# EMERGING CHALLENGES IN ACUTE CARE FOR OLDER ADULTS

A Dissertation

by

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ABSTRACT

The population of older adults (aged 65 years and above) in the United States, as a proportion of the population, is increasing. Between 1900 and 2010, a 300 percent increase in the proportion of this group was recorded. The disproportionate growth in this segment of the population comes with an unprecedented impact on the US health care system, mostly because the older adults consume a larger share of American health care services. This dissertation explores the trend in hospitalizations for traumatic brain injury for this population over a 12-year period, the likelihood that an older adult admitted to the hospital will acquire *Clostridium difficile* before discharge, the role of hospital in hospital acquired *Clostridium difficile* infection, and the impact of Medicare Part D on preventable hospitalization.

Our results indicate that traumatic brain injury hospitalizations occur at a disproportionate rate – approximately 58 times more hospitalizations per 10,000 populations for older adults. In addition, the rate at which older adults are hospitalized for TBI increased at a significantly higher rate – most especially patients within the age group of 75 to 84 years – than any other age group over the study period. Approximately 55 percent of all cases of TBI hospital discharges are fall related. The results also show that 60 percent of all hospital discharges with a diagnosis of hospital acquired *C. difficile* infection occurred in those above 65 years, surgical procedure did not affect whether or not a patient acquired *C. difficile* infection in hospital, and that the driving factors of hospital acquired *C. difficile* may be more attributable to individual characteristics than

hospital characteristics. Finally, the results also show that that the implementation of Medicare Part D in 2006 was associated with an increased uptake in older adults who had coverage for outpatients drug prescription, and that the increase in coverage reduced potentially preventable hospitalization by 40 percent for medication sensitive condition but no significant change in non-medication sensitive hospitalization.

## DEDICATION

I, first, must dedicate this dissertation to God for the gift of life and protection through this entire journey from start to finish. A very special dedication to my loving wife, Chinwe, and our “yet to be born” child. Babe, you stood by me through the most difficult times and the sleepless nights in the office. I have never made a better decision. I love you so much and can never thank you enough for providing comfort and encouraging words. I also dedicate this dissertation to my parents, Anthony and Cordelia Nwaiwu, for making the sacrifices and for instilling the work ethics and desire in me to pursue this dream. Your words of encouragement, guidance, and prayers saw me through the years. I want to appreciate my sisters, Ijeoma Ihekwoeme and Ngozi Opara, and their husbands, Felix Ihekwoeme and Oby Opara. They were a constant source of inspiration and support for me throughout the process. And to my brothers, Chuma, Emeka, and Chidi, you stood by me through the countless hours of “viber” calls and believed in me. Chuma, I couldn’t be happier having you as an elder brother. I wouldn’t trade you for anything in the world. You are indeed a pillar of support. Emeka and Chidi, I know I can always count on both of you. Much thanks also to Frances and Juliet.

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# NOMENCLATURE

| | |
|---|---|
| TBI | Traumatic Brain Injury |
| PPH | Potentially preventable hospitalization |
| CDI | *Clostridium Difficile* Infection |
| H. Hlth | Home Health |
| Med Fac. | Medical Facility |
| Nurs.Fac. | Nursing facility |
| *C. difficile* | *Clostridium difficile* |
| MSA | Metropolitan Statistical Area |
| FEHBP | Federal Employees Health Benefits Program |
| CMS | Centers for Medicare & Medicaid Services |

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# CHAPTER I

# INTRODUCTION

## OVERVIEW

The population of older adults (aged 65 years and above) in United States, as a proportion of the population, is increasing. In 2010, this group made up 13 percent of the entire population (West, 2014). This represents over a 300 percent increase in the proportion of elderly from 1900 when this group constituted 4.1 percent of the population. This is due to a combination of factors including both a declining fertility rate and a 20-year increase in the average life span during the second half of the 20th century (United Nations. Dept. of Economic, 2002).

The proportion of older persons in the U.S. population is expected to continue rising as more Baby Boomers (those born between 1946 and 1964) turn 65, and it is projected that by 2050, the population over 65 will comprise 20.9 percent of the population (West, 2014). The disproportionate growth in this segment of the population comes with an unprecedented impact on the US health care system, mostly because the older adults consume a larger share of American health care services, and also because of the reduction in the proportion of people in the health sector actively working as more health care workers retire.

The changes associated with aging may affect the physical, psychological, cognitive (Carstensen & Hartel, 2006), social, and cultural wellbeing of the elderly. The process of aging has been defined as an intrinsic, progressive, and generalized physical deterioration that occurs over time, starting at about the age of reproductive maturity (Austad, 2001). The physiological changes that occur due to aging results in declines in both speed and power of aerobic and anaerobic exercises (Douglas & O'Toole, 1992; Westerterp & Meijer, 2001). Physically, functioning of the body tends to slow down, muscles and bones become weaker, and reflexes are slowed. Older adults may also experience cognitive decline either due to disuse, physical illness, or actual neurobiological changes with age that will contribute to deterioration of cognitive abilities (Zec, 1995).

Studies have shown that normal aging affects the acquisition and retrieval of new information from secondary memory and the functioning of working memory (Fozard, 1980; Huppert, 1994; Kaszniak, 1986). Psychologically, older adults may experience some anxiety if they experience memory loss and or impaired cognitive functioning. Social isolation may affect greater proportion of the elderly as a result of a series of life changes—retirement, death of a spouse or significant other, children getting married and leaving homes, and chronic health conditions. Individual lifestyle choices, genetics, and environment may determine the onset, course, direction and sequence of changes associated with aging.

Adults over 65 years of age have a higher likelihood of developing chronic illnesses and health related disability. The relationship between chronic disease and development of disability in older adults is often complex and multifactorial with some studies suggesting that co-morbid chronic diseases are significant risk factors for developing disabilities (Verbrugge & Jette, 1994). Eighty percent of American 65 years or older have one form of chronic condition that requires regular care and maintenance (Jeannotte & Moore, 2007). The rise in chronic conditions for the elderly is expected to continue and it is estimated that by 2030, more than 60 percent of the Baby Boomers will be managing more than one chronic condition (Wolff, Starfield, & Anderson, 2002). This will add to the growing concerns and need for improved access and quality of healthcare for older adults.

In addition, acute care conditions in the elderly have been a cause of concern for health care policymakers. In 2003, older adults greater than 65 years had more hospital stays than any other age group, accounting for one in three hospital stays and approximately 44 percent of the national hospital bill (Hyder, Wunderlich, Puvanachandra, Gururaj, & Kobusingye, 2007a; C. A. Russo & Elixhauser, 2006) despite making up only 12 percent of the population. Older adults are also five times more likely to die while in hospital compared to those younger than 65 years (Hyder et al., 2007a; Hyder, Wunderlich, Puvanachandra, Gururaj, & Kobusingye, 2007b). The higher rate of hospitalization and mortality may be due to the effects of aging in weakening the body's immune system and rendering it defenseless against pathogens.

This has contributed to the considerable increase in the proportion of older adults 65 years or older in the United States. The higher proportion of older adults would potentially lead to strains in the budget of the government insurance programs (Medicaid and Medicare) as elderly persons use health care services at a greater rate than younger persons. The per capita health care cost for persons aged 65 years or greater in the United States and other developed countries is 3 – 5 times greater the cost for persons less than 65, and the rapid growth in the number of older persons, coupled with continued advances in medical technology, is expected to create upward pressure on health and long-term care spending (Jacobzone & Oxley, 2002). Some studies have predicted that the Medicare expenditure will double by 2040 from 1987 (Schneider & Guralnik, 1990). For this reason, cost containment efforts should be made to reduce the high cost associated with acute medical care of older adults.

The federal government has made some changes to its reimbursement system to provide hospitals with better incentive to contain cost and increase efficiency. Reimbursement for care provided to Medicare patients is currently through the prospective payment system. Under this system, specific fixed prospective payments defined by admitting diagnosis related groups are used to reimburse hospitals. Though this has be relatively successful in reducing certain health care cost in the past (Altman & Rodwin, 1988), cost containment alone will not be sufficient to reduce the overall impact of the aging population on health care costs (Schneider & Guralnik, 1990). Prevention has been proposed as the best alternative to cure and treatment, so it is imperative that researchers focus on identifying preventable causes of acute care conditions in the elderly, help formulate appropriate policies to address them before they arise, and in the process reduce overall cost of care. To achieve this, continued research must improve the efficacy and outcomes of existing management guidelines of acute care conditions. As such, researchers must almost strive to identify other health care cost drivers, develop more cost effective management, and to the extent possible, create a heathy social and healthy lifestyle that helps the body's immune system to fight pathogen or resist infection.

## PURPOSE OF STUDY

The more frequent causes of hospitalization in the older adults - like congestive heart failure, pneumonia, acute cardiac conditions including Coronary atherosclerosis, Cardiac dysrhythmias, and acute myocardial infarction – have received the greatest attention in policy circles. Other important issues have received less attention. Researchers have placed less emphasis on traumatic brain injury in the elderly, *Clostridium difficile*, and potentially preventable hospitalizations.

In this manuscript, I investigate three major issues of public health concerns in older adults:

- The rate of change in the incidence of traumatic brain injury for the elderly,
- Differences in older adults admitted with or without *Clostridium difficile* infection and the role of the hospital in hospital-acquired *Clostridium difficile* infection, and
- The impact of Medicare Prescription Drug, Improvement, and Modernization Act of 2003 on potentially preventable hospitalizations related to medication utilization.

First, I demonstrate the differential rate of increase in the incidence of traumatic brain injury using longitudinal data. Second, I explore the individual characteristics that increase the likelihood a patient admitted to hospital without a diagnosis of *C. difficile* infection will acquire the infection before discharge. Third, I examine the impact of expanding prescription drug coverage for medical conditions that are “medication sensitive” on preventable hospitalizations due to these conditions.

## ORGANIZATION OF DISSERTATION

This dissertation is organized into five separate chapters. Chapter I introduces the emerging challenges in acute care for older adults and briefly examines the scientific literature on overall health issues as it relates to those over 65. Chapter II, III, and IV respectively address the three major public health issues for older adults mentioned under the purpose of the study. Each chapter is presented in journal style format – background, methods, results, discussion, limitations, and conclusion. Chapter II specifically explores the incidence, trend, and rate of change in the incidence of traumatic brain injury among adults 65 and over discharged from hospitals in Texas from 1999 to 2010. Chapter III, on the other hand, looked at older adults and *Clostridium difficile* infection in hospitals, with the intent of finding the differences in patients admitted with or without the infection, and exploring the role of hospital in hospital acquired *Clostridium difficile* infection. Chapter IV focusses on the impact of passing or changing legislation and its effects on the health of older adults. Here we looked precisely at the impact of Medicare Prescription Drug, Improvement, and Modernization Act of 2003 – also known as Medicare Part D – on potentially preventable hospitalization for this population. Finally, we conclude with Chapter V, where we give an overview and public health implication of these acute care challenges for older adults.

## CHAPTER II

## EXPLORING THE INCIDENCE, TREND, AND RATE OF CHANGE IN HOSPITAL DISCHARGES AMONG ADULTS OVER 65 WITH TRAUMATIC BRAIN INJURY IN TEXAS

### BACKGROUND

Traumatic brain injury is emerging an important public health problem worldwide especially for older adults. An estimated 10 million people worldwide suffer from traumatic brain injury (TBI) every year (Zhou et al., 2013). It is a leading cause of death and disability among children, young adults, and the elderly. The standard definition, according to CDC published Guidelines for Surveillance of Central Nervous System Injury (Thurman, Sniezek, Johnson, Greenspan, & Smith, 1995) in 1995, can be summarized as an occurrence of injury to the head (arising from blunt or penetrating trauma or from acceleration–deceleration forces) that is associated with symptoms or signs attributable to the injury. The symptoms include decreased level of consciousness, loss of memory, other neurological or neuropsychological abnormalities, skull fracture, diagnosed intracranial lesions—or death. In recent years, the global burden of TBI has been rising and it is expected to become the third largest cause of global disease burden by 2020 (Faul, Xu, Wald, & Coronado, 2010).

In the United States, TBI is also a leading cause of death and disability among children, young adults, and the elderly and it accounts for about 1.7 million incidences every year (Langlois, Rutland-Brown, & Wald, 2006). Of the people who sustain a TBI annually, 52,000 die, 275,000 are hospitalized, and 1.365 million (nearly 80 percent) are treated and released from an emergency department (Langlois et al., 2006). In 2010, TBI, in association with other injuries, accounted for 2.5 million emergency department visits, hospitalizations, or death (Centers for Disease Control and Prevention (CDC) & Centers for Disease Control and Prevention (CDC), 2014; Langlois, Rutland-Brown, & Thomas, 2004). These estimates, which are conservative at best, are based on emergency department visits, hospitalizations, and death. They do not include estimates for the number of people with non-fatal TBI seen outside of an emergency department of hospital or who receive no care at all (Langlois et al., 2006). The true incidence of TBI is widely acknowledged to be higher than available estimates (Ribbers, 2007; Tate, McDonald, & Lulham, 1998; Zhou et al., 2013) because 70–90 percent of all TBIs are mild, (Ribbers, 2007) with only a small proportion of those affected by mild TBI being admitted to a hospital (Cassidy et al., 2004). More serious TBI is responsible for a third of all injury-related hospital deaths, and approximately 5.3 million Americans live with TBI associated disability (von Hoist, 2007).

While infants and children aged 0-4 and adolescents aged 15-19 years have the highest risk for sustaining a TBI, the older adults aged 75 years and above have the highest rates of TBI-related hospitalization and death (Langlois et al., 2004). Older patients have a higher rate of mortality secondary to non-penetrating head injury (Thompson, McCormick, & Kagan, 2006), and age has been shown to be an independent predictor of mortality in isolated traumatic brain injury (Finkelstein, Corso, & Miller, 2006; Mosenthal et al., 2002). Among the elderly (persons aged 65 and older), TBI is responsible for more than 80,000 emergency department visits each year, approximately three-quarters of which result in hospitalization (Finkelstein et al., 2006). The body physiology makes the recovery process in the elderly slower and the probability of death from TBI higher than in younger people.

The financial burden of TBI is enormous for the US health care system. Injuries that occurred in year 2000 were estimated to cost the U.S health care system $80.2 billion in medical care costs: 1.1 billion for fatal injuries; $33.7 billion for individuals who were hospitalized for TBI; and $45.4 billion for non-hospitalized injuries, with 70 percent ($31.7 billion) of the non-hospitalized cost attributable to injuries related to the emergency department use (Finkelstein et al., 2006). In addition, TBI is associated with a significant emotional burden on the caregivers and families of those injured. Aitken and colleagues found a strong association between perceived caregiver burden and the severity of children's functional impairments after a TBI, most especially in caregivers with perceived unmet health care needs (Aitken et al., 2009).

Previous studies have focused on traumatic brain injury outcomes (Gan, Lim, & Ng, 2004; Rapoport & Feinstein, 2000; Rutland-Brown, Langlois, Thomas, & Xi, 2006; Susman et al., 2002; Thompson et al., 2006), incidence (Rutland-Brown et al., 2006), and epidemiology (Bruns & Hauser, 2003; Thompson et al., 2006) of traumatic brain injury. This research focuses on the rate of change in the incidence of traumatic brain injury for older adults. The need to study TBI in older adult is urgent given the disproportionate rate at which TBI occurs in this population and the unsatisfactory outcomes including high mortality and morbidity (Mosenthal et al., 2002; Susman et al., 2002). This research can be considered exploratory, in that no published study has yet described the rate of change in the incidence of traumatic brain injury for this population over a comparable period using hospital discharge data.

This study used hospital discharge data from Texas for 1999 through 2010 to:

- estimate the incidence of traumatic brain injury,
- describe the trend in traumatic brain injury hospitalization rates over the study period,
- investigate the distribution by gender, race, severity and outcome, and
- analyze the rate of change in the incidence over time for the older adults above 65 years.

## METHOD

### Data source

Data for this study were obtained from the Texas hospital inpatient discharge public use data file, a publicly available database maintained by the Texas Health Care Information Council (THCIC) (Texas, 2012). The Texas Health Care Information Council (THCIC) is responsible for collecting hospital discharge data from all state licensed hospitals. Some hospitals are exempt from this requirement and they include those located in a county with a population less than 35,000, or those located in a county with a population more than 35,000 and with fewer than 100 licensed hospital beds and not located in an area that is delineated as an urbanized, and hospitals that do not seek insurance payment or government reimbursement (Texas, 2012).

This database contains records of approximately three million discharges annually. All discharge records include a list ICD 9 diagnosis and procedure codes along with other information including source of admission, external cause of injury, type of admission and discharges, patient's demographic information, and descriptive information about the discharging hospital. The Institutional Review Board at Texas A&M University approved the use of this database for this study (IRB2013-0022M).

Measurements

A sample of study subjects with a diagnosis of traumatic brain injury were selected by reviewing discharge records from January 1, 1999 to December 31, 2010, to identify hospital discharges with a recorded ICD-9-CM diagnosis code indicating a brain injury. Relevant ICD-9-CM diagnosis includes fracture of vault of skull (800), fracture of base of skull (801), other skull fractures (803), and multiple fractures involving skull or face with other bones (804). Others include concussion (850), cerebral laceration and contusion, subdural, subarachnoid, and extradural hemorrhage after injury (851), other unspecified intracranial hemorrhage after injury (852), intracranial injury, not otherwise specified (853). In addition, any late effects of fracture of the skull and face (905.0), intracranial injury without skull fracture (907.0), and other open wound to the head (873) were included in the sample. Note that in 2004, the number of spaces available to record secondary diagnostic codes for hospital admissions increased from 8 to 24 making it possible to identify more TBI cases.

The TBI incidence rates per 10,000 populations were calculated using US Census Bureau (US Census, 2013) intercensal population estimates for the years 1999, 2001-

2009 as denominators. The intercensal demographic estimates of population are generated from complex models joining administrative records with data from the previous census (Methodology, 2010) and are thought to supersede postcensal estimates(Lazarus, Autry, Baio, Avchen, & Braun, 2007). For years in which Census was conducted (i.e. 2000 and 2010), I used the actual census estimates (US Census, 2013) of the county population as denominators in this analysis.

In addition, I utilized the existence of ICD-9-CM supplementary classification of external cause of injury and poisoning ("E-codes") as an indication of an acute event. These codes were considered to indicate hospitalizations for an acute event, when present, rather than hospital readmission for previous injury. To allow for easy comparability of the findings with other studies, I adopted the framework by the International Collaborative Effort (ICE) on Injury Statistics developed in 1996 for displaying the mortality data (Centers for Disease Control and Prevention (CDC) & Centers for Disease Control and Prevention (CDC), 2014). This 'matrix' format allows data to be presented simultaneously by cause (mechanism of injury) and intent (manner of injury). "Other" causes of TBI injury include any injury in the category; firearm, poisoning, suffocation, drowning, fire/burn, cut/pierce, machinery, natural environment, others not specified and others specified. Motor vehicle crash injuries include the following; motorcyclist, pedal cyclist, pedestrian, unknown, other, other pedal cyclist, other pedestrian. In Texas, requirement for reporting E-Codes became available in 2004. Therefore, report of cause (mechanism of injury) and intent (manner of injury) of traumatic brain injury in the study are only present for 2004 – 2010. The number of hospitalizations for traumatic brain injury was used as the denominator in calculating the rate of hospitalizations by mechanism of injury.

Total cost of hospitalizations was estimated from billed charges using facility-specific ratio of costs to charges (RCCs). These costs do not necessarily reflect payments by Medicaid, Medicare, or other payers. Missing RCCs were imputed to be 0.3, approximately the median RCC for Texas hospitals. To account for inflation and to allow comparability of cost between multiple years, all costs in this analysis were converted to 2015 dollars using the Medical Care component of the Consumer Price Index.

Data analysis

Data were analyzed using SAS 9.3. First, I examine the trend in overall TBI discharges per 10,000 populations stratified by five age groups ('00 to 17', '18 to 39', '40 to 64', '65 to 74', and '75+'). Then I report the hospitalization rates by gender and race/ethnicity of traumatic brain injury in the population per 10,000 for those above 65 and those below 65 in 1999 and 2010.  I also present descriptive statistics, for the two age groups, of all discharges with a diagnosis of TBI by source of admission, severity, discharge status, lengths of stay, costs, mechanism of injury, intent of injury, and comorbidities. Second, I analyzed the rate of change in incidence for the same age group by gender, race, ethnicity, and mechanism of injury over a 12-year period. To further identify the age group within the older adult that has the higher rate of change in incidence of TBI over time, I further sub categorized adults over 65 years into three categories; 65 – 74, 75 – 84, and above 85years.

Finally, due to the correlated nature of the discharge data, in which a patient can have multiple discharges from different hospitals, a crossed random effects multilevel longitudinal data analysis to explore the factors associated with increasing costs, length of stay, and hospital mortality in patients with Traumatic brain injury. The facility provider name was included in the model as a random effect. The fixed effects include all the independent variables mentioned earlier (patient demographics; comorbidity; severity of injury; facility information; source of admission, discharge status, and lengths of stay; and co-diagnosis, procedures, and use of specialty units).

## RESULTS

The descriptive analysis presented in Table 2.1 reveals that in 1999, the rate of hospitalizations for males younger than 65 years of age with traumatic brain injury was almost double (31 hospitalizations per 10,000 populations) the rate for females (16 hospitalizations per 10,000 populations). In contrast, for those above 65 years, the rate of hospitalizations for males (46 hospitalizations per 10,000 populations) was 11 percent lower than for females (52 hospitalizations per 10,000 populations). By 2010, though the rate of hospitalizations for males and females less than 65 years of age with traumatic brain remained essentially unchanged, the rates for those above 65 years showed an increase of 53 percent for males to 71 hospitalizations per 10,000 populations and an increase of 50 percent for females to 77 hospitalizations per 10,000 populations.

The change in hospitalization rates for whites over 65 years increased 64 percent from 29 hospitalizations per 10,000 populations in 1999 to 48 hospitalizations per 10,000 populations in 2010. Only Native Americans of the same age group had greater increase (187 percent) in hospitalization rates (from 38 hospitalizations per 10,000 populations to 110 hospitalizations per 10,000 populations) for traumatic brain injury than whites. Asians or Pacific Islanders had the lowest hospitalization rates for both years (15 per 10,000 hospitalizations in 1999 and 18 per 10,000 hospitalizations in 2010), with an increase of 21 percent in hospitalization rate from 1999 to 2010. Blacks over 65 years were hospitalized for traumatic brain injury in 1999 at the rate of 19 hospitalizations for every 10,000 populations. In 2010 the rate of hospitalizations for blacks increased 37 percent to 26 hospitalizations for every 10,000 population. The trend for Hispanics greater than 65 years followed the same pattern increasing from 23 to 36 hospitalizations per 10,000 populations.

**Table 2. 1: Characteristics of patients discharged from hospitals in Texas for traumatic brain injury by age groups, 1999 & 2010**

| | Traumatic Brain Injury Hospitalizations | | | | Change | |
|---|---|---|---|---|---|---|
| | 1999 | | 2010 | | | |
| | Age<65 | Age>=65 | Age<65 | Age>=65 | Age<65 | Age>=65 |
| Overall Rate | | | | | | |
| Gender (per 10,000) | | | | | | |
| Male | 30.66 | 46.38 | 31.99 | 70.73 | 1.33 | 24.35 |
| Female | 15.58 | 51.71 | 15.52 | 77.34 | -0.06 | 25.63 |
| Race/Ethnicity (per 10,000) | | | | | | |
| White | 9.19 | 29.11 | 11.15 | 47.61 | 1.96 | 18.5 |
| Black | 8.38 | 18.89 | 8.89 | 25.82 | 0.51 | 6.93 |
| Hispanic | 7.34 | 22.94 | 7.27 | 35.71 | -0.07 | 12.77 |
| Asian and NH/PI | 2.05 | 14.80 | 2.54 | 17.97 | 0.49 | 3.17 |
| Amer Indian/AN | 2.72 | 38.38 | 13.47 | 110.20 | 10.75 | 71.82 |
| Other | | | 35.65 | 339.91 | | |
| *Mechanism/Cause of Injury (%) | 2004 | | | | | |
| Motor Vehicle Crash | 36.32 | 8.24 | 30.58 | 6.05 | -5.74 | -2.19 |
| Other | 13.65 | 4.23 | 17.08 | 4.77 | 3.43 | 0.54 |
| Fall | 14.19 | 50.01 | 20.05 | 55.01 | 5.86 | 5 |
| Struck by/against | 7.12 | 1.53 | 7.12 | 1.26 | 0 | -0.27 |
| Missing | 28.71 | 35.99 | 25.17 | 32.91 | -3.54 | -3.08 |
| *Manner/Intent of Injury (%) | 2004 | | | | | |
| Unintentional | 65.31 | 67.81 | 67.22 | 70.83 | 1.91 | 3.02 |
| Suicide | 0.99 | 0.28 | 1.24 | 0.25 | 0.25 | -0.03 |
| Homicide | 9.53 | 0.98 | 9.83 | 0.80 | 0.30 | -0.18 |
| Other | 0.12 | 0.01 | 0.20 | 0.02 | 0.08 | 0.01 |
| Undetermined | 0.58 | 0.16 | 0.66 | 0.09 | 0.08 | -0.07 |
| Missing | 23.46 | 30.75 | 20.86 | 28.01 | -2.60 | -2.74 |
| Source of Admission (%) | | | | | | |
| Hosp. /Other med. fac. | 10.02 | 13.57 | 14.20 | 17.17 | 4.18 | 3.6 |
| Pri. care | 14.50 | 22.91 | 49.67 | 48.84 | 35.17 | 25.93 |
| Nursing fac. | 0.16 | 0.53 | 1.21 | 1.85 | 1.05 | 1.32 |
| Emergency Room | 74.51 | 62.37 | 32.09 | 29.78 | -42.42 | -32.59 |
| Other/Unknown | 0.57 | 0.57 | 2.31 | 1.98 | 1.74 | 1.41 |
| Comorbidity (%) | | | | | | |
| No Comorbidity | 59.96 | 20.83 | 36.20 | 6.29 | -23.76 | -14.54 |
| One Comorbidity | 27.75 | 40.33 | 31.89 | 29.58 | 4.14 | -10.75 |
| More than one comorbidity | 12.29 | 38.84 | 31.92 | 64.14 | 19.63 | 25.3 |

*The earliest year for which complete data was available was in 2004

Table 2.1: Continued

| | Traumatic Brain Injury Hospitalizations | | | | Change | |
|---|---|---|---|---|---|---|
| | 1999 | | 2010 | | | |
| | Age<65 | Age>=65 | Age<65 | Age>=65 | Age<65 | Age>=65 |
| Discharge Status (%) | | | | | | |
| Home | 77.20 | 39.09 | 73.63 | 30.55 | -3.57 | -8.54 |
| Hosp /othr Med Fac. | 11.83 | 19.06 | 11.72 | 17.34 | -0.11 | -1.72 |
| Nurs.Fac./H. Hlth | 5.98 | 32.88 | 9.07 | 41.00 | 3.09 | 8.12 |
| Hospice or Expired | 4.96 | 8.92 | 4.27 | 10.62 | -0.69 | 1.7 |
| Length of hosp. stay (days) | | | | | | |
| Median | 4.00 | 5.00 | 4.00 | 5.00 | 0 | 0 |
| Mean | 8.53 | 8.33 | 8.30 | 7.09 | -0.23 | -1.24 |
| Std | 19.03 | 11.29 | 20.69 | 7.62 | | |
| *Cost ($) | 2004 | | | | | |
| Median | 8,025.44 | 7,565.48 | 11,428.05 | 10,609.36 | 3,402.61 | 3,043.88 |
| Mean | 15,944.80 | 13,270.63 | 22,423.33 | 16,949.94 | 6,478.53 | 3,679.31 |
| Std | 24,965.74 | 36,580.61 | 35,326.35 | 23,231.22 | | |

*The earliest year for which complete data was available was in 2004

The mechanism of injury in 50 percent of all cases of traumatic brain injury hospitalizations occurred secondary to falls in those above 65 years in 2004. In 2010, falls accounted for 55 percent of all TBI for the same age group. In contrast, Motor Vehicle Transport was the major cause of TBI hospitalizations for those below 65 in 2004 (36 percent) and 2010 (31 percent) with falls contributing the second major cause of hospitalizations. Over 60 percent of all hospitalizations secondary to TBI were unintentional. However, 10 percent of all TBIs were due to homicide in those below 65 in 2004 and 2010. In 1999, 60 percent of all TBI hospitalizations for those below 65 and 21 percent of all TBI hospitalizations for those above 65 occurred in patients with no associated comorbidity. In 2010, the percentage of TBI hospitalizations for patients with no comorbidity decreased for both age groups with 36 percent and 6 percent of hospitalizations having no comorbidity for those below and above 65. On the other end of the spectrum, hospitalizations associated with two or more comorbidities increased for both age group categories over the two time periods.

Seventy-seven percent of all hospitalizations secondary to TBI for patients less than 65 years were discharged home compared to 39 percent of hospitalizations for those above 65 years in 1999. Thirty three percent of those patients were discharged to a nursing facility or home health. In 2010, 41 percent of the older adults were discharged to a nursing facility or home health while only 31 percent were discharged home. Eleven percent of those above 65 years admitted with traumatic brain injury were discharged to hospice care or died in hospital, an increase of 19 percent from 1999. The length of stay for patients admitted for traumatic brain injury for the study period did not change from 1999 to 2010 for the both age categories in this analysis. However the older adults had a higher median length of hospital stay (5 days) than those less than 65 years (4 days). Likewise, the mean length of hospital stay was also higher in the older age category.

The 2015 adjusted cost of TBI hospitalization for older adults was less than the cost for those under 65 years for both years in table 2.1(1999 and 2010). The average cost of hospitalization for traumatic brain injury for older adults in 1999 was $13,271 and $15,945 for those below 65. However, the cost of TBI hospitalizations has increased over the years, with the average cost in 2010 increasing by $6,479 and $3,679 for those below and above 65 years respectively. The median costs for both groups follow similar but more modest trends in cost. The median costs for treating older adults increased 40 percent from 1999 to 2010. Figure 2.1 shows the trend in annual rates of discharges for traumatic brain injury by age category per 10,000. The result indicates that traumatic brain injury in Texas has been on a rising trend over the study period for those over 65 years.

Table 2.2 shows a longitudinal analysis of the rate of TBI hospitalization per 10,000 populations. After controlling for covariates, there was a statistically significant difference in the baseline hospitalization rates for gender ($p=0.03$) and age ($p<0.0001$). At baseline (in 1999), the adjusted hospitalization rate for those below 65 years was 0.75 per 10,000 populations (approx. 8 hospitalizations per 100,000 populations). In contrast, the hospitalization rate for those above 65years was 57.59 per 10,000 populations (approx. 576 hospitalizations per 100,000 populations). At the same time, the sex adjusted hospitalization rate for TBI for females was lower ($p = 0.03$) from the sex adjusted incidence rate per 10,000 of the male population. At baseline also, despite the lower rates of TBI hospitalizations for Blacks, Asians and Pacific Islander, and Hispanics, the race adjusted TBI incidence rates for Blacks, Native Americans, Asians and Pacific Islander, and Hispanics were not significantly different from the hospitalization rates for Whites after controlling for other factors.

From 1999 to 2010, the overall rate of hospitalization for TBI decreased annually by 0.88 per 10,000 populations (a decline of approximately 9 hospitalizations per 100,000 populations) for those below 65 years. This was however not significant ($p =0.4469$). On the contrary, there was a statistically significant increase ($p=0.0463$) in hospitalizations for those above 65 years by 2.77 hospitalizations per 10,000 populations (approximately 28 hospitalizations per 100,000 populations) per year.

**Figure 2. 1: Trends in annual rates of discharges of persons aged 65 years or older compared to other age groups**

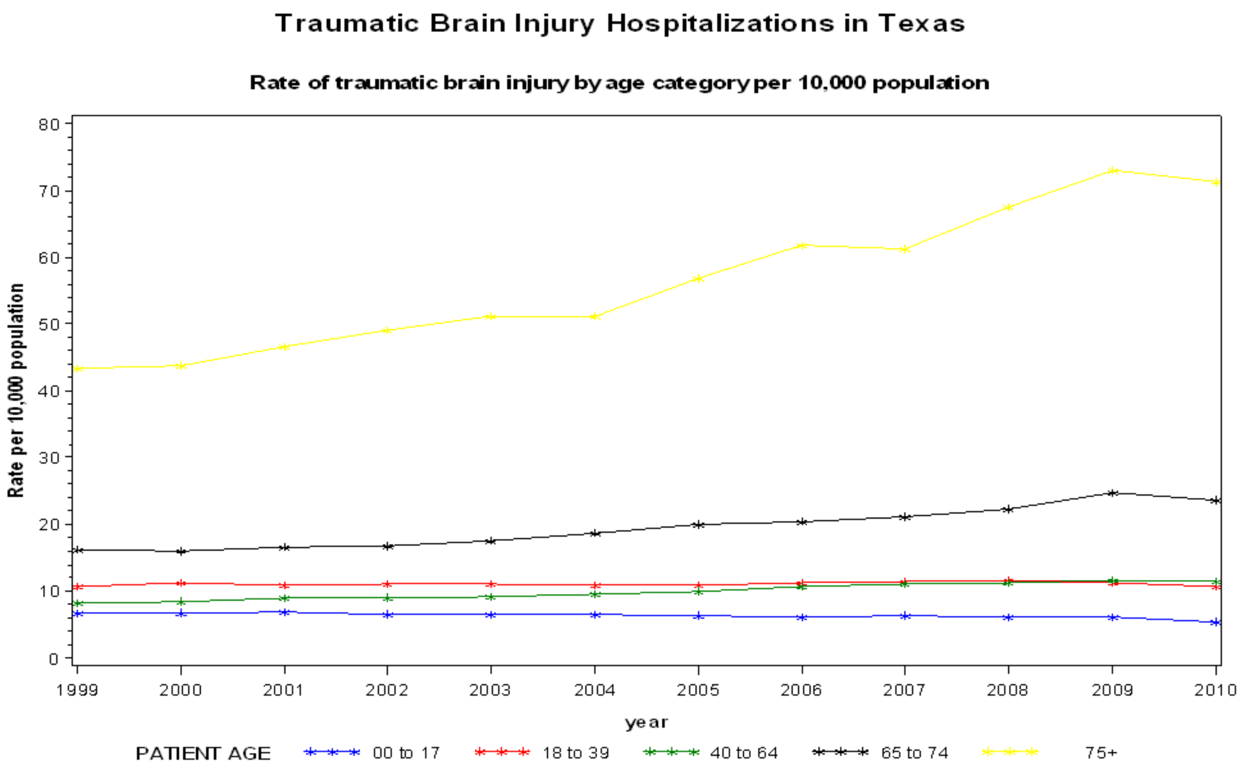


**Table 2. 2: Rate of change in incidence of TBI over time for each age group by race, ethnicity, and gender**

| Effect | Estimate | Std.Error | P value |
|---|---|---|---|
| Female | -13.1536 | 6.1024 | 0.0315 |
| 1. 65 and Above | 56.8404 | 12.0135 | <.0001 |
| Amer Indian/AN | 7.0080 | 10.6588 | 0.5111 |
| Asian and NH/PI | -8.7310 | 10.4218 | 0.4025 |
| Black | -6.6941 | 10.4218 | 0.5209 |
| Hispanic | -4.2920 | 10.4218 | 0.6806 |
| Other | 161.48 | 10.6654 | <.0001 |
| Time | -0.8756 | 1.1505 | 0.4469 |
| Interaction of time and age '65 and above' | 3.6461 | 1.8265 | 0.0463 |

Table 2.3 reveals the result of longitudinal analysis of the rate of TBI hospitalizations with age categorized into 4 groups (0 – 65 years, 65 – 74 years, 75 – 84 years, and above 85years) to identify the subgroup of older adults with the most significant change in rate of TBI hospitalizations. This analysis indicates that, though the hospitalization rates increased in general for older adults greater than 65 years, only adults between the ages of 75 years and 85 years had a statistically significant increase (p=0.004) in rate of TBI hospitalization over the study period when compared to those below 65 years.

**Table 2. 3: Rate of change in incidence of TBI over time for four age group categories**

| Effect | Estimate | Std.Error | P value |
|---|---|---|---|
| Female | -11.0948 | 3.0376 | 0.0003 |
| 1. 85+ | 30.1976 | 8.2574 | 0.0003 |
| 2. 75 to 84 | 51.1172 | 8.2440 | <.0001 |
| 3. 65 to 74 | 19.6800 | 8.3505 | 0.0187 |
| Amer Indian/AN | 6.1888 | 5.3208 | 0.2451 |
| Asian and NH/PI | -7.2758 | 5.1811 | 0.1606 |
| Black | -5.5785 | 5.1811 | 0.2819 |
| Hispanic | -3.5767 | 5.1811 | 0.4902 |
| Other | 134.55 | 5.3022 | <.0001 |
| Time | -0.7244 | 0.6265 | 0.2479 |
| Interaction of time and age '85 +' | 2.3462 | 1.2558 | 0.0621 |
| Interaction of time and age '75 to 84' | 3.5852 | 1.2551 | 0.0044 |
| Interaction of time and age '65 to 74' | 1.4812 | 1.2644 | 0.2418 |

DISCUSSION

The results show that hospitalizations for traumatic brain injury occur at a disproportionately higher rate in older adults (58 hospitalizations per 10,000 populations in older adults versus 1 hospitalization per 10,000 populations in the younger ones) and the hospitalization rates increased over the 12 year study period. This finding is consistent with previous published research showing older adults as having the highest rates of TBI hospitalizations (Langlois et al., 2004). In addition to the disproportionately higher rate, longitudinal analysis reveals that the rate at which traumatic brain injury occur in older adults increased at a significantly higher rate over the study period than in those below 65 (p value = 0.0463). Further analysis revealed, surprisingly, that TBI hospitalization for patients in the age group “75 to 84” was the major factor contributing to the significant difference in the rate of change in hospitalization over time.

The multivariate analysis (tables 2.2 & 2.3) indicate that females in general have lower rates of traumatic brain injury hospitalizations than males ($p=0.03$), after controlling for other covariates at the baseline (1999). This finding has been documented in previous literature (Bruns & Hauser, 2003). However, females over 65 have slightly higher TBI hospitalization rates (52 hospitalizations per 10,000 females over 65 in the population) than males over 65 (46 hospitalizations per 10,000 males over 65 in the population). This is in keeping with previous study findings where the rates of hospitalizations for TBI were the opposite in younger age groups for male and female (Coronado, Thomas, Sattin, & Johnson, 2005; Harrison-Felix et al., 2012). A possible explanation to this finding could be that the decline in estrogen levels in post-menopausal women accelerates bone loss and causes trabecular thinning and disconnection, cortical thinning and porosity (Seeman, 2002), and this in turn increases the risk of falls as a result of weakened bones.

The descriptive analysis show that though a higher proportion of older adults get hospitalized with traumatic brain injury, far lower proportion gets discharged. Furthermore, a disproportionately higher number of older adults are discharged to nursing homes, home health facilities or hospice care. This finding is consistent with previous research that identified older age as an independent predictor of worse outcome for TBI (Coronado et al., 2005; Czosnyka et al., 2005; Hukkelhoven et al., 2003).

Previously published studies have given too little or no attention to the rate of change of traumatic brain injury hospitalizations in older adults. In recent times, greater attention has been focused on addressing other causes of traumatic brain injury. For example, since 2007, all 50 states and the District of Columbia have enacted laws to address youth sports concussions (Lowrey, 2015). This is unfortunately not the case for fall related traumatic brain injury, which causes majority of TBI in the elderly. The results show that, while the overall rate of traumatic brain injury is increasing, the rate at which the incidence is increasing is higher for those above 65 year, most especially those between the ages of 75 and 85 years. This result highlights the need for more legislatures addressing TBI in this age cohort and further research into factors that predisposes those within this age group to have a significantly increasing higher rate of hospitalization. It further highlights the importance of developing regular exercise and community-based fall prevention programs, to reduce fall risk factors, as this result provide evidence of the overwhelming role falls play in the development of traumatic brain injury in this population.

## LIMITATIONS

The study had a number of limitations particularly those inherent in the use of retrospective administrative data. Any conclusions drawn from the data may be subject to errors caused by the inability of the hospital to communicate complete data due to form constraints, subjectivity in the assignment of codes, system mapping, and normal clerical error. The data are submitted by hospitals as their best effort to meet statutory requirements, not for research purposes. For instance, some states do not require that race/ethnicity information be collected and as such some hospitals do not code race and ethnicity reliably. We identified subjects and classified TBI based on the basis of ICD-9-CM coding of diagnosis on hospital discharge data. If this coding is inaccurate, patients used in this analysis may have been misidentified as having traumatic brain injury. Therefore, the validity of the research finding is dependent on the accuracy of record keeping by the hospitals included in this study. However, previous published studies have used similar methods in identifying traumatic brain injury cases (McGarry et al., 2002).

Although the change in the data collection instrument in 2004, allowing for increased number of spaces available to record secondary diagnostic codes for hospital discharges, could be responsible for increased incidence of TBI, this is not sufficient to explain the continued rise in trend of TBI incidence post 2004.

The generalizability of the study to the national remains unknown since all hospitals contributing to the study are within Texas; however there is no indication that hospitals within Texas are significantly different from the rest of the nation. The extent to which geographic differences in incidence, costs, and outcomes in TBI will limit the applicability of the findings of the study is yet to be determined.

The costs reported in this study are total costs of hospitalization and will include other inpatient treatment cost not directly related to TBI treatment. The mechanism of injury and the close relationship of TBI with other injuries make separating the costs attributable to only TBI extremely difficult. However, in the multivariate analysis, we accounted for the mechanism of injury and comorbidities, among other factors.

## CONCLUSION

Despite the limitations, this study provides a useful guide into the incidence, cost, and trend associated with traumatic brain injury in older adults in Texas. The results suggests that TBI constitute a significant burden for older adults, there is a growing trend in the rate of TBI discharges, and this rate of change over time is different for sub categories of age groups. Falls and motor vehicle crashes remain the leading cause of TBI in this study. The research indicate that further studies focused on those between 75 - 85 years might be beneficial in identifying the potential factors associated with increasing rate TBI hospitalizations. Policies aimed at addressing these issues may lead to a significant reduction in hospital costs and a reduction in overall mortality.

# CHAPTER III

# OLDER ADULTS AND CLOSTRIDIUM DIFFICILE IN HOSPITALS: EXPLORING THE DIFFERENCES IN PATIENTS ADMITTED WITH OR WITHOUT THE INFECTION AND THE ROLE OF THE HOSPITAL IN HOSPITAL-ACQUIRED CLOSTRIDIUM DIFFICILE

## BACKGROUND

*Clostridium difficile* (*C. difficile*) is a potentially life threatening healthcare-associated infection that presents with watery diarrhea and other intestinal conditions such as colitis and abdominal pain. Individuals suffering from this infection can be found in the community and in many different healthcare setting, including inpatient hospitals. The incidence and mortality associated with *C. difficile* infection has been on the rise. A national prevalence study in 2008 found that 13 of every 1,000 inpatients were either infected or colonized with *C. difficile*, a 6.5 – 20 times increase from previous estimates (Jarvis, Schlosser, Jarvis, & Chinn, 2009). Over the last decade, from 2000 to 2009, the number of hospitalized patients with any CDI discharge diagnoses more than doubled, and the number with a primary CDI diagnosis more than tripled, (Lucado, Gould, & Elixhauser, 2012). The Society of Healthcare Epidemiology of America (SHEA) and the Infectious Diseases Society of America (IDSA) have developed guidelines and infection control measures for hospitals facing *C. difficile* (Cohen et al., 2010; Fletcher & Cinalli, 2007). Despite the guidelines, the rate of *C. difficile* outbreaks continues to increase in hospital settings (McDonald, Owings, &

Jernigan, 2006a). Recent data indicate that *C. difficile* causes approximately one-quarter of a million hospital admissions and 14,000 deaths annually (CDC, 2013).

The risk of a *C. difficile* infection increases with a course of antibiotic treatment combined with any of a variety of factor including: gastrointestinal surgery, a long length of stay in a health care setting, serious underlying illnesses, a compromised immune system, and advanced age (age over 65) (Smith & Ratard, 2011; Jump, 2013). Though *Clostridium difficile* is found in stool of about 5 percent of the general population (McFarland, Mulligan, Kwok, & Stamm, 1989), it generally does not produce symptoms because the organism is suppressed by other intestinal flora (Borriello, 1990). Within the inpatient hospital setting, as many as 21 percent of adults become colonized with this organism (Fekety et al., 1981) and it is only after colonic flora has been altered by broad spectrum antibiotics that *C. difficile* proliferates and produces exotoxins (Jobe, Grasley, Deveney, Deveney, & Sheppard, 1995) and thereafter manifestations of the infection. Other risk factors for which there is evidence suggestive of association with *C. difficile* infection include non-surgical gastrointestinal procedures, presence of a nasogastric tube, anti-ulcer medications, stay on ITU, duration of hospital stay, duration of antibiotic course, and administration of multiple antibiotics (Bignardi, 1998). The above risk factors suggest that the combination of two major characteristics – individual and facility characteristics – play a significant role on whether an inpatient will acquire *C. difficile* in the hospital. However, how much of the risk of hospital acquired *C. difficile* infection is attributable to either individual or facility characteristic remain unknown.

The severity of the infection ranges from uncomplicated diarrhea to pseudomembranous colitis, a severe form of colitis that can lead to toxic megacolon, and in some cases, death (Campbell et al., 2009). Mortality rates associated with *C. difficile* infectious diarrhea are high and estimated to be between 17 to 29 percent (Crogan & Evans, 2007; Moshkowitz et al., 2007). Mortality is significantly higher for those over 65 (Gravel et al., 2009) with attributable mortality being 3.2% in those less than 65 years, 14.3% in those between 65 and 74 years, and 19.7% those greater than 75 years (Karas, Enoch, & Aliyu, 2010). Studies have predicted that recent increases in the incidence of *C. difficile* and in disease severity may signal the development of mutated forms of previously circulating strains, or emergence of new strains of *C. difficile*, with higher virulence factor and stronger antibiotic resistance (McDonald et al., 2005; (Loo et al., 2005)). The increase in *C. difficile* severity, treatment resistance, morbidity, and mortality are indications of the need for better diagnosis and development of best practices to manage antibiotics and the disease.

*Clostridium difficile* infection is associated with significant economic burden either as a direct cost of treating the infection, or due to lost productivity to prolonged hospitalization or death. The adjusted mean length of stay (LOS) is twice as long for patients with *C. difficile* and the adjusted mean cost for patients who developed health care associated *C. difficile* is significantly higher than those who were not diagnosed with this infection (Pakyz, Carroll, Harpe, Oinonen, & Polk, 2011). Dubberke and Olsen estimated that *C. difficile* infection may have resulted in $4.8 billion in excess costs in US acute-care facilities (Dubberke & Olsen, 2012). It is expected that the cost will continue to increase as the incidence and severity of *C. difficile* infection rises. The Centers for Disease Control and Prevention (CDC) recently named *C. difficile* an urgent threat to patient safety (ICT, 2013). Because of the limited resources available to arrest the rising trend, prevention strategies should focus on the most cost effective evidence based treatment and prevention efforts and interventions.

Previous studies have largely focused on the association between recent use of antibiotics and hospital stay on the likelihood of acquiring *C. difficile* infection (Owens, Donskey, Gaynes, Loo, & Muto, 2008), the increase rate of hospitalizations for *C. difficile* (Jagai & Naumova, 2009). This study differs from previous studies by its focus on the differences between hospital acquired *C. difficile* and those who acquired *C. difficile* prior to being admitted. In further contrast, I investigate which individual characteristics increase the likelihood a patient admitted to hospital without a diagnosis of *C. difficile* infection will acquire the infection before discharge. We compare these characteristics with those of patients who acquired the infection prior to their hospital admission. I also investigate the relative importance of individual characteristics and the site of care in modeling the likelihood of acquiring *C. difficile* in hospital. This is one of the first attempts to disentangle hospital and patient effects on the likelihood of acquiring *C. difficile* while in an acute care setting.

## METHOD

### Data source

Data for this study were obtained from the 2011 Texas hospital inpatient discharge public use data file maintained by Texas Health Care Information Council (THCIC). The council is responsible for collecting hospital discharge data from all state licensed hospitals except those that are statutorily exempt from the reporting requirement. Exempt hospitals include those that do not seek insurance or government reimbursements, those located in a county with a population less than 35,000, or those not located in an urbanized area and with licensed hospital beds fewer than 100 (Texas, 2012). A total of Eighty five hospitals were exempt from reporting in the first quarter of 2011 and eighty seven hospitals in the remaining three quarters of the year. Irrespective of this, some of the hospitals exempt from reporting requirements reported cases of *C. difficile* present on admission. To remove bias due to under-reporting by these facilities, we excluded all cases from facilities exempt from reporting Diagnosis present on admission (POA) codes. In addition, we excluded all cases with a diagnosis of *C. difficile* prior to being admitted to a hospital. After exclusions were applied, we retained over 2,300,000 hospital discharges for the analysis.

### Measurements

All discharges from hospitals in Texas in 2011were reviewed and any hospital discharges with any recorded ICD-9-CM diagnostic code of ‘00845’ indicating a *C. difficile* infection were identified. To further differentiate those cases of *C. difficile* infection acquired in hospital from those that were present on admission, I used the diagnosis present on admission (POA) indicator – a code used to indicate if a condition is present at the time the order for inpatient admission occurs. Note that conditions that develop in the outpatient settings including primary care, emergency department room, observation, and outpatient surgery are all considered present on admission.

The dependent variable in this analysis was a binary variable reflecting the presence or absence of hospital acquired *C. difficile* infection. The dependent variable equaled one when a hospital discharge had any diagnosis of *C. difficile* infection and zero when there was no diagnosis indicating *C. difficile* infection.  The independent variables included individual characteristics (age, ethnicity, race, and gender) to explore the differences between these characteristics and the likelihood of acquiring *C. difficile* infection in hospital. Age was categorized into 4 groups (0-17, 18 – 44, 45 – 64, and 65+). Race was categorized into 3 groups (White, Black, and others). Other variables included in this model include source of hospital admission, type of admission. Longer hospital stays has been shown to be positively associated with hospital associated *C. difficile* infection (Owens et al., 2008). We included length of hospital stay in this model as three categorical variable (less than 3 days in hospital, 3 days – 10 days in hospital, and greater than 10 days in hospital). Using the comorbidity software developed for use with administrative data at the Agency for Healthcare Research and Quality (Elixhauser, Steiner, Harris, & Coffey, 1998), we assigned variables to identify comorbidities and then categorized the results into three groups (discharges with no comorbidity, discharges with one comorbidity, and discharges with more than one comorbidity). A variable indicating if a patient had at least one surgical procedure or not, and illness severity were also included in the analysis. Severity level indicates the extent of physiologic decompensation. It is classified as Minor, Moderate, Major, and Extreme. I explored the effect of rural/urban environment of hospital acquired *C. difficile* infection by including rural/MSA in the model.

To differentiate between the three models in the multivariate analysis, we measure the c statistics. The c statistics measures how well each model can be used to discriminate between those who acquired *C. difficile* infection on admission and those that did not acquire the infection. It is the same as the area under the receiver-operating characteristic curve, (Bamber, 1975; Hanley & McNeil, 1982; Harrell Jr, 2001; Pepe, 2003) formed by taking the predicted values from the regression model to determine a threshold and then dichotomizing the predicted probabilities into those above and below the threshold. The value of c statistics measures from 0.5 (which indicates no discrimination) to a theoretical maximum of 1 (which indicates perfect discrimination). If the scores for all the cases are greater than those for all the non-cases, with no overlap then a c statistic of 1 is achieved.

Statistical analysis

Data analysis was done using SAS statistical software version 9.3. We ran three logistic regression models predicting the likelihood of acquiring *C. difficile* infection in hospital. Model 1 predicts the likelihood of acquiring *C. difficile* infection after adjusting for individual intrinsic characteristics like age, gender, race, and ethnicity. Model 2 predicts the likelihood of acquiring *C. difficile* infection after adjusting for both individual characteristics and condition specific characteristics without fixed effects or hospital. Variables adjusted for in model 2 include age, gender, race, ethnicity, comorbidity, surgical procedure performed or not, severity of illness, and metropolitan statistical area. In model 3, in addition to adjusting for all variables in model 2, we added the fixed effects for facility. We then used the c-statistics to assess the performance of the three fitted regression models.

## RESULTS

The descriptive statistics on Table 3.1 shows that 4,595 patients admitted without a diagnosis of *C. difficile* infection developed the infection in 2011. This represents 20 out of every 10,000 admissions. Fifty seven percent of those that developed *C. difficile* infection in hospital were females compared to 62 percent of those that were discharged without the infection.  Sixty eight percent of discharges with hospital acquired *C. difficile* infection identified their race as White while 13 percent identified as black. The result reveals that 60 percent of all hospital discharges with a diagnosis of hospital acquired *C. difficile* infection occurred in those above 65 years and only 17 percent occurring in discharges for patients less than 50 years. 81 percent of all cases of hospital acquired *C. difficile* infection had at least one surgical procedure performed in hospital. The table also shows that 66 percent of those that acquired *C. difficile* infection in hospital had a total length of stay greater than 10 days and 60 percent had an extremely severe illness. In contrast, greater than 90 percent of all discharges that did not acquire *C. difficile* infection were discharged less than 10 days after admission and had an illness severity score less than extreme. Seventy nine percent of discharges with hospital acquired *C. difficile* infection had at least two comorbid conditions compared to 41 percent of discharges without a diagnosis of *C difficile*.

**Table 3. 1: Characteristics of patients who acquired *C difficile* infection in hospital compared to those who did not**

| | Hosp acquired C.diff (N=4,595) | No C.diff on disch (N=2,329,367) | P value |
|---|---|---|---|
| 51 - 64 | 22.76 | 17.79 | <.0001 |
| 65 - 74 | 22.33 | 12.68 | |
| 75 - 84 | 24.74 | 11.36 | |
| 85+ | 13.04 | 6.43 | |
| 0 - 50 | 17.13 | 51.74 | |
| Female | 57.28 | 62.10 | <.0001 |
| Black | 12.75 | 12.84 | <.0001 |
| Other | 19.70 | 26.03 | |
| White | 67.55 | 61.13 | |
| Hispanic Origin | 20.57 | 30.53 | <.0001 |
| More than one comorbidity | 78.56 | 40.87 | <.0001 |
| At least one surgical procedure performed | 80.87 | 66.85 | <.0001 |
| LOS IN HOSPITAL | | | |
| 3 days - 10 days in Hosp | 31.69 | 46.75 | <.0001 |
| Greater than 10 days in Hosp | 65.98 | 8.44 | |
| Less than 3 days in Hosp | 2.33 | 44.80 | |
| APR-DRG illness severity score | | | |
| Extreme Severity | 59.54 | 6.89 | <.0001 |
| Major severity | 33.06 | 21.49 | |
| Minor or Moderate severity | 7.40 | 71.62 | |
| MSA | 85.03 | 86.06 | 0.0009 |

Table 3.2 presents the results of three multivariate regression models predicting the likelihood of acquiring *C. difficile* infection in hospital. Model 1 shows, after adjusting for age, gender, race, and ethnicity, older age (greater than 50 years) and non-Hispanic origin were associated with increased likelihood of acquiring *C. difficile* infection in hospital.

In Model 2, after further adjustment of condition specific characteristics, the odds of acquiring *C. difficile* while on admission was 16 percent, 30 percent, and 20 percent higher for those aged 65 – 74, 75 – 84, and 85+ respectively, compared to those less than 50 years. Females had 20 percent higher odds than males for acquiring *C. difficile* while on admission, and discharges identified as Blacks had lower odds of acquiring *C. difficile* on admission than discharges identified as White. Discharges for patients that are not of Hispanic origin had a lower likelihood of having the diagnosis of *C. difficile* infection in hospital than discharges for patients of Hispanic origin. Patients with one or more surgical procedure done had lower odds of developing *C. difficile* infection in hospital. Discharges with length of stay between 3 – 10 days and those with length of stay greater than 10 days had 5 times greater odds and 24 times greater odds of developing *C. difficile* infection in hospital respectively than discharges with length of hospital stay less than 3 days. Admissions with extremely severe physiologic decompensation had a 20 times higher odds and those with major physiologic decompensation had a 6 times higher odds of acquiring *C. difficile* infection in hospital compared to those with either mild or moderate levels of physiologic decompensation. No statistical difference was noted in the likelihood of acquiring *Clostridium difficile* in hospital for discharges associated with at least two comorbidities compared to discharges with one or no comorbidity.

In Model 3, the use of facility as fixed effects in the logistic regression revealed similar result with Model 2 except for ethnicity and surgical procedure. After controlling for individual and facility characteristics and using facility as fixed effect, the odds of acquiring *C. difficile* while on admission for those of Hispanic origin was no different than those of non-Hispanic origin. Also, there was no difference in the odds of acquiring *C. difficile* while on admission for those who had one or more surgical procedure on admission compared to those who had no surgical intervention.

**Table 3. 2: Multivariate results for three models predicting the likelihood of acquiring *C. difficile* infection in hospital**

| Variable | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| 51 - 64 | 3.735 (3.401,4.102)** | 1.035(0.940,1.140) | 1.023(0.928,1.129) |
| 65 - 74 | 5.130(4.667,5.639)*** | 1.159(1.051,1.279)** | 1.142(1.033,1.263)** |
| 75 - 84 | 6.378 5.813,6.997)*** | 1.304(1.184,1.437)*** | 1.284(1.162,1.418)*** |
| 85+ | 5.935(5.327,6.614)*** | 1.198(1.070,1.341)** | 1.171(1.043,1.314)** |
| Female | 0.950(0.896, 1.008) | 1.199(1.129,1.272)*** | 1.198(1.128,1.273)*** |
| Black | 1.073(0.981, 1.174) | 0.780(0.712,0.854)*** | 0.833(0.757,0.915)** |
| Other | 1.087(0.996, 1.186) | 1.007(0.922,1.099) | 0.943(0.850,1.047) |
| Hispanic Origin | 0.807(0.740,0.880)*** | 0.798(0.732,0.870)*** | 0.941(0.845,1.049) |
| More than one comorbidity | | 1.014(0.940,1.094) | 0.988(0.914,1.069) |
| At least one surgical procedure performed | | 0.899(0.831,0.974)** | 0.959(0.884,1.042) |
| 3 days - 10 days in Hosp | | 5.307(4.347,6.480)** | 5.320(4.356,6.495)** |
| Greater than 10 days in Hosp | | 24.330(19.891,29.759)*** | 23.163(18.911,28.369)*** |
| Extreme severity | | 20.45(17.98,23.26)*** | 17.293(15.19,19.70)*** |
| Major severity | | 6.459(5.70,7.32)*** | 5.736(5.06,6.51)*** |
| MSA | | 1.000(0.92,1.09) | 1.035(0.94,1.14) |
| Fixed effects for Hospital | No | No | Yes |

In table 3.3, we use the association of predicted probabilities and observed responses to assess the performance of the three fitted regression models. The c-statistics for of 0.89 for model 2 and 0.91 for model 3 shows that both models strongly predict the likelihood that a patient acquired *C. difficile* while on admission, while the c-statistics of 0.69 for model 1 shows that model 1 is a weaker predictor of hospital acquired *C. difficile.* Model 3, where facility is used as fixed effect, only increases the predictive ability of model 2 by 0.02 suggesting that the driving factors of hospital acquired *C. difficile* may be more attributable to individual characteristics than hospital characteristics.

**Table 3. 3: Association of predicted probabilities and observed responses of the three fitted regression models**

| **Variable** | **Model 1** | **Model 2** | **Model 3** |
|---|---|---|---|
| **Association of Predicted Probabilities and Observed Responses** | | | |
| **Somers' D** | 0.373 | 0.778 | 0.816 |
| **Gamma** | 0.556 | 0.879 | 0.903 |
| **c** | 0.686 | 0.889 | 0.908 |
| **Fixed effects for Hospital** | No | No | Yes |

## DISCUSSION

The result for model 3 show that by holding the facilities constant, there is only a marginal increase (0.02) in c statistics, which means that the probability that the predicted risk is higher in those who acquired *C. difficile* infection on admission than those that did not acquire the infection increased by only 2 percent. This leads us to suggest that the facility in which a patient receives care may play lesser role in whether a patient acquires *C. difficile* infection on admission than individual characteristics like age, gender, number of days in hospital, and illness severity of admitted patients.

Interestingly, the study did not reveal any association with hospital acquired *C. difficile* infection and surgical procedure. After controlling for individual and facility characteristics and using facility as fixed effect, the odds of acquiring *C. difficile* while on admission for those who had one or more surgical procedure on admission compared to those who had no surgical intervention were not statistically different. This is an interesting finding given that previous published reports have identified increasing incidence of *C. difficile* infection in surgical patients, most especially in those having emergency operation or intestinal tract resection (Zerey et al., 2007). More specifically, studies identified inpatient surgical treatment during the month before the onset of C difficile infection as a significant risk factor for progression to fulminant colitis (Greenstein et al., 2008). Other studies have linked the higher incidence of prophylaxis antibiotic for surgical patients as the main risk factor for the onset of *C. difficile* infection (Shah, Pass, Cox, Lanham, & Arnold, 2012).

The results demonstrate variations in *C. difficile* incidence among different age groups. Similar to model 2, model 3 shows 14 percent, 28 percent, and 17 percent higher odds of acquiring *C. difficile* while on admission for those aged 65 – 74, 75 – 84, and 85+ respectively, compared to those less than 50 years. This is in keeping with previous published reports identifying advanced age as a risk factor for *C. difficile* infection (McDonald, Owings, & Jernigan, 2006b). This finding may be as a result of multiple factors including poorer host defenses by older adults which increases their ability to acquire the infection, or decreased immune response that limit their ability to mount a humoral response to fight of the infection. For instance decreased gastric acidity seen in older adults are associated with higher *C. difficile* infection rates (Dial, Delaney, Barkun, & Suissa, 2005), and humoral response plays an important role in resisting colonization by *C. difficile* (Sambol, Merrigan, Tang, Johnson, & Gerding, 2002).

## LIMITATIONS

The analysis has several limitations. First, discharges were assigned as hospital acquired *C. difficile* using ICD-9 codes in the discharge data. Coding practices may differ among different facilities and financial incentives for facilities, in some cases, may influence the accuracy of the coding (Simborg, 1981; Hsia, Krushat, Fagan, Tebbutt, & Kusserow, 1988). This may be subject to errors inherent in the use of administrative data. However, study to compare *Clostridium difficile*–associated disease rates determined by *C. difficile*–toxin assays and ICD-9 codes showed a sensitivity of 78 percent and specificity of 99.7 percent (Dubberke, Reske, McDonald, & Fraser, 2006).

Second, the ICD-9 codes in the database does not allow reliable differentiation of the date post admission *C. difficile* infection was identified making it difficult to properly identify the impact of hospital acquired *C. difficile* infection on the length of hospital stay. For example, it is possible that hospital acquired *C. difficile* infection could have led to increased length of stay in the hospital, or the increased length of stay in the hospital for any other condition could have led to hospital acquired *C. difficile* infection. Third, since the data represents hospital discharges, and no information on readmission is given, it is possible that some patient admitted previously may have acquired the infection in the hospital and did not develop symptoms prior to discharge only to be admitted again, and wrongly excluded from the analysis, as a case of *C. difficile* infection present on admission. Lastly, the generalizability of the study to the national level remains unknown since all hospitals contributing to the study are within Texas; however there is no indication that hospitals within Texas are significantly different from the rest of the nation.

Despite these limitations, this study utilized the large number of records in the Texas inpatient database to investigate the relative importance of individual characteristics and the site of care in modeling the likelihood of acquiring *C. difficile* in hospital while controlling for potential confounding variables, including demographics, co-morbidities, institution, and illness severity.

## CONCLUSION

Recent data suggests that the incidence of *C. difficile* infection is increasing in U.S. The risk is increased in older adults that are hospitalized. Hospital eradication of *C. difficile* remains a challenge. Medicare, state Medicaid programs, and many private sector health plans are changing payment systems to reward better outcomes. Some of the changes include performance-based reimbursement measures that often include non-payment for hospital-acquired infections. The results indicate that the driving factors of hospital acquired *C. difficile* may be more attributable to individual characteristics than hospital characteristics and as such, the use of measures largely driven by individual characteristics is far from ideal and may create incentives for hospitals to transfer costs to other payers. Other measures may merit consideration in the reimbursement for the care of patients with hospital-acquired *C. difficile* infection.

# CHAPTER IV

# IMPACT OF MEDICARE PRESCRIPTION DRUG, IMPROVEMENT, AND MODERNIZATION ACT OF 2003 ON POTENTIALLY PREVENTABLE HOSPITALIZATIONS IN ADULTS OVER 65

## BACKGROUND

Potentially preventable hospitalizations (PPH) are hospitalizations for conditions that could be prevented if there is access to quality primary care and if timely and appropriate care is instituted in the outpatient setting (Florida & Vermont, 2011; A. Russo, Jiang, & Barrett, 2007). It is also known as ambulatory care sensitive admissions, prevention quality indicators, and/or potentially preventable admissions. Typically, managing patients for conditions before complications arise in primary care setting is less expensive than treating complications associated with same conditions in the hospital. Jacobs and colleagues estimated the cost of hospitalizations for late complications of diabetes in the U.S to be approximately $5,091 million dollars in 1987(Jacobs, Sena, & Fox, 1991). As a result, reducing potentially preventable hospitalizations by improving outpatient care and prescription adherence can serve the dual purpose of reducing cost of care for the payers and improving quality of care for providers and patients.   PPH can also be used as a measure of community access to primary care (Bindman et al., 1995; Homer et al., 1996) as people with adequate access will have lower hospitalizations for preventable conditions.

Potentially preventable hospitalizations account for significant financial burden to the healthcare system. Over $25 billion of United States annual healthcare expenditure is attributable to preventable hospitalizations (Kruzikas, 2004). Like many other conditions, the burden of potentially preventable hospitalization rates in older adults is disproportionately higher than the younger age groups (Kozak, Hall, & Owings, 2001). This disproportion is best depicted by the rate of congestive heart failure, which was the most common cause of preventable hospitalization in 2007, occurring at the rate of 14.3 per 10,000 for adults 45 to 64 years and at the rate of 190.5 per 10,000 for adults aged 65 year and above (Stranges & Friedman, 2009). This burden is expected to rise as the proportion of older adults with chronic conditions rises because the burden of preventable hospitalizations is more severe in adults with one or more chronic illness (Anderson & Horvath, 2004). It is thought that with increase access to preventive care, access to medication, and lifestyle modification, chronic conditions could be managed effectively and the burden of preventable hospitalizations reduced.

Medicare Prescription Drug, Improvement, and Modernization Act of 2003 expanded Medicare coverage to allow for outpatient prescription drug coverage as well as a host of other changes to the program. It offered a voluntary interim program beginning in mid-2004 that provided Medicare beneficiaries an immediate but modest financial relief in the form of drug discount cards sponsored by private firm with federal approval. It however required beneficiaries to choose between maintaining any existing prescription drug coverage and joining a new Medicare Part D program, beginning in January 2006 (Kaiser Family Foundation, 2004; Congressional budget office, 2004a, Health Policy Alternatives, 2003c). Because Medicare did not cover outpatient prescription coverage prior to the law, a great number of Medicare beneficiaries had to pay full retail price for drugs, unless they were enrolled in either employer retirement programs or managed care plans with outpatient prescription coverage, or privately purchased supplemental benefits ("Medigap"), or had dual coverage with Medicaid. It is expected that as the number of Medicare beneficiaries with access to outpatient prescription rises, adherence will increase, and as such complications due to non-adherence to medications will decrease in this population. Available evidence shows this to be the case as Soumerai (1999) found a 35 percent reduction in drug utilization and a 60 percent increase in nursing home admissions when New Hampshire restricted the number of outpatients' prescriptions by Medicaid (Soumerai, Ross-Degnan, Avorn, McLaughlin, & Choodnovskiy, 1991).

Previous research have documented decline in hospitalization rates (Afendulis, He, Zaslavsky, & Chernew, 2011) due to Medicare Part D, the effects of Part D on reducing pharmaceutical prices (Ketcham & Simon, 2008) and increasing drug utilization (Ketcham & Simon, 2008; Lichtenberg & Sun, 2007; Zhang, Donohue, Lave, O'Donnell, & Newhouse, 2009), the increase in adherence to prescription drug use by the elderly after Medicare Part D (Zhang et al., 2010), and the impact of MMA on drugs, medical spending (Zhang et al., 2009), reduction of out-of-pocket cost (Lichtenberg & Sun, 2007) and congestive heart failure. Other studies focused on the association between managed care enrollment and preventable hospitalization patterns of adult Medicaid enrollees (Basu, Friedman, & Burstin, 2004), racial disparity in preventable hospitalizations (Davis, Liu, & Gibbons, 2003; Gaskin & Hoffman, 2000; C. A. Russo, Andrews, & Coffey, 2006), and the burden of potentially preventable hospitalizations in the elderly with diabetes (Kim, Helmer, Zhao, & Boockvar, 2011; Sentell et al., 2013) .

However, there is limited information on the impact of Medicare part D on preventable hospitalizations among older adults. Review of recent literature did not find any published study that studied the impact of Medicare part D expansion on preventable hospitalizations for medication sensitive conditions for this population. This may be partly due to the unavailability of linked data between drug coverage, utilization, and outcome. We explore this important relationship by conducting an ecological study with the use of Texas hospital discharge data. Ecological or area level studies have been used in published studies to document the effects of Medicare Part D on Hospitalization rates (Afendulis et al., 2011).This study will focus on pre and post Medicare part D analysis of preventable hospitalizations on conditions that are medication sensitive, with the non-medication sensitive conditions as comparison group, using Texas Hospital discharge data for older adults. The use of the same adult population as a comparison group will help control for unobserved trends and other potential threats to the validity of research findings.

The analysis strategy uses the fact that both the study and comparison group share similar characteristics except on whether or not the reason for hospital admission is medication sensitive or not. We hypothesize that the rate of medication sensitive preventable hospitalizations will decline as Medicare beneficiaries with outpatient prescription drug coverage increases due to enrollment in Medicare Part D. We also hypothesize that the decline in hospitalizations for patients with non-medication sensitive preventable hospitalizations will be lower than the medication sensitive hospitalizations.

## METHOD

### Data source

Data for this study were obtained from the 1999 – 2011 Texas hospital inpatient discharge public use data file, a publicly available database maintained by the Texas Health Care Information Council (THCIC) (Texas, 2012). The Texas Health Care Information Council (THCIC) is responsible for collecting hospital discharge data from all state licensed hospitals. Some hospitals are exempt from this requirement and they include those located in a county with a population less than 35,000, or those located in a county with a population more than 35,000 and with fewer than 100 licensed hospital beds and not located in an area that is delineated as an urbanized, and hospitals that do not seek insurance payment or government reimbursement (Texas, 2012). This database contains records of approximately three million discharges annually. All discharge records include a list ICD 9 diagnosis and procedure codes along with other information including source of admission, external cause of injury, type of admission and discharges, patient's demographic information, and descriptive information about the discharging hospital.

Data for prescription coverage for individuals aged 65 and older were derived from the county level monthly Medicare Part D enrollment and penetration data available on CMS website. For years prior to Part D implementation, we used state-level estimates of Medicare Advantage prescription plan penetration and employer-based retiree health plans with outpatient prescription coverage to account for the proportion of the elderly with prescription plan coverage. Employer-based retiree health plans and Medicare Advantage plans were the major mechanism, prior to the implementation of Part D, through which older adults received outpatient prescription. Prescription coverage for individuals below 65 years were derived using the annual data on the percentage of workers aged 21 – 64 participating in employer-based retirement plan (Copeland, 2005).

Other sources of drug coverage include employer plans for active workers, Federal Employees Health Benefits Program (FEHBP), TRICARE, and Veterans Affairs (VA). However, due to the unavailability of complete data on the proportion of older adults receiving outpatient prescription drug coverage from these sources, and also because these sources contributed only a minimal percentage to the total coverage estimates, the outpatient prescription drug coverage from these sources were not used in the final calculation of coverage estimates.

## Measurements

### *Dependent variables*

The dependent variable in the multivariate analysis for medication sensitive preventable hospitalization is a binary variable that equaled one if a preventable hospitalization is associated with any of the nine admissions for medication sensitive preventable hospitalizations, and equaled zero if the hospitalization is not associated with any of the admissions.  Likewise, for the comparison group, we assigned a value of 1 if the hospitalization is associated with any of the three admissions for non-medication sensitive preventable hospitalizations, and equaled zero if the hospitalization is not associated it.

*Medication sensitive and non-medication sensitive hospitalizations*

This study used AHRQ's Prevention Quality Indicators (PQIs) software to identify all discharges from the Texas Discharge abstract in which hospitalizations could have been prevented with good outpatient care, or for which early intervention could have prevented complications or more severe disease. AHRQ's Prevention Quality Indicators (PQIs) are population based indicators that can be used with hospital discharge data to identify quality of care (Remus & Fraser, 2004). We then categorize the potentially preventable hospitalizations into two categories: 1) medication sensitive hospitalizations – conditions whose complications can be prevented by use of medications; and 2) non - medication sensitive hospitalizations – conditions whose complications may not be related to the use of medications. For medication sensitive potentially preventable hospitalizations, we include nine admissions involving hospitalizations for:

- Diabetes with short-term complications;
- Diabetes with long-term complications;
- Uncontrolled diabetes without complications;
- Diabetes with lower-extremity amputation;
- Chronic obstructive pulmonary disease;

- Asthma;
- Hypertension;
- Heart failure; and
- Angina without a cardiac procedure.

For non-medication sensitive potentially preventable hospitalizations, we include three admissions involving hospitalizations for:

- Dehydration
- Bacteria Pneumonia; and
- Urinary Tract Infection.

We then calculate the condition specific rates of hospitalization for each of these conditions by year for each county stratified by race and age category using the census population estimates as the denominator. To generate the rate of hospitalization for all "medication sensitive conditions" and "non-medication sensitive", we sum all the respective hospitalizations for the nine and three conditions listed above and divide by the population estimates.

*Independent variables*

*Outpatient prescription drug coverage*

Next, we estimate the level of outpatient prescription drug coverage for individuals aged 65 and older and for those below 65 years in Texas. The ideal comparison group to use in the analysis would be patients above 65 years with medication sensitive potentially preventable hospitalization but are not eligible for Medicare part D coverage. Unfortunately, no such group exists as everyone over the age of 65 qualifies for Medicare. Because of this limitation, we use potentially preventable hospitalizations for conditions that are not medication sensitive (e.g dehydration) for the same group of patients as the comparison group. Prior to 2006, most patients received prescription drug coverage through employer-sponsored retiree plans and Medicare Advantage plans. After Medicare Modernization Act of 2003 took full effect in 2006, a significant number of those above 65 enrolled in Medicare Part D plans (stand-alone PDPs and Medicare Advantage drug plans), including employer-only group plans. This meant that the percentage of older adults receiving prescription drug benefit through employer-based retiree plans declined post Medicare expansion.

For the period after Part D implementation (2006 -2011), we used county level Medicare Advantage (MA-PD) and Medicare Part D penetration (PDPs) rates to estimate outpatient prescription drug benefits for each individual. From July 2007 - December 2010, we used monthly county level stand-alone prescription drug plans (PDPs) and Medicare Advantage prescription drug (MA-PD) plans penetration rates (available on CMS website) to estimate Medicare Part D and Medicare Advantage Prescription Drug coverage. Because of the unavailability of monthly data for 2006 and part of 2007, we used state level year estimates to derive the respective coverage for Part D and Medicare Advantage coverage for the missing monthly data. We then summed the coverage rates for PDPs and MA-PD to derive the total Part D Coverage used in the analysis.

To estimate the probability that a patient received prescription drug coverage from employer-sponsored retiree plan, we use annual state level employer-sponsored retiree plan coverage percentage to estimate prescription drug coverage for individuals above and below 65.

Finally, we derive the total probability of outpatient prescription drug coverage by adding the probabilities of drug coverage through PDPs, MA-PD, and employer-sponsored retiree plans.

*Other independent variables*

We included patient's demographic characteristics (gender and race) in the multivariate analysis to control for changes due to individual characteristics. Race was categorized into 6 categories (White, Black, Hispanic, Asian or Pacific Islanders, Native Americans, and others). The expected primary payer was coded as Medicare, Medicaid, Private insurance, Self-pay, and "Others". Private insurance includes payment from Preferred Provider Organization (PPO), Point of Service (POS), Exclusive Provider Organization (EPO), Indemnity Insurance, Automobile Medical, Blue Cross/Blue Shield, Commercial Insurance, Health Maintenance Organization, Liability, and Liability Medical. CHAMPUS, Disability Insurance, Central Certification, Title V, Veteran Administration Plan, Worker's Compensation Health Claims, Other Federal Programs, and Other Non-Federal Programs were all classified as "Other" primary payer.

The main variable of interest is the part D drug coverage for both the medication sensitive hospitalizations and the non-medication sensitive hospitalizations. We want to estimate the difference in the impact of Medicare Part D Coverage on both types of preventable hospitalizations. We make the assumption that other sources of prescription drug coverage (including retiree drug benefit, employer plans for active workers, FEHBP, TRICARE, and Veterans Affairs (VA)) should not be systemically different between these two groups of preventable hospitalizations because they remained constant over the time period of the study.

Statistical analysis

Data analysis was done using SAS statistical software version 9.3. Because patients are clustered within hospitals and because the data contains multiple years, we analyzed the data using hierarchical model. These are models used to analyze nested sources of variability in clustered data, taking account of the variability associated with each level of the hierarchy (Dai, Li, & Rocke, 2006). SAS glimmix procedure, used for the multivariate analysis, is a highly useful tool for hierarchical modeling with discrete responses (Dai et al., 2006). It also takes into account the correlation that may arise because a patient may have been admitted and discharged on multiple occasions either from the same hospital or different hospitals within the same year and/or multiple years.

RESULTS

Table 4.1 presents the descriptive characteristics of hospital discharges for medication sensitive and non-medication sensitive conditions in the period before the implementation of Medicare Prescription Drug, Improvement, and Modernization Act of 2003 for older adults. The result show that the average hospitalization rate for medication sensitive conditions prior to part D implementation was 3,300 per 100,000 population, and 1,912 per 100,000 populations post part D implementation. The rates were however lower for non-medication sensitive hospitalizations, with pre-implementation rate accounting for 2,664 discharges per 100,000 population and post-implementation rates showing a discharge rate of 1,817 per 100,000 discharges. The average county level part D penetration rate increased to an average of 40 percent for both medication sensitive and non-medication sensitive conditions from 0 percent. The total average outpatient prescription coverage for both patients under both conditions increased from an average of 57 percent outpatient prescription drug coverage to 96 percent coverage. The average median income for patients discharged under both categories increased by over $6,000 for between the pre-implementation and post-implementation periods while the unemployment rate increased for both groups.

White females made up the majority of the discharges in this database for potentially preventable hospitalizations. In both periods, pre- and the post-implementation, the expected primary source of payment was through Medicare (approximately 90 percent of discharges), and the expected secondary source of payment was private pay (approximately 50 percent of the time) and Medicaid (approximately 30 percent).

**Table 4. 1: Descriptive characteristics of hospital discharges for medication sensitive and non-medication sensitive conditions in the period before the implementation of Medicare prescription drug, improvement, and modernization act of 2003 for older adults**

| | Pre-Part D (1999 – 2006) | | Post-Part D (2006 – 2011) | |
|---|---|---|---|---|
| | MS | NMS | MS | NMS |
| PPH rate/100,000 population | 3,300 | 2,664 | 1,912 | 1,817 |
| Average percent Penetration (county level) | | | | |
| Medicare part D | 0.000 | 0.000 | 40.0065 | 39.9014 |
| Medicare Advantage | 10.3791 | 10.2349 | 15.0062 | 15.2314 |
| Retirement Drug Benefit | 47.3241 | 47.0025 | 41.3412 | 41.2204 |
| Prescription drug coverage | 57.7033 | 57.2375 | 96.3540 | 96.3533 |
| Average Median Income | 39292.37 | 39595.06 | 45460.96 | 45850.43 |
| Unemployment rate | 5.10679 | 5.01405 | 6.42408 | 6.40380 |
| Gender | | | | |
| Male | 40.02 | 36.82 | 41.69 | 37.74 |
| Female | 59.98 | 63.18 | 58.31 | 62.26 |
| Race | | | | |
| 1 = 'White' | 62.55 | 68.59 | 59.84 | 68.33 |
| 2 = 'Black' | 12.08 | 8.52 | 13.65 | 8.18 |
| 3 = 'Hispanic' | 20.07 | 17.17 | 21.78 | 18.38 |
| 4 = 'Asian & NH/PI' | 0.82 | 1.04 | 0.81 | 0.93 |
| 5 = 'Am. Indian/AN' | 0.29 | 0.34 | 0.87 | 0.83 |
| 6 = 'Other' | 4.19 | 4.34 | 3.06 | 3.36 |
| Expected source of payment | | | | |
| 1 = 'Medicare’ | 89.80 | 91.63 | 87.40 | 90.42 |
| 2 = 'Medicaid' | 1.58 | 1.25 | 1.68 | 1.01 |
| 3 = 'Priv. insurance' | 7.19 | 6.02 | 7.55 | 6.48 |
| 4 = 'Self-pay' | 0.57 | 0.42 | 0.71 | 1.60 |
| 6 = 'Other'; | 0.86 | 0.68 | 2.67 | 0.49 |
| Secondary source of payment | | | | |
| 1 = 'Medicare’ | 11.96 | 10.11 | 10.94 | 9.31 |
| 2 = 'Medicaid' | 29.75 | 30.81 | 30.86 | 30.14 |
| 3 = 'Priv. insurance' | 48.79 | 50.34 | 44.98 | 49.41 |
| 4 = 'Self-pay' | 2.67 | 2.17 | 7.22 | 5.39 |
| 6 = 'Other'; | 6.84 | 6.57 | 6.00 | 5.75 |

Figure 4.1 shows the trend in hospital discharges for all potentially preventable hospitalization in Texas from 1999 to 2011 for older adults within the age category of 65

– 75, and above 75 years. In general higher rates were observed among those above 75 years for the study period. The result reveals a decline in hospitalizations for potentially preventable conditions. For older adults over 75 years, we see a 51 percent decline from over 9,000 discharges for every 100,000 population in 1999 to just under 4,500 discharges per 100,000 population in 2011. For those between 65 – 74 years, there was a 55 percent decline in potentially preventable hospitalization for the same time period, from 4,165 PPH per 100,000 to 1,850 PPH per 100,000 populations.

**Figure 4. 1: Graph depicting the trend in hospital discharges for preventable hospitalization for older adults**

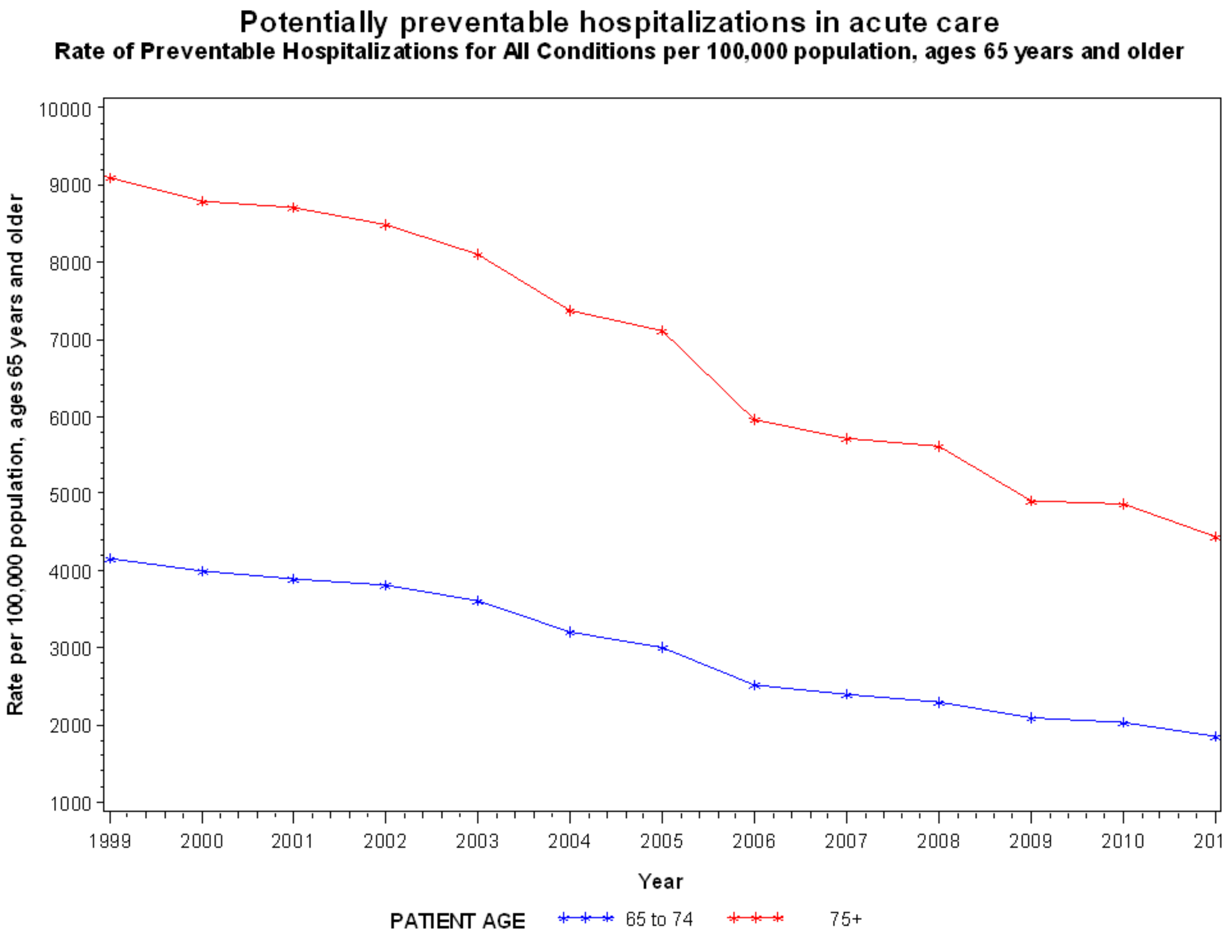
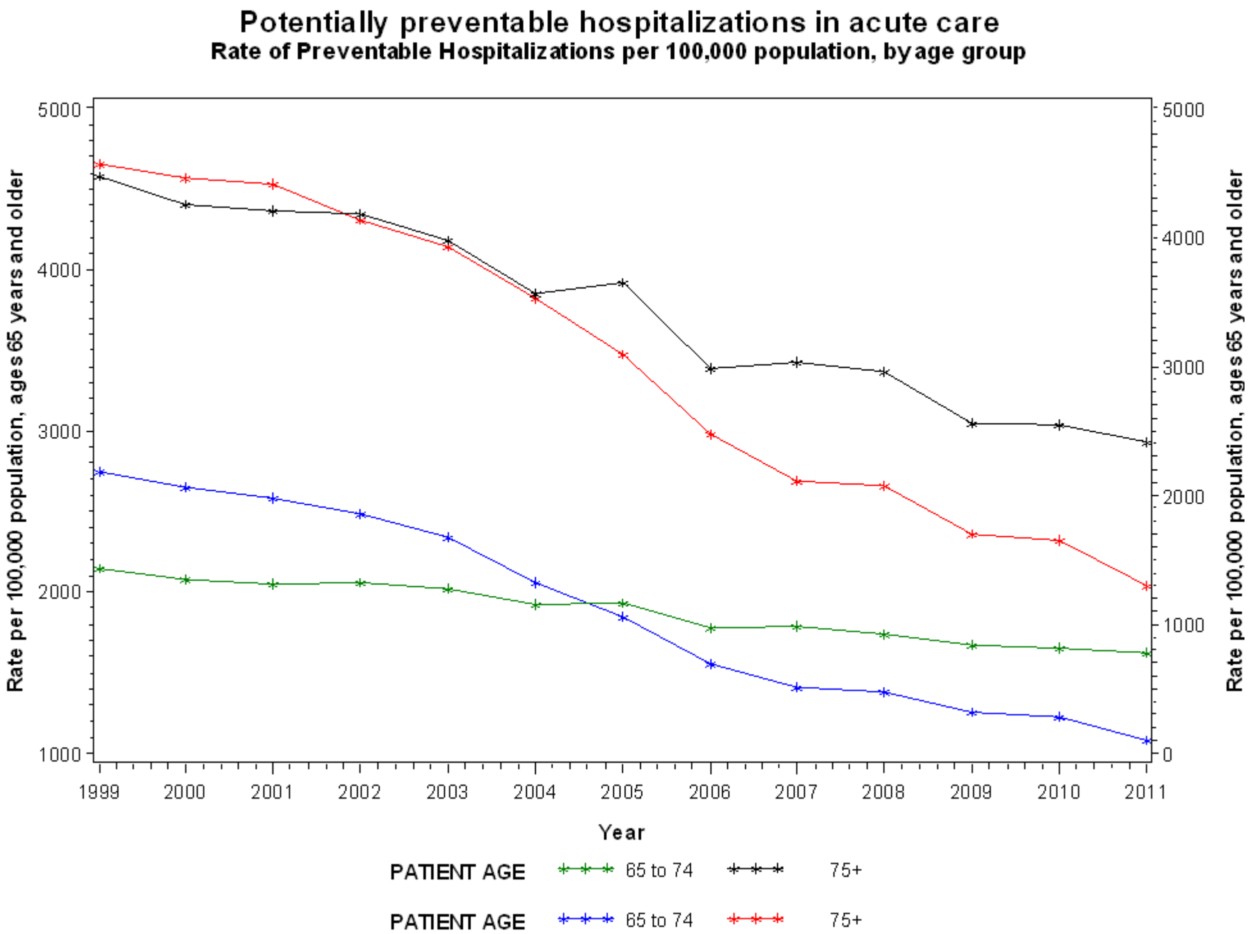



Figure 4.1 shows the trend in potentially preventable hospitalizations for medication sensitive and non-medication sensitive hospitalizations for the two age groups. Overall, hospitalization rates declines more for medication sensitive hospitalizations than non-medication sensitive conditions for both age groups over the study period. The number of discharges for medication sensitive hospitalizations fell 56 percent for adults over 75 years and 60 percent for those between 65 and 74. The rate of

hospitalizations declined 46 percent for non-medication sensitive hospitalizations for both age groups over the same time period.

**Figure 4. 2: Graph showing trend in hospital discharges for "medication sensitive" and "non-medication sensitive" for older adults**




Prior to the 2006 implementation of Medicare Prescription Drug, Improvement, and Modernization Act of 2003, the hospitalization rates for PPH for adults over 75 years declined by 18 percent and 25 percent for non-medication sensitive and medication sensitive conditions respectively. However, after the implementation of part D, the hospitalization rates of adults of the same age group declined by 19 percent and by 32 percent for non-medication sensitive and medication sensitive conditions respectively. For adults between 65 and 75 years, the hospitalization rates post implementation of part D declined by 20 percent and by 31 percent for non-medication sensitive and medication sensitive conditions respectively.

Table 4.2 displays the multivariate result predicting the likelihood that hospitalization is potentially preventable for both medication sensitive and non-medication sensitive conditions. This analysis shows that adults with age range between 65 and 74 are less likely to be admitted for both medication sensitive [OR=0.98 95% CI (0.975 – 0.985)] and non-medication sensitive [OR=0.57 95% CI (0.566 – 0.573)] potentially preventable conditions compared to adults over 75 years. Though females were less likely to be admitted for medication sensitive hospitalizations than males [OR=0.97 95% CI (0.966 – 0.975)], they were more likely to be in the hospital for non-medication sensitive conditions [OR=1.1 95% CI (1.095 – 1.106)]. American Indians/American Natives have a 45 percent higher odds of being hospitalized for medication sensitive conditions [OR=1.445 95% CI (1.40 – 1.492)] and a 25 percent higher odds of being admitted for non-medication sensitive conditions [OR=1.247 95% CI (1.205 – 1.291)] than Whites. Asian or Pacific Islanders have lower odds of being admitted for medication sensitive conditions [OR=0.946, 95% CI (0.922 – 0.971)] and higher odds for non-medication sensitive conditions [OR=1.089 95% CI (1.062 – 1.118)] than Whites. On the other hand, Black have a 40 percent higher odds of being admitted for medication sensitive conditions [OR=1.394, 95% CI (1.383 – 1.404)] and a 5 percent lower likelihood for non-medication sensitive conditions [OR=1.089 95% CI (1.062 – 1.118)] than Whites. For both conditions, Hispanics have a higher likelihood of being admitted for preventable hospitalizations than Whites. The result show a 30 percent higher likelihood for medication sensitive [OR=1.295, 95% CI (1.288 – 1.303)] and a 7 percent higher likelihood for non-medication sensitive conditions [OR=1.074, 95% CI (1.067 – 1.082)]. Discharge records with either Medicare or Medicaid as the expected primary source of payment increased the likelihood that discharge is potentially preventable when compared to self-pay. However, discharges with private insurance as the expected primary source of payment, decreased the likelihood a discharge is potentially preventable.

The main variable of interest is part D coverage. We are interested on the effect the change in coverage between the pre- and post-implementation of Medicare Part D had on both preventable hospitalization for medication sensitive and non-medication sensitive conditions. The results indicate that the increase in part D coverage reduced preventable hospitalization by 40 percent for medication sensitive condition but no significant change in non-medication sensitive hospitalization.

**Table 4. 2: Multivariate result predicting the likelihood that hospitalization is potentially preventable for both medication sensitive and non-medication sensitive conditions**

| | Medication Sensitive | Non-Medication Sensitive |
|---|---|---|
| 65 to 74 | 0.98 (0.975 – 0.985) | 0.57 (0.566 – 0.573) |
| 75+ | - | - |
| Female | 0.97 (0.966 – 0.975) | 1.1 (1.095 – 1.106) |
| Male | - | - |
| Amer Indian/AN | 1.445 (1.40 – 1.492) | 1.247 (1.205 – 1.291) |
| Asian and NH/PI | 0.946 (0.922 – 0.971) | 1.089 (1.062 – 1.118) |
| Black | 1.394 (1.383 – 1.404) | 0.95 (0.941 – 0.959) |
| Hispanic | 1.295 (1.288 – 1.303) | 1.074 (1.067 – 1.082) |
| Other | 0.869 (0.859 –0.880) | 0.834 (0.823 – 0.845) |
| White | - | - |
| Medicaid | 1.134 (1.093 – 1.177) | 1.251 (1.197 – 1.307) |
| Medicare | 1.048 (1.022 – 1.075) | 1.224 (1.187 – 1.262) |
| Other | 0.984 (0.953 – 1.016) | 1.069 (1.029 – 1.110) |
| Private insurance | 0.925 (0.900 – 0.950) | 0.983 (0.951 – 1.015) |
| Self-pay | - | - |
| PartDCoverage | 0.595 (0.563 – 0.630) | 0.986 (0.00 – 999) |

## DISCUSSION

This research demonstrates that increased coverage and access to outpatient prescription drug, by older adults, induced by the introduction of Medicare Part D had measurable health benefits. Specifically, the increase in drug coverage for this population from 57 percent in the periods prior to Medicare part D to 96 percent in the periods post Medicare part D reduced preventable hospitalizations – for those conditions that depend on medications to prevent complication – by 40 percent. Though previous studies have not looked specifically at medication sensitive versus non medication sensitive preventable hospitalizations, the finding is in keeping with the overall reduction in hospitalization rates (Afendulis et al., 2011) found by previous research. In addition, the overall outpatient prescription coverage estimates of 96 percent for older adults post Part D implementation derived by the analysis is similar to the prescription drug coverage of 92.5 percent in late 2006 reported by Safran and colleagues (Safran et al., 2010).

The analysis showed a declining trend in potentially preventable hospitalization rates over the study period. This finding is in contrast to the previous national study, conducted by Kozak and colleagues, which found an increasing trend in the rate of avoidable hospitalization for the group age 65 and older (Kozak et al., 2001). Specifically, for the age groups 65–74, 75–84, and 85 and older, they found the 1998 rate was 34 percent higher than the 1980 rate for the 65–74 group, 51 percent higher for the 75–84 group, and 61 percent higher for the group age 85 and older. The finding from the analysis may reflect improvements in patient management, technology, health awareness, and life style modifications over this period. More importantly, the analysis of trends in potentially preventable hospitalization can be used as a measurement tool to monitor inequalities in the distribution of access to quality primary care. The result shows racial and gender disparities in hospitalizations for potentially preventable chronic conditions. Blacks, American Indians, and Hispanics are more likely to be admitted to the hospitable for potentially preventable conditions than their White counterpart. Similar racial disparities on potentially preventable hospitalizations have been established in previous literatures (Davis et al., 2003; Kozak et al., 2001; Mayberry, 1999). The reason for the racial disparity is not very clear considering that everyone in the study population are almost all covered by Medicare, so insurance status should play minimal effect. Further research need to explore the likely reason for this disparity.

## LIMITATIONS

The analysis has some limitations. First, the measure of outpatient prescription drug coverage use a combination of multiple sources including state data, employer retirement benefits, administrative data, and county level part D penetration rates collected by CMS. These sources may introduce some imprecision in the measurement of outpatient drug coverage. We do not have actual data on discharges with outpatient prescription coverage. However, previous studies (Afendulis et al., 2011) have found similar increase in drug coverage post-implementation of part D. Second, the Medicare part D portion of the total outpatient drug prescription coverage used in this analysis pertains to all Medicare population (which includes people 65 or older, certain younger people with disabilities, and people with End-Stage Renal) but the analysis was limited to only adults over 65 years. We do not expect this limitation to significantly affect the result of this analysis because the coverage rates for the over 65 population are quite similar to the aggregate rates as those over 65 or older make up almost 81 percent of Medicare population. Third, I used AHRQ's Prevention Quality Indicators (PQIs) to identify medication and non-medication sensitive conditions from hospital administrative data. The use of hospital administrative data might have inherent limitations in identifying preventable hospitalizations. It is possible that there may be errors associated with coding patients into a particular group or the data may be incomplete. Some cases might be poorly diagnosed and un-coded in claims files because of reimbursement issues and failure to recognize symptoms. These misclassifications may underestimate the impact of part D on preventable hospitalization. Lastly, the sample included only discharges greater than 65 years from Texas hospitals, so the result might not generalize to other states or age groups.

## CONCLUSION

Despite these limitations, our analysis suggests that the expansion of Medicare by implementing the Medicare Prescription Drug, Improvement, and Modernization Act of 2003 significantly reduced preventable hospitalizations. Future study should explore the impact of the reducing preventable hospitalization on overall cost. This is especially important because of the high cost of Part D, an estimated $45.5 billion in 2008 [March 2008 baseline].

# CHAPTER V

# CONCLUSION

Traumatic brain injury, *Clostridium difficile* infections, and potentially preventable hospitalizations in older adults are issues that highlight the enormity of the problems that our senior citizens face today. They give us insight into the potential dangers the population will face in future if adequate research is not carried out. Because of scarce resources and rising healthcare cost, the major challenge lies in the organization and sustainability of governments' insurance programs to continue to provide services for older adults, resource allocation, and developing alternative cost effective modalities of treatment. The good news is that these conditions are preventable if appropriate guidelines are developed and healthcare professionals are encouraged to adapt best practice guidelines. Our study encourages a targeted approach to the identification of the various factors that increases the risk that an older adult will be hospitalized. This approach is a first step in the positive direction to yield best health outcomes and quality of care at equal or lower cost.

Our study reveals that traumatic brain injury, which is expected to become the third largest global disease burden in 2020, is increasing at a significantly higher rate for older adults – most especially patients within the age group of 75 to 84 years – than any other age group. In addition, patients are disproportionately hospitalized with a diagnosis of traumatic brain injury in older adults than younger age group (58 times more discharges per 10,000 populations). Majority of these cases are due to fall (55 percent of the cases in 2010) and unfortunately only about a third of those cases hospitalized get discharged home. Most are discharged to another hospital, other medical facilities, a nursing facility, or home health. About 10 percent will expire or be discharged to hospice care. This dissertation draws attention into the rising trend in traumatic brain injury as it pertains to older adults. Effective strategies and interventions are needed to curb this potential problem that is not only expensive, but associated with significant disability and burden on care givers and the health care system. Our study identified fall as a major driver of traumatic brain injury in the elderly. Evidence based fall prevention programs for this population should be encouraged and adopted by policy maker to reduce the incidence.

The emergence of *C. difficile* as a potentially life threatening healthcare associated infection occurred in the last two decades. The incidence and mortality has gradually risen, with the number of hospitalized patients with CDI diagnosis doubling from 2000 to 2009. Even though some healthy adults may be colonized asymptomatically with *C. difficile*, the risk of symptomatic *C. difficile* increases for hospitalized patients – especially the older adults. We investigated the characteristics that increases the likelihood that an older adult admitted into the hospital without a diagnosis of *C. difficile* will acquire the infection while on admission and the relative importance of individual characteristics and the site of care in modelling the likelihood of acquiring *C. difficile* infection. *C. difficile* can survive for long periods in the environment because they are able to form spores that are not easily destroyed by alcohol based and hand washing agents. This organism can be passed between individuals through contact with contaminated environment and equipment or directly through contact with an individual with the infection. The organism may not be able to multiply in the guts of healthy individuals, but however, in susceptible patients, especially those who have had an antibiotic treatment, the organism is able to multiply in the host and cause *C. difficile* infection. The result of my analysis indicates that the driving factors for hospital acquired *C. difficile* may be more attributable to individual characteristics than they are to facility characteristic. Identifying individuals who may be at an increased risk of having the infection before being admitted to the hospital, isolating them, and observing best practice guidelines and contact precaution in their care may be a cost effective way of reducing the rising incidence of the infection. From our results, white females, older than 65 years, and on admission for greater than 3 days with extremely severe or major illness are more likely to acquire *C. difficile* infection before discharge. Therefore policies aimed at reducing *C. difficile* infection should, in addition to best practice guideline, focus on these individual characteristics.

The third paper analyzes the impact of the decision of the government to Medicaid coverage to cover for outpatient prescription drugs on potentially preventable hospitalization. We specifically looked for the change in the rate of hospital admission for potentially preventable hospitalizations for medication sensitive hospitalizations and then compared with the change in hospitalization rate for non-medication sensitive hospitalizations before and after the law was implemented. The result of the analysis showed that hospitalization rates for medication sensitive condition declined significantly compared to the non-medication sensitive hospitalizations over the same time period. Since preventable hospitalizations contribute significant parts to the annual health care expenditure of the US, the implementation and adoption of this law will cause a reduction in the overall health care expenditure, and improve both quality of care and quality of life for older adults. The results also show that over 90 percent of older adults now have access to outpatient prescription coverage thereby increasing the likelihood that drugs prescribed in the outpatient setting will be purchased and adhered to by patients.

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