burn injury on mortality may contribute to this finding.

Discharge Destination

Discharge destination was significantly different in burn patients with diabetes in all age groups. Patients with diabetes were discharged home with home care and transferred to other services within the hospital at higher rates than patients without diabetes. Elderly patients were discharged to home at much lower rates with and without
diabetes than patients less than 65 suggesting that other comorbid conditions and the normal aging process may impact discharge destination. In patients 65 years and older those with diabetes were more likely to be discharged to a facility when compared to those who did not have diabetes. Chang et al.’s (2005) study of burn patients aged 65 years or older found that females had longer lengths of stay and were less likely to be discharged to home. Insurance status has been shown to effect discharge destination with uninsured patients being discharges without additional services however patients with diabetes had higher rates of Medicare coverage than burn patients without diabetes. This provides additional services for patients with diabetes at discharge.

This is a multi-year cross sectional study with a sample collected over 9.5 years from burn centers in the United States with ninety one of the 127 burn centers in the United States contributed data. Despite this data not being primary data, data quality control measures to ensure completeness and accuracy of the data are completed at each institution. A validity review of the NBR 2009 release found data inconsistencies and missing data as well as duplicate records however vast improvements have been made in the 2012 release (Taylor et al., 2013). Secondly, diabetes is self-reported by the patient and is collected by the registrar at each institution from the medical record. The diagnosis of diabetes is not cross-referenced with the diagnosis codes in the registry, so diabetes may be under-represented. Additionally, there is no data to validate the diagnosis of diabetes (such as admission HbA1c) for patients. The diagnosis of diabetes is dependent on the ability of the registrar at each facility to extrapolate the diagnosis from the chart. Murkerji and colleagues (2007) compared self-report of comorbidities with chart review and found good overall consistence between chart review and self-
report suggesting this is a valid method for collecting these data. No data is available on diabetic control or data on the long-term effects of poorly or uncontrolled diabetes (such as kidney complications, neuropathy, or retinopathy). Thirdly the sample may be biased because patients without comorbid conditions were not included in the sample and these patients may have had the comorbid condition of diabetes present.

In conclusion, the rise of diabetes in the general population is reflected in the burn injury data. The risk for burn injury in persons with diabetes is increasing with a higher proportion of these burn injuries in older adults. Because of these trends it is imperative that we gain a better understanding of the burn injury in persons with diabetes. This data provides essential knowledge for anticipating the needs of this population and for designing systems of care to address their needs. This study focuses the need for further studies to prevent injuries in patients with diabetes and to better identify this group of high risk patients in practice.
Chapter 4: Resource Utilization and Outcomes in Burn Patients With and Without Diabetes Using NBR Data 2002-2011
Abstract

Introduction: Resource utilization is a measure of the process and quality of care. In the changing health care environment identifying the resource utilization of high risk groups of burn patients is important for the development of evidence based treatment strategies to improve the quality of care. The aim of this study is to compare the resource utilization of burn patients with the comorbid condition of diabetes to those without.

Methods: Data from the NBR 2002-2011 was used to identify adult burn patients with diabetes in the United States. Records were included if they were 18 years of age or older, were first admissions for burn injury and had comorbidity data in the NBR. Records were excluded if they had no cutaneous burn injury or if they were a duplicate record. Resource utilization measures including length of hospital stay, Intensive care length of stay, ventilator days, and adjusted charges. Comparisons were made between those adult burn patients with and without diabetes for the entire sample, those under 65 years of age and for those 65 years of age and older. Subjects in the < 65 year age group were further stratified to < 40 and 40-< 65. Statistical analysis included t-test for continuous variables, χ² for categorical variables, and survival analysis.

Results: Adult burn patients with diabetes had significantly more hospital days (p < .0001), more intensive care unit days (p < .0001), more ventilator days (p = 0.0475) and higher charges (p < .0001). Those patients 65 years of age and older with diabetes had significantly higher charges (p = 0.0025). There were no significant differences in this age group in hospital days (p = 0.0563), intensive care unit days (p = 0.0991), or ventilator days (p = 0.6000). Patients < 65 years of age with diabetes and burn injury, had significantly longer hospital days (p < .0001), more intensive care unit days (p <
There were no significant differences in ventilator days \( (p = 0.5626) \). Subjects 18-40 with diabetes had significantly longer hospital stays \( (p = 0.0009) \), longer ICU days \( (p = 0.0007) \), and higher adjusted charges \( (p = 0.0009) \) than those without. There were no significant differences in ventilator days between patients with and without diabetes. In patients 40-65 burn patients with diabetes had significantly longer hospital length of stay \( (p = 0.0002) \), ICU stays \( (p < 0.0001) \), more ventilator days \( (p < 0.0001) \), and higher hospital charges \( (p < 0.0001) \) than patients without diabetes.

**Conclusions:** Resource Utilization is higher in those burn patients with diabetes in all age groups. Identifying best treatments strategies is important to impact resource utilization and process of care in this high risk population.
Introduction

Diabetes is a chronic health problem in the United States with high costs to the health care system. In 2012 the costs related to diabetes in the United States was $245 billion, with $176 billion related to direct medical cost of resource utilization. The remainders of the costs are accounted for by lost productivity (ADA, 2014). It is estimated that about 1 out of every 5 health care dollars in the United States is spent on the care of a person with diabetes and about 1 in every 10 health care dollars is linked to diabetes (CDC, 2013). It has been projected that the annual number of new cases of diabetes will increase from 8 cases per 1,000 people to about 15 per 1,000 people by 2050 further increasing the burden on the health care system (Boyle et al., 2010). It has been estimated that diabetes is present in 10% of all burn patients and as patient’s age increases, the incidence of diabetes increases. McCampbell and colleagues found that in burn patients older than 65, 85% have the comorbid condition of diabetes which is in contrast to the general population over 65 with only an 18% incidence of diabetes however this was not a national sample (ADA, 2014; McCampbell et al., 2002). Diabetes requires ongoing management by both the medical community as well as the patient to prevent the long-term complications that increase risk for burn injury including: retinopathy, kidney complications, non-traumatic lower limb amputations, and neuropathies (Murphy, Coffey, Wisler, & Miller, 2013). The impact of the physiology of diabetes coupled with physiologic response related to burn injury puts this group at high risk for more complications and poorer outcomes when compared with their counterparts without diabetes.
It has been demonstrated that best outcomes for the burn patient are obtained when patients are cared for in specialized burn centers and the percentage of patients admitted to verified burn centers has steadily increased in recent years (ABA, n.d.). Burn care is costly, with the average cost of a hospital stay of $97,000 (Mandal, 2007). In the 2015 NBR report, the average total charges for burns of all total body surface area burn was $93,893 with a range of $45,777 to $856,635 (ABA, 2015). Daily room rates, dressing change costs, operating room costs, laboratory costs, imaging costs, costs of complications, costs associated with preexisting chronic, and consultants’ charges all contribute to the high cost of care for this patient population. Hospital charges may not reflect all the charges related to burn care and consideration for those costs associated with outpatient care needs and long term rehabilitation need to be identified. Outpatient costs include care giving, labor and social costs, managing chronic diseases in relation to the burn injury, and rehabilitation needs that may persist for years after the burn injury. It has been estimated that the lifetime costs for burn deaths are almost four times higher than for cancer and six times higher than those for heart disease. Finally, comorbid conditions, such as diabetes that effect wound healing, the burn injury stress responses, and additional complications, all contribute to the high resource utilization in this subset of burn patients.

The presences of comorbid conditions have long been used as a measure of health prior to injury. No examination of resource utilization would be complete without considering the comorbid conditions each patient has. Thombs and colleagues (2007) developed a burn-specific list of comorbid diagnoses derived from the Charlson Index of Comorbidities, and the Elixhauser method of comorbidity measurement. Using the ICD-
9 diagnosis codes, the Charlson Index of 22 comorbidities was developed to predict the
ten-year mortality rate for patients. Each condition is assigned a number from 1 to 6,
depending on the risk of death from that condition. The scores are summed and the total
score has been used to predict mortality, however the use of this score has been limited in
the burn patient (Charlson, Pompei, Ales, & MacKenzi, 1987). The Elixhauser method
differs from Charlson method using a list of 30 comorbid conditions based on ICD-9
diagnoses and taking into account the length of hospital stay, hospital charges, and
mortality. The Charlson scale has been used to describe both disease burden and hospital
mortality. In Thombs et al.’s (2007) study of 31,338 burn patients, patients with
preexisting HIV/AIDS, metastatic cancer, liver disease, and/or renal disease had the
poorest prognosis. Patients with diabetes had a 26% longer length of stay, but the
diagnosis of diabetes did not affect mortality. Discharge to home and intensive care unit
stay was not examined.

Lundgren and colleagues (2009) studied burn patients age 55 and older to
examine the impact of age and baseline comorbidities on outcomes following a burn
injury. Calculating the Charlson Comorbidity Index for each patient they found that the
overall mortality rate for their sample of 325 subjects was 18.5%. The most significant
factors for hospital mortality were total body surface area burned and medical
comorbidities such as diabetes. Additional findings indicated a positive correlation
between the number of comorbidities and the risk for mortality at 1 year post-discharge
(Lundgren et al., 2009). The Rao et al. (2006) study of 63 elderly patients found a
positive correlation between the number of comorbid conditions and mortality but did not
examine specific comorbid conditions such as diabetes. Keck et al. (2009) found the
incidence of pre morbid conditions in burn patients over the age of 65 to be as high as 85% contributing to higher resource utilization.

The presence of diabetes affects the rate of wound healing, the incidence of infections post injury, the stress response and incidence of complications thereby increasing resource use. In order for hospitals that care for burn patients to stay viable, they must provide cost-effective, high-quality care, demonstrate the best outcomes, and maximize reimbursement for the services provided (Sanchez et al., 2007). Measurement of resource utilization and outcomes of care are reflections of the quality of care. Resource utilization has also become an important consideration for disaster planning. Understanding difference in resource utilization for burn patients with diabetes may contribute to better disaster planning (Taylor, Lawless, et al., 2014; Taylor, Jeng, et al., 2014). With the current health care environment, it is important to identify resource utilization patterns in this population to better understand the impact of the burn patient with diabetes on the health care system. This can only happen with an understanding of how diabetes effects resource utilization and outcomes in burn patients. The purpose of this study was to examine the effect diabetes has on resource utilization in adult burn patients measured by hospital length of stay intensive care length of stay, ventilator days and charges.

Methods

This is a retrospective cross sectional study using secondary data analysis. The sample using the NBR database release 2012 was used to examine the differences in resource utilization of burn patients with and without diabetes. Data is from 2002-2011. In this large national sample; all persons are de-identified and Institutional Review Board
permission sought but deemed not needed for this study. Permission was obtained from the American Burn Association for use of the data base.

**Data Set Description**

The NBR is the central repository where burn centers voluntarily contribute a minimal data set regarding their burn admission. Data was obtained in a call for data from each individual institution using clinical record review. Cases from the United States only were used. The current study used the data from the 2012 reporting period, reflecting burn cases submitted to the NBR from January 1, 2002 through June 30, 2011 and includes both pediatric and adult burn admissions (ABA, 2012).

Included in the minimum data set are the following data elements: reporting hospital number, number of operating room visits, the number of procedures performed, gender, cause of death, state where injury occurred, age, year of injury, year of arrival at reporting hospital, description of event, etiology of the injury, site where the injury occurred, body surface area burned, Lund Browder chart, total deep burn, inhalation injury, ICD-9 diagnosis codes for burn injury, DRG code for burn injuries, total hospital days, total ICU days, hospital disposition, primary payer source, and MS-DRG code. Other data that hospitals collect but that are not part of the minimal data set include occupation, comorbid conditions, alcohol or drug use, complications, and intensive care length of stay (ABA, 2012).

**Sample Description**

Figure 2.1 demonstrates how the sample size was obtained. Records from the NBR 2002-2011 were used to identify adults with diabetes in the United States. Records were included if they were 18 years of age or older, were first admissions for burn injury
and had comorbidity data in the NBR. Records were excluded if they had no cutaneous burn injury or if they were a duplicate record. Resource utilization measures including length of hospital stay, intensive care unit days, ventilator days, and charges. Comparisons were made between those adult burn patients with and those without diabetes for the entire sample, those less than 65 years of age and for those elderly burns 65 years of age and older. The cases in this data set represent all the burn cases in the burn registry from 2002-2011 who received specialized burn care and had comorbid data.

**Measures**

Elderly is defined as patients 65 years or older, which is consistent with the definition of “older adult” by the U.S. Census Bureau (1995).

Diabetes is extracted from the past medical history by each registrar at the institution. This is a self-reported diagnosis and no confirmatory testing is included in the data base such as admission glucose level or hemoglobin A1c.

Hospital length of stay has been defined by The Healthcare Cost and Utilization Project (HCUP), as: “the number of nights the patient remained in the hospital for his or her stay. A patient admitted and discharged on the same day has a length of stay equal to 0” (Agency for Healthcare Research and Quality, 2010). This is consistent with the in NTRAS User Manual.

Hospital discharge is defined as the point at which the patient leaves the hospital and either goes home or is transferred to another facility (Agency for Healthcare Research and Quality, 2014).

Hospital charges were all adjusted to 2011 dollars based on the MEPS hospital care inflation rate. The Medical Expenditure Panel Survey has developed indices to
aggregate charge data for health care costs. Indices have been developed for Personal Health Care and Component Indices by year. This index has been developed using the gross domestic product and the consumer price index. Guidelines for use state that if you are pooling only one type of health care expenditure then the use of that index from the Personal Health Care Index should be used. The Personal Health Care Index includes all of the personnel medical care costs, not just out of pocket expenses (Agency for Healthcare Research and Quality, 2015).

Intensive care unit (ICU) days are the total number of days the patient spent in the ICU (ABA, 2007).

Ventilator days, the ABA definition is the number of the days the patient required maintenance of an airway with active mechanical ventilation (ABA, 2007).

**Data Analysis**

The measures included in this study resource utilization measures included hospital length of stay, ICU length of stay, ventilator days, and hospital charges. Hospital charges were all adjusted to 2011 dollars using the Personal Health Care Index, hospital care indices rate. Table 4.1 illustrates the unadjusted yearly mean charges and the Personal Health Care adjustment based on the hospital care indices. All variable definitions are from the National TRACS Version 5.0 User’s Manual and include the definitions used by each registrar to enter data into the data base. Comparisons were made between those adult burn patients with and those without diabetes for the entire sample, those less than 65 years of age and for those 65 years of age and old. Statistical analysis will include t-test for continuous variables, \( \chi^2 \) for categorical variables and survival analysis. Survival analysis was done to analyze the time to an event – discharge.
from the hospital censoring for mortality in those with and without diabetes. SAS 9.4 was used for analysis.

Table 4.1

<table>
<thead>
<tr>
<th>Year</th>
<th>Unadjusted charges</th>
<th>MEPS hospital care adjustment rate</th>
<th>Adjusted to 2011 dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>$80,028.32</td>
<td>1.368010403</td>
<td>$109,479.57</td>
</tr>
<tr>
<td>2003</td>
<td>$69,452.57</td>
<td>1.311720698</td>
<td>$91,102.37</td>
</tr>
<tr>
<td>2004</td>
<td>$72,161.91</td>
<td>1.250891795</td>
<td>$90,266.74</td>
</tr>
<tr>
<td>2005</td>
<td>$74,620.48</td>
<td>1.205040092</td>
<td>$89,920.67</td>
</tr>
<tr>
<td>2006</td>
<td>$62,430.46</td>
<td>1.154774973</td>
<td>$72,093.13</td>
</tr>
<tr>
<td>2007</td>
<td>$80,197.39</td>
<td>1.116772824</td>
<td>$89,562.27</td>
</tr>
<tr>
<td>2008</td>
<td>$120,821.64</td>
<td>1.083419156</td>
<td>$130,900.48</td>
</tr>
<tr>
<td>2009</td>
<td>$133,456.71</td>
<td>1.052000000</td>
<td>$140,396.46</td>
</tr>
<tr>
<td>2010</td>
<td>$121,390.67</td>
<td>1.021359223</td>
<td>$123,983.48</td>
</tr>
<tr>
<td>2011</td>
<td>$140,101.83</td>
<td>1.000000000</td>
<td>$140,101.83</td>
</tr>
</tbody>
</table>

Results

The sample included total of 58,707 burn patients’ ages 18-98 with a mean age of 46.16. The mean total body surface area burned was 8.17% and mean full thickness was 3.58%. In those patients less than < 65 years of age \( n = 49,254 \) the mean age was 40.53, mean TBSA was 7.91 and the mean full thickness burn was 3.25. In those 65 years and older \( n = 9,453 \) the mean age was 75.48 mean TBSA was 9.55 and the mean area full thickness was 5.36. Over all patients with diabetes in all age groups used more resources and had higher rates of mortality.
**Resource Utilization**

Table 4.2 summarizes the resources utilized for the entire sample and patients less than 65 years of age and patients 65 years of age and greater. Overall patients with diabetes had significantly longer hospital stays ($p < .0001$), longer ICU stays ($p < .0001$), more ventilator days ($p = 0.0475$) and higher adjusted charges ($p < .0001$). For those less than 65, patients with diabetes had significantly higher hospital stays ($p < .0001$) longer ICU stays $p < .0001$) and higher adjusted charges ($p = 0.0001$). There were no differences between the groups in ventilator days ($p = 0.5626$). In the elderly cohort, no significant differences in hospital length of stay ($p = 0.0563$), ICU stay ($p = 0.0991$) or ventilator days ($p = 0.6000$) were found. Adjusted hospital charges were significantly higher for those with diabetes in the elderly cohort ($p = 0.0033$).

Table 4.3 demonstrates the differences in resource utilization when further stratifying subjects under 65 into two groups less 40 and 40-< 65 years of age. Patients < 40 years of age with diabetes had significantly longer hospital length of stay ($p = 0.0009$), longer ICU LOS ($p = 0.0007$) and significantly higher adjusted charges ($p = 0.0009$) when compared to patients without diabetes. There were no differences in the groups in ventilator days ($p = 0.7423$). Patients > 40 and < 65 years of age with diabetes had significantly longer hospital length of stay ($p = 0.0002$), longer ICU LOS ($p < .0001$), more ventilator days ($p < .0001$) and significantly higher adjusted charges ($p < .0001$) when compared to patients without diabetes.

Figures 4.1, 4.2, 4.3, 4.4, and 4.5 illustrate the hospital charges by year. In 2002, there were 12 patients with charges over 2.2 million dollars with a range of $2,224,312 to $6,950,718 and only one patient had diabetes. This patient was 58 years old and
Table 4.2

*Resource Utilization in Burn Patients*

<table>
<thead>
<tr>
<th></th>
<th>With diabetes</th>
<th>Without diabetes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Median range</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Hosp LOS</td>
<td>12.99 (19.03)</td>
<td>6 (0-267)</td>
<td>10.52 (19.14)</td>
</tr>
<tr>
<td>ICU LOS</td>
<td>7.30 (16.19)</td>
<td>0 (0-250)</td>
<td>5.59 (15.24)</td>
</tr>
<tr>
<td>Vent days</td>
<td>3.49 (15.33)</td>
<td>0 (0-511)</td>
<td>3.04 (6.31)</td>
</tr>
<tr>
<td>Adjust chrgs</td>
<td>$139,764 ($299,140)</td>
<td>$45,684.90 (0-$6,718,569)</td>
<td>$104,461 ($303,048)</td>
</tr>
</tbody>
</table>

Entire sample, N = 58,707

<table>
<thead>
<tr>
<th></th>
<th>With diabetes</th>
<th>Without diabetes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Median range</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Hosp LOS</td>
<td>10.03 (18.88)</td>
<td>6 (0-267)</td>
<td>12.23 (19.45)</td>
</tr>
<tr>
<td>ICU LOS</td>
<td>5.15 (14.99)</td>
<td>0 (0-250)</td>
<td>6.47 (15.97)</td>
</tr>
<tr>
<td>Vent days</td>
<td>2.8 (16.38)</td>
<td>0 (0-190)</td>
<td>.98 (11.81)</td>
</tr>
<tr>
<td>Adjust chrgs</td>
<td>$130,697 ($296,761)</td>
<td>$41,908 (0-$6,718,569)</td>
<td>$100,818 ($303,812)</td>
</tr>
</tbody>
</table>

Under 65, N = 49,254

<table>
<thead>
<tr>
<th></th>
<th>With diabetes</th>
<th>Without diabetes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Median range</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Hosp LOS</td>
<td>13.53 (20.32)</td>
<td>8 (1-168)</td>
<td>14.47 (18.04)</td>
</tr>
<tr>
<td>ICU LOS</td>
<td>8.26 (16.90)</td>
<td>1 (1-123)</td>
<td>9.04 (16.45)</td>
</tr>
<tr>
<td>Vent days</td>
<td>4.31 (18.85)</td>
<td>0 (0-511)</td>
<td>4.55 (20.78)</td>
</tr>
<tr>
<td>Adjust chrgs</td>
<td>$160,336 ($303,660)</td>
<td>$55,878 (0-$5,125,028)</td>
<td>$127,487 ($266,281)</td>
</tr>
</tbody>
</table>

65 and older, N = 9,453

Note: Charges all adjusted to 2011 dollars using the MEPS Hospital Care inflation rate.
Table 4.3

*Resource Utilization for Under 65 Years of Age Stratified By Age*

<table>
<thead>
<tr>
<th></th>
<th>With diabetes</th>
<th></th>
<th>Without diabetes</th>
<th></th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Median (Range)</td>
<td>Mean (SD)</td>
<td>median (Range)</td>
<td></td>
</tr>
<tr>
<td>Hosp LOS</td>
<td>10.98 (18.17)</td>
<td>5 (0-165)</td>
<td>8.78 (18.24)</td>
<td>3 (0-727)</td>
<td>0.0009</td>
</tr>
<tr>
<td>ICU LOS</td>
<td>6.11 (15.72)</td>
<td>0 (0-142)</td>
<td>4.21 (13.64)</td>
<td>0 (0-450)</td>
<td>0.0007</td>
</tr>
<tr>
<td>Vent days los</td>
<td>2.42 (1.70)</td>
<td>0 (0-125)</td>
<td>2.22 (14.15)</td>
<td>0 (0-700)</td>
<td>0.7423</td>
</tr>
<tr>
<td>Adjust chrgs total</td>
<td>$125,758 ($284,040)</td>
<td>$30,714 (0-$2,272,446)</td>
<td>$75,702 ($266,509)</td>
<td>$13,879 (0-$9,759,364)</td>
<td>0.0009</td>
</tr>
</tbody>
</table>

Note: Charges all adjusted to 2011 dollars using the MEPS Hospital Care inflation rate.

missing data for inhalation injury, vent days, and percent burn. In all years, patients with diabetes had higher charges overall than patients without diabetes. In the entire sample there has been a steady increase in hospital charges for patients with and without diabetes. In the elderly population charges for those with diabetes was higher each year than those without diabetes. Patients less than 65 years of age with diabetes had higher yearly charges than those without diabetes. In patients less than 40 years of age with diabetes, mean adjusted charges were higher except for 2007, when they were the same. In patients 40 and < 65, mean adjusted charges were higher for all ages.
Figure 4.1. Yearly mean adjusted charges for the entire sample.

Figure 4.2. Yearly mean adjusted charges by year for elderly patients.
Figure 4.3. Yearly mean adjusted charges for patients less than 65 years of age.

Figure 4.4. Yearly mean adjusted charges for patients < 40 years of age.
Figure 4.5. Yearly mean adjusted charges for patients 40 to < 65 years of age.

Kaplan-Meier testing was done for each cohort and are shown in Figures 4.6, 4.7, 4.8, 4.9, and 4.10. Included in the model were age, total body surface area, area of full thickness and diabetes to predict the hospital length of stay. Censoring was for death. Table 4.4 displays the forward stepwise sequence of Chi-Square for the model. In the entire sample there is a significant difference in length of hospital stay for burn patients with diabetes compared to those without (Logrank $p < .0001$, 95% Hall-Wellner Bands). In the forward stepwise sequence of Chi-Squares for the Log-Rank Test, age, area full thickness and total body surface area all had a probability of Chi-Square and Chi-Square increment of < .0001. In subjects less than 65 years of age, there is a significant difference in length of hospital stay for burn patients with diabetes compared to those without (Logrank $p < .0001$, 95% Hall-Wellner Bands). In the forward stepwise sequence of Chi-Squares for the Log-Rank Test, age, area full thickness and total body
Figure 4.6. Kaplan-Meier Curve. Burns with and without diabetes for time to discharge censoring death entire sample. Note Comorb_grp1 = 0 – without diabetes, Comorb_grp1 =1 – with diabetes.
Figure 4.7. Kaplan-Meier Curve. Burns with and without diabetes for time to discharge censoring death < 65 years of age. Note Comorb_grp1 = 0 – without diabetes, comorb_grp1 =1 – with diabetes.
Figure 4.8. Kaplan-Meier Curve. Burns with and without diabetes for time to discharge censoring death < 40 years of age. Note Comorb_grp1 = 0 – without diabetes, Comorb_grp1 = 1 – with diabetes.
Figure 4.9. Kaplan-Meier Curve. Burns with and without diabetes for time to discharge censoring death 40 to 65 years of age. Note Comorb_grp1 = 0 – without diabetes, Comorb_grp1 = 1 – with diabetes.
Figure 4.10. Kaplan-Meier Curve. Burns with and without diabetes for time to discharge censoring death ≥ 65 years of age. Note Comorb.grp1 = 0 – without diabetes, Comorb.grp1 = 1 – with diabetes.
Table 4.4

Forward Stepwise Sequence of Chi-Squares for the Log-Rank Test

<table>
<thead>
<tr>
<th></th>
<th>Chi-squared increment value</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire Sample, $N = 58,707$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>9449.2000</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>TBSA</td>
<td>2200.2000</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Area full</td>
<td>18.0276</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>&lt; 65, $N = 49,254$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>518.9000</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>TBSA</td>
<td>5020.9000</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Area full</td>
<td>8299.3000</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>18-&lt; 40, $N = 22,910$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>1435.8000</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>TBSA</td>
<td>86.6761</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Area full</td>
<td>4.2158</td>
<td>.0501</td>
</tr>
<tr>
<td>40-&lt; 65, $N = 26,344$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>8299.3000</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>TBSA</td>
<td>801.6000</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Area full</td>
<td>16.4367</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>&gt; 65, $N = 9,453$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>1435.8000</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>TBSA</td>
<td>86.6761</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Area full</td>
<td>4.2158</td>
<td>.0400</td>
</tr>
</tbody>
</table>

surface area all had a probability of Chi-Square and Chi-Square increment of < .0001. In subjects less than 40 years of age there is a significant difference in length of hospital stay for burn patients with diabetes compared to those without (Logrank $p < .0001$, 95% Hall Wellner Bands). In the forward stepwise sequence of Chi-Squares for the Log-Rank Test, age, and total body surface area all had a probability of Chi-Square and Chi-Square increment of < .0001. Area full thickness burn had a probability of Chi-Square increment of 0.0501. In subjects 40 to < 65 years of age, there is a significant difference in length of hospital stay for burn patients with diabetes compared to those without
(Logrank $p < .0001, 95\%$ Hall Wellner Bands). In the forward stepwise sequence of Chi-Squares for the Log-Rank Test, age, area full thickness and total body surface area all had a probability of Chi-Square and Chi-Square increment of $< .0001$. Subjects $> 65$ years of age there is no significant difference in length of hospital stay for burn patients with diabetes compared to those without (Logrank $p < .2901, 95\%$ Hall Wellner Bands). In the forward stepwise sequence of Chi-Squares for the Log-Rank Test, age and total body surface area all had a probability of Chi-Square and Chi-Square increment of $< .0001$ while full thickness was 0.0400.

**Discussion**

**Resource Utilization**

Historically, hospital length of stay has been used as both an outcome measure and a surrogate measure for quality of care. It is a measure of efficiency and appropriateness of care (Brasel, Lim, Nirula, & Weigelt, 2007) and is reflective of injury, associated morbidity, and costs (Hussain & Dunn, 2013). Lutjens (1993 identified multiple individual factors that were associated with longer LOS in the burn patient. These include multiple diagnoses, race, finances, and source of reimbursement, age, previous chronic illnesses, and complications. In general, comorbidities that affect wound healing, the ability to cope with illness (psychiatric disease), factors that would affect rehabilitation (chronic pain syndromes, other injuries) malnutrition and comorbid conditions that affect ability to respond to stress response associated with burn injury are important considerations in hospital length of stay. The number and types of comorbid conditions, percent third degree burns, or social situations including access to burn care may all impact outcomes (Yang et al., 2010).
Identifying trends in LOS in burn patients with the comorbid condition of diabetes is vital. McCampbell et al. (2002), in a retrospective study of one burn center, found that patient with diabetes in the 18-65 year age group had significantly longer lengths of stay when compared to those burn patients without diabetes ($P = 0.0001$). The ability to more accurately predict the length of stay of burn patients, as well as the determinants of length of stay, will help in both planning and managing resources for care.

Our findings of significantly more hospital days, more ICU days, ventilator days as well as higher charges in those patients with diabetes are consistent with the literature. Numerous studies have found that patients with comorbid conditions have longer lengths of stay (both hospital and ICU) and more ventilator days (L. Edelman, 2007; Thombs et al., 2007). Treatment for patients with burn injury and diabetes is complicated by the micro-vascular complications associated with the progression and control of diabetes and in large burns the marked and sustained hypermetabolic response (Jeschke et al., 2011). Because of the relationship between glycemic control, the stress response, and wound healing, burn patients with diabetes may be predisposed to more infections, more surgeries and longer lengths of hospital stay (Memmel et al., 2004). A prospective study by Schwartz and colleagues (2011) found that patients with diabetes and burn injury have significant delays in burn wound healing and therefore use more health care resources. Further prospective studies need done to examine the differences in length of stay in those with and without diabetes in relation to other patient characteristics.

Our findings that persons with diabetes had significantly longer lengths of stays may be related to the alterations in wound healing or the inability to obtain optimal glycemic control. In the person with diabetes, multiple factors including micro vascular
changes impede normal wound healing in acute burn wounds. Decreased blood flow to the wound, such as in the burn wound with the initial edema formation, can decrease oxygen delivery to the wound. The resultant hypoxia in the wound bed can increase strength and duration of the early inflammatory response; a normal response to the burn injury in patients with and without diabetes. Increased inflammation may prolong the injury and increase the amount of oxygen radicals. In the person with diabetes and a wound, the growth factor production (essential for the healing cascade) may be decreased, along with mechanisms that increase destruction of growth factors (Greenhalgh, 2003; Guo & DiPietro, 2010; Wellen & Hotamisligil, 2005). At the capillary level, people with diabetes may develop a thickened perivascular membrane, which alters nutrient delivery to the wound, and increases the capillary’s permeability. In the burn wound there is an increase in the capillary permeability in the first 24 hours post burn and with the added effects from diabetes local edema formation may be increase making leukocyte migration difficult (Brem & Tomic-Canic, 2007; Greenhalgh, 2003).

Neuropathy impacts wound healing because of the loss of the protective effect. Decreased sensation may lead to re-injury because the patient cannot feel pain. Denervated tissue has been demonstrated to alter wound healing, with changes in the inflammatory phase, the proliferative phase and the remodeling phase (Barker et al., 2006). Margolis, Kantor, and Berlin’s (1999) meta-analysis found that three factors were important in healing neuropathic diabetic foot wounds including smaller size of the wound, shorter duration of the wounds and being non White. No burn wounds were included in this analysis (Margolis et al., 1999). In general, protein losses associated with altered kidney function in diabetes can increase edema formation, making it difficult for
nutrients and oxygen to get to the healing tissues. Lastly, patients with diabetes tend to be more prone to infections, including burn wound infections, which further impede wound healing. This susceptibility to infection is related to glycemic control, with hyperglycemia affecting local tissue defense mechanisms (Greenhalgh, 2003; Hemmila, Taddonio, Arbabi, Maggio, & Wahl, 2008).

In the burn wound, changes in the microvasculature typically occur and include red cell aggregation, white cell adhesion, and platelet micro emboli. The release of the inflammatory mediators in response to the burn wound contributes to hyper permeability of the microcirculation. The ongoing tissue damage from the burn wound is partly due to failure of the surrounding tissue to supply borderline cells with oxygen. Micro vascular occlusion has been shown to occur in the wound with subsequent decreased perfusion (Jones et al., 2014). The combination of these mechanisms with the normal burn physiologic response can affect both wound healing and graft take. It is well-documented that diabetes has a negative effect on normal wound healing, from the effects related to local tissue ischemia and decreased local oxygen tension at the tissue level (Jones et al., 2014; Steed et al., 2006). The burn wound, skin grafts, and donor sites in the diabetic burn patient display increased extra-vascular osmotic activity, and edema formation. The non-intact skin provides a site for entry of bacteria compounded with local tissue effects, and the stress response the burn patient with diabetes is at higher risk for infection (Jones et al., 2014; Steed et al., 2006).

Numerous articles discuss the effects of poor glycemic control on wound healing. Hyperglycemia contributes to the oxidative stress and is a key factor in poor wound healing (Greenhalgh, 2003; Guo & DiPietro, 2010; Murphy, Coffey, Cook, Gerlach, &
Miller, 2011; Murphy et al., 2013). Effects of hyperglycemia include alterations in metabolic pathways, altered control of sodium, potassium and ATPase activity, and increased byproducts of oxidative stress which inhibits collagen cross-linking and degradation. Therefore, strategic interventions should target glycemic control. Elevated hemoglobin A1c levels, are a reflection of glycemic control and have been demonstrated to be predictive of a decreased rate of wound healing. A 2011 study of 183 patients with 310 wounds found that for each 1% increase in HbA1c, the rate of wound healing decreased by 0.028 cm$^2$/day ($P = 0.027$; Christman, Selvin, Margolis, Lazarus, & Garza, 2011). Schwartz et al. (2011) compared wound closure time in patients with burns and diabetes ($n = 24$) to burn patients without diabetes ($n=16$) found significantly longer healing times in the patients with diabetes (46.4±44.4 days) compared to patients without diabetes (19.6±8.8 days; $P = .01$; Schwartz et al., 2011). Thus longer length of hospital stay may be related to the effects of hyperglycemia or poor glycemic control on burn wound healing.

Major burn injuries, greater than 15% TBSA burn, cause overwhelming physiologic stress responses affecting the anatomic, physiologic, endocrine, and immune systems (Atiyeh, Gunn, & Dibo, 2008; Dungan et al., 2009). The stress response that occurs in burn patients with and without diabetes leads to challenges in the assessment of blood glucose values during hospitalization. Additionally, burn patients with and without diabetes suffer from both insulin resistance and hyperglycemia as a result of the physiologic stress response (Murphy et al., 2013). The hypermetabolic response following burn injury is associated with increases in catecholamine release, growth hormones, cortisol, and proinflammatory cytokines (Dungan et al., 2009). This
proinflammatory and hypermetabolic state results in stimulation of gluconeogenesis, glycogenolysis, and inhibition of insulin release as well as insulin resistance. The hypermetabolic response consists of an early ebb phase (first 48 hours post burn injury) and a later flow phase which is related to the size of the burn and can last up to 1 year post-burn. The hypermetabolic response contributes to the protein and lipid catabolism, total body protein loss, muscle wasting, and the increased energy expenditure to heal the burn wound (Atiyeh et al., 2008; Dungan et al., 2009). The hypermetabolic state has been associated with catabolism in burns with 40% TBSA or greater and in burns less than 40% TBSA if sepsis occurs (Pereira & Herndon, 2005). Although present in all critically ill patients, the hypermetabolic response has increased severity, duration and magnitude in critically burn-injured patients, and can persist for several years post burn injury (Gauglitz, Herndon, & Jeschke, 2008). The addition of the comorbid condition of diabetes coupled with the normal hypermetabolic response to burn injury can amplify this response making glycemic control difficult in this cohort of burn patients (Murphy et al., 2011).

Burn patients often exhibit hyperglycemic responses and insulin resistance, which complicates care for burn patients with diabetes and this hyperglycemia, is a result of the imbalance between glucose production and glucose metabolism (Marti & Leitman, 2013). In general, critically injured patients with diabetes have an altered response to hyperglycemia in the hospital setting, resulting in better tolerance to hyperglycemic episodes than patients without diabetes (Murphy et al., 2013). Chronic hyperglycemia before burn injury (in poorly controlled or undiagnosed diabetes) is associated with longer length of stay, and a higher rate of unplanned readmission (Murphy et al., 2013).
In a 2009 study of glucose variability of 49 severely burned patients found that patients with high glucose variability were twice as likely to die than patients with low glucose variability (50% vs. 22%, $p = 0.041$; Pidcoke et al., 2009). In a retrospective study of 46 critically-injured burn patients, failure to achieve early glycemic control was associated with higher mortality (Murphy et al., 2011). The debate about glycemic control for critically ill patient have demonstrated that tight glycemic control (blood glucose 80-100 mg/dl) has decreased mortality in ICU patients however follow up studies failed to show improved mortality except in patients with ICU stays greater than 3 days (Van den Berghe et al., 2006). Egi and colleagues (2008) found that hospitalized patients with preexisting diabetes had an altered response to hyperglycemia indicating that patients with diabetes may tolerate hyperglycemia better while in the hospital. Further studies demonstrated that the risk of mortality in critically ill patients with diabetes was significantly higher in patients with higher glucose levels suggesting that tight glycemic control may be detrimental in these patients (Egi et al., 2011). Targeted glycemic control in the burn patient has been demonstrated to reduce infection complications however controversy exist over what the ideal level is and further study needs to be done (Hemmila et al., 2008).

There has been limited work in the burn population and individualized goals for glucose need further study. Optimal target ranges for glucose levels in the burn patient have not been established because of conflicting findings in the literature with advocates for strict glycemic control (80-110 mg/dl) and a more liberal range of 140-180 mg/dl leading the debates (Marti & Leitman, 2013; Murphy et al., 2011; Murphy et al., 2013). Strict glycemic control has been linked to poorer outcomes because of multiple
hypoglycemic episodes that occur with trying to obtain strict glycemic control which are linked to higher mortality rates (Murphy et al., 2011). Wide variations in glucose post burn injury have also been associated with higher mortality rates in major burn patients (Marti & Leitman, 2013; Murphy et al., 2013; Pidcoke et al., 2009). Hyperglycemia has been linked to bacterial and fungal infections, decreased skin graft take, altered immune responses, and increases in catabolism (Pidcoke et al., 2009). Identifying glycemic control targets for burn patients with diabetes will improve both the process of care and resource utilization.

In burns less than 15% TBSA, the hypermetabolic response does not occur at the same rate and magnitude however glycemic control is still important for wound healing. In the burn patient with diabetes, glucose variability and HgA1c levels can affect wound healing rates, length of stay, and infection rates. A study (Dufton, Li, & Koehoorn, 2007) of 68 admitted burn patients with lower extremity and foot burns with a mean burn size of 4.5% (range 0.5-15%), and 57% having full thickness burns those with diabetes had longer lengths of stay (5.65 days per 1% TBSA) when compared to patients without diabetes (1 day per 1% TBSA). Those with diabetes had an average total length of stay of (15.2 days with a range of 1-95), 62 infections, 31 amputations in eleven patients with diabetes and 19 patients with diabetes required readmission. The mean admission hemoglobin A1c for patients with diabetes was 9.08%, suggesting that patients had poor diabetic control prior to admission (Barsun et al., 2013). A second study (Kimbal et al., 2013) of lower extremity or foot burns comparing patients with and without diabetes, the mean TBSA was 1.8±1.3 for patients with diabetes and 1.8±1.6 for those without. The group with diabetes had higher ICU admissions, longer total length of stays, and higher
rates of renal failure (Kimball et al., 2013). Despite small burn injuries, those with the comorbid condition of diabetes had longer lengths of stay, more complications, more amputations, and more readmissions than their counterparts without diabetes. Finally, Kaplan-Meier Survival Curves demonstrated that the presence of diabetes significantly impacted the LOS except for in the elderly. This may be related to the polypharmacy that occurs in the older patients combined with the effects of the aging process (Attia et al., 2000; Justiniano et al. 2015). Therefore, it is important to examine the role the comorbid condition of diabetes plays in all burn patients.

Burn patients with diabetes had significantly higher charges than those without and were significantly older. Hospital charges for burn patients have been found to be higher in patients older than 65 years of age when compared with their younger cohorts. Pham and colleagues (2009) divided patients 55 years and older into three groups: ages 55-64, ages 65-74, and ages 75 and older. Charges for patients in the 65-74 age groups were 1.3 times higher than those in the 55-64 year old group. For patients 75 years of age and older, the charges were 2 times higher (Pham et al., 2009). An Australian study comparing burn patients to matched controls in the ICU found no difference in the mean ICU daily charges (Patel et al. 2010). No mention of diabetes status was found in this study. In a study of patients with diabetes, patients who had improved diabetic control had lower health care costs, lower utilization of health care services, and lower number of primary care visits (Wagner et al., 2001). The impact of identifying targets for glycemic control in the burn patients may lower the hospital charges for this group of patients.

Depth of burn has been found to contribute to longer lengths of stay. In those burns with diabetes, one retrospective study found that diabetics in the 18-65 year age
group had significantly higher rates of full thickness burns when compared to non-diabetic patients \( (P = 0.025; \text{McCampbell et al., 2002}) \). This was true in our sample and patients with diabetes had significantly higher percent of full thickness injuries in all age groups. Since persons with diabetes and burn injury have deeper burns this may contribute to more resource use including more procedures, longer LOS, more ICU days, more ventilator days and higher charges.

This is the first study we know of that has compared the hospital charges of burn patients with and without diabetes. Published economic analyses of burn patients have predominately been based on data from nations other than the United States. The unique health care economy of the United States makes direct comparison of these charges unreliable, even though in many of these reports the practice patterns are similar to those in the United States. Comparison of charges is also difficult because of differences across the United States. Hospital charges may not reflect all the charges related to burn care. The true cost of burn care continues long after the patient leaves the hospital, with ongoing dressing changes, physical and occupational therapy, lost wages Hospital charges for burn patients have been found to be higher in patients older than 65 years of age when compared with their younger cohorts. Pham and colleagues (2009) divided patients 55 years and older into three groups: ages 55-64, ages 65-74, and ages 75 and older. Charges for patients in the 65-74 age groups were 1.3 times higher than those in the 55-64 year old group. For patients 75 years of age and older, the charges were 2 times higher (Pham et al., 2009). In this same study, older adults had higher resource use both during inpatient care and after discharge (Pham et al., 2009). In general, the cost of patients with diabetes in the United States in 2012 was 245 billion dollars (ADA, 2014).
In a study of the patient with diabetes, patients who had improved diabetic control had lower health care costs, lower utilization of health care services, and lower number of primary care visits therefore it is important to identify patients with diabetes early in their hospital stay (Wagner et al., 2001).

There are limitations to this study. Sampling bias may be present because those without comorbid data were not included in the analytic sample. Secondly the comorbid condition of diabetes may be over or under represented in the sample. Each registrar collects this information based on past medical history in the admission history and physical and is self-report by the patient. No confirmatory tests were done to verify the presence or absence of diabetes. Mukerji and colleagues (2007) demonstrated that self-report of comorbid conditions were statistically valid in identifying comorbid conditions therefore relying on self-report may be valid. Charges may also be over or under represented because not all institutions contribute charge data to the NBR however all charges were adjusted to 2011 dollars.

Conclusions

Patients with diabetes use more health care resources with longer lengths of stay, longer ICU lengths of stay and higher charges than those without diabetes. The practice of obtaining admission HgA1c levels may aid in identifying this high risk population. Earlier identification of this population may positively impact resource utilization and processes of care for the burn patient.
Chapter 5: Discussion and Conclusions

Introduction

This study has demonstrated that the incidence of burn injuries with the comorbid condition of diabetes is on the rise. This rise mimics the rise in incidence of diabetes in the general population and the rise seen in those over 65 year of age. Identifying the characteristics of this high risk population will identify the impact on patient outcomes and health care resource utilization. This chapter summarizes the overall findings from the studies presented in Chapters 2, 3, and 4, as well as identifying future directions for research and implications for practice. Appendix C illustrates the key findings comparing them to the literature.

Summary of Overall Findings

Chapter 2 findings demonstrated that burn injuries complicated by the comorbid condition of diabetes are on the rise in the United States. The prevalence of diabetes is also increasing in the older population, with an estimated 10.9 million people 65 years or older having diabetes or 25.9% of the population (CDC, 2015). This study’s findings demonstrated that in the burn population 65 years of age and older those patients with diabetes has risen using a national 9.5-year sample. This trend was both dramatic (2002, 12.29% to 2011, 30.27%) and statistically significant (p < .0001). If this holds true over the next 10 years, the rate of burn injuries in the elderly complicated by the comorbid condition of diabetes will be increasing at a faster rate than in the general population.
Even more alarming is the significant increasing trend in patients < 65 years of age with patients < 40 having a 3.3-fold increase in diabetes and burn injury.

With the cognitive decline, physical disabilities (such as retinopathy and neuropathy) associated with diabetes, and the risk of polypharmacy, the elderly are at higher risk for burn injury in the home (Gregg et al., 2002; Hornick & Aron, 2008; Keck et al., 2009). With the aging process, persons have a decrease in their ability to heal wounds because of alterations in the immune response and an increase in the inflammatory response. This decreased ability to heal the burn wounds makes patients more prone to infections and subsequently death (Kerby et al., 2006). The combination of an increase in the aging population with the increase in diabetes in the elderly burn patient the impact on resource utilization will be significant. This makes it imperative to identify the trends in this high risk population to develop prevention programs for burn injuries.

Andersen and Aday’s model described the influences of the population characteristics on patient’s health behaviors and their outcomes. In Chapter 3, the differences in characteristics in those burn patients with and without diabetes was described to better understand the population. In all age groups patients with diabetes were significantly older ($p < .0001$), and had significantly higher percent of full thickness burns ($p < .0001$). There were no significant differences in TBSA ($p = 0.1395$) or the percent of partial thickness area between the two groups ($p = 0.8980$). Patients with diabetes had significantly higher rate of inhalation injuries ($p < .0001$). These findings are important for the development of prevention programs and the identification and evaluation of best treatment strategies for improved outcomes.
It is known that not all burn centers identify those with diabetes on admission. Elevated hemoglobin A1c levels, are a reflection of glycemic control and have been demonstrated to be predictive of a decreased rate of wound healing. A 2011 study of 183 patients with 310 wounds found that for each 1% increase in HbA1c, the rate of wound healing decreased by 0.028 cm²/day ($P = 0.027$; Christman et al., 2011). Schwartz et al. (2011) compared wound closure time in patients with burns and diabetes ($n = 24$) to burn patients without diabetes ($n = 16$) found significantly longer healing times in the patients with diabetes (46.4±44.4 days) compared to patients without diabetes (19.6±8.8 days; $P = .01$; Schwartz et al., 2011). Murphy and colleagues (2011) obtained admission HgA1c levels for all adult burn patients and found that patients with similar size burns and known diabetes and or chronic hyperglycemia (HgA1c ≥ 6.5 on admission) had longer lengths of stay and were older compared to patients who were euglycemic. Further studies in the same institution found that obtaining an admission HgA1c allowed early identification of those patients with prediabetes. Those with prediabetes had significantly higher weighted glucose levels throughout their hospital stay, larger full thickness burns, and had more hypertension and higher mortality when compared to those with diabetes (Somerset, Coffey, Jones, & Murphy, 2014).

The treatment of burn patients with diabetes is complicated because of the microvascular complications associated with the progression and control of the disease and in large burns the marked and sustained hypermetabolic response (Jeschke et al., 2011). Because of the relationship between glycemic control, the stress response, and wound healing, burn patients with diabetes may be predisposed to more infections, more surgeries and longer lengths of hospital stay (Memmel et al., 2004). Numerous articles
discussed the effects of poor glycemic control on wound healing finding that hyperglycemia contributes to the oxidative stress in burn injury and is a key factor in poorer wound healing in this cohort of patients (Greenhalgh, 2003; Guo & DiPietro, 2010; Murphy et al., 2011; Murphy et al., 2013). Effects of hyperglycemia include alterations in metabolic pathways, altered control of sodium, potassium and ATPase activity, and increased byproducts of oxidative stress which inhibits collagen cross-linking and degradation. A prospective study by Schwartz and colleagues (2011) found that patients with diabetes and burn injury have significant delays in burn wound healing and therefore use more health care resources. Strategic interventions need to be studied to target glycemic control parameters for burn patients. Therefore, the implications for practice are many, including understanding the characteristics of this group of patients, identifying the best evidence and practice for those with burn injury and diabetes and the evaluation of outcomes in this population.

The question becomes should early identification using HgA1c levels be the new standard of care in adult burn patients? This allows for identification of patients with new diagnosis of diabetes, those with poorly controlled or well controlled diabetes and those with pre diabetes. This early identification of those at risk coupled with the our current understanding of the stress response from the burn injury will help in developing standards for glycemic control in both critically ill burn patients and those not critically ill. Knowing that diabetes requires ongoing management by both the medical community as well as the patient to prevent the long-term complication of retinopathy, kidney complications, non-traumatic lower limb amputations, and neuropathies early identification would aid in linking this groups of patients to services at discharge.
(Murphy et al., 2013). A cost benefit analysis would be helpful to identify the benefit of the admission HgA1c level on long term outcomes in this population.

The Behavioral Model of Health Services Utilization (Aday & Andersen, 1974; Andersen, 1995) can be used to explain the relationships that exist between the burn patient with and without diabetes and their resource utilization and outcomes. This is extremely important to guide the organization and delivery of burn care in the changing health care environment. There are many factors that influence a burn patient’s hospital outcomes and resource utilization including the health care system, the external environment, the person’s predisposing characteristics, the enabling resources, the need for care, the patient’s health beliefs (including the person’s health practices), his/her use of health services, and finally, outcomes related to the perceived health status, the evaluated health status, and consumer satisfaction. Andersen and Aday’s current model has the additional benefit of the ability to describe the interactions among the environment, the population characteristics, health behaviors, and outcomes. The outcomes of the health care delivery system are related to the equity, efficiency and effectiveness of the system (Andersen, 1995). This provides the opportunity to improve health care thru policy and improve the efficiency of throughput in the system. Therefore, the identification of differences in the outcomes of burn patients with and without diabetes provide a starting point for improving outcomes of care and efficiency in resource utilization.

Chapter 4 compared the resource utilization of those patients with burn injury and the comorbid condition of diabetes to those without. Patient resource utilization included hospital days, ICU days, ventilator days, and hospital charges adjusted to 2011 dollars.
In the analytic sample those with diabetes had significantly longer hospital days (12.99 vs. 10.52 days; \( p < .0001 \)), intensive care unit days (7.30 vs. 5.59 days; \( p < .0001 \)), more ventilator days (3.49 vs. 3.04 days; \( p = 0.0475 \)) and higher adjusted charges ($139,764 vs. $104,461; \( p < 0.0001 \)). Burn patients 65 years of age and older with diabetes had significantly higher charges ($160,336 vs. $127,487; \( p = 0.0033 \)) but no significant differences in hospital days (14.47 vs. 13.53 days; \( p = 0.0563 \)), intensive care unit days (9.04 vs. 8.26 days; \( p = 0.0991 \)), or ventilator days (4.55 vs. 4.31 days; \( p = 0.6000 \)) when compared to those without diabetes. In patients less than 65 years of age those with diabetes had significantly longer hospital days (12.23 vs. 10.03 days; \( p < .0001 \)), more intensive care unit days (6.47 vs. 5.15 days; \( p < .0001 \)), and higher adjusted charges ($130,697 vs. $100,818; \( p = 0.0001 \)). There were no significant differences in ventilator days (2.98 vs. 2.82 days; \( p = 0.5626 \)) between the two groups.

Various comorbid conditions have been studied in relationship to the burn patient but the majorities have examined the effect of comorbidities in general in the burn injury. Numerous studies have examined the number of comorbid conditions but not the type. Only one study comparing burn patients with diabetes (\( n = 57 \)) and patients without diabetes (\( n = 405 \)) found that diabetes effected mortality but not statistically significantly (Dahagam et al., 2011). With the increasing incidence of diabetes in the general population, and the lack of studies on the resource utilization of burn patients with diabetes, it is important to study the effect of the comorbid condition of diabetes alone on outcomes and resource use in burn patients.

Lundgren and colleagues (2009) studied burn patients age 55 and older to examine the impact of age and baseline comorbidities on outcomes following a burn
injury. Calculating the Charlson CoMorbidity Index for each patient they found that the overall mortality rate for their sample of 325 subjects was 18.5%. The most significant factors for hospital mortality were total body surface area burned and medical comorbidities such as diabetes. Additional findings indicated a positive correlation between the number of comorbidities and the risk for mortality at 1 year post-discharge (Lundgren et al., 2009). Rao et al. (2006) studied 63 elderly patients and found a positive correlation between the number of comorbid conditions and mortality but did not examine specific comorbid conditions such as diabetes. Keck et al. (2009) found the incidence of premorbid conditions in burn patients over the age of 65 to be as high as 85%. In a study to examine the effect of diabetes on outcomes in adult civilian patients admitted to the burn ICU, 57 diabetics were compared to 405 non-diabetic patients. The patients with diabetes were older (mean age 60±15), had higher admission glucose (196±81) and higher mean glucose (147±37), more glucose variability, and longer ICU stays (Dahagam et al., 2011). Therefore, the burn patient with diabetes is at high risk for more resource utilization and poorer outcomes.

**Implications for the National Burn Repository Data Base**

The NBR is an important national database for collection of burn injury data nationwide and for the study of the epidemiology of burn injury and outcomes. Continued improvements need to be made in data completeness and data quality. In regards to quality of the data, like variables need to be checked for congruence such as the age and computed age variable and the area total variable should equal the total percent partial thickness burn plus the total percent full thickness burn. Patients with non-burn injuries should be placed is a separate database would improve the ability to study
patients with and without burn injuries treated in burn centers. This would provide a rich source of data to compare outcomes in patients with non burn injuries cared for in burn centers with those who are not. Multiple studies including this one have demonstrated the impact comorbid conditions have on resource utilization therefore the addition of comorbid data in the minimal data set is needed to make meaningful conclusions from this data. Finally, the addition of outpatient data would provide valuable information for targeted prevention programs and long term outcome data.

**Strengths and Limitations**

This study has both strengths and limitations. The major strength is that this sample was from 91 of the 127 burn centers in the United States representing 72% of patients treated as inpatients in hospital burn centers in the United States, therefore, this may represent an accurate estimation of the population being studied. Fifty three percent of the eligible sample had comorbid data providing a sample of burn patients with diabetes large enough to analyze.

This study has limitations. The condition of diabetes is self-report and collected from the medical record. This may be an under or over representation of diabetes in this sample. This is a multi-year cross sectional study with a sample collected over 9.5 years from burn centers in the United States with 91 of the 127 burn centers in the United States contributed data. Despite this data not being primary data, data quality control measures to ensure completeness and accuracy of the data are completed at each 68 of the institutions. A validity review of the NBR 2009 release found data inconsistencies and missing data as well as duplicate records however vast improvements have been made in the 2012 release (Taylor et al., 2013). Secondly, diabetes is self-reported by the patient
and is collected by the registrar at each institution from the medical record. The diagnosis of diabetes is not cross-referenced with the diagnosis codes in the registry, so diabetes may be under-represented. Additionally, there is no data to validate the diagnosis of diabetes (such as admission HbA1c) for patients. The diagnosis of diabetes is dependent on the ability of the registrar at each facility to extrapolate the diagnosis from the chart. Murkerji and colleagues (2007) compared self-report of comorbidities with chart review and found good overall consistence between chart review and self-report suggesting this is a valid method for collecting these data. No data is available on diabetic control or data on the long-term effects of poorly or uncontrolled diabetes (such as kidney complications, neuropathy, or retinopathy). Thirdly sample selection bias may have been introduced. Comorbid data is not required data to be submitted to the NBR. Characteristics of the sample with comorbid data present were significantly older and had significantly higher percent of partial thickness injury however there were no differences in total percent burn. Older patients may have longer lengths of stay however this may not impact our findings because we stratified for age groups in the analysis and there were no significant differences in total burn surface area or full thickness burn which have been shown to increase length of stay.

**Opportunities for Future Research**

There are three major areas for future research identified by this dissertation. The first is better identification of diabetes and diabetes control on admission. The second would be identifying glycemic targets for both major and minor burns and the impact on resource utilization and outcomes. The third would be to develop and evaluate burn prevention programs that target the population with diabetes.
Identification of Diabetes and Diabetes Control on Admission

Diabetes is a multi-system, chronic disease that is characterized by abnormal insulin production, the inability of the body to use insulin, or both. It has been defined as a disorder of carbohydrate, fat, and protein metabolism that results in an imbalance of insulin need and insulin availability. Glucose provides the fuel cells need to carry on the work of the human body including energy production, organ function, and cell respiration. Glucose sources include ingestion of food as well as glycogen stores in the liver. Proper glucose balance is essential for the body to function properly. The hormone insulin is produced in the pancreas and is released into the bloodstream in response to blood glucose levels. Insulin is also an important hormone for the storage of fat. Insulin binds to receptors on the cells, which facilitates the entrance of glucose into the cell for use by the cell. The body uses insulin to maintain blood glucose levels at about 70-120 mg/dl. Counter-regulatory hormones produce the opposite effect by increasing glucose to prevent hypoglycemia. These counter-regulatory hormones include: glucagon, epinephrine, norepinephrine, cortisol, and growth hormone (Grossman & Porth, 2013).

Typically, after eating, insulin is released in response to glucose load. Insulin makes glucose available to the body cells so it can be used for fuel, converted to other substrates needed by the cell, or for storage in the liver and muscle as glycogen. Little or no insulin production means that the circulating glucose is not available for the cells to function properly, and storage of glucose in the liver and muscles will be altered. Inadequate absorption of glucose by the cells leads to high blood glucose levels, poor protein synthesis, and other metabolic derangements (Grossman & Porth, 2013).
Type 2 diabetes is characterized by decreased insulin production, decreased insulin sensitivity, or insulin malfunction. Type 2 is the most common type of diabetes in the adult and the risk for developing Type 2 increases with age. Over time, diabetes can lead to micro-vascular changes (retinopathy, nephropathy, and neuropathy) and macrovascular complications (heart disease, stroke, and peripheral artery disease) which affect overall health and risk for injury (Grossman & Porth, 2013; Sladek et al., 2007). The gold standard for the diagnosis of diabetes has been the use of the hemoglobin A1C level. Elevated hemoglobin A1c levels, are a reflection of glycemic control and have been demonstrated to be predictive of a decreased rate of wound healing. A 2011 study of 183 patients with 310 wounds found that for each 1% increase in HbA1c, the rate of wound healing decreased by 0.028 cm²/day ($P = 0.027$; Christman et al., 2011).

Schwartz et al. (2011) compared wound closure time in patients with burns and diabetes ($n = 24$) to burn patients without diabetes ($n = 16$) found significantly longer healing times in the patients with diabetes (46.4±44.4 days) compared to patients without diabetes (19.6±8.8 days; $P = .01$; Schwartz et al., 2011). In the hospitalized patient, both pre-existing diabetes and hyperglycemia have been associated with poorer outcomes and higher mortality rates in the critically ill and burn patient (Gauglitz et al., 2008; Schwartz et al., 2011; Vanhorebeek, Langouche, Van den Berghe, 2007).

In the burn wound, changes in the microvasculature typically occur and include red cell aggregation, white cell adhesion, and platelet micro emboli. The release of the inflammatory mediators in response to the burn wound contributes to hyper permeability of the microcirculation. The ongoing tissue damage from the burn wound is partly due to failure of the surrounding tissue to supply borderline cells with oxygen. Micro vascular
occlusion has been shown to occur in the wound with subsequent decreased perfusion (Jones et al., 2014). All of these mechanisms can affect both wound healing and graft take. It is well-documented that diabetes has a negative effect on normal wound healing, from the effects related to local tissue ischemia and decreased local oxygen tension at the tissue level (Jones et al., 2014; Steed et al., 2006). The burn wound, skin grafts, and donor sites in the diabetic burn patient display increased extra-vascular osmotic activity and edema formation. The non-intact skin provides a site for entry of bacteria compounded with local tissue effects, and the stress response the burn patient with diabetes is at higher risk for infection (Jones et al., 2014; Steed et al., 2006). A retrospective review of burn patients by Somerset et al. (2014) found that the pre diabetic population was significantly older, more hypertensive, higher rate of and had larger areas of full-thickness burns, and higher mortality after burn injury when compared to non diabetic controls (Somerset et al., 2013). Hemoglobin A1c values are considered the gold standard for evaluating diabetes control and using this cost effective test to identify burn patients with diabetes needs to be evaluated in a larger sample (ADA, 2011).

**Identification of Glycemic Targets for Both Major and Minor Burns**

In those with burn injuries greater than 15% TBSA burn overwhelming physiologic stress responses affecting the anatomic, physiologic, endocrine, and immune systems occurs (Atiyeh et al., 2008; Dungan et al., 2009). The stress response that occurs in burn patients with and without diabetes leads to challenges in the assessment of blood glucose values during hospitalization. Additionally, burn patients with and without diabetes suffer from both insulin resistance and hyperglycemia as a result of the physiologic stress response (Murphy et al., 2013). The hypermetabolic response
following burn injury is associated with increases in catecholamine release, growth hormones, cortisol, and proinflammatory cytokines (Dungan, et al., 2009). This proinflammatory and hypermetabolic state results in stimulation of gluconeogenesis, glycogenolysis, and inhibition of insulin release as well as insulin resistance. The hypermetabolic response consists of an early ebb phase (first 48 hours post burn injury) and a later flow phase which is related to the size of the burn and can last up to 1 year post-burn. The hypermetabolic response contributes to the protein and lipid catabolism, total body protein loss, muscle wasting, and the increased energy expenditure to heal the burn wound (Atiyeh et al., 2008; Dungan et al., 2009). The hypermetabolic state has been associated with catabolism in burns with 40% TBSA or greater and in burns less than 40% TBSA if sepsis occurs (Pereira & Herndon, 2005). Although present in all critically ill patients, the hypermetabolic response has increased severity, duration and magnitude in critically burn-injured patients, and can persist for several years (Gauglitz et al., 2008). The addition of the comorbid condition of diabetes with this hypermetabolic response can amplify this response making glycemic control difficult in this cohort of burn patients (Murphy et al., 2011).

Burn patients often exhibit hyperglycemic responses and insulin resistance, which complicates care for burn patients with diabetes. The hyperglycemia is a result of the imbalance between glucose production and glucose metabolism this population (Marti & Leitman, 2013). In general, critically injured patients with diabetes have an altered response to hyperglycemia in the hospital setting, resulting in better tolerance to hyperglycemic episodes than patients without diabetes (Murphy et al., 2013). Chronic hyperglycemia before burn injury (in poorly controlled or undiagnosed diabetes) is
associated with longer length of stay, and a higher rate of unplanned readmission (Murphy et al., 2013). In a 2009 study of glucose variability in 49 severely burned patients found that patients with high glucose variability were twice as likely to die than patients with low glucose variability (50% vs. 22%, \( p = 0.041 \); Pidcoke et al., 2009). In a retrospective study of 46 critically-injured burn patients, failure to achieve early glycemic control was associated with higher mortality (Murphy et al., 2011). Studies have demonstrated that tight glycemic control (blood glucose 80-100 mg/dl) has decreased mortality in ICU patients however follow up studies failed to show improved mortality except in patients with ICU stays greater than 3 days (Van den Berghe et al., 2006). Egi and colleagues (2008) found that hospitalized patients with preexisting diabetes had an altered response to hyperglycemia indicating that patients with diabetes may tolerate hyperglycemia better while in the hospital. Further studies demonstrated that the risk of mortality in critically ill patients with diabetes was significantly higher in patients with higher glucose levels suggesting that tight glycemic control may be detrimental in these patients (Egi et al., 2011). Targeted glycemic control in the burn patient has been demonstrated to reduce infection complications however controversy exist over what the ideal level is (Hemmila et al., 2008). However, there has been limited work in the burn population and individualized goals for glucose need to be established. Optimal target ranges for glucose levels in the burn patient have conflicting findings in the literature with advocates for strict glycemic control (80-110 mg/dl) and a more liberal range of 140-180 mg/dl leading the debates (Marti & Leitman, 2013; Murphy et al., 2011; Murphy et al., 2013). Strict glycemic control has been linked to poorer outcomes because of multiple hypoglycemic episodes that occur with when trying to obtain strict glycemic control.
control and multiple hypoglycemic episodes are linked to higher mortality rates (Murphy et al., 2011). Wide variations in glucose levels post burn injury have been associated with higher mortality rates in major burn patients (Marti & Leitman, 2013; Murphy et al., 2013; Pidcoke et al., 2009). Hyperglycemia has been linked to bacterial and fungal infections, decreased skin graft take, altered immune responses, and increases in catabolism (Pidcoke et al., 2009). Therefore, once identification of this high risk population at admission occurs, studies to identify the standards for glycemic control are imperative in the burn patient.

In burns less than 15% TBSA the hypermetabolic response does not occur at the same rate and magnitude however glycemic control is still important for wound healing. In the burn patient with diabetes, glucose variability and HgA1c levels can affect wound healing rates, length of stay, and infection rates. In a study of 68 admitted burn patients with lower extremity and foot burns with a mean burn size of 4.5% (range 0.5-15%), and 57% having full thickness burns those with diabetes had longer lengths of stay (5.65 days per 1% TBSA) when compared to patients without diabetes (1 day per 1% TBSA). Those with diabetes had an average total length of stay of (15.2 days with a range of 1-95), 62 infections, 31 amputations in 11 patients with diabetes and 19 patients with diabetes required readmission. The mean admission hemoglobin A1c for patients with diabetes was 9.08%, suggesting that patients had poor diabetic control prior to admission (Barsun et al., 2013). In a second study of lower extremity or foot burns comparing patients with and without diabetes, the mean TBSA was 1.8±1.3 for patients with diabetes and 1.8±1.6 for those without. The group with diabetes had higher ICU admissions, longer total length of stays, and higher rates of renal failure (Kimball et al.,
Despite small burn injuries, those with the comorbid condition of diabetes had longer lengths of stay, more complications, more amputations, and more readmissions than their counterparts without diabetes. As patients with larger burns are being treated in the outpatient area it is vital that early identification of those with diabetes and developing glucose control targets for this group occur. This will be important for optimal wound healing, functional outcomes and quality of life. Developing target glucose levels for burn patients with diabetes will be a first step in decreasing resource utilization in this population.

**Developing and Evaluating Targeted Burn Prevention Programs for Persons with Diabetes**

The increasing trend of diabetes in the general population and in burn patients is alarming. Targeted burn prevention programs in the community are needed. This dissertation found that scald and contract burns were significantly higher in those burn patients with diabetes compared to those without in all age groups. It is well known that etiology of burn injury differs based on age group, with prevalence of scald injuries being higher in the pediatric and elderly population (ABA, 2014; Herndon 2012). One study of elderly burn patients found that 55.6% of burn injuries that occurred in the home involving cooking and bathing which are preventable injuries (Pham et al., 2009). Normal changes associated with aging may put this age group at higher risk, in addition to physical disabilities that may occur with diabetes. Physical disabilities can lead to larger TBSAs, deeper burns, and more inhalation injuries with flame injuries (Ho et al., 2001; Keck et al., 2009). Cognitive declines and decreased mobility associated with neuropathy may predispose the elderly person with diabetes to burn injuries. In general
patients with diabetes and neuropathy are more likely to have a burn injury from scalding or contact with a hot object (Herndon, 2012). Targeted prevention programs need to include scald prevention and burn prevention in the home.

**Concluding Remarks**

In summary, we know that the current population in the United States is aging, and with the aging population, inpatient utilization for care in general will increase by about 10-20% over the next 10-20 years. Secondly the prevalence of diabetes in the United States is currently 8.2% of the population and the CDC has predicted that with the current aging trend and obesity epidemic that one in three persons will develop diabetes by the year 2050 (ADA, 2014; CDC, 2013). In relation to burn care we know that the cost for it is expensive with the average cost of hospital burn care for all TBSA of $86,146 for survivors and $285,225 for non survivors (ABA, 2015). As the population ages, with the addition of higher risk for diabetes, the incidence of burn injury complicated by diabetes is expected to continue to rise. Burn patients with the comorbid conditions of diabetes are older have poorer outcomes and use more resources than younger persons without diabetes. In this era of decreasing reimbursement, it is imperative that we understand resource utilization of health care services by patients with burn injury and diabetes to better plan for care.

Burn injury complicated by the comorbid condition of diabetes is on the rise in the United States. In this dissertation the understanding of the magnitude of this problem as well as a description of the population provides an understanding of the potential impact on resource utilization and outcomes for the burn community. This can offer
several future directions for research including development and evaluation of burn prevention strategies.
References


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National Burn Repository (NBR)

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Accepted By: [Signature]

Print Name: [Name]

Date: [Date]

Title: [Title]

148
Appendix C: Summary of Key Findings
### Summary of Key Findings

<table>
<thead>
<tr>
<th>Variable</th>
<th>Findings</th>
<th>Literature</th>
</tr>
</thead>
</table>
| **Trend**                 | - Overall prevalence of diabetes in burn injury significantly increased from 4.84% in 2002 to 16.68% in 2011 \( (p < .0001) \).
|                           | - < 65 years old prevalence increased from 8.84% in 2002 to 13.12% in 2011 \( (p < .0001) \).
|                           | - 18 to < 40 years old prevalence increased from 1.48% in 2002 to 4.94% in 2011 \( (p < .0001) \).
|                           | - <40 to < 65 years old prevalence increased from 5.98% in 2002 to 18.95% in 2011 \( (p < .0001) \).
|                           | - ≥ 65 years of age increasing trend from 12.29% in 2002 to 30.27% in \( (p < .0001) \).
|                           | - 1 in 8 persons in the United States have diabetes.                                                                                           | - Estimated number of persons with diabetes will rise to one in three by the year 2050 (American Diabetes Association [ADA], 2015).                                                                     |
|                           | - 2004 retrospective study of burn patient subjects < 55 years of age, 6% had diabetes and subjects ≥ age 55, 32% had diabetes (Memmel, Kowal-Vern, & Latenser, 2004).                                                  |
| **Age**                   | - Overall subjects with diabetes were older.                                                                                                                                                             | - 63 elderly patients studied positive correlation between the number of co-morbid conditions and mortality (Rao et al., 2006).                                                                     |
|                           | - Entire sample subjects with diabetes significantly older (57.23 vs. 43.31 years; \( p < .0001 \)).                                                                                                     | - Incidence of pre morbid conditions in burn patients over the age of 65 found to be as high as 85% (Keck et al., 2009).                                                                   |
|                           | - Under 65 years of age and diabetes significantly older (49.15 vs. 39.71 years; \( p < .0001 \)).                                                                                                     | - Burn patients with diabetes were older (mean age 60±15), had higher admission glucose (196±81) and higher mean glucose (147±37), more glucose variability, and longer ICU stays (Dahagam, Mora, Wolf, & Wade, 2011). |
|                           | - 18 to < 40 years old subjects with diabetes were significantly older (31.48 vs. 50.46 \( p < .0001 \)).                                                                                                 |                                                                                                                                                                                                         |
|                           | - <40 to <65 years old subjects with diabetes were significantly older (53.09 vs. 28.62 \( p < .0001 \)).                                                                                                 |                                                                                                                                                                                                         |
|                           | - ≥ 65 with diabetes significantly younger (74.11 vs. 75.87 years; \( p < .0001 \)).                                                                                                                                                  |                                                                                                                                                                                                         |
| **Full thickness injury** | - Entire sample patients with diabetes had significantly higher percent of full thickness burns (4.27 vs. 3.51; \( p < .0001 \))                                                                             | - 18-65 years old with diabetes had significantly higher rates of full thickness burns when compared to patient without diabetes \( (p = 0.025) \)McCambell et al., 2002).  |
|                           | - < 65 years of age and diabetes significantly higher percent of full                                                                                                                                         | - Maybe a result of the neuropathy                                                                                                                                                           |
### Thickness Burns
- 18 to < 40 years of age there were no significant differences in full thickness injury ($p = 0.0502$).
- < 40 to < 65 years old subjects, there were no significant differences in full thickness injury ($p = 0.4393$).
- ≥ 65 no difference in area of full thickness burn ($p = 0.8332$).

### Inhalation Injury
- Entire sample higher incidence of inhalation injury in diabetes ($p = < .0001$).
- < 65 years of age and diabetes inhalation injury not significant (3.68% vs. 4.45%; $p = 0.0552$).
- 18-< 40 years of age and diabetes inhalation injury was not significant (4.16% vs. 0.11% [p = 0.7097]).
- > 40 -< 65 years of age and diabetes inhalation injury was significantly higher in patients without diabetes ($p = 0.0177$).
- ≥ 65 inhalation injury was significantly higher in those without diabetes ($p < .0001$).

### Mortality
- Significantly higher mortality rates in burn patients with diabetes (7.35% vs. 4.80%; $p < 0.0001$).
- < 65 and diabetes had significantly higher mortality rates than patients without diabetes (4.50% vs. 3.60%; $p = 0.0026$).
- 18-< 40 years of age and diabetes mortality injury was not associated with diabetes (McCampbell et al., 2002; Herndon, 2012).
- ≥ 65 years and older had no significant differences in full thickness. Pre existing physical and cognitive decline in the elderly may contribute to this finding (Kerby et al., 2006; Herndon, 2012).
- Elderly have thinner skin, reduced microcirculation and slower turnover rate of the epidermis, changes in the inflammatory response, and changes in the healing process (Keck et al., 2009; Rani & Schwacha, 2012).
- Increase COPD in aging and smoking on oxygen may contribute higher rates in n (Ahrens, 2003).
- Inhalation injury predictor of mortality in numerous studies and in all age groups (Edelman, White, Tyburski, & Wilson, 2006; Colohan, 2010; El-Helbawy & Ghareeb, 2011).
- No studies found on diabetes and inhalation injury in the burn patient.

- Increase COPD in aging and smoking on oxygen may contribute higher rates in n (Ahrens, 2003).
- Inhalation injury predictor of mortality in numerous studies and in all age groups (Edelman, White, Tyburski, & Wilson, 2006; Colohan, 2010; El-Helbawy & Ghareeb, 2011).
- No studies found on diabetes and inhalation injury in the burn patient.

- Mortality rates increased with higher TBSA, advancing age, and with the presence of inhalation injury (Pham et al., 2009).
- Advancing age has consistently been the most significant independent predictor of mortality in the burn patient (Attia, Reda, Mandil, Arafà, & Massoud, 2000; ABA, 2014).
- Increased mortality ≥ 65
significantly different ($p = 0.6421$).

- > 40-< 65 years of age and diabetes mortality injury was not significantly different ($p = 0.6809$).
- ≥ 65 with diabetes mortality rate was significantly lower than patients without diabetes (13.28% vs.16.74%; $p = 0.0002$).
- Multivariate regression controlling for age, TBSA and are full thickness injury found that diabetes was not significant in predicting mortality in all 3 groups.

attributed to decreased wound healing ability, decrease in physiologic reserves, poor nutritional status pre injury, and increasing medical co-morbidities (Rani & Schwacha, 2012).

- Advancing age increases mortality with smaller TBSA.
- Mortality rates of elderly have improved due to advances in burn resuscitation, critical care, treatment of infections and wound care, higher mortality rates persist (Rao, Ali, & Moiemen, 2006; Pham et al., 2009; American Burn Association 2015; Chang, Edelman, Morris, & Saffle, 2005; Herndon, 2012; Lundgren et al., 2009).
- No differences in mortality were found after age 60 (OR 0.9, 95% CI 0.5-1.6; McGwin Jr., G., George, R. L., Cross, J. M., & Rue, L. W., 2008).
- Study of 308 patients > 60, found that the best predictor of mortality was the Baux score and not co-morbidities (Wibbenmeyer, Amelon, & Morgan, 2001).

<table>
<thead>
<tr>
<th>Hospital LOS</th>
<th>Whole sample patients with diabetes had significantly longer hospital days (12.99 vs. 10.52 days; $p &lt; .0001$).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 65 with diabetes had significantly longer hospital days (12.23 vs. 10.03 days; $p &lt; .0001$).</td>
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<tr>
<td></td>
<td>18-&lt; 40 years of age and diabetes had significantly longer hospital length of stay ($p = 0.0009$).</td>
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<tr>
<td></td>
<td>&gt; 40-&lt; 65 years of age and diabetes had significantly longer hospital length of stay ($p = 0.0002$).</td>
</tr>
<tr>
<td></td>
<td>≥ 65 with diabetes had no significant differences in hospital</td>
</tr>
</tbody>
</table>

Higher percentage TBSA and full thickness burn contribute to longer lengths of stay, increased resource utilization, and mortality (Herndon, 2012).

- Age alone was not a significant predictor of length of stay and may be related to the number and types of comorbidities, percentage of third degree burns, or social situations (Johnson et al, 2011).
- Multiple individual factors associated with longer LOS: multiple diagnoses, race, finances, source of
<table>
<thead>
<tr>
<th>ICU days</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>days</strong> (14.47 vs. 13.53 days; ( p = 0.0563 )).</td>
<td></td>
</tr>
<tr>
<td>- Kaplan-Meier Survival Analysis found that diabetes status was significant in predicting hospital LOS except for patients ( \geq 65 ).</td>
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</tr>
<tr>
<td>- The number and types of comorbid conditions, percent third degree burns, or social situations including access to burn care may all impact outcomes (Yang, 2010).</td>
<td></td>
</tr>
<tr>
<td>- Significant predictors of LOS for survivors were age and TBSA, and for non-survivors the only significant predictor was TBSA (Andel et al., 2007).</td>
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<tr>
<td>- Patients with diabetes in the 18-65 year age group had significantly longer lengths of stay when compared to patients without diabetes (( P = 0.0001 ); McCampbell et al., 2002).</td>
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</tr>
<tr>
<td>- Numerous studies have found that TBSA, depth of burn, and inhalation injury are all significant predictors of length of stay (Wong, Ngim, 1995; Ho, Ying, Burd, 2002).</td>
<td></td>
</tr>
<tr>
<td>- Effects of polypharmacy as well as natural effects of aging may contribute to the finding that LOS in elderly patients was not significantly different than those without diabetes in patients ( \geq 65 ) (Justiniano et al. 2015; Attia, Reda, Mandil, Arafà, &amp; Massoud, 2000).</td>
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<tr>
<td>- Whole sample patients with diabetes had significantly more intensive care unit days (7.30 vs. 5.59 days; ( p &lt; .0001 )).</td>
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<tr>
<td>- ( &lt; 65 ) with diabetes had significantly more intensive care unit days (6.47 vs. 5.15 days; ( p &lt; .0001 )).</td>
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</tr>
<tr>
<td>- 18-&lt; 40 years of age and diabetes had significantly longer ICU LOS</td>
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<tr>
<td>- No studies found comparing burn patients with and without diabetes and in relation to ICU days.</td>
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</tr>
</tbody>
</table>
(\(p = 0.0007\)).
- > 40-< 65 years of age and diabetes had significantly longer ICU LOS (\(p < .0001\)).

<table>
<thead>
<tr>
<th>Charges</th>
</tr>
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<tbody>
<tr>
<td>• Whole sample higher adjusted charges ($139,764 vs. $104,461; (p &lt; 0.0001)).</td>
</tr>
<tr>
<td>• &lt; 65 higher adjusted charges ($130,697 vs. $100,818; (p = 0.0001)).</td>
</tr>
<tr>
<td>• 18&lt;-40 years of age and diabetes had significantly higher adjusted charges ((p = 0.0009)).</td>
</tr>
<tr>
<td>• &gt; 40-&lt;65 years of age and diabetes had significantly higher adjusted charges ((p &lt; .0001)).</td>
</tr>
<tr>
<td>• (\geq 65) significantly higher charges ($160,336 vs. $127,487; (p = 0.0033)).</td>
</tr>
</tbody>
</table>

- Hospital charges higher in patients older than 65 years of age when compared with their younger cohorts (Pham et al., 2009).
- Cost of patients with diabetes in the United States in 2012 was 245 billion dollars (ADA, 2014).
- Comparison of burn patients to matched controls in the ICU found no difference in the mean ICU daily charges and no mention of diabetes status (Patel et al. 2010).
- To date, no studies have compared the hospital charges of Burn patients with diabetes.