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Impact of Diabetes Comorbidity on Health Outcomes in Patients Undergoing Medical Rehabilitation after Lower Extremity Joint Arthroplasty

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Impact of Diabetes Comorbidity on Health Outcomes in Patients Undergoing Medical Rehabilitation after Lower Extremity Joint Arthroplasty

by

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Dedication

I would like to dedicate this original capstone project to my family. My wife, *Kshitija*, her unconditional love and support kept me inspired and motivated throughout the pursuit of this goal. My three-year-old daughter, *Aarya*, whose curiosity kept me inspired to explore every aspect of this study. My one-year-old son, *Parth*, whose ability to be engaged in play, inspired me to focus and engage in this study. Finally, my parents, *Aai* and *Baba*, who have always been my greatest inspiration, and taught me to be humble and grateful for every aspect of life.

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Abstract:

Introduction: Diabetes is one of the rapidly increasing chronic conditions that can impact the health and well-being of individuals.

Objectives: To determine the prevalence of diabetes in patients receiving medical rehabilitation after lower extremity joint replacement and to examine the associations between diabetes as comorbidity and outcomes including functional status, likelihood of discharge to acute care, and 90-day hospital readmission.

Methods: Secondary analysis of Medicare data. We selected patients who underwent a primary hip/knee joint replacement procedure during 2007-2008. We identified diabetes-related ICD-9CM codes in the Medicare Provider Analysis and Review and Inpatient Rehabilitation Facilities Patient Assessment Instrument data files, and created a three-level diabetes status: no diabetes, non-tier diabetes (controlled diabetes), and tier diabetes (uncontrolled diabetes). The effect of diabetes status on functional status gain was estimated using multivariate regression models. Discharge to acute care (yes/no) after inpatient rehabilitation was compared against discharge to community using multinomial logistic regression. Hospital readmission (yes/no) rates were estimated using Cox regression hazard models.

Results: The prevalence of controlled diabetes in the knee and hip joint replacement cohorts was 21% and 17%, respectively; uncontrolled diabetes was identified in 4% and 3% of patients, respectively. The adjusted effect of diabetes status on functional status gain was minimal. The likelihood of discharge to acute care was explained by marital status and discharge functional scores, as compared to diabetes status, in both knee and hip cohorts. Using no diabetes as the reference group, the risk of hospital readmission in the hip cohort was 19% higher for those with controlled diabetes (HR=1.19, 95% CI=1.08-1.30) and 31% higher for those with uncontrolled diabetes (HR=1.31, 95% CI=1.08-1.59). In the knee cohort the risk was 22% higher for those with controlled diabetes (HR=1.22, 95% CI=1.14-1.30) and 43% higher for those with uncontrolled diabetes (HR=1.43, 95% CI=1.26-1.61).

Conclusion and Implications: Our findings indicate diabetes is an important comorbid condition across the continuum of care. Strategies to better manage diabetes, both prior to elective procedures such as joint replacement, and throughout the following rehabilitation stay and recovery phases, could improve the overall efficiency and quality of care in this population.

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List of Abbreviations

AHRQ	Agency for Healthcare Research and Quality
ADA	American Diabetes Association
CCW	Chronic Condition Warehouse
CDC	Centers for Disease Control and Prevention
CMG	Case Mix Group
CMS	Centers for Medicare and Medicaid Services
DM	Diabetes Mellitus
DRG	Diagnosis Related Groups
DUA	Data Usage Agreement
FFS	Fee-for-Service
HMO	Health Maintenance Organization
ICD-9 CM	International Classification of Diseases, 9th revision, Clinical Modification
IRB	Institutional Review Board
IRF	Inpatient Rehabilitation Facility
IRF-PAI	Inpatient Rehabilitation Facility Patient Assessment Instrument
IRF-PPS	Inpatient Rehabilitation Facility Prospective Payment System
FIM	Functional Independence Measure
MEDPAC	Medicare Payment Advisory Commission
MEDPAR	Medicare Provider Analysis and Review
MS-DRG	Medical Severity-Diagnosis Related Group

PPACA	Patient Protection and Affordable Care Act
PPS	Prospective Payment System
PQI	Prevention Quality Indicators
RIF	Research Identifiable Files
UTMB	University of Texas Medical Branch

Chapter 1 Introduction

Over the past few decades the prevalence of diabetes has grown significantly in the U.S. adult population. Studies have shown a negative association between the presence of diabetes and health outcomes across many health conditions (e.g. stroke, hip fracture etc.) [1, 2]. For patients undergoing a lower extremity joint arthroplasty (referred to as joint replacement in this paper), a long-term follow-up has been previously suggested in order to better understand the likelihood of complications and their prevention throughout the continuum of care [3]. However, the impact of diabetes as comorbidity in patients undergoing medical rehabilitation at inpatient rehabilitation facilities after lower extremity joint replacement has not been studied extensively.

The objectives of this study were to determine the prevalence of diabetes in patients on Medicare fee-for-service plans who were admitted to inpatient rehabilitation facilities after joint replacement, and to identify the impact of diabetes on health outcomes of these patients. This research study was conducted to investigate the following specific aims:

1. To determine prevalence of diabetes in patients undergoing medical rehabilitation after lower extremity (knee and hip) joint replacement.

2. To identify the association between presence of diabetes and functional gains during an inpatient rehabilitation stay in this sample population.

3. To investigate the risk factors associated with discharge to acute care after an inpatient rehabilitation stay.

4. To investigate the risk factors associated with hospital readmission within 90 days of discharge from inpatient rehabilitation facilities.

In order to accomplish these specific aims we conducted secondary data analyses of Medicare claims data for patients who have undergone medical rehabilitation at inpatient rehabilitation facilities after knee or hip joint replacement surgical procedures. We used data files from the Centers for Medicare and Medicaid services (CMS): (a) Inpatient Rehabilitation Facilities Patient Assessment Instrument (IRF-PAI), (b) Medicare Provider and Analysis Review (MEDPAR), and (c) the Medicare Beneficiary Summary data files from 2007-2008.

Chapter 2 Background and Significance

According to a report released in 2011 by the American Diabetes Association, an estimated 8.3% of the U.S. population has either type-1 or type-2 diabetes [4]. For adults aged 65 and older, the prevalence of diabetes is approximately 27% [4]. This is the same age group that has the highest number of individuals undergoing joint replacement procedures. Among Medicare beneficiaries, lower extremity joint replacement is one of the most common surgical procedures. The number of joint replacement procedures per 1,000 Medicare enrollees, involving primary hip and knee joint replacement, was reported to be 4 and 9 respectively [5]. Recent studies report a steady increase in the proportion of patients with diabetes undergoing total hip arthroplasty and total knee arthroplasty. This rate was reported to be around 11% for the years 2001-2002, and 15% from 2007-2008 [6, 7]. Another study reported the rate of uncontrolled diabetes in patients undergoing joint arthroplasty to be over 8% [8].

Although joint replacement is a relatively low risk surgical procedure, there is some risk for development of post-operative infection, which may necessitate a revision of the original procedure. Several factors increase the risk of developing post-operative infection, ranging from demographic characteristics (e.g. younger age, male); health-related factors/comorbidities (e.g. rheumatoid arthritis, or Systemic lupus erythematosus as etiological conditions for joint replacement), and underlying chronic conditions, such as obesity and uncontrolled glycemic levels (diabetes). The presence of diabetes is one risk factor reported in literature that increases the probability of infection and post-operative complications in patients undergoing joint arthroplasty [8-13]. A study by Malinzak and colleagues (2009) also reported a three times higher risk for patients with diabetes to develop infections that lead to joint replacement revision procedures, as compared to their controls [11].

The Prospective Payment System (PPS) for inpatient rehabilitation facilities (IRF-PPS) was implemented in 2002. The objective of IRF-PPS was to prospectively allocate resources for each patient being admitted to IRF, and replaced the existing fee-for-service payment structure, which was based on reimbursing IRF average cost per discharge [14]. In order to pre-determine and allocate resources, the IRF-PPS classifies patients at the time of their IRF admission into several case-mix groups (CMGs). This CMG classification is based on patient-level factors such as medical conditions, admission functional status, and age [14]. The reimbursement structure for each CMG is further classified into a payment tier system, which takes into account presence of certain comorbidities associated with greater use of resources. The tier system is a four-level system, with comorbidities falling under tier 1 having the highest projected resource use (highest payments), followed by tier 2 (medium cost), tier 3 (low cost), and no tier [1]. The Centers for Medicare and Medicaid Services (CMS) releases composition of comorbidities that formulate these tiers for every fiscal year. This composition has been consistent throughout the years, except for the addition of several new comorbidities (e.g. addition of avian flu in 2007 under tier 3 payment system) [15]. Sub-types of diabetes mellitus that are part of the tier system, are classified under tier 3 (low cost) payment system [15]. More information related to classification of diabetes codes is provided in the methods section and later presented in Table 3.

Prevalence of diabetes mellitus in individuals undergoing medical rehabilitation in IRF is reported in previous studies [14-17]. One such study by Weeks and colleagues reported a 17.8% prevalence rate among all patients who were admitted to IRF in the state of Washington from

2001-2007 [16]. In this study, the prevalence of diabetes mellitus in patients receiving rehabilitation services after joint replacement was 14.2% [16]. The impact of diabetes on rehabilitation outcomes in impairment groups such as stroke, and hip fracture were demonstrated in previous investigations. However, the evidence from these studies is mixed, with some reporting an adverse effect of diabetes on outcomes, and some reporting minimal to no effect of diabetes on rehabilitation outcomes. For outcomes related to stroke rehabilitation, Ripley and colleagues reported minimal impact of diabetes status on short-term outcomes, such as rehabilitation length of stay, and type of discharge settings after rehabilitation stay [17].Another study reported no differences in functional outcomes during rehabilitation stay for patients after ischemic stroke and those with or without diabetes [18]. However, more recent studies using population-based data sources, reported a negative impact of diabetes on rehabilitation outcomes, including: (a) increased length of rehabilitation stay, (b) lower functional discharge scores, and (c) lower probability of discharge to community in patients undergoing medical rehabilitation after stroke [1]. A similar methodological approach was taken by another study by Reistetter et. al. (2011), which reported a negative impact of diabetes comorbidity on outcomes in patients with hip fracture undergoing medical rehabilitation [2].

No significant research has been done related to studying post-acute (rehabilitation) outcomes in individuals who have undergone lower extremity joint replacement with diabetes as an underlying comorbidity. With joint replacement typically being an elective surgical procedure, there is a great need to control for diabetes (glycemic levels), and to understand the impact of diabetes on patients after joint replacement along the continuum of care.

In terms of designing effective public health interventions for these individuals, there is a need to implement a “high risk” strategy of prevention [19]. This strategy, in the context of our study, can be described as a screening process for identifying patients with diabetes, and to develop targeted interventions that can minimize the negative impact of diabetes on health outcomes. For those patients who are discharged to any type of inpatient post-acute care setting (e.g. inpatient rehabilitation facilities), this could be effectively done by first understanding the prevalence of diabetes and examining its impact on health outcomes: (a) during medical rehabilitation, and (b) after patients are discharged from IRF.

In conclusion, the purpose of this capstone project was to assess both short-term and long-term outcomes in patients with diabetes undergoing medical rehabilitation following knee or hip joint replacement in terms of functional gains, discharge setting at the end of rehabilitation stay, and hospital readmission within 90 days post-discharge from inpatient rehabilitation. In the future, information from this study could be used to (a) design intervention strategies that could limit the negative impact of diabetes on outcomes, if any, and (b) distribute accountability for managing and minimizing the risk of developing long-term complications from diabetes across the continuum of care, with the intent to involve stakeholders from acute as well as post-acute care facilities.

Chapter 3 Methods

Data Source

We examined data for Medicare beneficiaries who were on the Medicare-fee-for-service plan from 2007-2008. The Medicare data files are available for research purposes in different formats. For this study we had access to Center for Medicare and Medicaid Services (CMS), Research Identifiable Files (RIF). The Data Usage Agreement (DUA) for these data was obtained for the parent study titled "Impact of Prospective Payment System on Rehabilitation Outcomes". For this study we examined three CMS data files: Inpatient Rehabilitation Facility Patient Assessment Instrument (IRF-PAI), Medicare Provider Analysis and Reviews (MEDPAR), and the Medicare beneficiary summary files (Table 1) [20]. The University of Texas Medical Branch (UTMB) Institutional Review Board (IRB) approved the study protocol for the "Impact of Prospective Payment System on Rehabilitation Outcomes".

Table 1: Data File Characteristics

Data Source and Characteristics		
Medicare Provider Analysis and Review File (MEDPAR)	2007-2008	The MEDPAR file contains utilization of services and claims data for Medicare beneficiaries during their stay in Medicare certified inpatient short-term hospitals, skilled nursing facilities, inpatient rehabilitation facilities, and long-term care facilities. These records are all from inpatient facilities (Part A) and do not have any information related to outpatient care (Part B). The claims data in MEDPAR are final after taking into account all payment adjustments.
Beneficiary Summary File (Formerly known as Denominator file)	2007-2008	The Beneficiary Summary File contains demographic (e.g., age, gender, race, residential) and enrollment information (e.g., original reason for enrollment under Medicare, current reason for enrollment under Medicare, monthly entitlement indicators) for each beneficiary enrolled in Medicare during a calendar year.
Inpatient Rehabilitation Facility Patient Assessment Instrument (IRF-PAI)	2007-2008	These files contain information related to: rehabilitation outcomes, functional status, activities of daily living, mobility, cognitive status, case-mix groups, comorbidities, and IRF quality indicators.

Study Sample Selection

Sample selection in observational studies using secondary data analysis involves multiple computational steps. For our study, we combined IRF-PAI files with MEDPAR files from two years and selected patients admitted to IRF for rehabilitation following knee or hip joint replacement. We also used a combination of several codes to identify patients admitted to inpatient rehabilitation facilities from acute hospitals. These codes included impairment group codes from the IRF-PAI files, International Classification of Diseases, 9^{th} revision (ICD-9) procedure codes from the MEDPAR data files, and Medical Severity Diagnosis Related Groups (MS-DRG) codes from the MEDPAR files. More information related to these codes is provided in Table 2.

We applied several other filters in order to select our study sample. We only selected those cases that were admitted to IRF directly from acute hospitals. Individuals who were living in community settings (home, board and care, assisted living, and transitional living settings) were selected for this study. Also included were cases admitted to IRF for initial rehabilitative services. We excluded patients who died during rehabilitation stay and only included those patients who completed a typical rehabilitation program stay. Finally, we did not consider patients that were admitted to inpatient rehabilitation facilities in the state of Maryland. The state of Maryland is not included in the IRF-PPS. Maryland state had implemented an all payer system for all inpatient facilities [21, 22].

We included only those patients who were age 66 and older. This ensured that all patients were enrolled in the Medicare program for a minimum of one year. We also excluded those patients on Medicare for reasons other than age (e.g. disability, end stage renal disease, etc.).

Finally, we only considered those patients on Medicare fee-for-service plans for the entire study duration (two years), excluding those on the Medicare Health Maintenance Organization (HMO) plan during any month in 2007-2008.

Table 2: Codes for Identifying Cases with Joint Replacement

Data File	Code Type	Codes	Description
IRF-PAI	Impairment Groups	08.51	Unilateral Hip Replacement
		08.52	Bilateral Hip Replacements
		08.61	Unilateral Knee Replacement
		08.62	Bilateral Knee Replacements
		08.71	Knee and Hip Replacements (same side)
		08.72	Knee and Hip Replacements (different sides)
MEDPAR	Procedure Codes	81.51	Total Hip Replacement
		81.54	Total Knee Replacement
MEDPAR	Medical Severity Diagnosis Related Groups	469	Major joint replacement or reattachment of lower extremity with Major Complications and Comorbidities
		470	Major joint replacement or reattachment of lower extremity without Major Complications and Comorbidities

For the fourth aim of this study, we considered a sub-sample of the entire cohort. We examined hospital readmission only in those patients who were discharged to community settings such as: home, board and care, assisted living, and transitional care, after IRF stay. We replicated this method from the recent report by the Medicare Payment Advisory Commission (MedPAC) that identified 30-day hospital readmissions as an IRF quality indicator [23].

Independent Variable

Diabetes Mellitus Status

The combination of IRF-PAI and MEDPAR data files resulted in each patient record containing a maximum number of 20 comorbid conditions. We refined an algorithm that was developed by Graham and colleagues (2009), which was tested in stroke patients and patients with hip fractures undergoing medical rehabilitation [1, 2]. In our study, patients were identified as having diabetes mellitus if one or more of the following diabetes related ICD-9 CM codes were presented in the comorbid conditions: 250.0 through 250.9 (diabetes mellitus), 357.2 (polyneuropathy in diabetes), or 785.4 (gangrene). Patients with diabetes mellitus were further classified based on the comorbidities assigned into one of the four tiers (no tier, tier 1, tier 2, and tier 3). For the purposes of this study we operationally defined each patient's diabetes status as no diabetes, non-tier diabetes (*controlled diabetes)*, or tier diabetes (*uncontrolled diabetes)*. CMS updates the list of tier comorbidities every fiscal year. All the diabetes tier comorbidities were classified as tier 3 comorbidities from 2007-2008. More information related to codes that were used for classifying diabetes mellitus is given in Table 3.

Outcomes

Specific Aim 1: Diabetes Prevalence

We computed prevalence of diabetes mellitus separately for the hip joint replacement and the knee joint replacement cohorts.

Table 3: Schematic Used for Classifying Diabetes Mellitus Status

ICD- 9 CM	Description	Tier Eligibility	Diabetes Status
250.0x	DM without complications	No	Controlled Diabetes
250.1x	DM with ketoacidosis	No	Controlled Diabetes
250.2x	DM with hyperosmolarity	No	Controlled Diabetes
250.3x	DM with other coma	No	Controlled Diabetes
250.4x	DM with renal manifestations	Tier 3	Uncontrolled Diabetes
250.5x	DM with opthalmic manifestations	Tier 3	Uncontrolled Diabetes
250.6x	DM with neurological manifestations	Tier 3	Uncontrolled Diabetes
250.7x	DM with circulatory disorders	Tier 3	Uncontrolled Diabetes
250.8x	DM with other manifestations	Tier 3	Uncontrolled Diabetes
250.9x	DM with unspecified complications	Tier 3	Uncontrolled Diabetes
357.2x	Polyneuropathy in DM	Tier 3	Uncontrolled Diabetes
785.4x	Gangrene	Tier 3	Uncontrolled Diabetes

Table adapted from Graham et al. (2009), DM=Diabetes Mellitus

Specific Aim 2: Functional Status Gains

Functional status gains were computed by taking a difference between discharge functional status and the admission functional status ratings. Functional status in the IRF settings is measured by using the Functional Independence Measure (FIM) instrument. The FIM instrument is a part of the IRF-PAI. The FIM instrument contains 18 items, of which 13 items represent motor domain, and 5 items represent cognitive domain. All items are scored on a 1-7 scale, with a score of 1 indicating "total assistance" and 7 indicating "complete independence". The motor domain of the FIM instrument has four sub-scales: self-care, sphincter control, transfers, and mobility. The cognitive domain has two sub-scales: communication and social cognition. The FIM instrument is used by the rehabilitation professionals (occupational therapists, physical therapists, speech-language pathologists, and rehabilitation nurses) to assess functional status of all patients admitted to IRF settings. These assessments are made within 72 hours of admission to IRF, and 72 hours prior to discharge from the IRF settings. There is a good amount of research conducted using FIM instrument, which has established its psychometric properties [24-26]. The IRF-PAI can be accessed on the CMS website at http://www.cms.gov/Medicare/CMS-Forms/CMS-Forms/downloads/cms10036.pdf.

Specific Aim 3: Acute Care Discharge

The IRF-PAI data files contain information related to discharge settings at the end of the rehabilitation stay. For the purposes of this study, we classified discharge settings into three categories. Our main outcome of interest was discharge to acute care, which was compared with discharge to community settings, and discharge to sub-acute settings. We used the following classification method for creating these three categories.

Discharge to acute care: Acute unit of own facility or acute unit of another facility.

Discharge to community setting: home, board and care, transitional living, or assisted living facilities.

Discharge to sub-acute care facility: Intermediate care, skilled nursing facility, chronic hospital, rehabilitation facility, alternate level of care unit, or sub-acute setting.

Specific Aim 4: Hospital Readmission

Hospital readmission was computed as a yes/no variable for this study in patients who were discharged to community settings, and later were readmitted to acute hospitals. To compute this rate, we censored patients who were admitted to settings other than acute hospitals (e.g. skilled nursing facilities, nursing homes etc.). We also computed time (in days) from IRF discharge date to readmission date (to acute hospitals), using 90-days as a right censoring parameter. However, for discussion purposes, the re-hospitalization time was divided into three categories: 30 days, 60 days, and 90 days from IRF discharge.

Covariates

Socio-demographic Variables

For socio-demographic variables we included age (years), sex (male/female), race/ethnicity (white, black, Hispanic, and other), and marital status (yes/no).

Comorbidities

We identified Elixhauser comorbidities and used them as a binary variable (yes/no) in all our models. The 30 Elixhauser comorbidities that can be computed in administrative claims data are: congestive heart failure, cardiac arrhythmias, valvular disease, pulmonary circulation disorders, peripheral vascular disorders, hypertension (uncomplicated), hypertension (complicated), paralysis, other neurological disorders, chronic pulmonary disease, diabetes (uncomplicated), diabetes (complicated), hypothyroidism, renal failure, liver disease, peptic ulcer disease excluding bleeding, AIDS/HIV, lymphoma, metastatic cancer, rheumatoid arthritis, coagulopathy, obesity, weight loss, fluid and electrolyte disorders, blood loss anemia, deficiency anemia, alcohol abuse, drug abuse, psychoses, and depression [27, 28]. We did not consider diabetes status, which is an Elixhauser comorbidity; rather, we used previously discussed method to create diabetes status: no diabetes, controlled diabetes, and uncontrolled diabetes.

Statistical Analysis

All the analyses were done separately for the hip joint replacement cohort and the knee joint replacement cohort. We only presented descriptive results for the combined group. Patients' sociodemographic characteristics, functional status, and comorbidities were compared across diabetes status (no diabetes, controlled diabetes, and uncontrolled diabetes). One-way analysis of variance (ANOVA) tests were computed for all the continuous variables. Chi-square statistics were used for all the categorical variables. All the data management and data analyses were conducted using SAS 9.2 analytical software, SAS 9.2 Cary, NC [29]. Analytical methodology for each specific aims of this study is presented in the following sub-sections.

Specific Aim 1: Diabetes Prevalence

The prevalence of both controlled diabetes and uncontrolled diabetes was computed using the following equations, which were adapted from the method indicated by the Centers for Disease Control and Prevention (CDC) for computing prevalence of a condition [30]:

$$\textit{Controlled Diabetes Prevalence} = \frac{\textit{Number of Patients after Joint Replacement with Controlled Diabetes admitted to IRF between } 2007-2008}{\textit{Total Number of Patients admitted to IRF between } 2007-2008} \text{X100}$$

$$\textit{Uncontrolled Diabetes Prevalence} = \frac{\textit{Number of Patients after Joint Replacement with Uncontrolled Diabetes admitted to IRF between } 2007-2008}{\textit{Total Number of Patients admitted to IRF between } 2007-2008} \text{X100}$$

Specific Aim 2: Functional Status Gain

We computed multivariate regression models to predict impact of diabetes status on changes in functional status from IRF admission to IRF discharge. These differences in functional status, labeled as 'functional status gains' were computed separately for the motor items (FIM motor gain), and for the cognitive items (FIM cognitive gain). In computing these prediction models, we chose “no diabetes” as a reference category, while controlling for sociodemographic variables, rehabilitation length of stay, and top 10 Elixhauser comorbidities. In order to test for significant individual effect of these comorbidities, and keeping the number of these comorbidities entering the models minimal, we used a ‘stepwise selection’ method in these regression models.

Specific Aim 3: Acute Care Discharge

The objective of this analysis was to determine likelihood of discharge to acute care versus community after IRF stay. However, unlike previously conducted studies we chose not to combine community discharge with discharges to other settings (e.g. sub-acute, skilled nursing facilities etc.). With three categories of outcomes (community, acute, and other), we computed a multinomial logistic regression model, to test two models simultaneously, one model testing for likelihood of discharge to acute care compared to community discharge, and other testing likelihood of discharge to other settings versus community discharge.

Specific Aim 4: Hospital Readmission

Hospital readmission was coded as yes/no for patients who were discharged to community settings and rehospitalized within 90 days of discharge from IRF settings. Thus, we used a sub-set of the sample that was used in the first three Aims. We excluded 7,785 patients in this process, who were not discharged to community settings after IRF stay. Detailed information related to this sub-set sample is presented in Table 7. We first computed unadjusted rehospitalization rate using Kaplan-Maier estimation method. We divided this into 30-day rehospitalization rates, 60-day rehospitalization rates, and 90-day rehospitalization rates. However, we will be focusing our discussion on 90-day rehospitalization rates only.

For testing risk associated with diabetes status (using no diabetes as a reference category) and 90 days rehospitalization, we used Cox regression models, stratified by knee and hip joint replacement, and controlling for covariates such as sociodemographic characteristics, rehabilitation length of stay, discharge functional scores (motor and cognitive), and Elixhauser comorbidities. We also tested for the proportionality assumption of the hazard models, and made adjustments in the models accordingly (see Table 9 for details).

Chapter 4 Results

Specific Aim 1: Diabetes Prevalence

Knee Joint Replacement

A total of 52,259 patients were admitted to IRF during the two years following knee joint replacement. The prevalence of diabetes mellitus in this impairment group was 24.9%. Of these, 21.0% were controlled diabetes, and 3.9% were uncontrolled. Descriptive statistics related to socio-demographic variables and functional status are presented in Table 4. Due to the high number of Elixhauser comorbidities [28], the proportions are only presented for the top 10 Elixhauser comorbidities (Table 4).

Hip Joint Replacement

A total of 25,729 patients were admitted to IRF for the two-year duration. The prevalence of diabetes mellitus in this impairment group was 19.6%. Of these, 16.6% were cases of controlled diabetes, and 3.0% uncontrolled.. Descriptive statistics related to socio-demographic variables, functional status, and Elixhauser comorbidities are presented in Table 4.

Specific Aim 2: Functional Status Gains

Results related to functional status gains are presented in Table 5. We ran regression models separately for motor items (motor gains) and cognitive items (cognitive gains). The results are presented in both mean and median format of the FIM instrument scores. However, the discussion is based on changes associated with the mean scores. The values indicate parameter estimates and associated standard errors.

Table 4: Patient Characteristics Stratified by Diabetes Mellitus Status for Knee and Hip Joint Replacement

	Knee Joint Replacement					Hip Joint Replacement			
	Total	No Diabetes	Diabetes (–)	Diabetes (+)	*P* Value	No Diabetes	Diabetes (–)	Diabetes (+)	*P* Value
N (%)	77,988	39,262 (75.1)	10,977 (21)	2,020 (3.9)		20,678 (80.4)	4,273 (16.6)	778 (3)	
Age (years)	76.8 (6.6)	76.6 (6.6)	75 (6)	74.8 (5.7)	<.0001	78.3 (6.8)	76.5 (6.4)	76.1 (6)	<.0001
Female (%)	68.8	70.6	64.8	64.2	<.0001	70	61.3	56.6	<.0001
Ethnicity / Race (%)					<.0001				<.0001
White	88.2	89.1	80.2	82.1		92	86	85.6	
Black	6.4	5.6	10.3	10.2		4.7	9.3	9.5	
Hispanic	3.7	3.7	7	5.5		2.2	3.2	2.8	
Married (%)	50.78	51.8	53.8	53.3	.001	46.8	51	55.1	<.0001
Length of stay (days)	9.5 (3.7)	9.1 (3.5)	9.6 (3.7)	10.4 (4)	<.0001	10 (3.9)	10.3 (4)	11.4 (4.1)	<.0001
FIM admission									
Motor	43.6(9.3)	44.7 (9.3)	43.1(9.4)	41.7(9.4)	<.0001	42.5(9.1)	41.6(9.2)	39.7(8.8)	<.0001
Cognition	29(5.4)	29.2(5.3)	28.9(5.4)	28.3(5.4)	<.0001	28.6(5.5)	28.6(5.4)	27.8(5.3)	<.0001
FIM discharge									
Motor	69.6(10.1)	70.8(9.5)	69.6(9.8)	68.9(11)	<.0001	67.9(10.7)	67(11)	65.3(11.7)	<.0001
Cognition	31.7 (3.8)	31.9(3.6)	31.7(3.7)	31.3(3.8)	<.0001	31.4(4)	31.4(3.7)	30.8 (4)	<.0001
FIM gain									
Motor	26(9.8)	26.2(9.7)	26.5(10.0)	27.2 10.4)	<.0001	25.4(9.9)	25.4(10.1)	25.6 10.5)	.823
Cognition	2.8(4)	2.7(3.9)	2.9(4.1)	3(4.2)	<.0001	2.8(4)	2.8(4)	3(4)	.243
Elixhauser Comorbidities (%)									
Hypertension	64.4	64.6	71.1	56.1	<.0001	61	67.5	53.3	<.0001
Deficiency Anemia	28.4	29.5	25.4	19.6	<.0001	29.9	24.5	21.3	<.0001
Hypothyroidism	14.3	15.5	12.3	8.6	<.0001	14.9	10.9	7.8	<.0001
Chronic pulmonary disease	12.6	12.1	11.6	10.9	.099	13.7	14.6	12.3	.126
Arrhythmias	12.1	12.2	10.6	10.9	<.0001	12.8	12.5	10.4	.145
Obesity	12	11.8	20.1	20.7	<.0001	6.9	12.8	13	<.0001
Fluid and electrolyte disorders	10.2	10.3	9.1	9.6	.001	10.6	9.5	8.5	.016
Depression	7.4	7.9	4.5	5	<.0001	7.6	5.4	4.4	<.0001
Congestive heart failure	4.4	3.6	5.6	7.5	<.0001	4.1	6.9	10.2	<.0001
Rheumatoid arthritis /collagen vascular diseases	4.3	4.5	3.2	2.2	<.0001	4.7	3.6	3.9	.004
Other neurological disorders	4.3	4.7	3.1	3	<.0001	4.7	2.5	3.5	<.0001

Note: 1. Diabetes (-) and Diabetes (+) are controlled diabetes mellitus and uncontrolled diabetes mellitus, respectively.
2. For continuous variables, mean and the corresponding standard deviation is presented

Knee Joint Replacement

Overall there was an approximate 30-point gain in the FIM motor items for this cohort. On the contrary, the overall cognitive scores were slightly lower at the time of discharge, compared to admission (0.74). After adjusting for all the covariates (sociodemographic, length of stay, and comorbidities), FIM motor gain in the knee replacement cohort was 0.27 (SE=0.10, $p<.05$) lower in the controlled diabetes sub-group as compared to those in the no diabetes group. Similarly, for the uncontrolled diabetes group, the FIM motor gain was 0.25 lower than those in the no diabetes group (SE=0.21, $p>.05$). We also identified race/ethnicity differences. For black patients, the overall gain in the FIM motor score was significantly lower compared to white patients ($\beta=-1.23$, SE=0.16, $p<.05$). See Table 5 for more details.

Hip Joint Replacement

Overall there was an approximate 31.34 point gain in the FIM motor items for this cohort. On the contrary, the overall cognitive scores were slightly lower at the time of discharge compared to admission (0.52). After adjusting for all the covariates, FIM motor gain was 0.51 (SE=0.16, $p<.05$) lower in the controlled diabetes sub-group compared to the no diabetes group. Similarly, for the uncontrolled diabetes group, the FIM motor gain was 0.84 lower than in the no diabetes group (SE=0.35, $p<.05$). For patients in the other race/ethnicity category, the overall gain in the FIM motor score was significantly lower compared to white patients ($\beta=-1.30$, SE=0.55, $p<.05$). See Table 5 for more details.

Table 5: Results of Multivariate Regression Analyses for Modeling Gains of Functional Independence Measure (FIM)

	Knee Joint Replacement				Hip Joint Replacement			
	FIM Motor Gain		FIM Cognition Gain		FIM Motor Gain		FIM Cognition Gain	
	Median (50%)	Mean	Median (50%)	Mean	Median (50%)	Mean	Median (50%)	Mean
Intercept	**29.14** (0.49)	**30.23** (0.50)	−**2.86** (0.21)	−**0.74** (0.19)	**31.34** (0.88)	**31.54** (0.72)	−**2.38** (0.38)	−**0.52** (0.27)
Diabetes mellitus status								
No Diabetes (Reference)	–	–	–	–	–	–	–	–
Diabetes (−)	−**0.25** (0.12)	−**0.27** (0.10)	**0.21** (0.05)	**0.15** (0.04)	−**0.49** (0.21)	−**0.51** (0.16)	−0.01 (0.08)	−0.01 (0.06)
Diabetes (+)	0.10 (0.26)	−0.25 (0.21)	**0.29** (0.10)	0.19 (0.08)	−**1.13** (0.39)	−**0.84** (0.35)	**0.43** (0.16)	0.07 (0.13)
Age	−**0.15** (0.01)	−**0.16** (0.01)	**0.04** (0.00)	**0.03** (0.00)	−**0.16** (0.01)	−**0.17** (0.01)	**0.03** (0.01)	**0.02** (0.00)
Male	−**0.40** (0.11)	−**0.45** (0.09)	**0.09** (0.05)	**0.15** (0.04)	−**0.32** (0.16)	−**0.44** (0.14)	**0.14** (0.07)	**0.18** (0.05)
Ethnicity/Race								
White (Reference)	–	–	–	–	–	–	–	–
Black	−**0.97** (0.22)	−**1.23** (0.16)	−**0.46** (0.06)	−**0.32** (0.06)	−0.45 (0.36)	−**0.63** (0.26)	−**0.42** (0.11)	−**0.25** (0.10)
Hispanic	−**0.96** (0.18)	−**1.01** (0.19)	**0.21** (0.09)	**0.26** (0.08)	0.39 (0.37)	0.19 (0.39)	−0.23 (0.19)	−0.04 (0.15)
Other	−**1.01** (0.38)	−**0.99** (0.30)	−0.09 (0.14)	0.01 (0.11)	−1.15 (0.61)	−**1.30** (0.55)	−0.14 (0.22)	−0.19 (0.21)
Not married	−**0.31** (0.10)	−**0.32** (0.09)	0.02 (0.04)	−0.03 (0.03)	0.01 (0.15)	−0.18 (0.13)	−0.08 (0.06)	−**0.10** (0.05)
Length of stay	**0.99** (0.02)	**0.90** (0.01)	**0.14** (0.01)	**0.13** (0.00)	**0.67** (0.02)	**0.67** (0.02)	**0.14** (0.01)	**0.14** (0.01)
Elixhauser Comorbidities								
Hypertension	**0.41** (0.09)	**0.44** (0.08)			**0.55** (0.15)	**0.70** (0.12)		
Deficiency Anemia	**0.37** (0.10)	**0.41** (0.09)	**0.16** (0.04)	**0.09** (0.03)	0.30 (0.16)	**0.54** (0.13)		
Hypothyroidism	**0.26** (0.12)	**0.34** (0.11)			**0.52** (0.22)	**0.65** (0.17)		
Chronic pulmonary disease			0.09 (0.06)	**0.15** (0.05)				
Arrhythmias	−**0.39** (0.16)	−**0.46** (0.13)			−**0.52** (0.20)	−**0.42** (0.18)		
Obesity	**0.94** (0.14)	**0.84** (0.12)	**0.20** (0.06)	**0.20** (0.05)	**0.91** (0.28)	**0.78** (0.22)		
Fluid and electrolyte disorders	−**0.36** (0.16)	−**0.35** (0.13)			−**0.54** (0.23)	−**0.60** (0.19)		
Depression			**0.23** (0.08)	**0.18** (0.06)			**0.28** (0.10)	**0.27** (0.09)
Congestive heart failure	−**0.85** (0.23)	−**0.96** (0.20)			−**1.24** (0.39)	−**1.64** (0.28)	−0.20 (0.14)	−**0.28** (0.11)
Rheumatoid arthritis /collagen vascular diseases	−**0.86** (0.24)	−**0.77** (0.20)			−0.68 (0.47)	−**0.69** (0.28)	0.15 (0.14)	**0.25** (0.11)
Other neurological disorders	−**1.74** (0.27)	−**1.77** (0.20)	**0.66** (0.10)	**0.53** (0.08)	−**2.28** (0.36)	−**2.45** (0.29)		

Note: 1. Diabetes (-) and Diabetes (+) are controlled diabetes mellitus and uncontrolled diabetes mellitus, respectively.
2. Bolded values indicate parameter estimates are statistically significant at the significance level, .05.
3. The corresponding standard error of parameter estimates are shown within parentheses.

Specific Aim 3: Acute Care Discharge

Table 6 presents odds ratios with 95% confidence intervals for three diabetes status codes, stratified by knee and hip replacement. Since the purpose of this study was to look at factors associated with discharge to acute care as compared to community discharge, the discussion is focused on this aspect. The characteristics of sub-acute/skilled nursing facilities are very different than those of community settings. Thus, we did not combine these two groups for computing probabilities.

Knee Joint Replacement

In the knee joint replacement cohort, after adjusting for all the covariates, we did not find a significant relationship between diabetes status and the probability of discharge to acute care after IRF stay. As compared to the no diabetes group (reference group), the odds for acute discharge were lower in the controlled diabetes group (OR=0.93, 95% CI=0.79-1.09). Similarly, compared to the no diabetes group, the odds of discharge to acute care was lower for those in the uncontrolled diabetes group (OR=0.94, 95% CI=0.68-1.29). The odds of acute discharge for those not married were 1.36 times higher as compared to married patients (OR=1.36, 95% CI=1.17-1.56). Lower motor and cognitive scores at discharge were both associated with higher likelihood of discharge to acute care after IRF stay. Detailed results are presented in Table 6.

Hip Joint Replacement

We found similar trends in the hip joint replacement cohort; the odds were 1.08 times higher in the controlled diabetes group for discharge to acute care compared to those in the no diabetes group (OR=1.08, 95% CI=0.88-1.32). For those in the uncontrolled diabetes group the odds for acute discharge were 1.36 times higher as compared to those in the no diabetes group (OR=1.36, 95% CI=0.92-2.01). For marital status, we found significantly higher odds of discharge to acute care after IRF in non-married patients as compared to married patients (OR=1.59, 95% CI=1.35-1.89). Discharge FIM scores (both motor and cognitive) were significant predictors of discharge to acute settings: lower FIM scores resulted in higher likelihood of discharge to acute care after IRF stay. Detailed results are presented in Table 6.

Specific Aim 4: Hospital Readmission

We censored patients who were discharged to acute or sub-acute/other facilities, and considered only those patients who were discharge to community settings after IRF stay. Thus, the descriptive statistics for this sub-sample is different from the sample for the first three specific aims of this study. For this sub-sample, the overall diabetes prevalence in the knee joint replacement cohort was 24.6% with 20.8% patients with controlled diabetes and 3.8% with uncontrolled diabetes. For the hip joint replacement cohort, the overall prevalence was 19.5%, of which 16.6% were in the controlled diabetes category, and 2.9% in the uncontrolled diabetes category. Table 7 presents descriptive statistics for this sub-sample.

Table 6: Results of Multinomial Logistic Regression Analyses for Probability of Acute Discharge Post-IRF Stay

	Knee Joint Replacement				Hip Joint Replacement			
	Acute Care / Community		Sub-Acute Care / Community		Acute Care / Community		Sub-Acute Care / Community	
	OR	95% Wald CI	OR	95% Wald CI	OR	95% Wald CI	OR	95% Wald CI
Diabetes mellitus status								
No Diabetes (Reference)	–	–	–	–	–	–	–	–
Diabetes (–)	0.93	(0.79 to 1.09)	1.03	(0.92 to 1.15)	1.08	(0.88 to 1.32)	0.91	(0.79 to 1.05)
Diabetes (+)	0.94	(0.68 to 1.29)	0.91	(0.73 to 1.14)	1.36	(0.92 to 2.01)	1.18	(0.89 to 1.55)
Age	1.01	(0.99 to 1.02)	**1.03**	(1.02 to 1.04)	1.00	(0.99 to 1.02)	**1.03**	(1.02 to 1.03)
Male	**1.17**	(1.01 to 1.36)	1.01	(0.90 to 1.13)	1.08	(0.91 to 1.29)	**0.88**	(0.78 to 1.00)
Ethnicity/Race								
White (Reference)	–	–	–	–	–	–	–	–
Black	0.97	(0.75 to 1.26)	**0.73**	(0.62 to 0.87)	0.83	(0.59 to 1.16)	**0.63**	(0.50 to 0.80)
Hispanic	1.12	(0.83 to 1.50)	**0.76**	(0.61 to 0.95)	0.61	(0.36 to 1.04)	**0.57**	(0.40 to 0.82)
Other	1.24	(0.79 to 1.93)	0.90	(0.63 to 1.27)	0.81	(0.40 to 1.64)	0.84	(0.51 to 1.39)
Not married	**1.36**	(1.17 to 1.56)	**2.75**	(2.48 to 3.06)	**1.59**	(1.35 to 1.89)	**2.54**	(2.25 to 2.86)
Length of stay	**0.84**	(0.83 to 0.86)	**1.09**	(1.08 to 1.10)	**0.88**	(0.87 to 0.90)	**1.07**	(1.06 to 1.09)
Discharge FIM motor	**0.86**	(0.85 to 0.86)	**0.89**	(0.88 to 0.89)	**0.86**	(0.85 to 0.86)	**0.86**	(0.88 to 0.89)
Discharge FIM cognition	**0.98**	(0.97 to 1.00)	**0.97**	(0.96 to 0.98)	0.99	(0.98 to 1.01)	**0.97**	(0.95 to 0.98)
Elixhauser Comorbidities								
Hypertension					**0.83**	(0.71 to 0.97)	0.96	(0.87 to 1.07)
Deficiency Anemia	**0.81**	(0.70 to 0.94)	0.93	(0.84 to 1.03)	0.96	(0.81 to 1.14)	**1.12**	(1.00 to 1.26)
Hypothyroidism	0.99	(0.81 to 1.21)	**1.23**	(1.08 to 1.40)				
Chronic pulmonary disease								
Arrhythmias	**1.70**	(1.44 to 2.02)	1.05	(0.92 to 1.19)	**1.49**	(1.22 to 1.82)	**1.17**	(1.01 to 1.35)
Obesity								
Fluid and electrolyte disorders								
Depression	0.79	(0.60 to 1.04)	**1.22**	(1.04 to 1.43)	**0.60**	(0.43 to 0.84)	**1.20**	(1.00 to 1.44)
Congestive heart failure	**1.53**	(1.19 to 1.97)	1.14	(0.95 to 1.38)				
Rheumatoid arthritis /collagen vascular diseases								
Other neurological disorders	**0.71**	(0.52 to 0.96)	0.97	(0.80 to 1.17)				

Note: Diabetes (-) and Diabetes (+) are controlled diabetes mellitus and uncontrolled diabetes mellitus, respectively. Bolded values indicate odds ratios for the corresponding logits are statistically significant at the significance level, .05.

Table 7: Patient Characteristics on Community Discharge Stratified by Diabetes Mellitus Status for Knee and Hip Joint Replacement

		Knee Joint Replacement				Hip Joint Replacement			
	Total	No Diabetes	Diabetes (–)	Diabetes (+)	*P* Value	No Diabetes	Diabetes (–)	Diabetes (+)	*P* Value
N (%)	70,203	36,119 (75.4)	9,984 (20.8)	1,813 (3.8)		17,936 (80.5)	3,709 (16.6)	642 (2.9)	
Age (years)	76.5 (6.5)	76.4(6.5)	74.8(6)	74.6(5.7)	<.0001	77.9(6.7)	76.2(6.2)	75.8(5.9)	<.0001
Female (%)	68.6	70.5	64.8	64.3	<.0001	69.5	60.8	56.9	<.0001
Ethnicity / Race (%)					<.0001				<.0001
White	88.2	89.2	80	82.2		91.8	86	85.5	
Black	6.4	5.6	10.4	10.3		4.9	9.3	10	
Hispanic	3.8	3.6	7.1	5.5		2.2	3.2	2.5	
Married (%)	52.5	53.2	55.1	54.8	.002	49	53.1	57.6	<.0001
Length of stay (days)	9.4(3.6)	9.0(3.4)	9.4(3.5)	10.3 (3.7)	<.0001	9.8(3.7)	10.1(3.8)	11.2(3.9)	<.0001
FIM admission									
Motor	43(9.4)	44(9.4)	42.4(9.5)	41(9.5)	<.0001	42.2(9)	41.2(9.2)	39.5(8.6)	<.0001
Cognition	29.2(5.1)	29.5(5.1)	29.1(5.2)	28.5(5.2)	<.0001	29(5.2)	28.9(5.2)	28.2(5)	.001
FIM discharge									
Motor	71.1(8.2)	72.0(7.9)	71.0(8.1)	70.7(8.7)	<.0001	69.9(8.5)	69.1(8.6)	68.1(9)	<.0001
Cognition	32 (3.4)	32.2(3.3)	32.0(3.3)	31.6 (3.5)	<.0001	31.8(3.5)	31.7(3.4)	31.3(3.4)	.003
FIM gain									
Motor	28.1(9.4)	28.1(9.4)	28.6(9.6)	29.6(9.7)	<.0001	27.7(9.2)	27.9(9.4)	28.6(9.7)	.049
Cognition	2.8(3.9)	2.7(3.8)	2.9 (4)	3.1(4.1)	<.0001	2.8(3.9)	2.8(3.9)	3.1(3.8)	.121
Elixhauser Comorbidities (%)									
Hypertension	64.8	64.8	71.5	56.4	<.0001	61.6	68.8	53.6	<.0001
Deficiency Anemia	28.7	29.9	25.7	20.0	<.0001	30.1	24.8	21	<.0001
Hypothyroidism	14.4	15.5	12.2	8.7	<.0001	15	11	8.1	<.0001
Chronic pulmonary disease	12.5	12.1	11.6	11.1	.239	13.6	14.8	12.2	.063
Arrhythmias	12.4	12.5	11.0	12.0	.0001	12.9	12.8	12.9	.984
Obesity	12.2	11.9	20.3	21.0	<.0001	7.2	13	14.3	<.0001
Fluid and electrolyte disorders	10	10.2	9.1	9.7	.01	10.3	9.1	7.9	.023
Depression	7.3	7.8	6.4	5.2	<.0001	7.4	5.4	4.4	<.0001
Congestive heart failure	4.0	3.3	5.2	7.2	<.0001	3.7	6.6	10.3	<.0001
Rheumatoid arthritis /collagen vascular diseases	4.2	4.5	3.2	2.2	<.0001	4.7	3.6	3.9	.013
Other neurological disorders	4.0	4.4	3.1	3	<.0001	4.3	2.2	3.4	<.0001

Note: 1. Diabetes (-) and Diabetes (+) are controlled diabetes mellitus and uncontrolled diabetes mellitus, respectively.
2. For continuous variables, mean and the corresponding standard deviation are presented .

Knee Joint Replacement

We computed both unadjusted and adjusted rates (controlling for covariates) of rehospitalization after discharge to community settings. Table 8 presents rates for 30, 60, and 90 days. However, we will be discussing rehospitalization within 90 days of discharge from IRF settings. Among the knee replacement cohort with no diabetes, the rate of rehospitalization was approximately 10%. For the patients with controlled diabetes, this rate was 12.3%, and for those with uncontrolled diabetes it was 15.1%. Detailed results are presented in Table 8 and Figure 1.

Cox regression models were used to compute 90-day rehospitalization rates, controlling for sociodemographic variables, functional status, length of stay, and Elixhauser comorbidities. Detailed results are presented in Table 9. The discussion will address the hip and knee cohorts separately. For patients with controlled diabetes, the risk for rehospitalization was 22% higher than that for those with no diabetes (HR=1.22, 95% CI=1.14-1.30). Similarly, for patients with uncontrolled diabetes, the risk of rehospitalization was 43% higher as compared to those with no diabetes (HR=1.43, 95% CI=1.26-1.61). We did not observe a significant effect of discharge functional scores (motor and cognitive) on risk of rehospitalization.

Hip Joint Replacement

In hip joint replacement patients with no diabetes, the unadjusted 90-day rehospitalization rate was 12.1%. This rate was 14.8% in those with controlled diabetes, and 17.5% in those with uncontrolled diabetes. Detailed results are presented in Table 8, and Figure 1.

For patients with controlled diabetes, the risk of rehospitalization was 24% higher compared to those with no diabetes (HR=1.24, 95% CI=1.13-1.36). Similarly, for patients with uncontrolled diabetes, the risk of rehospitalization was 48% higher, compared to those with no diabetes (HR=1.48, 95% CI=1.22-1.78). We did not observe a significant effect of discharge functional scores (motor and cognitive) on risk of rehospitalization. Results related to these models are presented in Table 9.

Table 8: Unadjusted (Kaplan-Meier) Estimated Re-Hospitalization Rates from Community Settings

		Estimated Re-Hospitalization Rate (%)		
		Re-Hospitalization Time (Day)		
Joint Replacement	Diabetes Mellitus	**≤ 30**	**≤ 60**	**≤ 90**
Knee	No Diabetes	5.22	7.62	9.98
	Diabetes (–)	6.18	9.22	12.25
	Diabetes (+)	8.11	11.64	15.11
Hip	No Diabetes	6.19	9.23	12.12
	Diabetes (–)	7.63	11.43	14.75
	Diabetes (+)	7.63	13.55	17.45

Note: 1. Diabetes (-) and Diabetes (+) are controlled diabetes mellitus and uncontrolled diabetes mellitus, respectively.

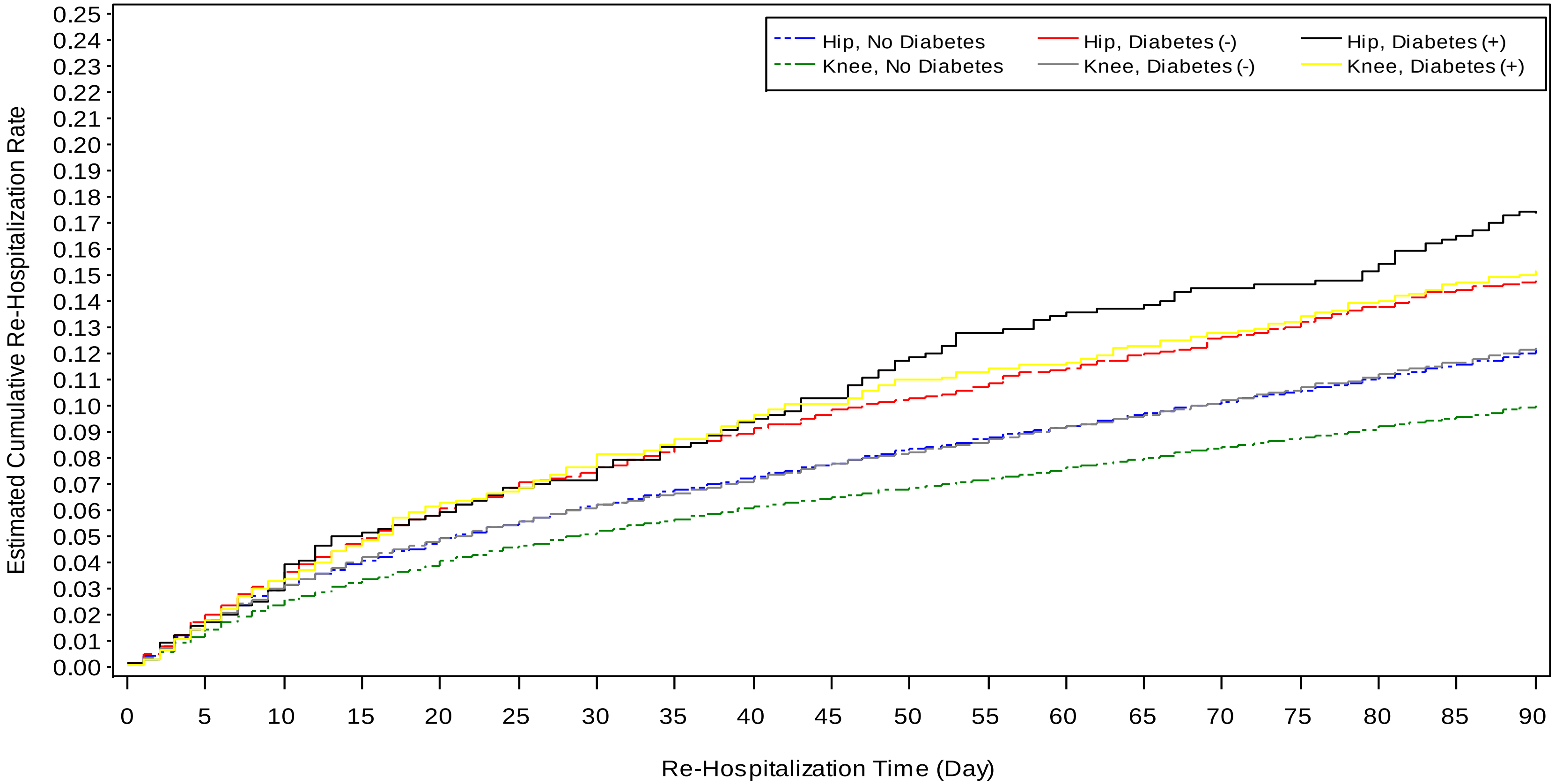

Figure 1: Kaplan-Meier Cumulative Rehospitalization Rate Curve within 90 Days Discharge from IRF

Table 9: Results of Cox Regression Models for 90 Days Rehospitalization

	Knee Joint Replacement		Hip Joint Replacement		Combined	
	Unadjusted	Adjusted†	Unadjusted	Adjusted	Unadjusted	Adjusted†
	HR (95% Wald CI)		HR (95% Wald CI)		HR (95% Wald CI)	
Hip					**1.22 (**1.17 to 1.28**)**	**1.11** (1.05 to 1.16)
Diabetes mellitus status						
No Diabetes (Reference)						
Diabetes (-)	**1.24** (1.16 to 1.33)	**1.22** (1.14 to 1.30)	**1.24** (1.13 to 1.36)	**1.19** (1.08 to 1.30)	**1.24** (1.18 to 1.31)	**1.21** (1.14 to 1.28)
Diabetes (+)	**1.55** (1.38 to 1.76)	**1.43** (1.26 to 1.61)	**1.48** (1.22 to 1.78)	**1.31** (1.08 to 1.59)	**1.53** (1.38 to 1.70)	**1.39** (1.25 to 1.54)
Age		**1.02** (1.01 to 1.03)		0.99 (0.99 to 1.00)		**1.02** (1.01 to 1.03)
Male		**1.15** (1.08 to 1.22)		1.05 (0.96 to 1.14)		**1.11** (1.05 to 1.17)
Ethnicity/Race						
White (Reference)						
Black		1.05 (0.94 to 1.18)		0.93 (0.79 to 1.09)		1.02 (0.93 to 1.11)
Hispanic		1.13 (1.00 to 1.29)		0.88 (0.68 to 1.13)		1.07 (0.96 to 1.20)
Other		1.02 (0.83 to 1.26)		1.01 (0.71 to 1.42)		1.02 (0.86 to 1.22)
Not married		**1.15** (1.08 to 1.22)		0.98 (0.91 to 1.06)		**1.09** (1.04 to 1.15)
Length of stay		**1.04** (1.03 to 1.05)		**1.03** (1.02 to 1.04)		**1.03** (1.03 to 1.04)
Discharge FIM motor		**0.97** (0.96 to 0.98)		**0.98** (0.98 to 0.99)		**0.97** (0.97 to 0.98)
Discharge FIM cognition		**0.98** (0.98 to 0.99)		**0.98** (0.97 to 0.99)		**0.98** (0.97 to 0.99)
Elixhauser Comorbidities						
Hypertension		**0.90** (0.85 to 0.96)				**0.92** (0.88 to 0.96)
Deficiency Anemia						0.95 (0.91 to 1.00)
Hypothyroidism				0.89 (0.80 to 1.00)		0.94 (0.88 to 1.01)
Chronic pulmonary disease		**1.33** (1.23 to 1.44)		**1.35** (1.22 to 1.49)		**1.34** (1.26 to 1.42)
Arrhythmias		**2.09** (1.95 to 2.23)		**1.92** (1.75 to 2.10)		**2.02** (1.91 to 2.13)
Obesity		**1.12** (1.04 to 1.22)				**1.08** (1.01 to 1.16)
Fluid and electrolyte disorders		1.08 (0.99 to 1.19)		1.13 (1.00 to 1.27)		**1.09** (1.02 to 1.17)
Depression		**1.17** (1.06 to 1.30)		**1.16** (1.01 to 1.33)		**1.17** (1.07 to 1.27)
Congestive heart failure		**1.36** (1.22 to 1.52)		**1.38** (1.19 to 1.59)		**1.36** (1.24 to 1.48)
Rheumatoid arthritis /collagen vascular diseases		**1.20** (1.05 to 1.37)		**1.36** (1.16 to 1.60)		**1.25** (1.13 to 1.39)
Other neurological disorders		**1.19** (1.05 to 1.35)				**1.15** (1.04 to 1.28)

Note: 1. Diabetes (-) and Diabetes (+) are controlled diabetes mellitus and uncontrolled diabetes mellitus, respectively.

2. †, Age × logarithm of re-hospitalizing time and Discharge FIM motor × logarithm of re-hospitalizing time are added into the model for adjusting the violation of proportional assumption.

Chapter 5 Discussion

To our knowledge, this is the first study to examine the impact of diabetes as a comorbidity in Medicare beneficiaries undergoing inpatient medical rehabilitation after joint replacement. One of the several advantages of using Medicare data is the fact that findings from investigations like ours can be generalized to other patients undergoing joint replacement procedures. Unlike previously conducted investigations, our study also examined the impact of diabetes on both short-term outcomes (functional status and acute care discharge) and long-term outcomes (90- day rehospitalization).

Specific Aim 1: Diabetes Prevalence

The overall prevalence of diabetes (controlled and uncontrolled diabetes combined) in our sample was 23%. One such comparable study that investigated data from Washington state IRF identified prevalence of diabetes to be approximately 14% in the orthopedic disorders impairment group (which included patients admitted to IRF for joint replacement) [16]. Our results also suggest a higher prevalence of diabetes in non-white groups (black and Hispanic) in both knee and hip joint replacement cohorts. These findings are similar to what was first reported in 2001 by the Agency for Healthcare Research and Quality (AHRQ), which indicated higher rates of diabetes and associated complications in individuals from racial/ethnic minorities (Black, Hispanic, and other) compared to whites [31]. Recent data and statistics produced by the CDC also indicate the age-adjusted rate of diabetes in black males is 9.7%, compared to 7.5% in Asian males, and 6.8% in white males [32]. Exploring racial/ethnic differences is beyond the scope of this study, but should be examined in future work on this topic.

Specific Aim 2: Functional Status Gains

The impact of diabetes status on changes in functional status (functional gains) was minimal. For example, in the knee replacement cohort, the overall motor FIM gain in patients with uncontrolled diabetes was 30.0 points compared to 30.2 points in the no diabetes group. Similarly, in the hip replacement cohort, the overall motor FIM gain was 30.7 points in patients with uncontrolled diabetes, as compared to 31.5 points in the no diabetes group. These findings are similar to what was reported in studies done by Mizrahi and colleagues in patients with ischemic stroke and hip fracture. These studies did not show a significant impact of diabetes status on functional outcomes (functional gain) in patients undergoing rehabilitation for stroke and hip fracture [18, 33]. However, our findings are in contrast with those reported by Graham (2009) and Reistetter (2011) who used IRF-related population-based data sources, and reported negative impact of diabetes status on discharge FIM scores in patients undergoing medical rehabilitation after stroke and hip fracture, respectively [1, 2]. Graham and colleagues (2009) reported an average of eight points higher discharge FIM scores in stroke patients with no diabetes, as compared to those with uncontrolled diabetes [1]. One plausible reason for these contrasts is the fact that we operationally defined functional status as gains in both motor and cognitive FIM scores from admission to discharge of IRF stay, rather than using FIM scores only at IRF discharge, as done by other studies. In summary, we feel that the negative impact of comorbidities on functional recovery is an important concept as reported by some other studies/reports in the past [34, 35]. Thus, this issue may need further exploration, such as by looking at changes associated with motor sub-scales (self-care, sphincter, transfer, and mobility). This level of analysis may differentiate the responsive scales and non-responsive scales, and tease out impact of comorbidities like diabetes on recovery associated with each of those areas.

Specific Aim 3: Acute Care Discharge

We did not find a significant effect of diabetes status on discharge to acute care as compared to community discharge in either the knee and hip joint replacement cohorts. To our knowledge none of the previously conducted studies have tested effect of diabetes status on likelihood of acute discharge for patients after joint replacement receiving medical rehabilitation. However, a study by Graham and colleagues (2009) demonstrated higher likelihood of discharge to settings, other than home, in stroke patients with controlled or uncontrolled diabetes [1]. These results were also echoed in a study by Reistetter et al. (2011) which reported lower likelihood of discharge to home settings associated with the presence of either controlled or uncontrolled diabetes in patients admitted to IRF after hip fractures [2]. One of the possible explanations for lack of strong association between diabetes status and discharge to acute care in our sample is the low percentage of patients discharged to acute care. For our sample, the overall percentage (combined for knee and hip replacement) of discharge to acute care was 2.7%. Though our analytical methods were robust, we did not consider acute discharge as a 'rare event', and used specialized type of logistic regression method to account for inflated rates of 'no events' (community discharges). In not doing so, we could have underestimated the likelihood of discharge to acute care, and underestimated risk associated with (presence) of controlled or uncontrolled diabetes. Limitations that are associated with use of traditional (binomial or multinomial) logistic regression in analyzing outcomes with 'rare events' are listed in the literature [36]. In future, it would be worth exploring the option of considering acute discharges as 'rare events' for impairments like joint replacement.

In testing the relationship between diabetes status and acute care discharge, we found significance of marital status in predicting likelihood of acute discharge. In both knee and hip joint replacement cohorts, we identified a higher likelihood of non-married patients to be discharged to acute care settings compared to being discharged to community settings. A study that was published by our research group last year found a strong association between availability of 'social support' (measured by the Duke–University of North Carolina Functional Social Support Index) and lower likelihood of hospital readmission in stroke patients [37]. However, that relationship dealt with the idea of maintaining independence in community after discharge from IRF stay, than discharge to acute care immediately after rehabilitation stay. We can attempt to draw some parallels between the investigation we conducted last year, to this study. However, another way to improve predictability of this model would be to have more explanatory variables in the models and test it with the existing set of variables.

We also found a significant relationship between motor discharge scores and admission to acute care after IRF discharge in both knee and hip joint replacement cohorts. Within both these cohorts, a 1 point increase in discharge FIM motor ratings was associated with 14% lower odds of discharge to an acute hospital. Our results suggest the importance of using functional status as an essential factor in developing the hospital discharge/readmission risk prediction models, along with other covariates. The association between discharge FIM scores and community/home discharge after IRF stay has been well established in prior investigations [38-41].

Specific Aim 4: Hospital Readmission

Hospital readmissions have received significant attention of providers, public health professionals, and policy makers following a publication by Jencks and colleagues in 2009. The study reported 19.5% and 34.0% readmission rates in Medicare beneficiaries within 30 days and 90 days of discharge from index hospital stay, respectively [42]. Since then, hospital readmission was identified as one of the quality indicators, with financial penalties/incentives tied to it in the Patient Protection and Affordable Care Act (PPACA) for acute hospitals, and more recently for post-acute care settings like inpatient rehabilitation facilities [23, 43]. Also, there is a substantial amount of work related to developing standardized risk prediction models using both claims data and clinical data. However, predictability of most of these models has been shown to be limited. A recently published report by Medicare Payment Advisory Commission (MedPAC) reported the adjusted hospital readmission rate for Medicare beneficiaries admitted to IRF to be around 9% [23]. However, this work was reported to have been preliminary and the readmission rate was not stratified by impairment groups.

The objective of our study, investigating diabetes status as a risk factor for hospital readmissions after IRF discharge, was novel. We found unadjusted 90-day readmission rates to be 15% and 17% for patients with uncontrolled diabetes with knee and hip replacements, respectively. Some may argue that the magnitude of readmission rates for our study were significantly lower than what were reported by Jencks in 2009 (34%). However, the severity of medical conditions (primary diagnosis) for our sample population was relatively mild compared to those reported by Jencks and colleagues [42]. Yet, we found a significant association between diabetes status and risk of rehospitalization. Our results are similar to those reported by previously conducted investigations using clinical data that demonstrated diabetes as one of the risk factors associated with revisions and infections after joint replacement procedures [8-12, 44-48]. One of the limitations of our study is the fact that we considered ‘all cause hospital readmission’ and did not categorize them by causes; e.g. rehospitalization that were directly related to joint replacements (infections, sepsis etc.) versus rehospitalization that are more generic in nature (heart failure, pneumonia etc.). We also did not look at risk factors that were associated with rehospitalization occurring within the first two weeks or first 30 days after discharge from IRF, to see if they compared with those associated with occurring towards the end of our pre-determined time period (close to 90 days following discharge from IRF). We feel that the risk factors may be significantly different in cases of early, versus those of late rehospitalization, and would be something worth exploring in future investigations.

The Prevention Quality Indicators (PQI) were first released by the Agency for Healthcare Research and Quality (AHRQ) in 2000, and were last updated in March 2012 [49]. These indicators provide assessment criteria for providers/policymakers for conditions that could have been prevented in order to avoid its negative impact (hospital admission/readmissions). These PQI include three indicators related to diabetes that are pertinent to our study [49]:

1. PQI 01: Diabetes short-term complications admissions rates
2. PQI03: Diabetes long-term complications admission rates
3. PQ14: Uncontrolled diabetes complication rate

Future work expanding this study could focus on investigating the causes of readmission and taking into account the presence of these PQI, in order to assess the overall quality of provider performance in the management of diabetes across the continuum of care.

Our study has some limitations. First, we used Medicare claims data for this study. These data were not collected for research purposes, so there are limitations in terms of availability of variables that can be used for building prediction/risk models. Also, the algorithm we used was based on using ICD-9 CM codes from rehabilitation stays, which could have resulted in underestimation of diabetes status in this sample. In our existing analyses, we did not consider interactions between diabetes and other comorbidities. Some previously conducted studies reported interaction between obesity and diabetes as an important risk factor for negative outcomes and complications (including hospital readmission) in patients after joint replacement. We felt that it was first necessary to establish the independent effect of diabetes status, and later explore interaction effects. However, in the future, predictability of the risk models, especially related to readmission, could be improved if we can include such interaction terms in the models. Our study did not take into consideration any facility-level variables (proportions of race/ethnic minority patients, specialty status for joint replacement surgery and rehabilitation). Thus we ignored the 'nested structure' of patients nested in facilities in our analyses. These outcomes could also be be tested in the future using more sophisticated analytical methods, like multilevel regression analysis, that takes into account the nesting effects of the data.

A strength of our study is the fact that we used large national sample data, and the results can be generalized to all patients admitted to inpatient rehabilitation facilities after joint replacement. In addition, to our knowledge no previously conducted investigation has used such data to investigate both short-term and long-term outcomes associated with diabetes comorbidity in patients after knee and hip joint replacement. In that sense, this is a novel approach, which can be refined in future work to answer more meaningful and time sensitive questions related to implementation of prevention and diabetes management policies across the continuum of care.

Chapter 6 Conclusion

Our findings indicate that diabetes is a significant comorbid condition within the patient population, creating a major impact on the overall continuum of care. This study has several implications for care delivery and management of underlying comorbidities, such as diabetes, in post-acute care settings in light of significant forthcoming changes in U.S. healthcare services. We based this study on the premise of 'high-risk strategy' suggested in the Public Health literature, which suggests better screening and identification of individuals, who are at high risk of developing a condition or complications associated with a pre-existing condition. The purpose of such (early) identification is to better manage, and prevent, the occurrence of subsequent complications. Traditionally, management of individual-level comorbidities like hypertension and diabetes has been the responsibility of primary care providers; however acute inpatient-level care takes into consideration these underlying comorbidities during the provision of their services. On the contrary, evidence is mixed for post-acute care settings in terms of the impact of these comorbidities on outcomes during the process of care, as well as after discharge from such settings back into the community.

Implementation of 'episode of care payment' or 'bundled payment' will bring substantial changes in the way an 'episode' (joint replacement in the context of this study) will be managed by providers across different levels of care (inpatient, outpatient, and community-level). Public health practice principles that include better management of underlying diabetes and prevention of complications, both, prior to elective procedures such as joint replacement, and throughout the recovery phases, could improve the overall efficiency and quality of care, and avoid financial penalties associated with poor outcomes.

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Vita

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