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Examination of discharge settings and readmission rates following hospitalization for total knee arthroplasty

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Examination of discharge settings and readmission rates following hospitalization for total knee arthroplasty

by

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Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas Medical Branch

in Partial Fulfillment

of the Requirements

for the Degree of

Doctor of Philosophy

The University of Texas Medical Branch

February, 2016

Dedication

This dissertation is dedicated to my family. My wife, Karen, continuously supported my efforts and thoughtlessly paid my tuition over the years. My children, Devin, Dillon and Katie, for being my other, “greatest life accomplishments” and my driving force. My friend and faculty advisor, Dr. Amol Karmarkar, for your kindness, guidance and support over the years. My father-in-law, Dr. Cary Cooper, for your wisdom, support and being my educational role model. Lastly, to my friend and mentor, Dr. James Graham for his everlasting support, kindness and patience. This dissertation would not have been possible without him and I will be forever grateful.

Acknowledgements

I acknowledge my dissertation committee, Drs. James Graham, Kenneth Ottenbacher, Amol Karmarkar, Dana Wild, Jacques Baillargeon, and Natalie Leland, for their support, feedback, and guidance throughout my entire dissertation process. Drs. Steve Fisher, Laura Rudkin, Christine Arcari, Melanie de Boer, James Graham, Kenneth Ottenbacher, and Amol Karmarkar provided me with early educational guidance and support.

Shannon Carroll, Beth Cammarn and Vivian Brannen consistently and patiently provided administrative assistance to a poor doctoral student who always seemed to have special needs. My supervisor, Dr. Patricia Fingerhut afforded me her support and allowed me to dedicate valuable time and energy into this project. Dr. Diane Collins provided valuable editing assistance.

Fellow Students and friends, Drs. Rebecca Galloway and Amit Kumar provided inspiration, advice, and an open shoulder or ear whenever needed. Your kindness and support will never be forgotten.

Dr. Dorian Coppenhaver assisted me greatly with the gift of compassion, when it was needed the most. My father in law, Dr. Cary Cooper, your mentoring, kindness and support over the years guided my educational transformation from a once-struggling high school student to one of the greatest accomplishments of my life.

Examination of discharge settings and readmission rates following hospitalization for total knee arthroplasty

Publication No.____________

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The University of Texas Medical Branch, 2016

Supervisor: James Graham

Abstract

Total knee arthroplasty (TKA) is one of the most common surgical procedures performed in the United States with tremendous growth expected. Reducing unplanned hospital readmissions has become a focal point in minimizing healthcare cost within the Medicare population through several initiatives within the Patient Protection and Affordable Care Act (PPACA). Policy changes have also impacted the availability of post-acute care following TKA. Medicare's 75% rule effectively limits the number of patients with unilateral TKA discharged to inpatient rehabilitation facilities (IRFs). The other two common post-acute settings include skilled nursing facilities (SNFs) and home- and community-based rehabilitation. We used Medicare data from beneficiaries who received TKA to examine 1) time trends in hospital discharge settings and 30-day readmission rates by discharge setting, 2) predictors of hospital discharge setting, and 3) factors associated with 30-day and 90-day readmission rates and reasons for readmission following TKA. We showed that IRF discharge decreased approximately 20% from 2002 to 2010 making it the least utilized post-acute setting. In addition, trends in 30-day readmission rates were lowest in community discharge and relatively the same in SNF and IRF in all study years. Using IRF discharge as the reference, patients who received a bilateral procedure had lower odds of both SNF and community discharge; patients with more comorbidity had lower odds for community discharge and higher odds for SNF discharge; and patients who received their TKA from hospitals with lower TKA volumes had lower odds of SNF and community discharge. Patients that discharged to either SNF or IRF had greater likelihood of 30-day readmission and greater risk for 90-day readmission versus patients discharged to the community. We found similar reasons for readmission from each discharge setting and time period. This study examines the topic of discharge settings and their effect on unplanned hospital readmission following TKA. These findings provide new information to the growing knowledge base on post-acute utilization patterns and hospital readmission rates among older adults receiving TKA.

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List of Abbreviations

ASA	American Society of Anesthesiologists
BBA	Balanced Budget Act
CJR	Comprehensive Care for Joint Replacement
CMS	Center for Medicare & Medicaid Services
CCI	Charlson Comorbidity Index
CI	Confidence Intervals
DRG	Diagnosis Related Group
HR	Hazard Ratios
HCFA	Health Care Financing Administration
HMO	Health Maintenance Organization
HRRP	Hospital Readmissions Reduction Program
ICD-9-CM	International Classification of Diseases, 9th revision, Clinical Modification
ICU	Intensive Care Unit
IRF	Inpatient Rehabilitation Facility
LOS	Length of Stay(s)
MedPAR	Medicare Provider Analysis and Review
MS-DRG	Medicare Severity-Diagnosis Related Groups
OR	Odds Ratio
PAC	Post-Acute Care
PPACA	Patient Protection and Affordable Care Act
PPS	Prospective Payment System

RTI	Research Triangle Institute
SNF	Skilled Nursing Facility
THA	Total Hip Arthroplasty
TKA	Total Knee Arthroplasty
U.S.	United States
UTMB	University of Texas Medical Branch

CHAPTER 1

Introduction

Recent healthcare reform initiatives continue to transform the way services are delivered and reimbursed, and how the quality of care is being measured for Medicare beneficiaries. Many more initiatives are pending implementation. One of the most highly publicized and anticipated of the pending programs is the *Comprehensive Care for Joint Replacement Model*, which is scheduled to begin on April 1, 2016.[1, 2] The new model encourages and incentivizes different types of providers to work together to improve both care quality and continuity across the entire episode of care: from initial hospital admission through completion of the necessary post-acute rehabilitation services.[1, 2] This dissertation looks back at healthcare utilization patterns and select quality-related outcomes among Medicare beneficiaries receiving total knee arthroplasty (TKA) in the context of prior significant healthcare reform initiatives implemented during the early-to-mid 2000s, that had a direct impact on post-acute care services. The remainder of this Chapter provides brief overviews and literature reviews of key topics for the studies performed.

Total Knee Arthroplasty (TKA)

TKA has been described as "one of the most common major surgical procedures performed"[3] in the United States (U.S.) with more than 600,000 procedures performed each year with an average cost of $15,000 each.[3-6] In 2013, more than 400,000 Medicare beneficiaries received either a TKA or total hip arthroplasty (THA) costing more than $7 Billion for the index hospitalization stays alone with the average total cost of care ranging from $16,500 to $33,000 per recipient.[1,2] The number of TKA procedures performed on Medicare beneficiaries increased 161.5% between 1991 to 2010.[3] By 2030, the total number of TKAs performed in this country is expected to grow an additional 673%.[7]

Nearly 33% of patients who receive a TKA have similar knee problems on the opposite side.[8] Simultaneous bilateral procedures, wherein both knees are operated on during a single anesthetic period, make up an estimated 6% of the TKA procedures.[9, 10] Proponents of the bilateral TKA cite many advantages: single surgical and anesthesia event, symmetrical rehabilitation, and one hospitalization versus two reducing overall length of stay (LOS).[11] However, bilateral TKA result in increased risk for postoperative complications, especially for individuals with advanced age.[10] Consequently, a trend exists towards younger patients receiving bilateral procedures; however, the age of patients receiving any TKA is also decreasing in general.[10] Current research suggests that the timing between these staged procedures range between 3.8 days to 5.9 years.[11] Limited research is available regarding the appropriateness of bilateral versus two separate (unilateral) staged procedures over time.[11]

TKA is regarded as a cost effective procedure for improving both the quality of life and functional abilities of patients.[4, 12] However, the benefits can vary across different patient socio-demographic and clinical characteristics. Advanced age, female gender, black and Hispanic race/ethnicity, lower socio-economic status and higher numbers of comorbidities are associated with poorer TKA outcomes.[4, 13, 14] In addition, LOS following TKA declined from 7.9 days in 1991 to 3.5 days in 2010, placing larger emphasis of care on post-acute care (PAC) settings.[3, 15]

Post-Acute Care (PAC)

PAC includes several different settings, which vary in terms of the volume, intensity, and costs of rehabilitative services they provide; e.g., inpatient rehabilitation facility (IRF), skilled nursing facility (SNF), long-term acute care hospitals, outpatient services, and home-based services provided by home health agencies.[16, 17] More than 10 million Medicare beneficiaries receive PAC each year in these settings.[16] IRF settings are highly focused on rehabilitation and expect the patient to participate in 3 hours of cumulative therapy sessions per day.[16] Patients who discharge to IRF tend to be more medically complex while those who receive SNF tend to be older or have cognitive deficits.[18, 19] Patients who discharge directly to home with services are more likely to be healthier. However, outpatient and/or home-based services may also be selected for patients who are unable to tolerate more aggressive therapy in IRF, if IRF beds are not available, or based on patients' preferences.[17]

Discharge planning to determine PAC is a complex process where discharge decisions are based on a multitude of factors. These factors have been classified into 4 distinct categories: 1) financial, 2) structural, 3) attitudinal, and 4) socio-demographic.[17] Specific examples include the type and availability of insurance, primary diagnosis and presence of comorbidities, current functional level, home situation or assistance availability, clinician and patient preferences, hospital or payer policies, and PAC availability.[19, 20]

Discharge to IRF following TKA among Medicare patients doubled during the 1990s (14.6% in 1991-1994 vs. 29.4% in 1999-2002) and then declined substantially during the first decade of the 2000s to levels below the early 1990s (11.4% in 2007-2010).[3] Discharge to SNF and outpatient therapy combined demonstrated a similar increase during the 1990s (16.6% in 1991-1994 vs. 28.4% in 1999-2002), but then continued to rise slightly over the subsequent decade (30.1% in 2007-2010).[3]

Policies and Procedures

Since its inception in 1965, Medicare has been attempting to control rising healthcare costs and the growth of post-acute care.[21, 22] In 1983, the then governing agency over Medicare, the Health Care Financing Administration (HCFA), instituted the prospective payment system (PPS), which paid a set amount per episode for acute hospitalization.[22] Under this system, hospitals are incentivized to reduce their patients' LOS and transfer the remaining care responsibilities to PAC and sub-acute providers.[17, 22] The surge of PAC usage led to development of PPS for all major PAC settings by the Balanced Budget Act (BBA) of 1997,[17, 22] which introduced PPS for SNF in 1998, home health in 2000, and IRF in 2002.[23]

In 2002, the Centers for Medicaid and Medicare Services (CMS), formerly known as HCFA, enacted the payment allocation plan known as the "75% rule" for IRF settings, which was initially conceived by HCFA in 1984.[23, 24] This ruling has a direct influence on IRF availability[16, 23, 24] and requires that a specified percentage of an IRF's annual admissions must fit into one of the following 13 rehabilitation impairment categories:

> (1) stroke, (2) spinal cord injury, (3) congenital deformity, (4) amputation, (5) major multiple trauma, (6) fracture of femur (hip fracture), (7) brain injury, (8) neurological disorders (multiple sclerosis, motor neuron diseases, polyneuropathy, muscular dystrophy, and Parkinson disease), (9) burns, (10) polyarticular rheumatoid arthritis, psoriatic arthritis, and seronegative arthropathies (with otherspecific criteria), (11) Systemic vasculidities with joint inflammation (and other specific criteria), (12) Severe or advanced osteoarthritis involving two or more major weight bearing joints (and other specific criteria), (13) knee or hip joint replacement (only if bilateral or body mass index > 50 or age ≥ 85 years).[24 (p.25775-25776)]

According to CMS, only patients with TKA who meet the above criteria (bilateral replacement, or body mass index > 50 or age ≥ 85 years) should be admitted into IRF as they require more intensive and multidisciplinary rehabilitation.[24, 25] However, CMS reports that data supporting these restrictions for patients with joint replacement are lacking.[24, 25] These specified percentages were initially enforced at 50% in 2004 followed by yearly increases to 65% in 2006; however, Congress revised the law in 2007, permanently setting the threshold at 60%, never reaching the full 75% target.[19, 26] *Figure 1* shows the threshold changes by year.

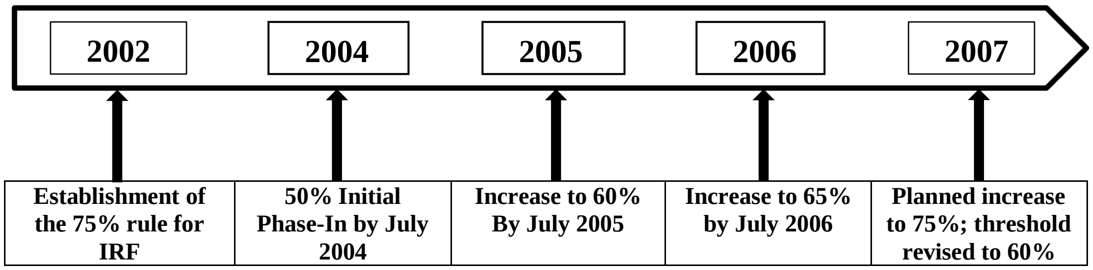

Figure 1: Changes in the 75% rule for IRF admission by year

In a more recent attempt to control health care costs, the Patient Protection and Affordable Care Act (PPACA) was signed into law (HR 3590; Public Law 111-148) in 2010.[27] Specific items within the PPACA relevant to this study include: 1) Hospital Readmissions Reduction Program (HRRP)[28] and 2) bundling payment for acute hospitalization and PAC services.[27]

Effective October 1, 2012 CMS levied financial penalties for hospitals with excessive 30-day readmissions in select diagnosis related groups (DRGs).[27] Initial conditions impacted by HRRP include: 1) acute myocardial infarction, 2) heart failure and 3) pneumonia.[28] However, additional conditions were added to the readmission measure in October 2014: 1) chronic obstructive pulmonary disease 2) total hip arthroplasty (THA) and 3) TKA.[28]

PPACA also set in motion the national pilot program on "payment bundling" which became effective on January 1, 2013.[27, 29] This current initiative is examining 48 DRG related episodes of care, using four models of measurement focusing on either 30-, 60- or 90-day timeframes.[29] These models vary in the types of services to be included in the bundled payment as well as the duration of the episode.[29] These episodes of care can potentially include costs of all services related to the specified condition from 3 days prior to the initial hospitalization to as many as 90 days post discharge.[27, 29] The pilot program has two phases: 1) preparation phase in which participants prepare for the assumption of financial risk and 2) the implementation phase in which participants assume financial risk for some or all of their measured episodes of care.[29] Currently, there are currently 870 phase one and 105 phase two health care organizations participating in the bundled payment initiative.[29]

CMS has included an additional initiative with specific focus on lower extremity joint replacements.[1, 2] The Comprehensive Care for Joint Replacement (CJR) model is being implemented at 75 facilities across the U.S. in April 2016.[1, 2]

Hospital Readmission

Hospital readmission rates have become an important quality indicator which can be easily measured;[30] however, CMS have stated that there is insufficient research regarding hospital readmission from IRF, SNF and community based discharge settings.[31, 32] With the aforementioned Medicare policy changes, it is imperative to examine ways of reducing healthcare costs and complications that result in hospital readmission.[33]

A practical starting point is determining if readmission rates differ based on the patient's initial (index) PAC setting admission.[32] Studies on hospital readmission have become increasingly prevalent. Previous research found an overall 19.6% 30-day, 28% 60-day, and 34% 90-day overall hospital readmission rate among all Medicare recipients.[34] That study also showed that beneficiaries who received "major hip or knee surgery" had a 9.9% 30-day readmission rate.[34] The 30-day readmission rate following TKA increased from 4.2% in 1991-1994 to 5.0% in 2007-2010,[3] which is similar to other reported readmission rates specific to the Medicare population.[33, 35] Other hospital readmission studies have been performed on TKA recipients; however, many were not specifically performed utilizing the Medicare population.[36-39] Those studies report rates ranging from 4.0%-4.7% for 30-day and 8.0%-15.6% for 90-day unplanned hospital readmissions.[36-39] Several other studies examined the effect of hospital discharge setting on readmission using facility level data and found those who discharged home with either home health or outpatient services had lower readmission rates (2.7%-3.3%) as compared to those who received IRF or SNF placement (3.7%-4.4%).[40, 41]

Summary

As healthcare policy continues to push for improving the efficiency and quality of care, it is vital to examine the role of the most frequently encountered PAC services following TKA. This research has the potential to provide valuable insight into the patient and facility-level characteristics that influence hospital readmission following TKA in the Medicare population.

This dissertation includes three aims designed to improve our understanding of trends in PAC utilization and 30-day readmission rates. Aim 1 (Chapter 2) focuses on time trends of hospital discharge settings and 30-day readmission rates of Medicare beneficiaries who received a TKA in 2002-2010. Aim 2 (Chapter 3) examines predictors of hospital discharge settings in Medicare TKA recipients. Aim 3 (Chapter 4) examines predictors of 30-day hospital readmission in Medicare TKA recipients and reports differences in readmission rates and reasons for readmission by discharge setting.

The conceptual framework for this study was based on the Andersen's Phase-3 Model of Health Services Utilization.[42, 43] This model maintains primary determinants influence health behavior and have direct consequences on health outcomes.[43] The primary determinants section of the Andersen model consists of population characteristics, the healthcare system, and the external environment.[43] In this study, primary determinants include patient socio-demographic variables, disability entitlement, and the volume of TKA procedures performed yearly by hospital facilities.[42, 43] The health behavior section of the Andersen model includes patient's health characteristics and their use of health services.[42, 43] Our study incorporates patient's clinical characteristics, such as LOS and co-morbidities, into the health behavior section of the conceptual model. The Health Outcome area of the Andersen model includes patient's perceived or evaluated health status.[43] This section includes the dependent variables for our study: discharge setting, hospital readmissions, and reasons for hospital readmission. See *Figure 2* for a graphical representation of how the Andersen conceptual model was adapted for this study.

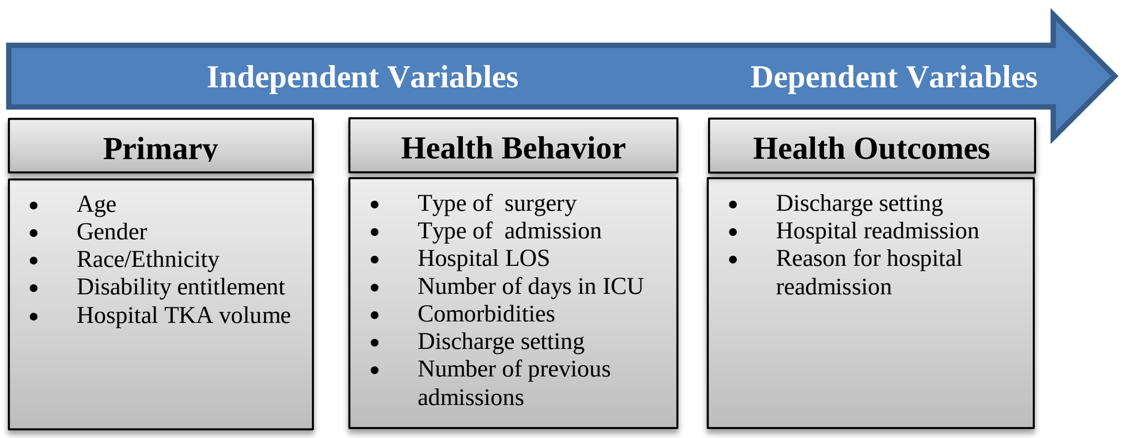

Figure 2: Modified Andersen's phase-3 model of health services utilization

CHAPTER 2

Trends in hospital discharge setting and 30-day all-cause readmission rates following total knee arthroplasty from 2002-2010.

Introduction

Policy changes within the Medicare payment system aimed at reducing healthcare costs have effectively reduced hospital lengths of stay (LOS).[44] The Balanced Budget (BBA) of 1997,[17, 22] ended the fee-for-service payment system for post-acute care settings and developed prospective payment systems (PPS) which were implemented for skilled nursing facilities (SNFs) in 1998, home health agencies (HHAs) in 2000, and inpatient rehabilitation facilities (IRFs) in 2002.[23] More recent attempts to control health care costs are holding hospitals liable for quality measures, such as higher-than-expected 30-day readmission rates.[34, 45]

As part of the IRF-PPS, the Centers for Medicare and Medicaid Services (CMS) initiated the "75% rule,"[16, 23] which mandated that 75% of an IRF's annual admissions be for 1 of 13 specified rehabilitation impairment categories. The percentages were initially enforced at 50% in 2004, increasing to 65% in 2006. However, Congress revised the law in 2007, permanently setting the threshold at 60%, never reaching the full 75% requirement.[19, 26] Bilateral total knee arthroplasty (TKA) is 1 of the 13 specified rehabilitation impairment categories by the CMS. In order for patients with a unilateral TKA to meet the "75% rule" criteria, they must also have a body mass index > 50 or be age ≥ 85 years.[24, 25]

Post-acute care (PAC) includes a wide range of settings such as IRF, SNF, long-term acute care hospitals, and HHA.[16] More than 10 million Medicare beneficiaries receive PAC each year in these settings.[16] Discharge planning to determine the type(s) of

PAC setting(s) is a complex process based on a multitude of factors. These include patient socio-demographics and functional level at the time of acute discharge, home assistance availability, comorbidities, available funding, clinician and patient preferences, and availability of PAC settings.[19, 20]

TKA is one of the most commonly performed major surgical procedures in the United States.[6] The number of TKA procedures in Medicare beneficiaries increased 161.5% from 1991 to 2010. It is estimated that by 2030, the total number of TKAs performed in the U.S. is expected to grow 673%.[3, 7] More than 600,000 TKA procedures are performed annually in the United States with bilateral procedures accounting for approximately 6% of this total.[10] TKA can be described as either being primary, usually an elective procedure for the treatment of osteoarthritis, or a revision of the initial primary procedure.[36]

Previous research examined trends in discharge settings following TKA from 1991 to 2010.[3] Comparing a 4-year pre-IRF PPS period (1999-2002) to a similar post-IRF PPS period (2007-2010) the authors reported that discharge to IRF decreased from 29.4% to 11.4% and discharge to home increased from 39.9% to 56.2% within the same period.[3] However, this study did not differentiate outpatient rehabilitation from skilled nursing facilities, which increased slightly from 28.4% to 30.1% over the same time period.[3]

The number of studies on hospital readmissions has increased substantially over the past few years, including those relating to TKA. Jencks et al. found that overall 30-day readmission was 19.6% among all Medicare beneficiaries and 9.9% in the category of “major hip or knee surgery” in patients who did not receive PAC.[34] Following TKA specifically, 30-day readmission rates have ranged from 4.0% to 5.5%.[32, 36] Cram and colleagues[3] showed that 30-day all-cause readmission rates increased from 4.2% (1991-1994) to 5.0% (2007-2010).

Previous research states that we need to "better understand factors associated with hospital readmission following inpatient rehabilitation and how these factors compare with other post-acute care (PAC) settings."[32] Although previous studies have examined discharge settings and their impact on 30-day readmission, they did not clearly distinguish between outpatient rehabilitation and intermediate care facilities. Therefore, the purpose of this study was to more explicitly examine the time trends in hospital discharge settings and 30-day readmission rates of patients who received a TKA in 2002-2010 based on the three most common discharge settings following TKA: community, SNF, and IRF. We hypothesized that 1) there will be a decrease in the percentage of patients discharged to IRFs over time and 2) all-cause 30-day readmission will demonstrate increasing trends over time in patients discharged to community, SNF and IRF settings.

Materials and Methods

Study Design and Sample. The study was a secondary analysis of Medicare claims data for the years 2002-2010. The study utilized the Medicare Beneficiary Summary files and the Medicare Provider Analysis and Review (MedPAR) files. The sample consisted of Medicare beneficiaries on fee-for-service plans, aged 65 years or older who had received a primary TKA, either unilateral or bilateral, and discharged from an acute care hospital between January 1, 2002 and November 30, 2010. These cases were identified using the *International Classification of Diseases, Ninth revision, Clinical Modification* (ICD-9-CM) procedure code for TKA: 81.54.[46] Bilateral procedures were identified by using the TKA 81.54 procedure code listed in two surgical procedure code columns associated with a single stay in the MedPAR files. Patients who received a primary TKA on the other lower extremity at a different 30-day time point were counted as separate index admissions. Patients receiving a TKA revision were not included in this study. This study was approved by the University's Institutional Review Board. We have a data use agreement with the CMS.

Sample preparation. A total of 2,476,703 patients met the inclusion criteria. We excluded patients who died in hospital (n=3,713) and who were discharged to a setting other than three post-acute care settings of interest (n=77,083) leaving 2,395,907 (97% of the eligible population) included in the demographic table and discharge setting trend analysis. For the 30-day readmission trend analysis, we also excluded an additional 246,078 patients who were enrolled in the Medicare Advantage Program (health maintenance organizations) during the study period. In addition, we censored patients who died within 30 days and prior to being readmitted (n=5,773). The final sample for the readmission analyses included 2,144,056 patients (89.4% of the original sample).

Outcome Measures. The first outcome variable used in the study was a three-level nominal variable for post-acute discharge settings: SNF, IRF, and community. Two categories, SNF and IRF, already exist within the discharge settings section of the MedPAR files.[47] The community category was coded using both the home health and outpatient rehabilitation services variables of the discharge category. The 2nd outcome measure used in the study was the dichotomized (yes/no) variable reflecting all-cause 30-day readmission, which was indicated by any MedPAR claim for an acute hospital setting within 30 days of discharge from the index TKA-related stay.

Demographic Information. Age and sex variables were obtained directly from MedPAR. Race/Ethnicity was extracted from the beneficiary summary files using the variable developed by the Research Triangle Institute (RTI).[48] Non-Hispanic white, Non-Hispanic black and Hispanic were coded directly from the original source variable in the beneficiary summary file. Individuals listed as Indian, Alaskan, Asian or "other" were re-coded as "other" for study purposes. The original reason for Medicare benefits was also extracted from the beneficiary summary file. This variable was coded as a dichotomous (yes / no) for disability as the original reason for entitlement. Patients were also dichotomized (yes / no) as being enrolled in Medicare's Health Maintenance Organization (HMO) during the study period.

Clinical Characteristics. Additional clinical variables included hospital length of stay (LOS), surgery type (unilateral vs bilateral), survived for 30 days (yes / no), and admission type (elective vs traumatic) for the surgical intervention. Elective admission type was directly coded from MedPAR. Traumatic admissions were re-coded using the categories of emergent, urgent or traumatic. *Table 1* provides information on variable names, sources and definitions for all variables used in this study.

Table 1: Variable list with data source and variable information

		Variable type		
Demographic variables	**Data source**	**H^1**	**H^2**	**Definition**
Age	MedPAR	-	-	Age in years at time of surgery
Gender	MedPAR	-	-	Male/Female
Race/Ethnicity	Beneficiary summary file	-	-	White/Black/Hispanic/Other
Disability entitlement	Beneficiary summary file	-	-	Yes/No Medicare disability entitlement
HMO	Beneficiary summary file	-	-	Yes/No Enrolled in health maintenance organization
Clinical variables	**Data source**	**H^1**	**H^2**	**Definition**
Surgery type	MedPAR	-	-	Unilateral/Bilateral
Length of stay	MedPAR	-	-	Index hospital discharge date – index hospital admission date
30-day survival	MedPAR	-	*	Yes/No died within 30 days
Outcome variables	**Data source**	**H^1**	**H^2**	**Definition**
Discharge setting	MedPAR	DV	**	IRF/SNF/Community
30-day readmission	MedPAR	-	DV	Yes/No 30-day all-cause hospital readmission
# of days until readmission	MedPAR	-	DV	Number of days until patient readmitted into the hospital

***Legend*: H^1 = Hypothesis 1; H^2 = Hypothesis 2; DV = Dependent Variable;**
*** = variable used for 30-day death censor; ** = variable used for stratification; (-) variable not used in analysis but included in demographic table**

Statistical Analysis. Descriptive summaries of patient demographic and clinical characteristics were tabulated and reported by discharge year from the index acute hospitalization. Discharge settings and all-cause 30-day readmission by discharge setting were graphically plotted by calendar year to show trends over time. The Cochran-Armitage trend test assesses the linearity of trends in binomial proportions across a continuous or ordinal-level variable.[49] Trends by time were examined for each outcome variable within the discharge setting and 30-day readmission graphs. All analyses were performed using IBM SPSS Statistics 23 (IBM) and SAS 9.3 (SAS Institute Inc.).

Results

Descriptive statistics for all 2,395,907 patients included in the discharge setting trend analysis are listed in *Table 2*. The number of TKA procedures performed yearly increased from approximately 168,000 in 2002 to 355,000 in 2010. A majority of the patients across time were white (> 89%) and female (> 65%). Mean age of the sample decreased slightly from 73.0 (SD 7.6) to 72.3 (SD 7.9) years. The proportion of patients with disability entitlement increased from 15.0% to 18.0% and membership in Medicare HMO increased substantially from 2.0% to 23.0% over the study period. Bilateral TKA decreased from 6.0% to 4.0% and average length of hospital stay decreased from 4.2 (SD 2.4) days to 3.4 (SD 1.5) days.

Figure 3 shows unadjusted hospital discharge settings by year. Community discharges were the most frequent category across all time points. A significant increasing trend ($p < .0001$) was found for community discharge from 45.5% in 2002 to 56.9% in 2010. SNF discharge also demonstrated a significant increasing trend ($p < .0001$) from 29.1% in 2002 to 32.8% in 2010. Conversely, IRF discharge had a significant decreasing trend ($p < .0001$) which peaked at 32.0% in 2003 and steadily declined to 10.3% in 2010.

Table 2: Patient characteristics by hospital discharge year; values are reported as mean (SD) or column percent.

	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total, N	168,045	206,804	241,834	263,383	262,568	269,107	309,314	320,157	354,695
Age	73.0 (7.6)	73.0 (7.7)	73.0 (7.7)	72.9 (7.7)	72.9 (7.8)	72.7 (7.9)	72.5 (7.9)	72.6 (7.9)	72.3 (7.9)
Female	64.6%	65.8%	65.9%	65.7%	64.9%	65.2%	65.0%	64.8%	64.7%
Race									
White	91.0%	90.6%	90.4%	90.2%	90.3%	90.2%	89.4%	89.3%	89.0%
Black	5.7%	6.0%	6.0%	6.2%	6.2%	6.3%	6.8%	6.9%	7.2%
Hispanic	1.3%	1.3%	1.3%	1.2%	1.2%	1.2%	1.3%	1.4%	1.4%
Other	2.0%	2.2%	2.3%	2.3%	2.3%	2.3%	2.5%	2.4%	2.4%
Disability	14.7%	14.9%	15.1%	15.5%	15.8%	16.5%	17.2%	17.8%	18.3%
Bilateral TKA	5.6%	5.7%	5.7%	5.5%	5.3%	4.8%	4.4%	4.0%	3.7%
HMO	2.2%	2.1%	2.1%	2.7%	2.8%	4.7%	17.5%	20.9%	22.9%
LOS (SD)	4.2 (2.4)	4.1 (2.0)	3.9 (1.9)	3.9 (1.0)	3.8 (1.8)	3.7 (1.8)	3.6 (1.7)	3.5 (1.6)	3.4 (1.5)
Survived 30 days	99.7%	99.7%	99.7%	99.8%	99.8%	99.8%	99.8%	99.8%	99.8%

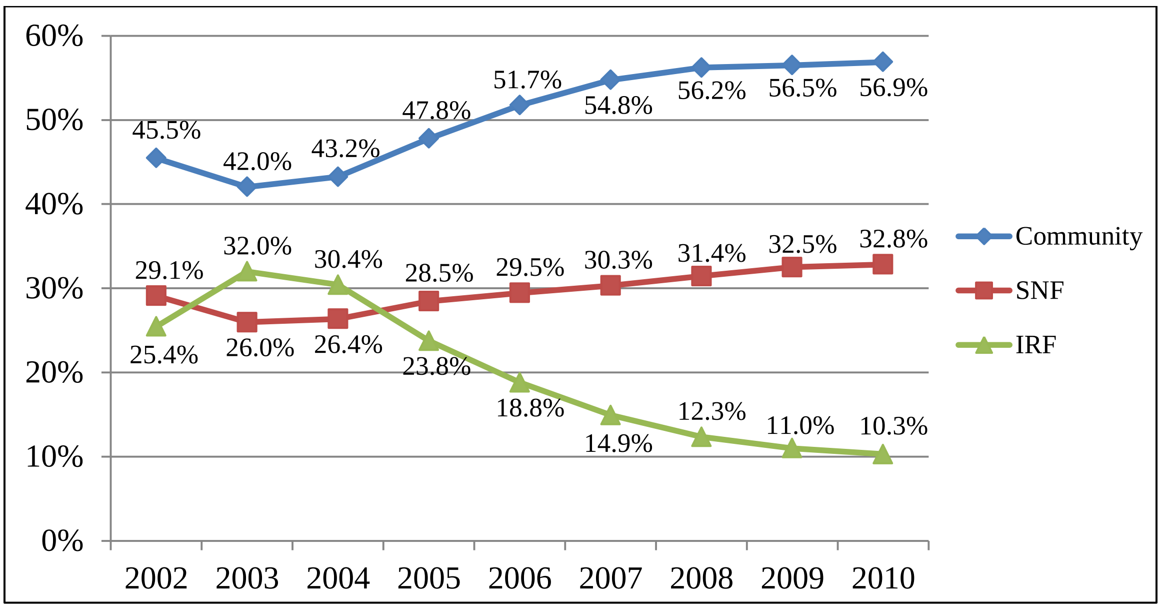

Figure 3: Discharge setting by year

Figure 4 shows yearly unadjusted, all-cause 30-day hospital readmission rates stratified by discharge setting. Readmission rates in the community discharge group consistently demonstrated the lowest readmission rates across time, remaining under 5% over the entire study period. Overall readmission demonstrated a significant decreasing trend ($p < .0001$) from 2002-2010. Likewise, a significant decreasing trend ($p < .0003$) in readmission was observed in the community discharge group from 4.6% in 2002 to 4.3%

in 2010. Conversely, a significant increasing trend ($p < .0003$) in readmission was observed in the IRF group from 6.4% in 2002 to 7.0% in 2010. A non-significant linear trend ($p = 0.93$) in readmission was observed in the SNF group with 7.0% in 2002, increasing to 7.5% in 2005, and then decreasing back to 7.0% in 2010.

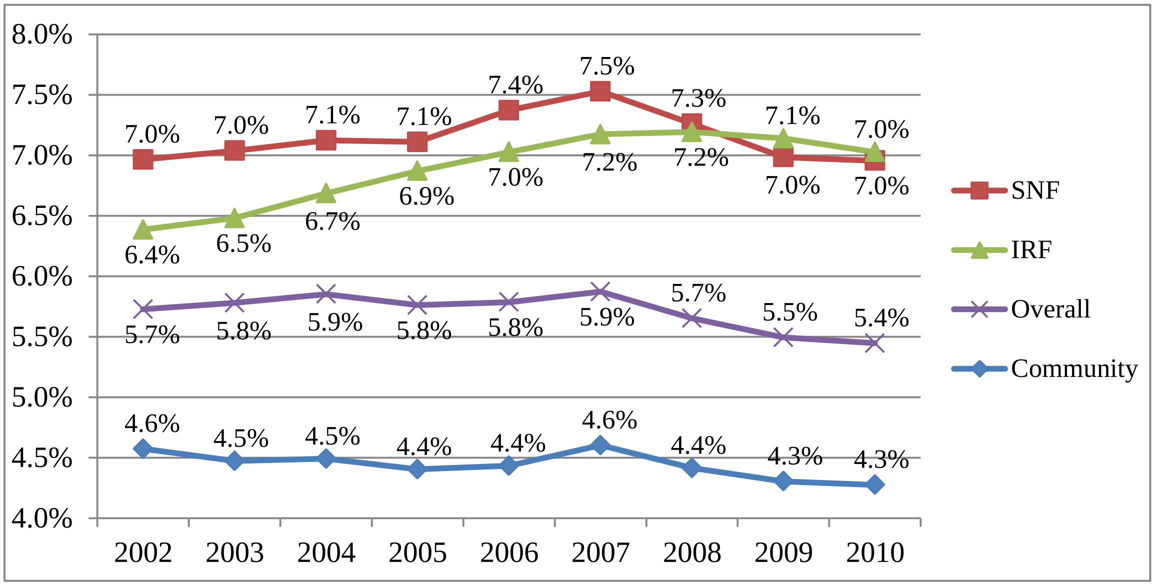

Figure 4: 30-day hospital readmission by discharge setting

Discussion

Policies within the Balanced Budget (BBA) of 1997[17, 22] substantially changed reimbursement models for post-acute care services for TKA recipients.[23] Provisions within the Affordable Care Act of 2010[27] are now holding hospitals liable for quality measures, such as 30-day readmission, following index hospitalization.[34, 45] This study used 100% Medicare data to examine the trends of discharge settings and 30-day readmission for TKA patients from 2002 to 2010, with an overarching goal of examining these time trends in relationship to policy change.

Our first hypothesis was supported: there will be a decrease in the percentage of patients discharged to IRFs from the years 2002 to 2010. Yearly discharge rates to IRF decreased significantly while rates to both SNF and community increased significantly over the nine-year study period. Our rates are similar to those for TKA patients reported by other researchers.[3, 32, 36] Cram et al.[3] analyzed Medicare data and found that discharges home and SNF increased while IRF decreased from 29% during the 1999-2002 period to 11% in 2007-2010. This decrease in IRF discharge and increase in both SNF and Community settings across time coincide with the enforcement of the "75% rule."[16, 23] During the early years of implementation of IRF-PPS, more patients having single TKA were able to discharge to IRF without penalty to the rehabilitation facility. As enforcement of the "75% rule" increased and eventually stabilized at 60%, fewer unilateral TKA patients received IRF care and more were discharged to SNF or to community settings.

This study also examined 30-day all-cause readmission rates by the three primary discharge settings: IRF, SNF, and community. Each of these settings were either not included or not clearly defined in previous literature examining this topic.[3] Our hypothesis for this aim was partially supported. Based on previous literature,[3] we hypothesized that Community, SNF and IRF discharge settings would demonstrate increasing trends in all-cause 30-day readmission from 2002 to 2010. Although we found an increasing trend in readmission rates in the IRF group (6.4% - 7.0%), we found a decreasing trend in the community discharge group (4.6% - 4.3%) and a non-significant trend in the SNF group. Cram et al.[3] reported unadjusted all-cause readmission rates of 4.0% in 1999-2002 to 5.0% in 2007-2010, which is lower than our resultant all-cause readmission rates across time: 5.7% - 5.4%. Other smaller studies using non-Medicare data report similar 30-day readmission rates of 4.0% to 5.5% following TKA.[35, 36, 50] It is believed that Cram et al.[3] found overall lower readmission rates over similar time frames because of differences in subject inclusion and exclusion methodology. In order to avoid under-estimating the 30-day readmission rates, our study censored patients who died within 30 days and prior to being readmitted. Cram et.al.[3] did not indicate such censoring in their published study. In addition, Cram and colleagues, in an attempt to focus on elective procedures, excluded patients who were admitted through the emergency room, from outside hospitals, received bilateral procedures or any 2nd TKA procedure occurring within 30-days.[3] Our study included any index admission for TKA and all admission sources.

While testing our explicit hypotheses, we also verified some general findings in the literature: most Medicare beneficiaries receiving TKA are predominantly white and female.[3] Mean age of the Medicare TKA patients was > 72 years throughout the study period and bilateral procedures decreased from 6.0% to 4.0% over the study period. We also found that hospital LOS decreased from 4.2 days in 2002 to 3.4 days in 2010, which may be one of the primary determinants of discharge setting and subsequent healthcare utilization. Examining the independent effects of decreasing LOS on changes in PAC utilization and readmission rates following TKA are important topics for future research.

We acknowledge several limitations in our study. One such limitation is the use of Medicare data which has the potential for coding errors that may limit reliability, completeness, and accuracy.[51] Also, the discharge setting variable in the claims reflects the intended setting, but does not guarantee that an individual was actually admitted for care to that setting. In addition, we examined all-cause hospital readmissions and did not differentiate between unplanned versus planned and potentially preventable versus non-preventable readmissions, which would better reflect quality of care issues at PAC settings.

In sum, we observed increases in both community and SNF discharges and substantial decreases in IRF discharges among Medicare beneficiaries receiving TKA from 2002-2010. These trends in discharge setting were most likely influenced by the progressive enforcement of Medicare's 75% rule for IRFs,[16, 23] which restricted IRF admissions for patients with unilateral TKA over those years. Regarding 30-day all-cause readmission rates, we observed slight decreases in the community discharge group and slight increases in the IRF group over the 9-year study period. The increasing rates in the IRF group are likely influenced by shorter hospital LOS following TKA and greater relative comorbidity burden in TKA patients meeting the eligibility requirements of the IRF 75% rule.[3, 44, 52]

This study is timely in the context of the continuing emphasis on value-based purchasing and provider-level quality measures, such as 30-day readmission rates following TKA.[34, 45] CMS is also currently exploring the concept of "bundled payments", and specifically on beneficiaries receiving TKA through the Comprehensive Care for Joint Replacement (CJR) model.[2] This initiative can potentially affect reimbursements for a hospital stay and up to 90 days of aftercare following the index hospitalization.[1, 2] Our findings may help healthcare practitioners, payers, patients, and hospital administrators to have a better understanding of how prior policy changes affected post-discharge PAC utilization and how the commonly-used PAC settings are associated with 30-day readmission following TKA.

Acknowledgements

This study was supported in part by grants from the National Institutes of Health (P2C HD065702) and the National Institute on Disability and Rehabilitation Research (H133G140127). The content is solely the responsibility of the author and does not necessarily represent the official views of the funding agencies. The agencies did not influence the design, analysis or interpretation of the study results.

CHAPTER 3

Predictors of discharge settings following total knee arthroplasty in Medicare patients

Introduction

Total knee arthroplasty (TKA) procedures increased by 162% in Medicare patients from 1991 to 2010.[3, 7] Over that same time period hospital lengths of stay for TKA declined by 44%, shifting more burden of care to post-acute care (PAC) settings.[3, 15] The number of TKAs in the Medicare population is expected to increase 6-fold by 2030.[7] Thus, it is imperative to better understand the appropriate PAC setting for these patients to reduce healthcare cost while maximizing the rehabilitation needs of the patient.[15]

The goal of PAC is to restore recently hospitalized patients to their highest level of function and/or provide other necessary medical services for recovery.[16] The primary institutional-based PAC options following TKA include skilled nursing facilities (SNF) and inpatient rehabilitation facilities (IRF). Community-based PAC options include outpatient rehabilitation therapy, home-based rehabilitation and nursing services provided by home health agencies (HHA).[16] In 2002-03, approximately 37% and 19% of the Medicare TKA recipients were discharged to SNF and IRF, respectively, with the remaining 43% of patients receiving community based therapy.[53, 54]

Previous studies, using single facility data, have examined predictors of discharge settings following TKA.[15, 52, 55, 56] Patients who receive bilateral TKA procedures are discharged to IRF more often than to SNF or community-based rehabilitation. In addition, those with more comorbid conditions are more likely to be discharged to inpatient PAC facilities than to community-based services.[15, 52, 55, 56] Positive associations have been found between facility TKA procedural volume and patient outcomes of functional status, mortality rates and post-operative complication rates.[4, 13, 57, 58] However, literature is lacking on the relationship between hospital volume and post-acute discharge settings.

The objective of this study was to identify predictors of post-TKA hospital discharge settings, specifically IRF, SNF or community, within the national Medicare fee-for-service population. We hypothesized that patients 1) receiving bilateral TKA, 2) with more comorbidity, and 3) receiving TKA from lower volume hospitals would all have greater likelihood of discharging to IRF than to either SNF or the community.

Materials and Methods

Study Design and Sample. The study was a secondary analysis of Medicare claims data for 2009-2011. The study utilized Medicare Beneficiary Summary files and Medicare Provider Analysis and Review (MedPAR) files. The sample consisted of Medicare beneficiaries on fee-for-service plans, aged 65 years or older who had received a primary TKA, either unilateral or bilateral, and discharged from an acute care hospital between 2009 and 2011. These cases were identified using the *International Classification of Diseases, Ninth revision, Clinical Modification* (ICD-9-CM) procedure code for TKA: 81.54.[46] Bilateral procedures were identified by using the TKA 81.54 procedure code listed under two surgical procedure code columns associated with a single stay in the MedPAR files. Patients receiving a TKA revision were not included in this study. This study was approved by the University's Institutional Review Board. We have a data use agreement with the CMS.

Sample preparation. A total of 1,229,924 patients met the above inclusion criteria. We excluded patients who died in hospital (n=1,347), had more than two TKA procedures during the study period (n=323), with unknown race / ethnicity (n=1,743), and who were discharged to a setting other than three post-acute care settings of interest (n=37,225). After exclusions, a total of 1,189,286 (96.7% of the eligible sample) patients were used for the analyses.

Discharge Settings. The outcome variable used in the study is a three-level nominal variable representing acute hospital discharge settings: SNF, IRF, community. Two categories, SNF and IRF, already exist within the discharge settings section of the MedPAR files.[47] The community category was coded using both the home health and outpatient rehabilitation services variables of the discharge category.

Demographic Information. Age and sex were obtained directly from MedPAR. Race/Ethnicity was extracted from the beneficiary summary files using the variable developed by the Research Triangle Institute (RTI).[48] Non-Hispanic white, Non-Hispanic black and Hispanic were coded directly from the original source variable. Individuals listed as Asian/Pacific Islander, American Indian / Alaska Native, Unknown, and Other were re-coded as "other" for the study purposes.

Clinical Characteristics. The Charlson Comorbidity Index (CCI) was computed to control for associated comorbid conditions during the hospital stay.[59] This index quantifies health status by examining ICD-codes related to 17 medical conditions.[59, 60] Based on the frequency distribution of those comorbidities in our sample, the index was categorized into a 3-level variable (0, 1, 2+). Additional clinical variables include: hospital length of stay (LOS), surgery type (unilateral vs bilateral), and the admission type (elective vs traumatic) for the surgical intervention. Elective admission type was directly coded from MedPAR. Admissions coded as "traumatic" were re-coded using the MedPAR categories of emergent, urgent or traumatic.

Facility Characteristics. Hospital-level TKA volumes were averaged from the annual number of claims in the MedPAR and categorized into quartiles (1-19, 20-58, 59-137, 138+) for analysis. *Table 3* provides information on variable names, sources and definitions for all variables used in this study.

Table 3: Variable list with data source and variable information

Demographic variables	**Data source**	**Variable Type** H^1	H^2	H^3	**Definition**
Age	MedPAR	CV	CV	CV	Age in years at time of surgery
Gender	MedPAR	CV	CV	CV	Male/Female
Race/Ethnicity	Beneficiary summary file	CV	CV	CV	White/Black/Hispanic/ Other
Clinical variables	**Data source**	H^1	H^2	H^3	**Definition**
Surgery type	MedPAR	IV	CV	CV	Unilateral/Bilateral
Admission type	MedPAR	CV	CV	CV	Elective/Traumatic
Hospital length of stay	MedPAR	CV	CV	CV	Days spent in the hospital
Charlson comorbidity index	MedPAR	CV	IV	CV	Comorbidity score categories
Facility variable	**Data source**	H^1	H^2	H^3	**Definition**
Hospital TKA volume-frequency	MedPAR	CV	CV	IV	Frequency of TKA, quartiles
Outcome variable	**Data source**	H^1	H^2	H^3	**Definition**
Discharge setting	MedPAR	DV	DV	DV	IRF/SNF/Community

***Legend*: H^1 = Hypothesis 1; H^2 = Hypothesis 2; H^3 = Hypothesis 3; DV = Dependent Variable; IV = Independent Variable; CV = Covariate.**

Statistical Analysis. Demographic, clinical and facility characteristics were stratified by discharge setting (IRF, SNF, and Community). Bivariate differences for continuous variables were tested using ANOVA. Differences in categorical variables were examined using estimates of proportions and 95% confidence intervals (CIs).[71] Estimates with 95% CIs that did not overlap were considered to be statistically different. Fully adjusted multinomial logistic regression was used to assess the independent contributions of surgery type, CCI, and hospital volume in predicting discharge setting controlling for the covariates of age, gender, race/ethnicity, admission type, and hospital length of stay. In this model, IRF served as the reference category for the outcome variable. Predicted probabilities for discharge settings (IRF, SNF, and Community) were calculated from the parameter estimates for each of the primary independent variables (Surgery type, CCI, and Hospital TKA volume). All analyses were performed using IBM SPSS Statistics 23 (IBM).

Results

Descriptive statistics by discharge settings for all 1,189,286 patients are presented in *Table 4*. Mean age of the sample was 73.6 (SD 6.0) years. A majority of the patients were white (87%) and female (64%). Unilateral TKA comprised 96% of the procedures. Over 94% of the patients received an elective TKA and the average length of stay was 3.4 (SD 1.6) days. Following TKA, approximately 57% of patients were discharged to the community, 32% received SNF and 11% received IRF.

Both continuous variables demonstrated significant associations ($p < 0.001$) with discharge settings in the un-adjusted analyses. Overall, patients discharged to either IRF or SNF shared many characteristics. They tended to be older, female, minorities, have a higher degree of comorbidity, and had TKA performed in middle volume hospitals compared to patients discharged to the community. Patients discharged specifically to IRF tended to have greater proportions of bilateral and trauma-related procedures.

Table 5 displays adjusted odds ratios (OR) from the multinomial logistic regression analysis with 95% confidence intervals (CI) for discharge to SNF or Community using IRF as the reference category. Statistically significant associations are discussed below. When compared to unilateral procedures, patients who received a bilateral TKA had 54% lower odds (OR 0.46, 95% CI 0.45–0.47) of SNF discharge and 73% lower odds (OR 0.27, 95% CI 0.26–0.27) of community discharge as compared to discharge to IRF. *Figure 5* represents the adjusted predicted probabilities of discharge setting by surgery type (unilateral, bilateral). Patients with the unilateral procedure had higher probability of discharging to community (48%) than SNF (32%) or IRF (20%) while patients who received a bilateral procedure had higher probability of receiving IRF (42%) than either SNF (31%) or community (27%).

Table 4: Patient demographics stratified by discharge setting, mean (SD) or % (95% CI)

	Total	IRF	SNF	Community
N	1,189,286	10.9 (10.8- 10.9)	32.3 (32.2 – 32.4)	56.8 (56.7 – 56.9)
Age *	73.6 (6.0)	74.9 (6.5)	75.4 (6.3)	72.3 (5.4)
Gender				
Female	761,158	11.8 (11.7 – 11.9)	36.9 (36.8 – 37.0)	51.4 (51.2 – 51.5)
Male	428,128	9.3 (9.2 – 9.4)	24.2 (24.1 – 24.3)	66.5 (66.4 – 66.7)
Race/Ethnicity				
White	1,040,184	10.4 (10.4 – 10.5)	31.7 (31.6 – 31.7)	57.9 (57.8 – 58.0)
Black	67,170	16.0 (15.7 – 16.3)	40.0 (39.6 – 40.4)	44.0 (43.6 – 44.4)
Hispanic	56,486	12.8 (12.6 – 13.1)	34.3 (33.9 – 34.7)	52.8 (52.4 – 53.3)
Other	25,446	11.4 (11.1 – 11.8)	33.8 (33.3 – 34.4)	54.7 (54.1 – 55.3)
Surgery type				
Unilateral	1,142,556	9.3 (9.3 – 9.4)	32.4 (32.4 – 32.5)	58.2 (58.1 – 58.3)
Bilateral	46,730	49.2 (48.7 – 49.6)	28.9 (28.5 – 29.3)	21.9 (21.6 – 22.3)
Admission type				
Elective	1,121,094	10.8 (10.7 – 10.9)	32.3 (32.3 – 32.4)	56.9 (56.8 – 57.0)
Traumatic	68,192	12.3 (12.1 – 12.6)	31.7 (31.3 – 32.0)	56.0 (55.6 – 56.4)
Hospital LOS *	3.4 (1.6)	3.7 (2.1)	3.7 (1.7)	3.2 (1.3)
Charlson index score				
0	676,690	9.9 (9.8 – 9.9)	29.6 (29.4 – 29.7)	60.6 (60.5 – 60.7)
1	383,106	11.7 (11.6 – 11.8)	34.5 (34.4 – 34.7)	53.8 (53.6 – 54.0)
2+	129,490	13.8 (13.6 – 14.0)	40.2 (39.9 – 40.4)	46.0 (45.7 – 46.3)
Hospital TKA volume, quartiles				
1-19	19,902	11.3 (10.9 – 11.8)	31.8 (31.1 – 32.4)	56.9 (56.2 – 57.6)
20-58	97,992	12.0 (11.8 – 12.3)	34.6 (34.3 – 34.8)	53.4 (53.1 – 53.7)
59-137	266,468	12.2 (12.1 – 12.3)	35.0 (34.8 – 35.1)	52.8 (52.6 – 53.0)
138+	804,924	10.3 (10.2 – 10.4)	31.2 (31.1 – 31.3)	58.5 (58.4 – 58.7)

*** Variables statistically significant ($p < 0.001$) by ANOVA**

Relative to patients without comorbidity, those with one comorbid condition had 3% higher odds (OR 1.03, 95% CI 1.02-1.05) and those with two or more (2+) comorbid conditions had 6% higher odds (OR 1.06, 95% CI 1.04-1.08) of discharging to SNF than to IRF. In addition, relative to patients without comorbidity, patients with one comorbidity had 10% lower odds (OR 0.90, 95% CI 0.89-0.91) and those with two or more (2+) comorbidities had 21% lower odds (OR 0.79, 95% CI 0.78-0.81) of community discharge than to IRF level discharge. *Figure 6* represents the adjusted predicted probabilities of discharge setting by comorbidity. Patients with one and two or more (2+) comorbid conditions had 46% and 42% probability of community discharge, respectively, 33% and 36% probability of SNF discharge, respectively, and 21% and 22% of IRF level discharge, respectively.

When compared to the largest volume (+138) hospitals the smallest quartile group (1-19) had 5% lower odds (OR 0.95, 95% CI 0.92-0.99) of discharging to SNF than to IRF. Also, when compared to the largest volume (138+) hospitals, the two middle quartile groups (20-58 & 59-137) had 8% lower odds (OR 0.92, 95% CI 0.90-0.93) and 10% lower odds (OR 0.90, 95% CI 0.89-0.91), respectively, of discharging to community than to IRF. *Figure 7* represents the adjusted predicted probabilities of discharge setting by hospital TKA volume. The smallest quartile group (1-19) had 31% probability of SNF discharge while the middle two quartile groups (20-58 & 59-137) had 46% and 45% probability of community discharge, respectively.

Table 5: Results of logistic regression for discharge settings following TKA

	SNF		**Community**	
	Odds Ratio	**95% CI**	**Odds Ratio**	**95% CI**
Surgery type (Unilateral = reference)				
Bilateral	0.46	0.45–0.47	0.27	0.26–0.27
Charlson comorbidities (0 = reference)				
1	1.03	1.02–1.05	0.90	0.89–0.91
2+	1.06	1.04–1.08	0.79	0.78–0.81
Hospital TKA volume (138+ = reference)				
1-19	0.95	0.92–0.99	0.98	0.94–1.02
20-58	0.99	0.97–1.01	0.92	0.90–0.93
59-137	1.00	0.98–1.01	0.90	0.89–0.91
Age	1.01	1.01–1.01	0.97	0.97–0.97
Gender (Female = reference)				
Male	0.86	0.85–0.87	1.24	1.23–1.26
Race/Ethnicity (White = reference)				
Black	0.97	0.95–0.99	0.76	0.75–0.78
Hispanic	0.97	0.95–0.99	0.89	0.87–0.91
Other	1.01	0.98–1.05	0.95	0.92–0.91
Admission type (Elective = reference)				
Traumatic	0.93	0.91–0.95	1.00	0.97–1.02
Hospital LOS	1.03	1.03–1.03	0.93	0.93–0.94

IRF is the reference category for the 3-level dependent variable.

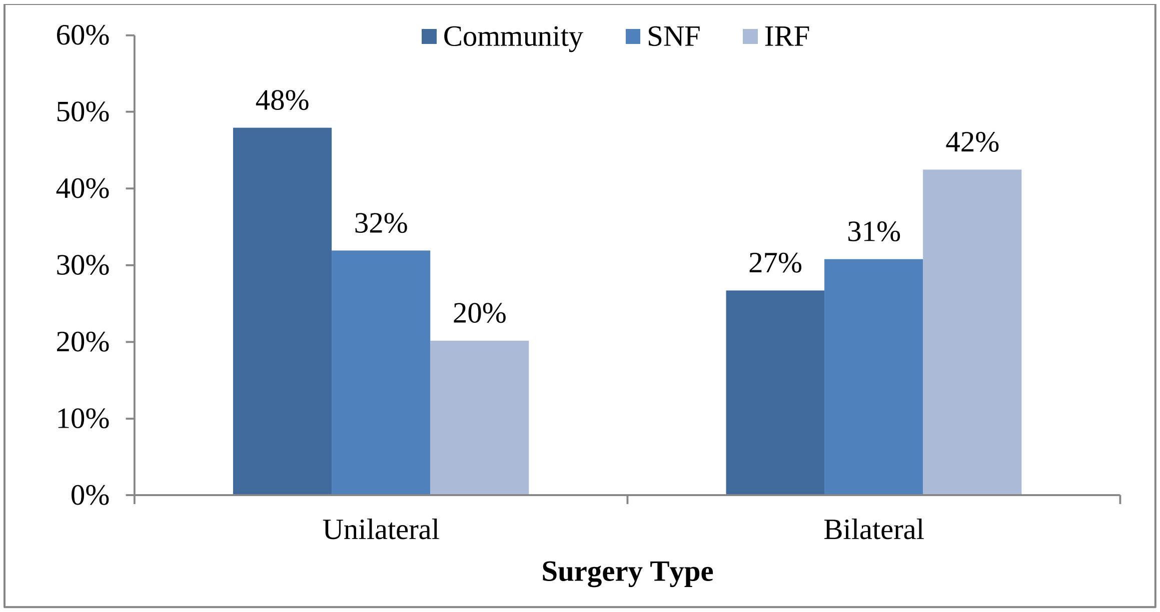

Figure 5: Predicted probabilities of discharge setting by surgery type

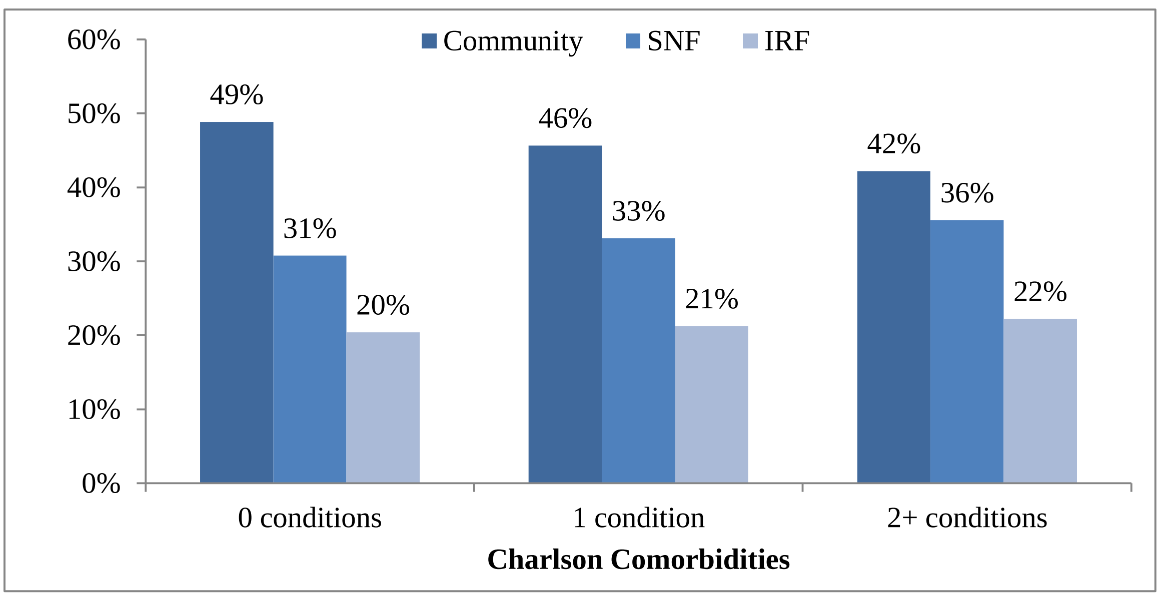

Figure 6: Predicted probabilities of discharge setting by comorbidity

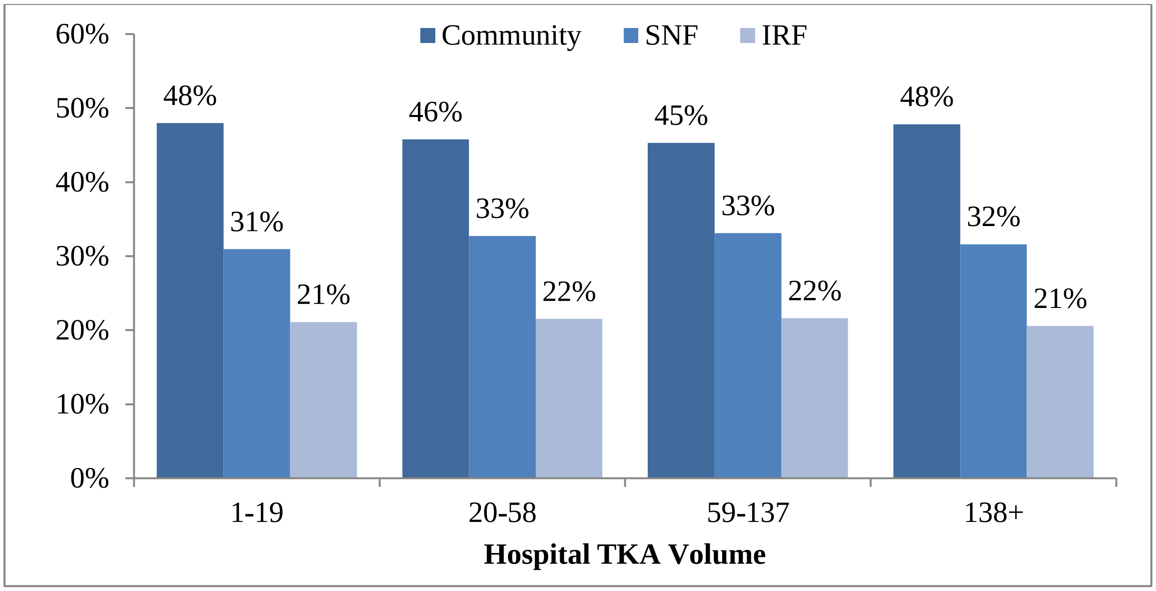

Figure 7: Predicted probabilities of discharge setting by TKA volume

Discussion

As the number of TKA procedures increase[7] and the budgetary constraints continue to impact healthcare utilization,[33] it has become critical to determine appropriate PAC settings for continued and efficient provision of rehabilitation services. Our study using the 100% Medicare data examined several clinical and facility level characteristics to predict PAC discharge settings following TKA in the Medicare population.

Our first hypothesis was supported: patients who received a bilateral TKA will have greater likelihood of discharging to IRF than to SNF or community. Barsoum et al.[56] found that 95% of patients receiving a bilateral TKA required institutional-based post-acute care (IRF or SNF). Our study added clarity to the PAC utilization patterns and showed that patients with bilateral TKA procedures had lower odds of discharging to SNF or to community than to IRF.

Our second hypothesis was not supported. We hypothesized that patients with more comorbidity will have greater likelihood of receiving IRF discharge than to SNF or community. Compared to patients with no comorbidities, patients with either 1 or 2 or more comorbid conditions had lower odds of discharge to community but higher odds of discharging to SNF when compared to IRF. Several smaller clinical studies have reported associations between measures of health status and likelihood of discharge to inpatient PAC, but they either did not include SNF as a PAC option or did not distinguish between SNF and IRF in their studies.[15, 55, 56] Additionally, these studies utilized the American Society of Anesthesiologist (ASA)[61] physical status classification to predict PAC settings.[15, 55] It was found that higher ASA scores, reflecting decreased health status, had higher odds of receiving SNF or IRF than a community based setting.[15, 55] Barsoum and colleagues[56] identified three specific comorbid conditions (heart disease, diabetes and pulmonary disease) which were statistically associated with SNF or IRF versus home discharge. Munin et al.[52] also showed patients with greater than two comorbid conditions had greater likelihood of discharge to IRF when compared to those who discharged directly home. The ASA classification system is not available for Medicare data and is recommended for clinical use to predict post-operative complications. It can also be used to determine rehabilitation needs following joint replacements.[62] Our study used the Charlson Comorbidity Index[59] which provided ordinal rankings of comorbidity burden. This index is frequently used with administrative claims data studies to adjust for potential confounding health status on inpatient health outcomes; however, the clinical severity of disease is not coded in administrative data.[63, 64]

Our final hypothesis, patients receiving TKA from lower volume hospitals will have greater likelihood of discharging to IRF than to SNF or community was supported by our findings. When compared to the largest volume category per year (138+), the lowest volume category (1-19) had lower odds of discharging to SNF than to IRF. Both middle volume categories (20-58 and 59-137) had lower odds of community discharge compared to IRF. There is limited prior research on this outcome. However, several studies have examined hospital TKA volume and found positive associations with postoperative functional status and mortality rates.[4, 57, 58] In addition, Katz et al.[13] found hospitals with an annual TKA volume > 200 had lower 90-day post-operative complication rates.

While examining the above hypotheses, we verified some general findings in the literature: most TKA Medicare fee-for-service beneficiaries over the age of 65 are predominantly white and female.[3] We also found that in 2002-03 utilization of post-acute services by Medicare beneficiaries following TKA was distributed evenly across the three primary settings: community-based (35%), IRF (35%), and SNF (30%).[19, 54] In this study 57% of patients were discharged to the community, 32% received SNF and only 11% received IRF.[3] This observed increase in discharges to community-based settings and decrease in IRF usage following TKA was most likely influenced by Medicare's initiation of the payment allocation plan known as the "75% rule."[16, 23] This directive required 75% of IRF admissions must be from one of 13 rehabilitation impairment categories which does not include unilateral TKA procedures.[23] This percentage was initially enforced at 50% in 2004, increased to 65% in 2006; and ultimately, the threshold was permanently set at 60% in 2007.[19, 26]

Our study builds on the knowledge provided by other investigators on predictors of discharge settings following TKA. Advantages of our study over previous studies include our large and representative sample from the 100% Medicare files, the use of a standardized comorbidity index which include 17 conditions,[59] and uses a multinomial regression modeling approach which can control for effects of several patient and clinical factors to differentiate likelihood of discharge between the three settings: IRF, SNF and community.

We also acknowledge several limitations in our study. The findings are only generalizable to Medicare Fee-for Service beneficiaries 65 years and older. Information was not available in these data files regarding availability of social support or living situation, which has been shown to influence discharge destination in prior investigations.[52, 56, 65, 66] The data files also lacks information on patients functional status, such as walking or performance of self-care tasks, which can significantly influences a patient's ability to discharge home.[52, 56, 66] Another limitation in the use of Medicare data is the potential for coding errors, which can lead to biased estimation primarily related to use of comorbid conditions.[63, 67, 68] Further studies including functional status, living situation and/or support systems are recommended. In addition, the inclusion of patient's discharge preference and expectations would be valuable, as these factors have been found to be significant predictors for community versus inpatient placement.[66, 69]

In conclusion, this study adds to our understanding of the predictors of discharge settings following TKA in the Medicare population. We were able to verify many "clinically" known realities with empirical evidence: patients receiving bilateral procedures, those with more comorbidity, and those who received TKA in lower volume hospitals have higher likelihood of discharging to IRF than to SNF or community level settings. As the number of TKA procedures continues to grow and hospital lengths of stays decrease, the need for appropriate PAC will inevitably increase.[3, 7, 15] Our findings can be useful for healthcare practitioners, hospital administrators, payers, and patients to better understand which patient or clinical factors influence PAC settings following TKA.[15] There is evidence in the literature suggesting that better PAC prediction can decrease hospital length of stay and decrease the need for extended inpatient rehabilitation.[3, 7, 15] This study enhances our ability to more accurately predict which type of post-acute settings typically used following TKA in the Medicare population using several important demographic and clinical variables.

Acknowledgements

This study was supported in part by grants from the National Institutes of Health (P2C HD065702) and the National Institute on Disability and Rehabilitation Research (H133G140127). The content is solely the responsibility of the author and does not necessarily represent the official views of the funding agencies. The agencies did not influence the design, analysis or interpretation of the study results.

CHAPTER 4

Effects of hospital discharge setting on 30-, 60- and 90-day readmission rates and reasons for readmission following total knee arthroplasty among older adults

Introduction

Since 2012, the Hospital Readmission Reduction Program (HRRP)[28] within the Patient Protection and Affordable Care Act (PPACA)[27] began holding hospitals accountable for higher-than-expected unplanned 30-day readmission rates following hospitalization for certain medical conditions.[34, 45] Beginning fiscal year 2015, total knee arthroplasty (TKA) was added as an eligible condition under the HRRP program.[28] In 2013, the PPACA also initiated the "payment bundling" national pilot program.[27 29] This initiative examines 30-, 60- or 90-day episodes of care and include all cost of services within the stated time periods.[29] In addition, the Centers for Medicare and Medicaid Services (CMS) specifically includes joint replacement into the bundling initiative through the Comprehensive Care for Joint Replacement (CJR) model.[1, 2] These existing and pending policy changes have resulted in a critical need to examine ways of improving coordination of care among acute and post-acute providers and reducing complications that result in unplanned hospital readmission.[33] A need also exists to determine if the rates and causes of readmission differ based on the patient's initial (index) discharge setting to home or inpatient post-acute care settings.[32]

Post-Acute care (PAC) following TKA encompasses several different types of health care services at both institutional and community-based settings, all of which aim to provide medical needs for recovery and functional restoration.[16] PAC services are available through skilled nursing facilities (SNF), inpatient rehabilitation facilities (IRF), long term acute care hospitals, outpatient centers, and home health agencies (HHA).[16]

There are more than 600,000 TKA procedures performed yearly in the United States and it has been described as one of the most commonly performed major surgical procedures.[3] TKA, both revision and primary procedures, are expected to drastically increase in frequency during the upcoming decades due to rapidly growing aging population.[7] This growth, coupled with the inclusion of TKA in several different policy implications[1, 2,28] highlights the need to examine the effects of discharge setting on readmission rates following TKA.[40]

Previous research indicates that TKA patients who discharged home had lower 30- and 90-day readmission rates than those who discharged to IRF or SNF.[40, 41 39] Commonly cited reasons for hospital readmission at 30 or 90 days include problems associated with the surgery itself (infection or stiffness)[36, 37, 39] or cardiovascular events.[33] Overall re-hospitalization rates among Medicare recipients regardless of diagnosis have been found to be 19.6% within 30 days and 34.0% within 90 days.[34] Readmission following TKA has also been well-documented at 3.4% to 5.6% over 30 days and 3.5% to 15.6% over 90 days.[33, 37] However, previous studies which focused on either 30- or 90-day readmission following TKA had relatively small samples and did not include all commonly used PAC settings.[39-41]

One objective of this study was to identify predictors of 30-day unplanned readmission following TKA among Medicare beneficiaries. A secondary objective was to examine hospital readmission rates up to 90 days hospital readmission rates and the reasons for readmission following PAC discharge from IRF, SNF or community. We hypothesized that those discharging to SNF or IRF will have higher odds of (30-, 60- and 90-day) hospital readmission than community.

Materials and Methods

Study Design. This study was a secondary analysis of Medicare claims data for 2008-2011. We used the Medicare Beneficiary Summary and Medicare Provider Analysis and Review (MedPAR) files. To examine the number of times a patient was readmitted in the previous year as a covariate, a retrospective observation period of one-year was performed using 2008 data. Therefore, to examine 90-day readmission following hospitalization discharge, only those patients who received a primary TKA (unilateral or bilateral), and discharged from an acute care hospital between Jan 1st, 2009 and September 30th, 2011 were included. We included only Medicare beneficiaries aged 66 years or older on the fee-for-service plans during the index hospitalization. TKA procedures were identified using the *International Classification of Diseases, Ninth revision, Clinical Modification* (ICD-9-CM) procedure code of 81.54.[46] Bilateral procedures were identified by using the TKA 81.54 procedure code listed under two surgical procedure code columns for a single stay in the MedPAR files. This study was approved by the University's Institutional Review Board. We have a data use agreement with the CMS.

Sample preparation. 963,438 patients met the initial inclusion criteria. We excluded patients that were < 66 years of age at the index hospitalization (n=119,465), enrolled in a Health Maintenance Organization (HMO) at any time during the study period (n=215,473), died during initial hospitalization following TKA (n=638), had missing race/ethnicity data (n=461), had other than elective or traumatic reasons for admission (n=952), and who received a discharge setting other than three post-acute sites of interest (n=18,418). Following exclusions, 608,031 patients (63% of original sample) were included in the univariate analysis, frequencies and reasons for readmission, and 90-day survival analysis. An additional 862 patients (0.1%) who died within 30 days of their index stay were excluded in the logistic modeling for 30-day readmission. This left

607,169 patients (63%) for logistic regression analysis. *Figure 8* represents a graphical representation of the study's inclusions and exclusion criteria and results.

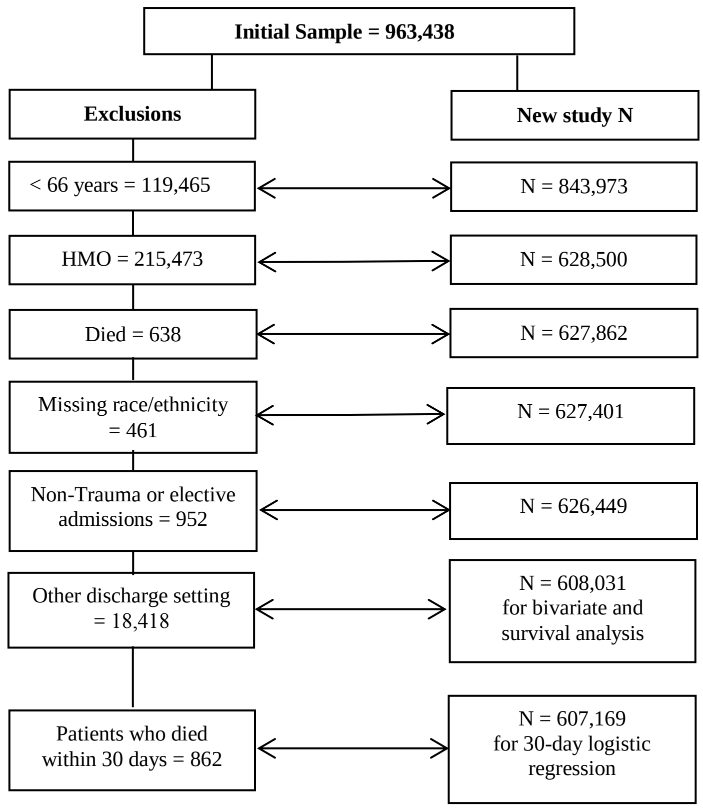

Figure 8: Flow chart representing study inclusions and exclusion criteria

Outcome Measures. Readmissions were indicated if a patient had an additional claim for an unplanned acute hospital stay in the MedPAR within the specified timeframes (30, 60, or 90 days) following discharge from the index stay for TKA. Unplanned readmissions were coded using the methodology from CMS' hospital-wide readmission measure.[70] The variable was coded as a dichotomous (yes / no) variable for the 30-day readmission logistic regression analysis. Days to readmission were also recorded and used along with the dichotomous indicator variable for the 90-day readmission survival analysis. Reasons for hospital readmission were obtained from the

Medicare Severity-Diagnosis Related Groups (MS-DRG) diagnostic codes in the MedPAR.

Demographic Information. Age and sex were obtained from the MedPAR. Race/Ethnicity was extracted from the beneficiary summary files using the variable developed by the Research Triangle Institute (RTI).[48] Non-Hispanic white, Non-Hispanic black and Hispanic were coded directly from the original source variable. Individuals listed as Asian/Pacific Islander, American Indian / Alaska Native, Unknown, and Other were re-coded as "other" for the analyses purposes.

The original reason for Medicare benefits was also extracted from the beneficiary summary file; we coded this as a dichotomous variable indicating disability as the original reason for entitlement (yes / no).

Other Clinical Characteristics. The Charlson Comorbidity Index (CCI) was used to control for comorbidity burden during the hospital stay.[59] This index quantifies health status by examining ICD-codes related to 17 medical conditions.[59, 60] The comorbidity index was categorized into a 3-level (0, 1, 2+) variable based on the sum of conditions listed for a given patient. Other clinical variables included in this analysis include hospital length of stay (LOS), number of days (0, 1+) in the intensive care unit (ICU), surgery type (unilateral, bilateral); number of times a patient was admitted in the hospital within one year prior to the index acute admission date, and the index stay admission type (elective, traumatic) for the TKA intervention. Elective admission type was obtained from the MedPAR. Traumatic admissions were coded using the MedPAR variables of emergent, urgent or traumatic. The discharge setting variable used in the study is a three-level variable: SNF, IRF, and community. Two categories, SNF and IRF, already exist within the discharge settings section of the MedPAR files.[47] The community category was coded using both the home health and outpatient rehabilitation services variables of the discharge category.

Facility Characteristics. Previous studies found associations between facility TKA volume and patient outcomes of functional status, mortality rates and post-operative complication rates.[4, 13, 57, 58] For this study, hospital-level TKA volumes were averaged from the annual number of claims in the MedPAR and categorized into quartiles (1-19, 20-58, 59-137, 138+) for analysis. *Table 6* represents information on the variable names, source location and definitions for all variables used in this study.

Statistical Analysis. Demographic, clinical and facility characteristics were stratified by 30-day readmission. Bivariate differences for continuous variables were tested using t-test. Differences in categorical variables were examined using estimates of proportions and 95% confidence intervals (CIs).[71] Estimates with 95% CIs that did not overlap were considered to be statistically different. Fully adjusted logistic regression was performed in order to assess the independent effects of discharge setting after controlling for age, gender, race/ethnicity, disability entitlement, surgery type, admission type, number of times a patient was admitted in the hospital within the previous year, hospital, LOS, number of ICU days, discharge setting, CCI, and hospital TKA volume for predicting 30-day hospital readmission. Non-readmission was used as the referent category.

Cox proportional hazards model was used to assess the independent effects of discharge setting in predicting the event time variable, time-to-readmission over 90 days following the initial TKA procedure, after controlling for gender, race/ethnicity, age, disability entitlement, surgery type, admission type, number of admissions in previous year, hospital LOS, number of days spent in the ICU, discharge setting, comorbidity, and hospital TKA volume. Patients who were not readmitted within 90 days were censored at the 90-day point. Patients who either died or enrolled in a Health Maintenance Organization (HMO) were censored at those respective time points. Kaplan-Meier curves were used to assess the proportion of 1st time hospital readmissions of patients from each discharge setting at the 30-, 60- and 90-day time points and groups were compared using a log-rank test with a $p = < .05$ indicating statistical significance.

Table 6: Variable list with data source and variable information

Demographic variables	**Data source**	**Variable type**	**Definition**
Age	MedPAR	CV	Age in years at time of surgery
Gender	MedPAR	CV	Male/Female
Race/Ethnicity	Beneficiary summary	CV	White/Black/Hispanic/Other
Disability entitlement	Beneficiary summary	CV	Disability entitlement yes/no
Clinical variables	**Data source**	**Variable type**	**Definition**
Surgery type	MedPAR	CV	Unilateral/Bilateral
Admission type	MedPAR	CV	Elective/Traumatic
Previous admissions	MedPAR	CV	Number of admissions in previous year
Hospital Length of stay	MedPAR	CV	Days spent in the hospital
Stay in the ICU	MedPAR	CV	1+ days spent in ICU during index hospitalization
Discharge setting	MedPAR	IV	IRF/SNF/Community
Charlson comorbidity index	MedPAR	CV	Comorbidity score categories
Time until death	MedPAR	*	Number of days until death
Facility variable	**Data source**	**Variable type**	**Definition**
Hospital TKA Volume-Frequency	MedPAR	CV	Frequency of TKA, quartiles
Outcome variables	**Data source**	**Variable type**	**Definition**
30-day Readmission	MedPAR	DV	Yes/No
Number of days until readmission	MedPAR	**	Number of days until 1st readmission
Reason for readmission	MedPAR	**	MS-DRG at time of 1st readmission

***Legend*: DV = Dependent variable; IV = Independent variable; CV = Covariate, * = variable used for 30-day death censor; ** = variables used for secondary objectives.**

To examine the number of times individual patients were readmitted into the hospital within 30-, 60-, and 90-days, frequencies of patient readmissions up to 90 days were stratified by calendar year and discharge settings.

To examine the reasons for hospital readmission, the top 10 MS-DRGs were identified at the 30-, 60- and 90-day time points and stratified by discharge setting.

Readmissions for TKA, representing a staged bilateral procedure, within the readmission period were not counted as a condition of readmission following the index stay. All analyses were performed using IBM SPSS Statistics 23 (IBM).

Results

Descriptive statistics and bivariate results of 30-day readmission for all 608,031 patients are presented in *Tables 7 and 8*. Mean age of the sample was 74.4 (SD 6.0) years. A majority of the patients were white (89%) and female (64%). A total of 32,226 (5.3%) patients were re-admitted to the hospital within 30 days. Patients with disability entitlement comprised 7.8% of the sample. Unilateral TKA encompassed 96% of the procedures. Over 94% of the patients received an elective TKA procedure. The average number of admissions in the previous year was 0.3 (SD 0.6) times. The average length of stay in acute hospitals was 3.4 (SD 1.5) days. Most (96%) patients did not have any days in the ICU during their hospitalization. Less than 1% of the patients died within 90 days following their initial hospitalization. More than half (56%) of the patients discharged to community following TKA.

On average, patients readmitted within 30 days were older (1.6 years), had more hospital stays in the previous year (0.1 stays), and longer hospital LOS (0.6 days) compared to those who were not readmitted (p = < .001 for all comparisons). Using non-overlapping 95% confidence intervals as the criterion, all variables listed in Table 8 were significantly associated with 30-day readmission. Males (6.0%) were more likely to be readmitted than females (5.0%). Regarding race/ethnicity, black patients experienced the highest readmission rates (6.4%) and patients classified as other experienced the lowest rates (5.0%). Patients with disability entitlement (7.5%) were more likely to be readmitted than those without (5.2%). Bilateral surgery (6.2%) was associated with higher rates than unilateral (5.3%). Similarly, traumatic admission (6.0%) was associated with higher rates than the more common elective admission (5.3%). Patients with two or more comorbid conditions from the Charlson list (8.9%) were much more likely to be readmitted than those with none (4.3%). Being admitted to the ICU during the hospital stay was also associated with substantially higher readmission rates (9.2% vs. 5.2%). Interestingly, more than half (56.1%) of patients who died within 30 days of discharge were readmitted first. Hospital TKA volume demonstrated a stepwise decrease in readmission rates from the lowest quartile (6.7%) to the highest (5.1%). Discharge setting also demonstrated a discernable gradient in readmission rates from community (4.1%) to SNF (6.9%) to IRF (7.2%).

Table 7: Sample characteristics stratified by 30-day readmission, mean (SD)

		30-day Readmission		
	Total	No	Yes	*p*-value
Age	74.4 (6.0)	74.3 (5.9)	75.9 (6.3)	< .001
Prior hospitalizations	0.3 (0.6)	0.3 (0.6)	0.4 (0.8)	< .001
Length of stay	3.4 (1.5)	3.3 (1.4)	3.9 (2.5)	< .001

Table 9 displays the adjusted odds ratios (OR) from the logistic regression analysis with 95% confidence intervals (CI) for 30-day readmission using non-readmission as the referent category.

Compared to community discharge, patients who were discharged to IRF or SNF had 44% higher odds (OR 1.44, 95% CI 1.39–1.49) and 40% higher odds (OR 1.40, 95% CI 1.36–1.44) of 30-day readmission, respectively. *Figure 9* represents the adjusted predicted probabilities of 30-day readmission by discharge setting (Community, SNF and IRF). Patients who discharged from Community had 4.6% probability while SNF had 6.3% and IRF had 6.5% probability of 30-day hospital readmission.

Table 8: Overall 30-day readmission by patient characteristics, % (95% CI)

	N	Readmitted
Total	608,031	5.3 (5.3 - 5.4)
Sex		
Female	388,495	5.0 (4.9 - 5.1)
Male	219,536	6.0 (5.9 - 6.1)
Race/ethnicity		
White	541,719	5.3 (5.2 - 5.3)
Black	30,111	6.4 (6.1 - 6.7)
Hispanic	23,507	5.5 (5.2 - 5.7)
Other	12,694	5.0 (4.6 - 5.4)
Disability		
No	560,507	5.2 (5.1 - 5.2)
Yes	47,524	7.5 (7.2 - 7.7)
Surgery type		
Unilateral	584,626	5.3 (5.2 - 5.4)
Bilateral	23,405	6.2 (5.9 - 6.5)
Admission type		
Elective	572,532	5.3 (5.2 - 5.4)
Traumatic	35,499	6.0 (5.8 - 6.3)
Charlson Comorbidities		
0 conditions	347,905	4.3 (4.3 - 4.4)
1 condition	195,086	5.9 (5.8 - 6.0)
2+ conditions	65,040	8.9 (8.7 - 9.1)
Days in ICU		
0 days	582,273	5.2 (5.1 - 5.2)
1+ days	25,758	9.2 (8.8 - 9.5)
Death		
Survived	605,945	5.2 (5.1 - 5.2)
1-30 days	862	56.1 (52.8 - 59.5)
31-60 days	643	50.7 (46.8 - 54.6)
61-90 days	581	33.4 (29.6 - 37.2)
TKA volume (Quartiles)		
1-19	10,581	6.7 (6.2 - 7.2)
20-58	51,715	6.0 (5.8 - 6.2)
59-137	134,819	5.6 (5.5 - 5.7)
> 137	410,916	5.1 (5.1 - 5.2)
DC setting		
Community	343,498	4.1 (4.0 - 4.2)
SNF	192,792	6.9 (6.8 - 7.0)
IRF	71,741	7.2 (7.0 - 7.4)

Increased odds of 30-day readmission were also predicted by age, male gender, Black race, disability entitlement, bilateral TKA, traumatic admissions, increased number of previous admissions, increased length of stay, days in ICU, comorbidity, and smaller hospital TKA volume.

Table 9: Results of logistic regression analysis for 30-day readmission

	Odds Ratio	**95% CI**
Discharge setting (Community = reference)		
IRF	1.44	1.39–1.49
SNF	1.40	1.36–1.44
Age	1.04	1.03–1.04
Gender (Female = reference)		
Male	1.24	1.22–1.27
Race/Ethnicity (White = reference)		
Black	1.12	1.07–1.18
Hispanic	0.99	0.93–1.05
Other	0.95	0.88–1.03
Disability entitlement (No = reference)		
Yes	1.41	1.36–1.46
Surgery type (Unilateral = reference)		
Bilateral	1.10	1.03–1.16
Admission type (Elective = reference)		
Traumatic	1.05	1.00–1.10
# Previous admissions	1.24	1.22–1.25
Hospital LOS	1.09	1.08–1.10
# days in ICU (0 days = reference)		
1+	1.25	1.19–1.31
Charlson comorbidities (0 = reference)		
1	1.28	1.25–1.31
2+	1.72	1.66–1.78
Hospital TKA volume (138+ = reference)		
1-19	1.21	1.12-1.31
20-58	1.10	1.06-1.14
59-137	1.04	1.01-1.07

Non-readmission = reference category for readmission dependent variable.

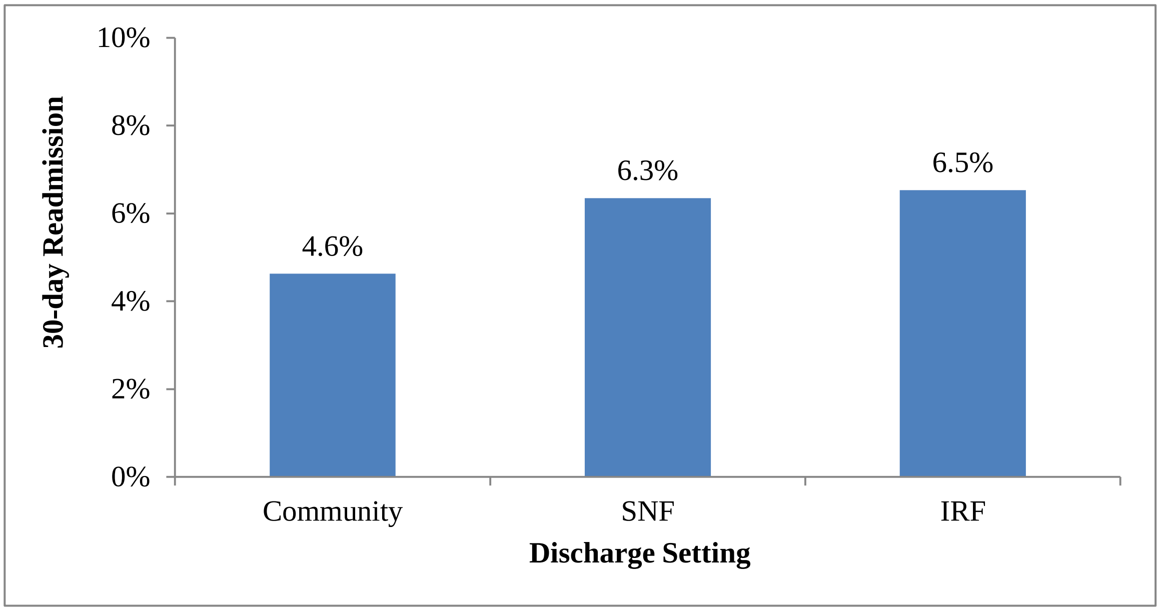

Figure 9: Predicted probabilities of 30-day readmission by discharge setting

Table 10 shows adjusted hazard ratios (HR) for the time to first unplanned readmission within 90 days of hospital discharge. IRF and SNF discharge settings were associated with a 48% higher (HR 1.48 95% CI 1.44 – 1.52) and 45% higher (HR 1.45 95% CI 1.42 – 1.47) risk of 90-day readmission, respectively, compared to community discharge. Other factors associated with higher risk included age, males, blacks, disability entitlement, traumatic admission, number of previous admissions, +1 days in ICU, increased comorbidities, and smaller hospital TKA volumes.

Figure 10 represents the unadjusted readmission probabilities for the 1st unplanned readmission for both the overall sample and by discharge settings. Overall, cumulative readmission rates increased by time and readmissions were lower in community discharges than IRF or SNF in each time period. The largest increase in readmissions occurred within 30 days of hospital discharge in each discharge setting. A significant difference ($p < .0001$) was found across discharge setting groups.

Table 10: Results of Cox regression model for readmission within 90 days

	Hazard Ratio	95% CI
Discharge setting (Community = reference)		
IRF	1.48	1.44–1.52
SNF	1.45	1.42–1.47
Age	1.04	1.03–1.04
Gender (Female = reference)		
Male	1.17	1.15–1.19
Race/Ethnicity (White = reference)		
Black	1.11	1.07–1.15
Hispanic	1.00	0.96–1.04
Other	0.96	0.90–1.02
Disability entitlement (No = reference)		
Yes	1.41	1.38–1.45
Surgery type (Unilateral = reference)		
Bilateral	1.01	0.96–1.05
Admission type (Elective = reference)		
Traumatic	1.06	1.03–1.10
# Previous admissions	1.28	1.27–1.29
Hospital LOS	1.05	1.05–1.06
# days in ICU (0 days = reference)		
1+	1.32	1.27–1.36
Charlson comorbidities (0 = reference)		
1	1.28	1.26–1.30
2+	1.73	1.69–1.77
Hospital TKA volume (138+ = reference)		
1-19	1.18	1.12–1.26
20-58	1.09	1.06–1.13
59-137	1.04	1.03–1.07

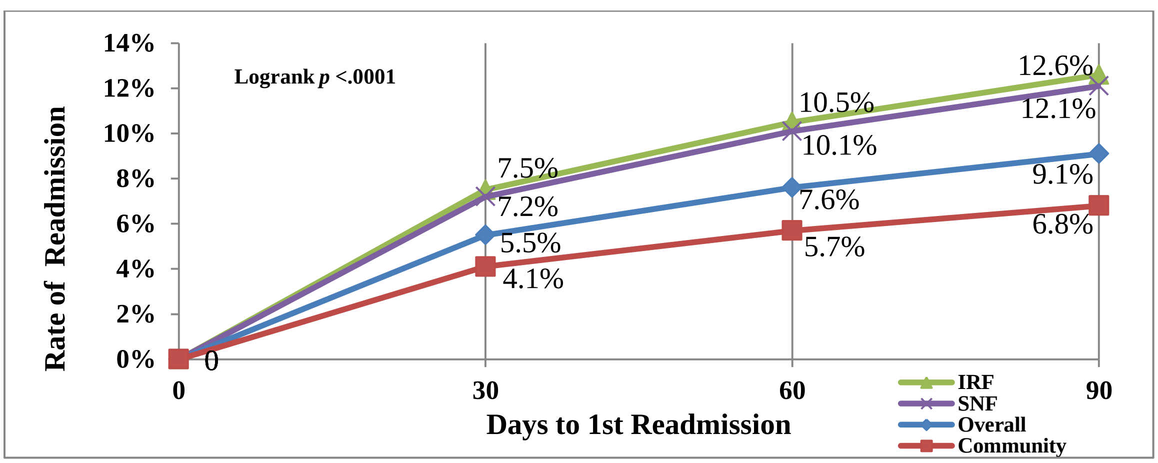

Figure 10: Probability of readmission by time stratified by discharge setting

Table 11 shows frequencies of readmissions by time: 1-90 (total) days, 1-30 days, 31-60 days, & 61-90 days, reflecting the number of times patients readmitted into the hospital within that time category. Less than 10% of patients experienced a readmission in the 90-day study period. Cumulative frequencies decreased over successive time periods: 1-30 days = 5%; 31-60 days = 3%; 61-90 days = 2%. Among those readmitted, single readmission was the most common pattern across all three time periods.

Table 11: Frequency of total readmissions within 1-30, 31-60, 61-90 and 1-90 days

Times readmitted	**1-30 days**	**31-60 days**	**61-90 days**	**1-90 days**
1	4.8%	2.3%	1.8%	7.2%
2	0.5%	0.2%	0.1%	1.2%
3	< 0.1%	< 0.1%	< 0.1%	0.3%
4	< 0.1%	< 0.1%	< 0.1%	0.1%
5	< 0.1%	< 0.1%		< 0.1%
6		< 0.1%		< 0.1%
7		< 0.1%		< 0.1%
9				< 0.1%
Total readmitted	N=32,445	N=15,196	N=11,709	N=53,228
Total %	5.3%	2.5%	1.9%	8.8%

Appendices A, B, & C list the 10 most common reasons (MS-DRG) for hospital readmission within each of the three time periods, by discharge setting. Similar MS-DRGs are observed in all three discharge settings and time categories. In the early (1-30 days) category, MS-DRG 863 (post-operative or traumatic infections) was among the top causes for readmission in all three discharge settings. Other reasons at 1-30 days include MS-DRGs 603 (Cellulitis), 392 (Esophagitis, Gastroenteritis and miscellaneous digestive disorders), 176 (Pulmonary Embolus), and other cardiac or miscellaneous diagnoses. At 31-60 days, MS-DRG 863 (post-operative or traumatic infections) remains within the top 5-7 reasons for readmission in the settings, does not appear in the 61-90 day period. Reasons for readmission at 31-60 and 61-90 days show several other similarities. The primary reason for readmission at 31-60 and 61-90 days is MS-DRG 392 (Esophagitis, Gastroenteritis and miscellaneous digestive disorders) in all settings, except for IRF at 61-90 days, where it is second to MS-DRG 690 (Kidney & Urinary tract infections). Other codes include MS-DRG 603 (Cellulitis), 312 (Syncope and Collapse) and other cardiac related or miscellaneous diagnoses.

Discussion

Healthcare reform has led to policy changes that hold hospitals responsible for quality measures, such as 30-day readmission following TKA. [27, 28, 34, 45] In addition, the Centers for Medicare and Medicaid Services is currently examining the concept of "payment bundling" and specifically for lower extremity joint replacements through the Comprehensive Care for Joint Replacement (CJR) initiative, which would encompass all costs for acute and post-acute services within 30, 60 or 90 days of the initial TKA procedure.[1, 2, 27, 29] These changes, coupled with the growing trend of TKA, point towards a critical need to examine ways of reducing healthcare costs, and factors for improving quality of care.[7, 33, 40]

A previous study using 2003-2004 Medicare data found 20% of all beneficiaries were readmitted within 30 days and 34% within 90 days following their index hospitalization.[34] Also, 10% of those receiving combined knee or hip surgery were readmitted back into the hospital within 30 days. However, that study did not define which surgical procedures specifically made up the surgery cohort.[34] In another study, Cram et al. utilized 100% Medicare data from 1991-2010 and found all-cause 30-day readmission following TKA increased from 4% in 1991-1994 to 5% in 2007-2010.[3] Using the 100% Medicare data from 2009-2011, our study examined several patient demographic and clinical characteristics as well as hospital volume to predict 30-day hospital readmission. Unlike previous studies, our study emphasized readmission rates based on the three most common discharge settings following TKA: community, SNF, and IRF. We also examined cumulative rates and most common reasons for readmission up to 90 days.

Our hypotheses were supported by the data: patients discharging to SNF or IRF would be more likely to be readmitted over all time periods compared to those discharged to the community. Using logistic regression we found 44% and 40% higher odds of 30-day readmission in patients who discharged to IRF or SNF compared to those who discharged to community. There have been limited prior studies examining the effect of discharge setting on 30-day hospital readmission. Ramos et al. found no significant trend in 30-day unplanned readmission in those sent to IRF than the combined variable of SNF or community when examining by patient's age, gender and comorbidity.[40] Bini et al. examined 90-day hospital readmission using hospital level data and found those discharged to a SNF had higher odds of readmission than those sent home.[41] Nonetheless, these studies only provide partial information regarding the most prevalent discharge settings following TKA and their impact on hospital readmission, particularly 30-day readmission in Medicare beneficiaries, which is the primary quality indicator of the HRRP.[28]

To further investigate the role of discharge setting in hospital readmission following TKA, risk for readmission was assessed up to 90 days following hospital discharge. We found 5.5% (30-day), 7.6% (60-day) and 9.1% (90-day) overall unplanned readmission rates. Rates were lower for community discharges than IRF or SNF at each time point. Other studies examining readmission using non-Medicare data found overall 3.1% to 4.0% 30-day and 3.5% to 8.0% 90-day unplanned readmission rates.[36, 39, 41] These lower rates may be explained by these studies having a younger patient population, < 65 years, while our study focused on the Medicare population.

Our time-to-event analysis indicated 48% and 45% greater risk for unplanned hospital readmission up to 90 days for those discharged to IRF and SNF, respectively, compared to those discharged to community. There is limited literature related to 90-day readmission by discharge settings. Schairer et al. found in their all-payer sample, patients who received either a primary or a revision TKA and were discharged to SNF had a 62% increase in risk of 90-day unplanned readmission when compared to those who discharged to other settings combined.[36] The higher rate reported by these authors could be due to the inclusion of revision TKA in their sample and their use of a combined discharge setting variable of IRF and community.[36] In addition, those findings were obtained from a single facility, which may vary from our national sample including more than 2,500 acute hospitals.

A secondary objective in this study was to examine the top 10 reasons for readmission by discharge setting at each (30, 60, 90) time point. Previous literature indicates surgical-related infections, cardiovascular events, and wound or joint problems are common reasons for readmission following joint replacement surgery.[36, 39] Our study stratified the 10 most prevalent MS-DRGs by discharge setting (IRF, SNF, and community) and found commonalities in all three discharge settings and time categories. Gastrointestinal and cardiovascular conditions were observed in all three time periods and settings. We also found that post-operative infections were most common within in the first 30 days; however, the prevalence decreased during days 31-60 and was no longer present after 61 days.

This study builds on the current body of knowledge provided by other investigators regarding the rates and causes of readmission following TKA. The advantages of our study over previous studies include our large and representative sample from the 100% Medicare files, the use of a standardized comorbidity index which include 17 conditions,[59] and the inclusion of the three most common discharge settings following TKA to determine the relationships between settings and hospital readmission. This study investigated patient, clinical and facility level variables for their impact on recent policy changes affecting TKA beneficiaries such as the Hospital Readmission Reduction Program[28] and the Comprehensive Care for Joint Replacement model.[1, 2]

We also acknowledge several limitations in our study. Study findings are only generalizable to Medicare Fee-for Service beneficiaries 66 years and older. Another limitation is the use of Medicare data. There is potential for coding errors, which can lead to misdiagnosis, false identification of complications and comorbidities, or under-reporting of comorbid conditions.[63, 67, 68] While we accounted for comorbidity as an aggregate, we did not account for or examine specific comorbidities and their effect on hospital readmission. Lastly, we differentiated planned from unplanned readmissions using established criteria in the hospital-wide readmission measure, but we did not try to distinguish preventable from non-preventable readmissions, which would better reflect opportunities for quality improvement.

This study adds to our understanding of the rates and reasons of hospital readmission following TKA in the Medicare population, specifically the influence of discharge setting on readmission. We found community discharge following TKA is associated with lower odds of 30-day readmission and lower risk of readmission up to 90 days. Also IRF and SNF show similarly higher trends of readmission. We know from previous literature that differences in patient functional status, comorbidity and support systems following TKA[52, 56, 65] can influence discharge setting. Therefore, as the number of TKA procedures continues to grow[7] and with current initiatives to reduce hospital readmissions and costs associated with TKA in the Medicare population,[28, 29] examining the reasons driving discharge options have become critical. Further studies including functional status, living situation and/or support systems are warranted. In addition, studies investigating the effects of different combinations of comorbidities on readmission may improve our ability to identify high-risk patients prior to discharge. Our current findings can be useful for healthcare practitioners, hospital administrators, payers, and patients to better understand which factors are associated with hospital readmission following TKA.

Acknowledgements

This study was supported in part by grants from the National Institutes of Health (P2C HD065702) and the National Institute on Disability and Rehabilitation Research (H133G140127). The content is solely the responsibility of the author and does not necessarily represent the official views of the funding agencies. The agencies did not influence the design, analysis or interpretation of the study results.

CHAPTER 5

Summary and Conclusions

The preceding studies examined predictors of discharge setting and rates, and correlates of hospital readmission following total knee arthroplasty (TKA). In doing so, several Medicare policies and regulatory changes were discussed which potentially affect post-acute care access following TKA and also could impact health outcomes, including hospital readmissions. First, the Centers for Medicare and Medicaid Services (CMS) implemented the inpatient rehabilitation facility (IRF) prospective payment system in 2002. This regulation included progressive increases and enforcement of the "75% rule." The 75% rule requires that a certain percentage of an IRF's annual admissions be from a list of 13 specified rehabilitation impairment categories; unilateral TKA does not qualify unless the patient is 85 years and older or is obese.[16, 23, 24] Second, the studies in this dissertation were influenced by several provisions in the 2010 Patient Protection and Affordable Care Act (PPACA).[27] The Hospital Readmissions Reduction Program (HRRP), for example, applies financial penalties to hospitals with higher-than-expected 30-day readmission rates for certain conditions including TKA.[28] In addition, the PPACA[27] began the national pilot program on "payment bundling"[27, 29] and specifically included TKA through the Comprehensive Care for Joint Replacement (CJR) model which is examining payment methodology based on 30, 60 or 90-day readmission in select healthcare facilities across the U.S.[1, 2, 29, 31] The studies in this dissertation also provide valuable insight regarding the factors influencing immediate discharge setting, unplanned readmission rates, and reasons for readmission following index hospitalization for TKA.

The primary objective of Aim 1 was to examine Medicare data from 2002 to 2010 for time trends in discharge setting and 30-day all-cause readmission rates by discharge setting following TKA. The results of our study reflect the yearly percentage changes set forth by the "75% Rule,"[16, 23, 24] restricting the number of TKA beneficiaries discharging to IRF following their index hospitalization. Prior to implementation, IRF was the 2nd most common discharge setting after community, with nearly 1-in-3 TKA patients being discharged to IRFs. By 2010, IRF utilization had fallen to 1-in-10 TKA patients. We also found that 30-day readmission rates were lowest in patients discharged to the community and similarly higher in patients discharged to either SNF or IRF across time. This 1st aim is largely descriptive in nature and provides new information on trends as they relate to changes in utilization of PAC settings and 30-day readmission rates following TKA.

Aim 2 examined predictors of discharge setting following index hospitalization for TKA. We found patients who received a bilateral procedure had lower odds of SNF or community discharge compared to IRF. It is important to note that bilateral TKA meets the eligibility requirements of the "75% rule." We also found patients with more comorbidity had lower odds for community discharge and higher odds for SNF discharge compared to IRF. Lastly, this study demonstrated that patients who received their TKA from hospitals with lower TKA volumes had lower odds of SNF discharge compared to IRF. This aim provided valuable insight into predictors of discharge setting following TKA. Further studies which include patient's functional status, living situation, and the patient's discharge preference or expectations would be beneficial, as these have been found to be strong predictors of discharge setting following TKA.[66, 69]

The final aim of this dissertation examined unplanned hospital readmission rates and reasons for readmission following TKA. The rationale for this study was guided by both the 30-day readmission focus of the HRRP[28] and the CJR model examining 30, 60 or 90-day episodes of care in select healthcare facilities across the U.S.[1, 2] Overall unadjusted readmission rates for the 30-, 60-, and 90-day periods were 5.5%, 7.6%, and 9.1%, respectively. We found patients who discharged to either SNF or IRF had > 40% odds of 30-day readmission compared to those who discharged to community. Our time-event analysis indicated > 45% greater risk for unplanned readmission up to 90 days for those discharged to IRF or SNF when compared to community discharge. We also listed the 10 most prevalent MS-DRGs for each of the 3 discharge settings. We found similarities in MS-DRGs across all three discharge settings and time periods. Infections were the most common reason for readmission with the first 30 days and cardiovascular and gastrointestinal conditions were consistent diagnoses across all three time periods. Previous studies have reported similar reasons for readmission following joint replacement surgery.[36, 39] Further studies evaluating patient's functional status, living situation and support systems and their effects on readmission would be beneficial for future policy implications. In addition, further study on comorbidities and their individual effects on unplanned hospital readmissions are warranted to improve the risk-standardization procedures for this quality measure.

In conclusion, these studies contribute new information to existing knowledge regarding PAC utilization and hospital readmission following TKA. Collectively, they examine the topic of discharge settings and their effect on unplanned hospital readmission following TKA. This information is presented as timely additions to available knowledge as the PPACA[27] strives though various programs to reduce hospital readmissions and curtail rising healthcare costs. These findings can also be helpful for healthcare practitioners, administrators, payers, and recipients of TKA to better understand and manage important factors related to unplanned hospital readmission following TKA.

APPENDICES

Appendix A: Top 10 MS-DRG codes for hospital readmission within 1-30 days by discharge setting

	DRG	N	%	Label
Community	863	879	6.12%	POSTOPERATIVE & POST-TRAUMATIC INFECTIONS W/O MCC
	176	644	4.48%	PULMONARY EMBOLISM W/O MCC
	392	560	3.90%	ESOPHAGITIS, GASTROENT & MISC DIGEST DISORDERS W/O MCC
	603	455	3.17%	CELLULITIS W/O MCC
	560	392	2.73%	AFTERCARE, MUSCULOSKELETAL SYSTEM & CONNECTIVE TISSUE W CC
	310	378	2.63%	CARDIAC ARRHYTHMIA & CONDUCTION DISORDERS W/O CC/MCC
	641	366	2.55%	MISC DISORDERS OF NUTRITION,METABOLISM,FLUIDS/ELECTROLYTES W/O MCC
	312	334	2.33%	SYNCOPE & COLLAPSE
	378	329	2.29%	G.I. HEMORRHAGE W CC
	300	302	2.10%	PERIPHERAL VASCULAR DISORDERS W CC
SNF	863	707	5.09%	POSTOPERATIVE & POST-TRAUMATIC INFECTIONS W/O MCC
	603	448	3.22%	CELLULITIS W/O MCC
	392	438	3.15%	ESOPHAGITIS, GASTROENT & MISC DIGEST DISORDERS W/O MCC
	812	427	3.07%	RED BLOOD CELL DISORDERS W/O MCC
	176	352	2.53%	PULMONARY EMBOLISM W/O MCC
	378	343	2.47%	G.I. HEMORRHAGE W CC
	641	297	2.14%	MISC DISORDERS OF NUTRITION,METABOLISM,FLUIDS/ELECTROLYTES W/O MCC
	560	292	2.10%	AFTERCARE, MUSCULOSKELETAL SYSTEM & CONNECTIVE TISSUE W CC
	871	290	2.09%	SEPTICEMIA OR SEVERE SEPSIS W/O MV 96+ HOURS W MCC
	310	288	2.07%	CARDIAC ARRHYTHMIA & CONDUCTION DISORDERS W/O CC/MCC
IRF	863	205	3.81%	POSTOPERATIVE & POST-TRAUMATIC INFECTIONS W/O MCC
	310	190	3.53%	CARDIAC ARRHYTHMIA & CONDUCTION DISORDERS W/O CC/MCC
	176	170	3.16%	PULMONARY EMBOLISM W/O MCC
	392	166	3.08%	ESOPHAGITIS, GASTROENT & MISC DIGEST DISORDERS W/O MCC
	603	141	2.62%	CELLULITIS W/O MCC
	309	135	2.51%	CARDIAC ARRHYTHMIA & CONDUCTION DISORDERS W CC
	641	129	2.40%	MISC DISORDERS OF NUTRITION,METABOLISM,FLUIDS/ELECTROLYTES W/O MCC
	312	117	2.17%	SYNCOPE & COLLAPSE
	378	102	1.90%	G.I. HEMORRHAGE W CC
	812	96	1.78%	RED BLOOD CELL DISORDERS W/O MCC

***Legend*: W = With; W/O = Without; CC = Complicating or Comorbid Condition; MCC = Major Complicating or Comorbid Condition; MV = Mechanical Ventilation.**

Appendix B: Top 10 MS-DRG codes for hospital readmission within 31-60 days by discharge setting

	DRG	N	%	Label
Community	392	298	5.51%	ESOPHAGITIS, GASTROENT & MISC DIGEST DISORDERS W/O MCC
	310	157	2.90%	CARDIAC ARRHYTHMIA & CONDUCTION DISORDERS W/O CC/MCC
	176	124	2.29%	PULMONARY EMBOLISM W/O MCC
	603	121	2.24%	CELLULITIS W/O MCC
	863	114	2.11%	POSTOPERATIVE & POST-TRAUMATIC INFECTIONS W/O MCC
	378	106	1.96%	G.I. HEMORRHAGE W CC
	554	106	1.96%	BONE DISEASES & ARTHROPATHIES W/O MCC
	312	100	1.85%	SYNCOPE & COLLAPSE
	561	100	1.85%	AFTERCARE, MUSCULOSKELETAL SYSTEM & CONNECTIVE TISSUE W/O CC/MCC
	641	99	1.83%	MISC DISORDERS OF NUTRITION,METABOLISM,FLUIDS/ELECTROLYTES W/O MCC
SNF	392	317	4.72%	ESOPHAGITIS, GASTROENT & MISC DIGEST DISORDERS W/O MCC
	603	190	2.84%	CELLULITIS W/O MCC
	690	178	2.65%	KIDNEY & URINARY TRACT INFECTIONS W/O MCC
	641	159	2.37%	MISC DISORDERS OF NUTRITION,METABOLISM,FLUIDS/ELECTROLYTES W/O MCC
	871	144	2.14%	SEPTICEMIA OR SEVERE SEPSIS W/O MV 96+ HOURS W MCC
	863	129	1.92%	POSTOPERATIVE & POST-TRAUMATIC INFECTIONS W/O MCC
	310	128	1.90%	CARDIAC ARRHYTHMIA & CONDUCTION DISORDERS W/O CC/MCC
	372	127	1.89%	MAJOR GASTROINTESTINAL DISORDERS & PERITONEAL INFECTIONS W CC
	176	126	1.87%	PULMONARY EMBOLISM W/O MCC
	312	118	1.76%	SYNCOPE & COLLAPSE
IRF	392	119	4.58%	ESOPHAGITIS, GASTROENT & MISC DIGEST DISORDERS W/O MCC
	603	72	2.77%	CELLULITIS W/O MCC
	310	58	2.23%	CARDIAC ARRHYTHMIA & CONDUCTION DISORDERS W/O CC/MCC
	312	56	2.16%	SYNCOPE & COLLAPSE
	690	55	2.12%	KIDNEY & URINARY TRACT INFECTIONS W/O MCC
	292	52	2.00%	HEART FAILURE & SHOCK W CC
	863	52	2.00%	POSTOPERATIVE & POST-TRAUMATIC INFECTIONS W/O MCC
	641	51	1.96%	MISC DISORDERS OF NUTRITION,METABOLISM,FLUIDS/ELECTROLYTES W/O MCC
	871	47	1.81%	SEPTICEMIA OR SEVERE SEPSIS W/O MV 96+ HOURS W MCC
	309	45	1.73%	CARDIAC ARRHYTHMIA & CONDUCTION DISORDERS W CC

***Legend*: W = With; W/O = Without; CC = Complicating or Comorbid Condition; MCC = Major Complicating or Comorbid Condition; MV = Mechanical Ventilation.**

Appendix C: Top 10 MS-DRG codes for hospital readmission within 61-90 days by discharge setting

	DRG	N	%	Label
Community	392	155	3.86%	ESOPHAGITIS, GASTROENT & MISC DIGEST DISORDERS W/O MCC
	310	105	2.61%	CARDIAC ARRHYTHMIA & CONDUCTION DISORDERS W/O CC/MCC
	378	88	2.19%	G.I. HEMORRHAGE W CC
	176	82	2.04%	PULMONARY EMBOLISM W/O MCC
	603	74	1.84%	CELLULITIS W/O MCC
	292	68	1.69%	HEART FAILURE & SHOCK W CC
	312	65	1.62%	SYNCOPE & COLLAPSE
	690	61	1.52%	KIDNEY & URINARY TRACT INFECTIONS W/O MCC
	287	60	1.49%	CIRCULATORY DISORDERS EXCEPT AMI, W CARD CATH W/O MCC
	641	60	1.49%	MISC DISORDERS OF NUTRITION,METABOLISM,FLUIDS/ELECTROLYTES W/O MCC
SNF	392	178	3.67%	ESOPHAGITIS, GASTROENT & MISC DIGEST DISORDERS W/O MCC
	871	127	2.62%	SEPTICEMIA OR SEVERE SEPSIS W/O MV 96+ HOURS W MCC
	603	125	2.58%	CELLULITIS W/O MCC
	690	120	2.47%	KIDNEY & URINARY TRACT INFECTIONS W/O MCC
	292	110	2.27%	HEART FAILURE & SHOCK W CC
	310	84	1.73%	CARDIAC ARRHYTHMIA & CONDUCTION DISORDERS W/O CC/MCC
	641	82	1.69%	MISC DISORDERS OF NUTRITION,METABOLISM,FLUIDS/ELECTROLYTES W/O MCC
	312	80	1.65%	SYNCOPE & COLLAPSE
	552	77	1.59%	MEDICAL BACK PROBLEMS W/O MCC
	293	71	1.46%	HEART FAILURE & SHOCK W/O CC/MCC
IRF	690	48	2.59%	KIDNEY & URINARY TRACT INFECTIONS W/O MCC
	392	46	2.48%	ESOPHAGITIS, GASTROENT & MISC DIGEST DISORDERS W/O MCC
	312	40	2.16%	SYNCOPE & COLLAPSE
	603	38	2.05%	CELLULITIS W/O MCC
	292	34	1.83%	HEART FAILURE & SHOCK W CC
	293	34	1.83%	HEART FAILURE & SHOCK W/O CC/MCC
	481	31	1.67%	HIP & FEMUR PROCEDURES EXCEPT MAJOR JOINT W CC
	310	29	1.57%	CARDIAC ARRHYTHMIA & CONDUCTION DISORDERS W/O CC/MCC
	313	29	1.57%	CHEST PAIN
	871	29	1.57%	SEPTICEMIA OR SEVERE SEPSIS W/O MV 96+ HOURS W MCC

***Legend*: W = With; W/O = Without; CC = Complicating or Comorbid Condition; MCC = Major Complicating or Comorbid Condition; MV = Mechanical Ventilation.**

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Vita

Rodney (Rod) Laine Welsh was born on December 25, 1964 in Galveston, Texas to Robert and Christine Bertolino Welsh. He graduated from Ball High School in 1983. Rod did not immediately attend higher level education but instead choose a career in local law enforcement. After several years, he made the decision to pursue a career in rehabilitation and began taking pre-requisite courses at Galveston Community College. Rod obtained a Bachelor of Science degree in Occupational Therapy from the University of Texas Medical Branch (UTMB) in 1997. After several years in practice, Rod returned to UTMB and obtained a Master's degree in Physical Therapy in 2004. Rod primarily functioned as a clinical practitioner at UTMB until 2014. Rod currently holds an Assistant Professor position in the Occupational Therapy department at the School of Health Professions where he educates both Occupational and Physical Therapy students.

Publications

Welsh Rod, Kumar Amit, Ottenbacher Allison, Fisher Steve. Abstract: Predictors of a Physical Therapy Consultation Among Older Patients During Acute Hospitalization. *Archives of Physical Medicine and Rehabilitation.* 2011;92-10:1734

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