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Effect of Obesity on Outcomes following Total Hip/Total Knee Arthroplasty among Medicare Beneficiaries with Osteoarthritis

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Effect of Obesity on Outcomes following Total Hip/Total Knee Arthroplasty among Medicare Beneficiaries with Osteoarthritis

by

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Dedication

This original work is dedicated to my husband, Dr. Amol Karmarkar, and to our children, Aarya Karmarkar and Parth Karmarkar.

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Effect of Obesity on Outcomes following Total Hip/Total Knee Arthroplasty among Medicare Beneficiaries with Osteoarthritis

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Abstract: This study examined the effect of obesity on immediate rehabilitation outcomes including functional performance, length of stay (LOS) at inpatient rehabilitation facility (IRF), and discharge destination following IRF stay, and on long-term outcomes following discharge from the IRF including 30-day hospital readmissions, the reasons for readmission and mortality within the duration of the study period. The study population was Medicare beneficiaries 65 years and older, with osteoarthritis, who underwent elective primary total hip (THA) or total knee arthroplasty (TKA) during the years 2012 and 2013 and were directly admitted to IRF. The study design was a secondary data analysis of 100% Medicare Claims data. Outcomes deemed undesirable included longer LOS, lower functional status, discharge to a non-community setting, hospital readmission, and/or death, after completion of IRF stay. Reasons for hospital readmission were further classified based on their connection to the index surgical procedure: local complications, systemic complications, or unrelated. Chi-square statistics and one-way ANOVA were used for descriptive statistics. Multivariable linear regression analysis was used for each of the numerical outcomes: discharge motor function, discharge cognition function, and IRF LOS. Multivariable logistic regression

was used for the categorical outcomes: community discharge and 30-day hospital readmission. Among each of the THA and TKA sub-cohorts of beneficiaries who were readmitted, multinomial logistic regression was used for the categorical outcome of reason for readmission. Survival analyses using cox proportional hazard modeling were conducted for 30-day hospital readmission and mortality. Normal weight was used as the reference category in all multivariable analyses. Differential effects of obesity were also examined by race/ethnicity and gender. Overweight-obesity was associated with higher discharge motor functional status. Morbid obesity was associated with lower discharge motor functional status, but a higher discharge cognition status. Obesity status was not significantly associated with difference in IRF LOS or with the likelihood of community discharge. In the THA cohort, time to 30-day hospital readmission was significantly different between the three obesity-related categories, and morbid obesity was significantly associated with greater risk for 30-day hospital readmission. Among those who were readmitted, morbid obesity was associated with greater odds of local/procedure-related reasons for readmission. Among the THA cohort, time to death was significantly different between the three obesity-related categories, and morbid obesity had a protective effect for the outcome of risk for mortality.

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List of Abbreviations

AHRQ	Agency for Healthcare Research and Quality
ANOVA	Analysis of Variance
BMI	Body mass index
BRFSS	Behavioral Risk Factor Surveillance System
CAH	Critical Access Hospital
CDC	Centers for Disease Control and Prevention
CLRD	Center for Large Data Research and Data Sharing in Rehabilitation
CMG	Case Mix Group
CMS	Centers for Medicare and Medicaid Services
CY	Calendar year
DC C-FIM	Discharge cognition FIM
DC M-FIM	Discharge motor FIM
EC	Elixhauser Comorbidity
FIM	Functional Independence Measure
HAC	Hospital Acquired Condition
HCUP	Healthcare Cost and Utilization Project
ICD-9-CM	The International Classification of Diseases, Ninth Revision, Clinical Modification
IRF	Inpatient Rehabilitation Facility
IRF-PAI	Inpatient Rehabilitation Facility-Patient Assessment Instrument
IRF-LOS	Inpatient Rehabilitation Facility Length of Stay
IRF-PPS	Inpatient Rehabilitation Facility Prospective Payment System
Kg/m2	Kilograms per meter-squared
LOS	Length of Stay

MEDPAR	Medicare Provider Analysis and Review File
MS-DRG	Medical Severity Diagnosis Related Group
NCHS	National Center for Health Statistics
NHANES	National Health and Nutrition Examination Survey
NHIS	National Health Interview Survey
OA	Osteoarthritis
ResDAC	Research Data Assistance Center
RIC	Rehabilitation Impairment Category
SAS 9.4	Version number 9.4 of the Statistical Analysis System Software
THA	Total Hip Arthroplasty
TJA	Total Joint Arthroplasty
TKA	Total Knee Arthroplasty
US	United States (United States of America)
UTMB	University of Texas Medical Branch, Galveston, Texas

CHAPTER 1

Background and Significance

BACKGROUND FOR THIS STUDY

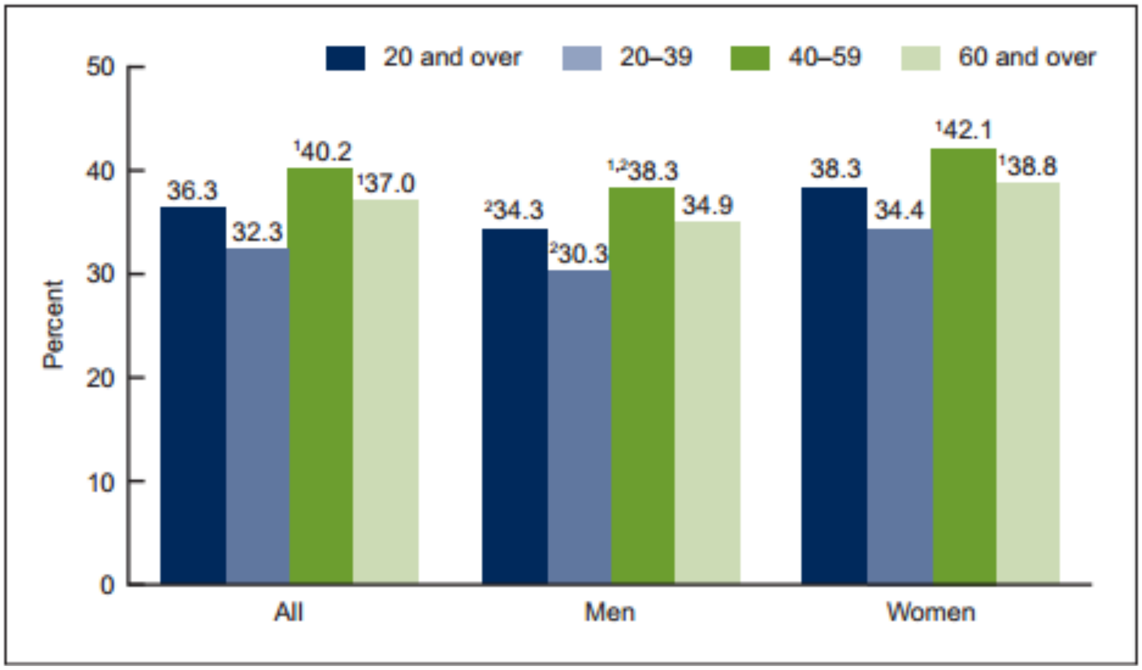
Prevalence of Obesity

Obesity has increased over the past few decades and is now considered to be an epidemic in the United States (US) [1] and a pandemic worldwide [2]. In 2012, the prevalence of obesity among all US adults of age 60 years and older was 35%, and that of overweight and obesity combined was 72% [3]. Data from the 2013 Behavioral Risk Factor Surveillance System (BRFSS) showed that the prevalence of obesity is greater than or equal to 20% in all states of the US.

In 2011 the worldwide population of individuals with obesity was estimated to be approximately 500 million [2]. In 2010, the US was one of the nations with the highest prevalence of obesity in the world (contributing greater than 50% of the global population of individuals with obesity) [2]. Prevalence of obesity among US adults is projected to rise by 65 million by 2030 [4].

As demonstrated in Illustration 1, obesity is more prevalent among women than men for all age groups, and is greater than 38% for women of age 60 years and older.

Illustration 1: Prevalence of obesity during 2011-2014 among all US adults, age 20 years and older, categorized by age group and gender



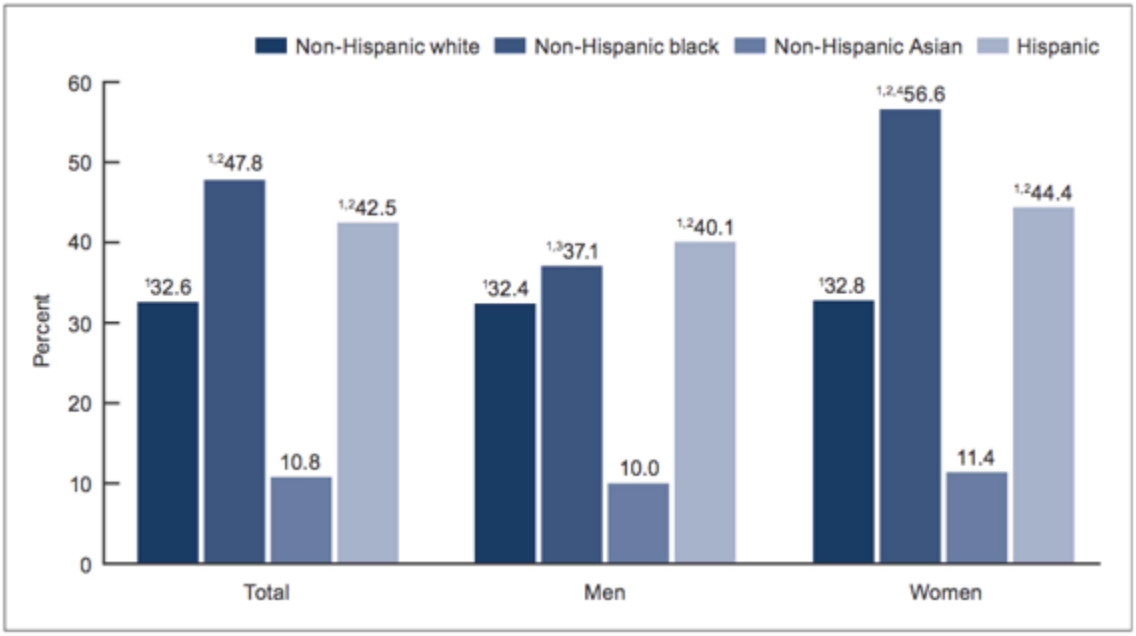
Source: National Center for Health Statistics (NCHS) data brief available on the Centers for Disease Control and Prevention (CDC) website. The data source for this brief, namely, NCHS Obesity Data, was the National Health and Nutrition Examination Survey (NHANES), 2011-2014.

Although the overall rates of prevalence of obesity have increased in all age and racial/ethnic groups, and at all levels of formal education and socioeconomic status [1], they vary greatly by gender, age, and race/ethnicity [3 5 6]. In US, individuals of non-Hispanic black origin have the highest age-adjusted rates of obesity (47.8%), followed by those of Hispanic origin (42.5%), non-Hispanic white origin (32.6%), and the non-Hispanic Asian origin (10.8%) [5].

Data from NHANES 2014 showed prevalence of obesity was higher among adults of age 40-59 years (40.2%) than, among those aged 60 years or older (37%) or, among those between 20-39 years of age (36.3%)[7].

Illustration 2 presents the age-adjusted obesity prevalence, categorized by gender and racial and Hispanic origin, among US individuals, during 2011-2012.

Illustration 2: Age-adjusted obesity prevalence during 2011-2012, among US adults age 20 years and older, categorized by gender, race and Hispanic origin



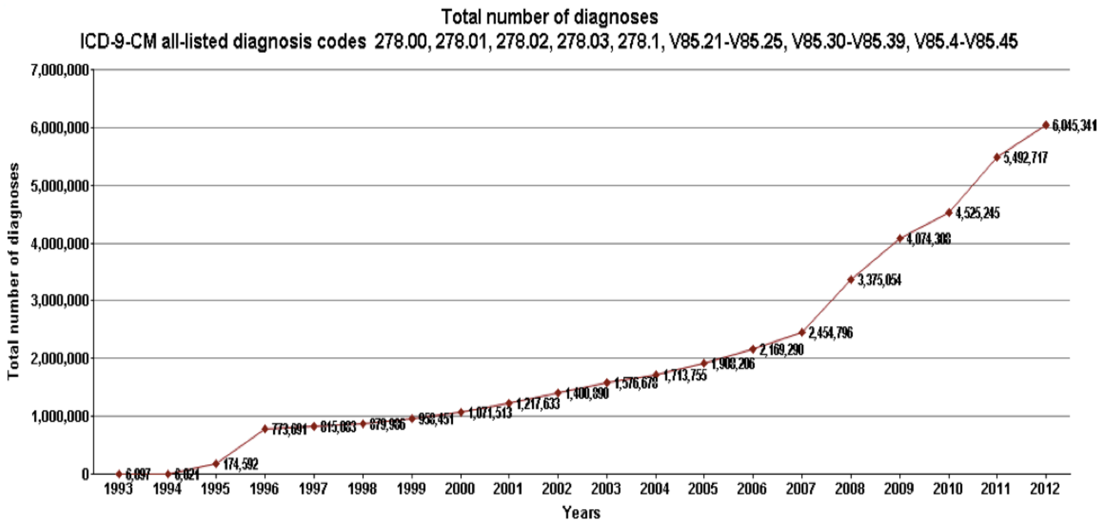
1 = Significant difference from Non-Hispanic Asian
2 = Significant difference from Non-Hispanic White
3 = Significant difference from women
4 = Significant difference from Hispanic
NOTE: Estimates are age-adjusted by the direct method to the 2000 U.S. census population using the age groups 20-39, 40-59, and 60 and over.
SOURCE: CDC/NCHS, National Health and Nutrition Examination Survey, 2011-2012.

Obesity: A Health Indicator

Obesity is, not only a comorbid condition in and of itself, but also a risk factor for other diseases/conditions such as hypertension, type-2 diabetes, cardiovascular disease, osteoarthritis, cancer (ovarian, esophageal, breast, endometrial, colon and rectal, kidney, pancreatic, thyroid, gallbladder, and possibly other types), gallbladder disease, insulin resistance, and sleep apnea [8]. Obesity is thus an indicator of poor health and increases the individual's risk for acute hospital admission.

Figure 1 presents the increasing trend in the total number of acute hospital admissions of individuals with a diagnosis of obesity, over the past two decades. It is interesting to note from this figure that the number of inpatient admissions with a diagnosis of obesity rose from less than 2.5 million to over 6 million in just half a decade: from 2007 to 2012.

Figure 1: Trend in Inpatient Admissions with Diagnoses of Obesity



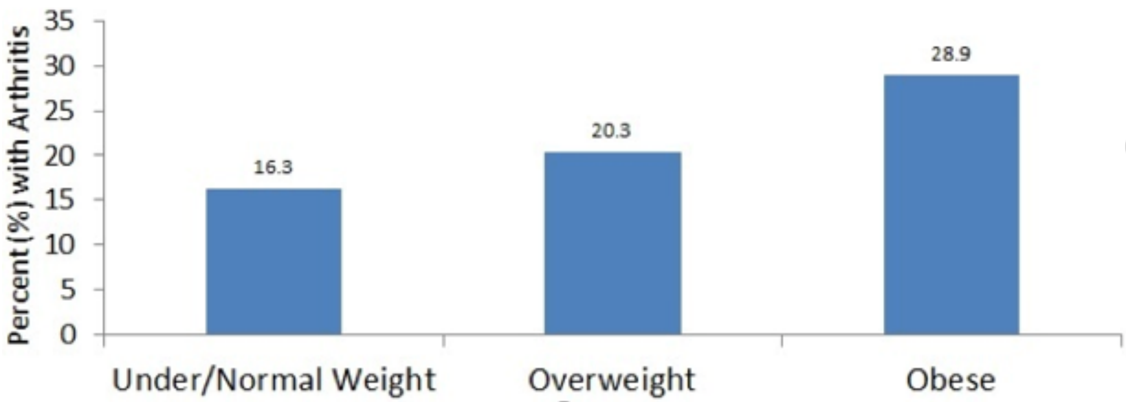
Source: Trends data extracted using Hcup.Net Online portal using ICD9-CM codes of 278.0, 278.0, 278.0, 278.0, 278.1, V85.2X, V85.3X, and V85.4X http://hcupnet.ahrq.gov

Among other chronic conditions obesity may also precipitate osteoarthritis. Osteoarthritis (OA) is a joint disease involving the cartilage, joint lining, ligaments, and underlying bone. OA most commonly affects knees, hips, hands and joints in the spinal column. OA symptoms include joint pain, stiffness and limitation in pain-free active and passive joint range of motion that lead to limitation in performance of activities of daily living. This in turn affects the individual's health-related quality of life [9]. OA may be caused by both mechanical as well as molecular events in the affected joint(s). The onset is gradual and usually begins after the age of 40 years [10].

Obesity and Arthritis

The age-adjusted prevalence of arthritis differs by body mass index - increasing from 16.3% for underweight and normal weight adults to 28.9% for adults with obesity. Excess weight can also contribute to activity limitations. Among the underweight and normal weight adults with arthritis, 38.2% reported arthritis-attributable activity limitations, as compared to 44.8% among adults with obesity and arthritis (Illustration 3).

Illustration 3: Age-adjusted Arthritis Prevalence by BMI categories



Source: CDC webpage titled National Statistics. Data from National Health Interview Survey (NHIS) 2010-2012.

Osteoarthritis

The prevalence of doctor-diagnosed arthritis is higher among women than men in all age groups (Illustration 4). It is clear that the prevalence of doctor-diagnosed arthritis for all age groups is not only higher among women but also rises sharply with each increasing age group. It is estimated that 27 million adults had a diagnosis of OA in 2005 [11]. Among the individuals of age 65 years and older, 49.7% reported doctor-diagnosed arthritis. According to the 2010-2012 National Health Interview Survey (NHIS) data, 26% of all women and 19.1% of all men reported having doctor-diagnosed arthritis.

Illustration 4: Gender-specific prevalence of doctor-diagnosed arthritis by 10 years' age groups, National Health Interview Survey, 2007-2009

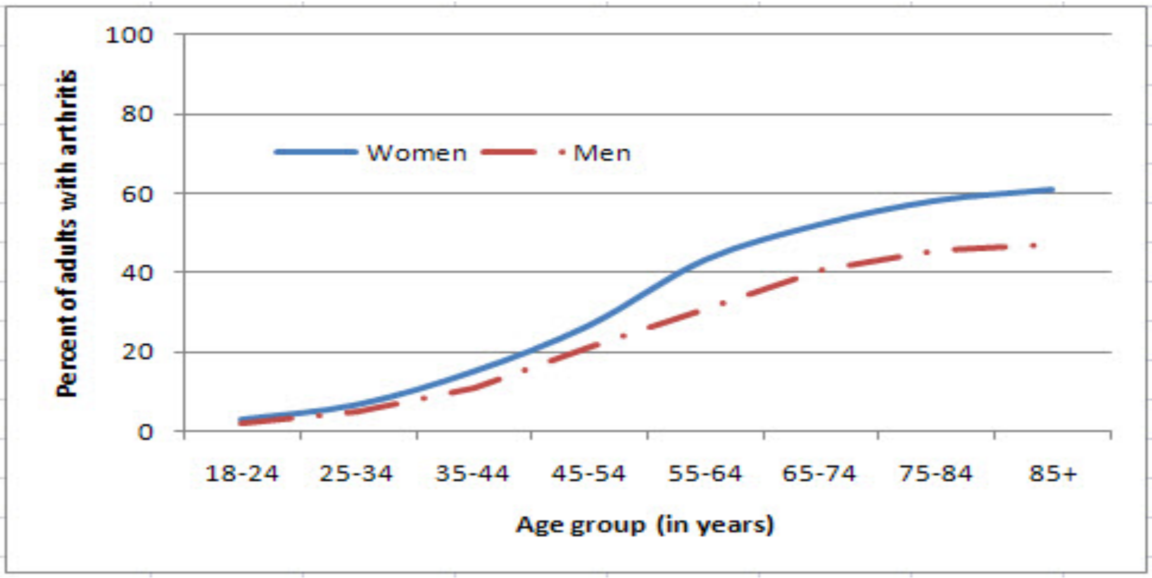
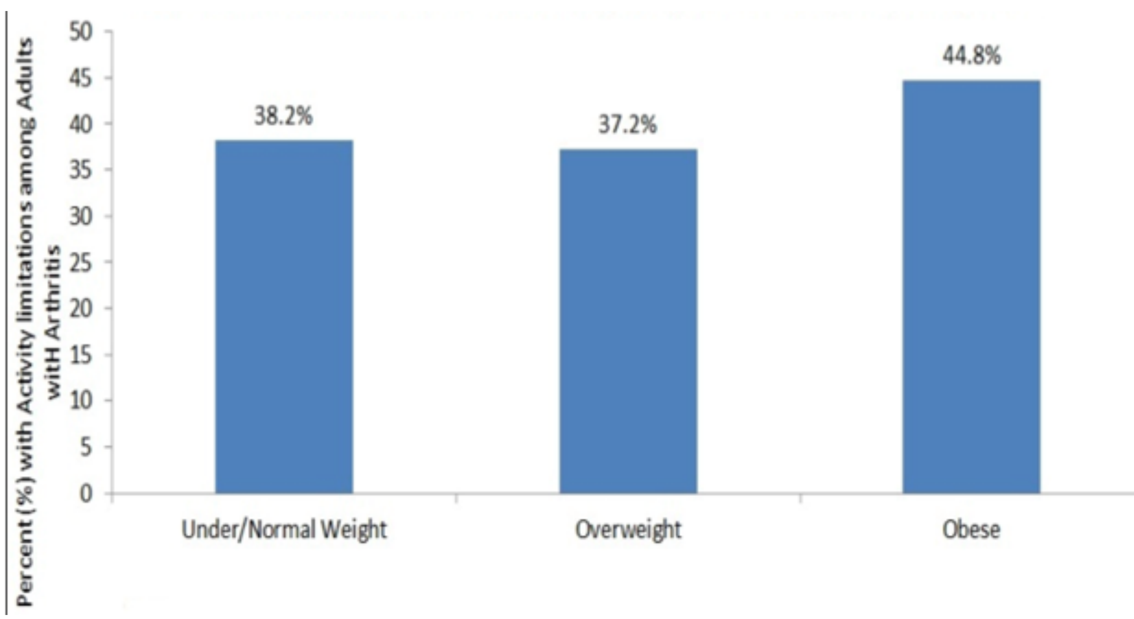


Illustration 5: Age- Adjusted Arthritis-Attributable Activity Limitations among Adults with Arthritis by Body Mass Index (BMI) Categories, NHIS 2010-2012



Source: National Health Interview Survey 2007-2009 data

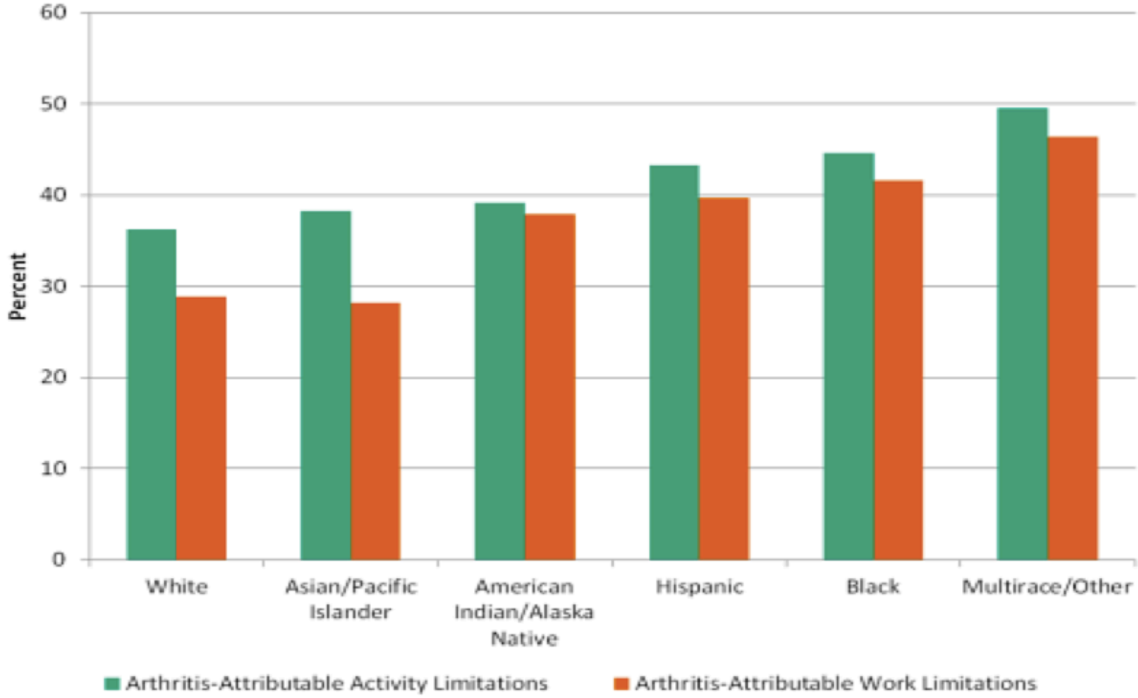
The limitations in activities are the direct result of the joint pain and stiffness that are associated with OA. The disabling effects of arthritis include arthritis-attributable activity and work limitations (Illustration 5)[12].

Based on the 2010-2012 NHIS data, among all those who reported doctor-diagnosed arthritis, 2.9 million were Hispanics, 4.6 million Non-Hispanic Blacks, 667,000 Asian/Pacific Islanders and 280,000 American Indians/Alaska Natives. Nearly 10% of all civilian non-institutionalized US adults (22.7 million) reported having both, doctor-diagnosed arthritis, as well as arthritis-attributable activity limitations. Among the adults with doctor-diagnosed arthritis, 43.2% reported arthritis-attributable activity limitations [13].

Limitations in vital activities among the adults with doctor-diagnosed arthritis included: walking 1/4 mile (6 million), stooping/bending/kneeling (8 million), climbing stairs (5 million), and social activities such as church and family gatherings (2 million) [13]. Despite arthritis being a frequent problem and having a large impact on all racial/ethnic groups in the US, the disabling effects of the condition affect racial/ethnic minorities such as Hispanics and non-Hispanic Blacks more frequently (Illustration 6).

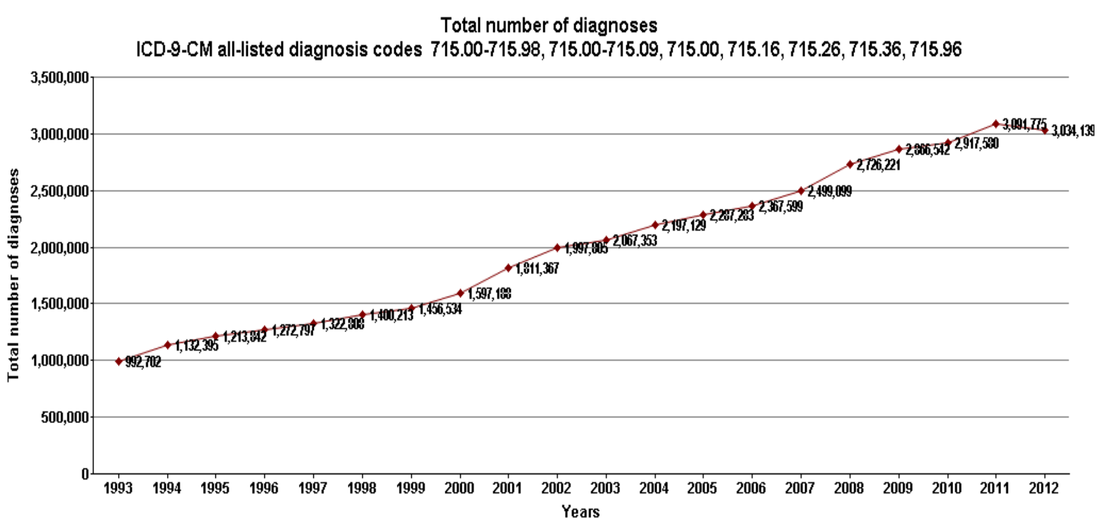
Osteoarthritis negatively impacts health status by causing functional limitations; and often coexists with other health conditions. This is evident by the increasing proportions of hospital admissions with the diagnosis of osteoarthritis (Figure 2 on the next page). This figure demonstrates the trend of these hospital admission over time - rising from less than 2 million in 2002 to more than 3 million within just a decade.

Illustration 6: Proportion of US adults with arthritis who have arthritis-attributable limitations by racial/ethnic group



Source: National Health Interview Survey 2002, 2003, 2006.

Figure 2: Time trend of the total number of acute hospital admissions with a diagnosis of osteoarthritis



Trends data extracted using Hcup.Net Online portal using ICD9-CM codes of 715, 7150, 71500, 71516, 71526, 71536, and 71596 http://hcupnet.ahrq.gov.

Relationship between Obesity and Osteoarthritis

The mechanisms that have been proposed to explain how excess of weight influences OA disease and progression include structural, biomechanical and metabolic. Greater mechanical loads on the weight-bearing joints of the lower extremities in obese individuals produce structural changes and biomechanical effects. The structural changes include narrow joint space, decreased hyaline cartilage volume and thickness, osteophysis or increased bony growth inside the joint, and joint misalignment (most commonly varus misalignment of the knee joint). Biomechanical changes include increased mechanical forces, torques, shear and tensile stresses, and hydrostatic pressure; and abnormal gait pattern [14].

Metabolic inflammation associated with excess adipose tissue and lipids [15-19], and increased biomechanical load across articular cartilage [20-23] have been proposed as possible mechanisms to explain the obesity and knee OA relationship. Metabolic inflammation associated with obesity exacerbates OA by sustained production of pro-inflammatory mediators [17]. Leptin, a hormone produced mainly by adipose tissue has been suggested as an important factor [19]. Elevated levels of leptin have been found in the synovial fluid in the knees of patients with OA, and expressed by OA chondrocytes [19]. Clinical and animal studies of joint loading show that abnormal loads can lead to changes in the composition, structure, and mechanical properties of the articular cartilage [20-23].

Muscle forces are a major determinant of how loads are distributed across a joint surface. Therefore, decreasing the muscle forces acting on joints or malalignment alter loading conditions [23 24].The prevalence of overweight or obesity among all the adults with doctor-diagnosed arthritis is 66% as compared to 53% among those without doctor-diagnosed arthritis [25]. Approximately 50% of all adults 65 years and older reported a diagnosis of arthritis, during 2010 through 2012 [13], and greater than 12% of those aged 60 years and above had symptomatic radiographic OA of knee [26].

The proportion of OA in the US that can be attributable to obesity is 50% [14]. Women have higher rates of prevalence and incidence for OA of the knee [27 28]. Obesity is one of the significant factors contributing to the increase in the number of elective lower extremity joint replacement procedures over the past two decades [29].

Elective Lower Extremity Joint Replacement Procedures as Treatment for Symptomatic Osteoarthritis

OA cannot be cured. The conservative line of treatment consists of medications to relieve pain and inflammation, exercise and weight management. Despite conservative treatment approaches, OA symptoms may affect the individual's daily functioning. Total joint replacement of one or more joints of the lower extremities may be recommended for symptomatic relief. Total hip arthroplasty (THA) and total knee arthroplasty (TKA) are the most common elective surgical intervention procedures performed for this purpose [30]. Both TKA and THA provide remarkable post-operative benefits including reduced pain and stiffness. Improved joint mobility translates to improved functional independence and overall health-related quality of life [31-33].

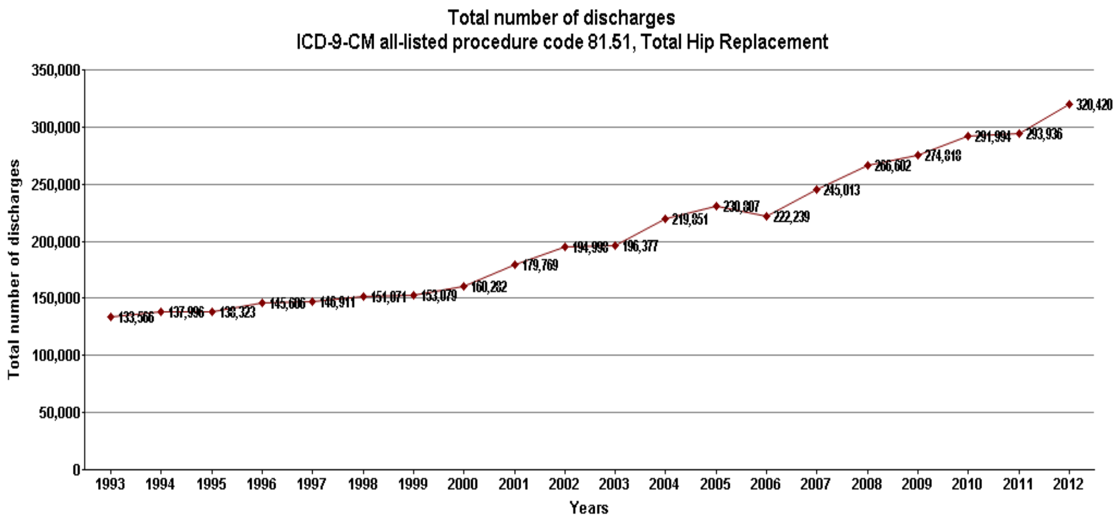
In the year of 2010, 719,000 TKA were performed in the US [34]. The rate of TKA among persons of age 65 years and older in the US increased eight fold from 1979 to 2002 [9]. Men and women who were overweight were respectively 1.7 times and 1.6 times more likely, and men and women with obesity were respectively 5.6 times and 4 times more likely, to undergo a TKA; as compared to men and women in the normal weight range respectively [35]. Women were at greater risk for 30-day hospital readmission compared to men following primary total joint arthroplasty (TJA) [36].

The rates of TKA performed are lower among individuals of minority groups including those of Non-Hispanic Black origin and persons with low income, as compared to those among individuals of Non-Hispanic white origin. However the rates of complications and mortality following TKA are higher among these minority groups as compared to those among individuals of Non-Hispanic white origin [37] [38]. THA ranks among the top most commonly performed procedures in the US [39]. In 2012, nearly 440,000 hospital admissions in the US were for primary THA.

Symptomatic OA of the hip joint is the underlying cause for two-thirds of all primary THA procedures [40]. Individuals of age 65 and older comprise 53.2% of the all those who undergo THA and 56.6% of all those undergo TKA. The greater proportion of the individuals undergoing both THA and TKA is that of women: 56% and 62.3% respectively. Medicare beneficiaries comprise 55.1% and 52.6% of all the individuals who undergo TKA and THA [41].

The time trends of the total number of acute hospital discharges in the US that had the index procedure of hip and knee arthroplasty from 1993 to 2013 are presented in Figures 3 and 4 (next page). As seen in figure 3, the number of total hip replacements performed in 2012 was over 320 thousand as opposed to less than 200 thousand just a decade ago (in 2002).

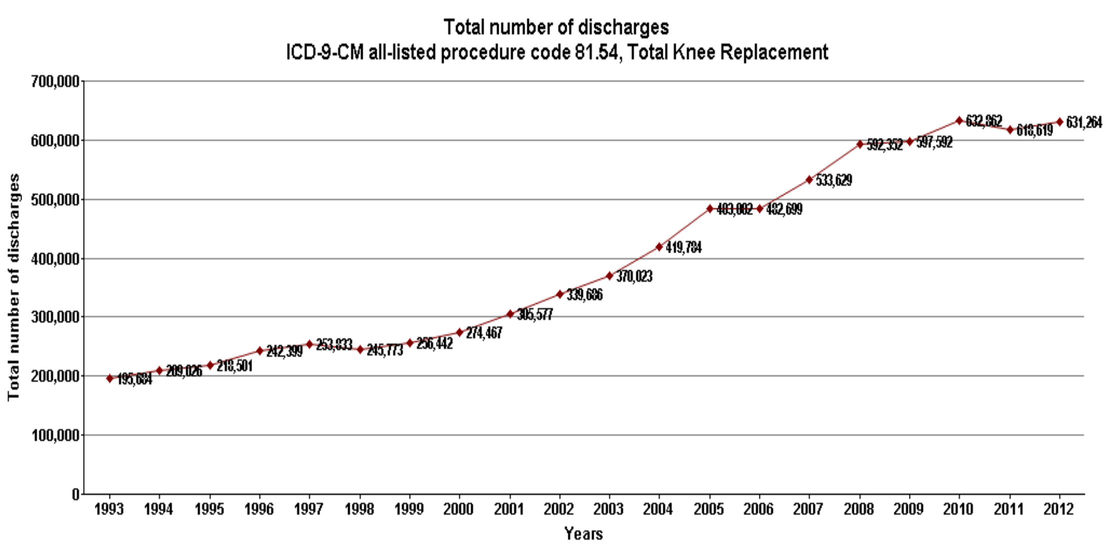
Figure 3: Time Trend of Total Hospital discharges in US with index Procedure of Hip Arthroplasty



Source: Trends data extracted using Hcup.Net Online portal using ICD9-CM procedure code 81.5 (hip replacement)

The increase in the number of total knee replacement procedures is even more dramatic (Figure 4), with the numbers increasing from nearly 340 thousand procedures in 2002 to over 630 thousand procedures in 2012.

Figure 4: Time Trend of Total Hospital discharges in US with index Procedure of Knee Arthroplasty



Source: Trends data extracted using Hcup.Net Online portal using ICD9-CM procedure code 81.5 (knee replacement)

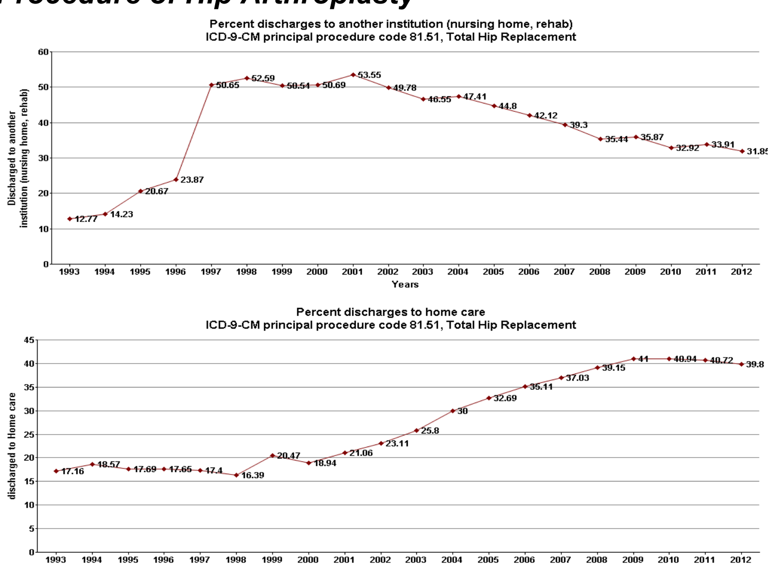
Post-Acute Inpatient Rehabilitation Following Lower Extremity Joint Replacement

Patients undergoing a THA or a TKA procedure require structured post-acute rehabilitation immediately following the procedure to optimize the surgical outcomes. This rehabilitation needs to be provided by trained rehabilitation professionals, including physical and occupational therapists, with knowledge and clinical expertise in OA, THA and TKA.

Self-directed rehabilitation is unadvisable, and appropriate tools and methods need to be used for measuring function at the beginning, during and following the rehabilitation process. Many individuals undergoing THA and TKA receive these specialized services in inpatient rehabilitation facilities (IRFs). These facilities may operate either as a rehabilitation unit - located and nested within a hospital, or as a freestanding facility [42].

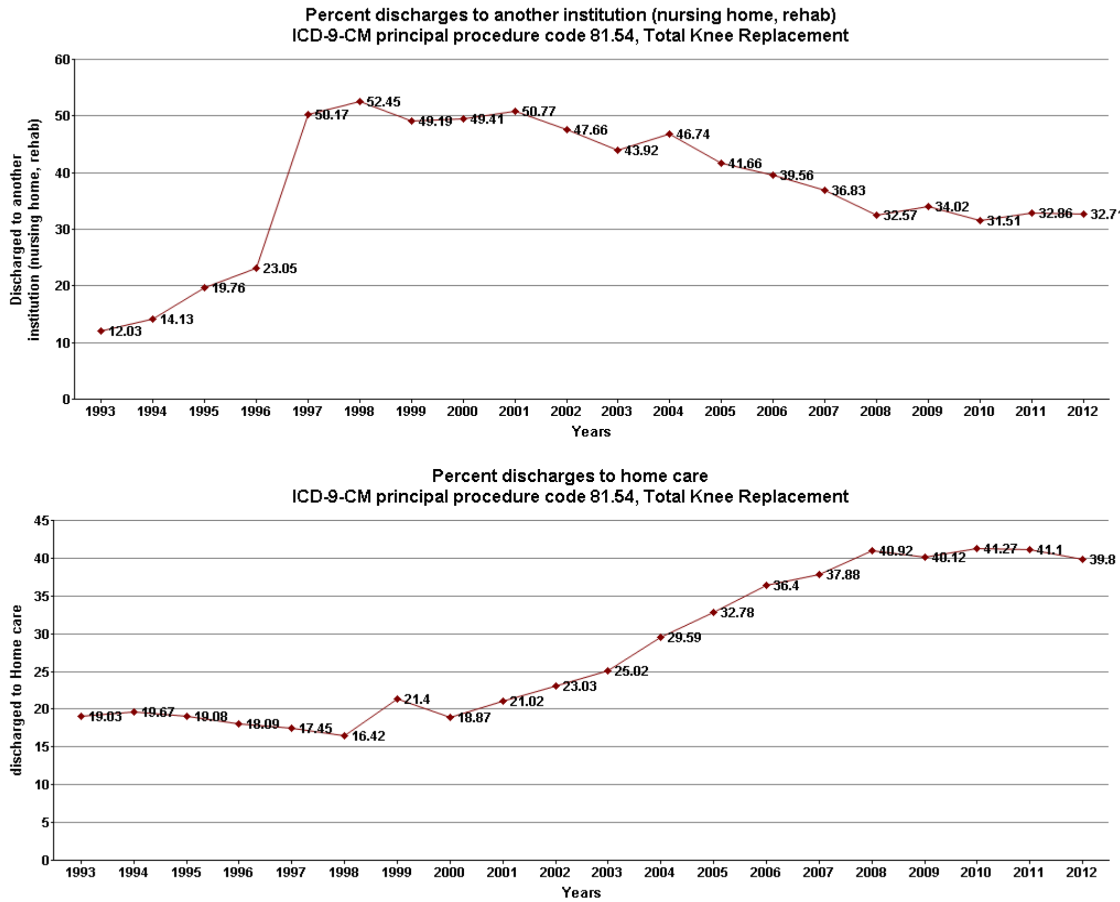
Figures 5 (below) and 6 (next page), demonstrate the time trends of total number of institution versus home discharges for THA and TKA respectively. The figures depict the changes in post-acute care service utilization in response to the various post-acute payment systems implemented between 1996 and 2003[43].

Figure 5: Time Trend of Discharge Status (Institution versus Home) after index Procedure of Hip Arthroplasty



Source: Trends data extracted using Hcup.Net Online portal using ICD9-CM procedure code 81.5 (hip replacement)

Figure 6: Time Trend of Discharge Status (Institution versus Home) after index Procedure of Knee Arthroplasty



Source: Trends data extracted using Hcup.Net Online portal using ICD9-CM procedure code 81.5 (knee replacement)

With the implementation of home health interim payment system towards the end of 1997, home health care utilization for joint replacements subsequently reduced. With the implementation of prospective payment system for skilled nursing care, use of skilled nursing services following joint replacement reduced. Since the implementation of the inpatient rehabilitation prospective payment system in 2002, post-acute acute care service utilization has been steadily decreasing[43].

With the changes in the policies of the Centers for Medicare and Medicaid services (CMS) over a three-year transition period from 2004, the 75%/60% rule came in enforcement in 2007 – which required facilities to demonstrate that 75% of their admission cases required intensive rehabilitation, for those facilities to qualify for being reimbursed as IRFs. CMS identified thirteen qualifying conditions/procedures[44]. Typical, unilateral joint replacement is not on that list, which helps explain the continuing decrease in the percentage of total IRF patients with joint replacement since 2004. However, a joint replacement can qualify for the 60% rule if one of the following criteria are also met: a. the patient received bilateral knee or bilateral hip joint replacement during the hospitalization that preceded the IRF admission, b. the patient has severe obesity with minimum body mass index of 50 at time of IRF admission, and c. the patient is 85 years or older at time of IRF admission[45].

For the individuals undergoing THA or TKA who receive rehabilitation in an IRF, the Federal Register has enlisted the pre-allocated IRF lengths of stay (as per the prospective payment system). This pre-allocation is based on their functional status determined at the time of IRF admission, and is based on the individual's level of tier comorbidity status. Individuals with obesity, undergoing TKA or THA for advanced and symptomatic OA, are at an increased risk of complications and therefore more likely of undergoing multiple revision procedures over their lifetime.

These complications therefore may translate into detrimental impacts on their long-term functional independence and health-related as well as overall quality of life [46]. A systematic review and two meta-analyses have demonstrated that the outcomes of both TKA and THA are worse in individuals with obesity as compared to those without.

These three review studies have concurrently stated that individuals with obesity have higher rates of complications and procedure failures needing revisions for both TKA and THA, as compared to those without [46-48].

Obesity and Outcomes Following Lower Extremity Joint Replacement

Obesity and morbid obesity are independent risk factors for post-operative infection complications following primary TKA and primary THA [46-48]. Each 5-unit increase in the BMI above 45 increases the risk of readmission by twofold (odds ratio = 2.0) and hospital length of stay by 13.8% after TKA or a THA [49]. Extreme obesity was found to significantly increase the rates of post-operative complications [50]. Upon adjusting for age, race, income, gender and hospital volume, obesity has shown to increase the risk of post-operative complications by 1.3 times compared to non-obesity (non-obesity being the reference category). After controlling for hypertension and diabetes mellitus, obesity was found to be an independent predictor of non-community discharge following TKA or THA [51]. Obesity and morbid obesity are significant independent risk factors of dislocation of the operated joint following primary THA [52]. Of these studies, two demonstrated lower overall improvements in functional outcomes after TKA among patients with obesity[53 54].

Two studies demonstrated no higher rates of complications in patients with obesity who underwent TKA[53 55] and two others[54 56] did show higher rates of complications as a result of obesity in TKA patients. Thus the American Academy of Orthopedic Surgeons Clinical Practice Guidelines for surgical management of OA of knee have concluded that obesity is a risk factor for less improvement following TKA[57].

This risk factor has not, however, been established for THA because of inadequate research evidence.

Obesity is associated with increased hospital length of stay and the risk of being discharged into a long-term care facility following TKA or THA [58]. It is known that obesity results in increased operative time for surgical procedures, which greatly influences the development of surgical site complications and systemic complications [47 59]. Obesity is associated with an increased risk for developing in-hospital complications such as urinary tract infections by 50% in TKA, and being discharged to a rehabilitation facility [60]. Other long-term complications associated with obesity following a TKA or a THA are, deep vein thrombosis and pulmonary embolism [48].

SIGNIFICANCE OF THIS STUDY

Given the increase in life expectancy, the current epidemic of obesity, the expected increase in arthritis, and the increase of joint replacement procedures in the US; it is necessary to study the effects of obesity on rehabilitation outcomes in patients after TKA or THA procedures. Specifically, to examine the independent effect of obesity on length of stay at an IRF, functional status at the time of IRF discharge, discharge disposition upon completion of IRF stay, risk of developing complications leading to readmissions and/or mortality following IRF discharge. Recent reports show a dramatic increase in the number of TKA and THA surgeries performed in the US [34 39].

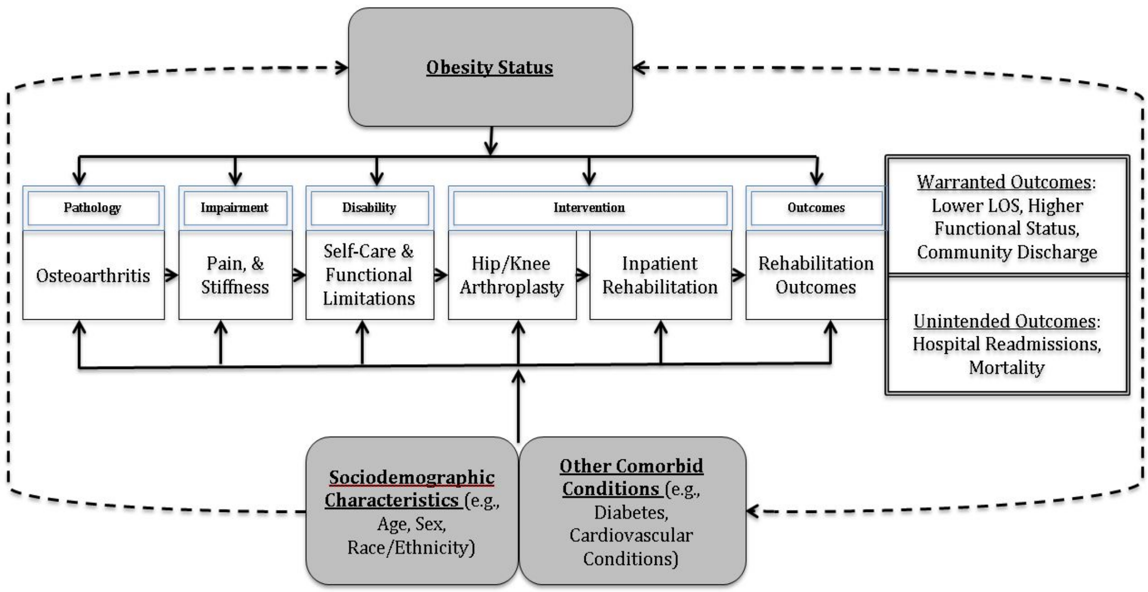
The increase in these procedures will increase the likelihood of a person with obesity entering IRF for post-acute inpatient medical rehabilitation for TKA and THA. Cram and colleagues noted an increase in number of 30-day and 90-day all-cause hospital readmission rates among Medicare beneficiaries undergoing primary THA over the period of 1991-2008. The authors also noted a decrease in 30-day and 90-day mortality in this cohort [61]. According to the Healthcare Cost and Utilization Project (HCUP) data, nearly 9% and more than 5% of all the individuals 65 years and older who underwent THA and TKA respectively, experienced any-cause hospital readmission within 30-days of discharge from the acute hospital stay [41].

The specific aims of this study, the research methods (including the research design, data source, sample selection, variables and covariates, statistical methods) and the descriptive statistics of the overall study sample; comprise the next chapter namely Methods. Research has shown gender and racial differences in outcomes following THA and TKA. In these studies, women (as compared to men) and patients of Non-Hispanic Black and Hispanic origin (compared to those of Non-Hispanic White origin) had lower/poorer outcomes and increased risk of readmission/complication[35 61 62]. In addition to studying the impact of obesity, our study will examine whether such demographic disparities in outcomes exist in our study cohort.

CONCEPTUAL FRAMEWORK FOR THIS STUDY

The conceptual framework (Figure 14 on the next page) used for developing the design and methodology of this study is based in the disablement process model described by Verbrugge & Jette (1994) [63]. The primary variable of interest is *Obesity status* and its impact on rehabilitation outcomes for patients with OA as a primary reason for undergoing primary elective hip or knee arthroplasty.

Figure 7: Conceptual Framework for the Study



SPECIFIC AIMS OF THIS STUDY

The specific aims of this study were:

Aim 1

To examine the association between obesity and rehabilitation outcomes at the time of discharge from IRF stay for total hip or total knee arthroplasty

Hypotheses

1a. Beneficiaries with obesity will have greater proportion of undesirable rehabilitation outcomes compared to those without obesity.

1b. Female beneficiaries with obesity will have greater proportion of undesirable rehabilitation outcomes compared to male beneficiaries with obesity.

1c. Non-Hispanic Black beneficiaries with obesity and Hispanic beneficiaries with obesity will have greater proportion of undesirable rehabilitation outcomes compared to Non-Hispanic White beneficiaries with obesity.

Aim 2

To examine the association between obesity and 30-day hospital readmission following discharge from IRF stay for total hip or total knee arthroplasty.

Hypotheses

2a. Beneficiaries with obesity will have higher risk for 30-day hospital readmission compared to those without obesity.

2b. Female beneficiaries with obesity will have a greater risk for 30-day post-rehabilitation hospital readmission compared to male beneficiaries with obesity.

2c. Non-Hispanic Black beneficiaries with obesity and Hispanic beneficiaries with obesity will have a greater risk for 30-day post-rehabilitation hospital readmission compared to Non-Hispanic White beneficiaries with obesity.

Aim 3

To examine the association between obesity and mortality, following discharge from IRF stay for total hip or total knee arthroplasty.

Hypothesis

3a. Beneficiaries with obesity will have higher risk for mortality, compared to those without obesity.

CHAPTER 2

Methods

INTRODUCTION

The effect of obesity on rehabilitation outcomes including functional performance and length of stay (LOS) at inpatient rehabilitation facility (IRF), discharge destination (community versus non-community setting), 30-day post-rehabilitation readmission complications, and mortality following discharge from IRF, was examined. The study population was Medicare beneficiaries 65 years and older, with osteoarthritis, who underwent elective primary total hip (THA) or total knee arthroplasty (TKA) during the years 2012- 2013 and who were admitted to IRF directly following the procedure.

Rehabilitation outcomes that were deemed undesirable included longer LOS, lower functional status and discharge to a non-community setting at the end of the IRF stay. Readmissions occurring within 30 days of IRF discharge were examined and classified as local/procedure-related and systemic complications. Mortality occurring within the study period following IRF discharge was examined.

DATA SOURCE

We used the 100% of the Medicare data files namely the Medicare Provider Analysis and Review File (MEDPAR), the Beneficiary Summary File, and Inpatient Rehabilitation Facility Patient Assessment Instrument (IRF-PAI), for the years 2012-2013. All the variables for the study (independent variables, outcome variables and covariates) were derived from these three data source files. Table 1 provides the description of the characteristics of each of these data source files.

Table 1: Description of MEDPAR, Beneficiary Summary, and IRF-PAI files

Data Source and Characteristics		
Medicare Provider Analysis and Review File (MEDPAR)	2012-2013	The MEDPAR file contains utilization of services and claims data for Medicare beneficiaries during their stay in acute hospitals, skilled nursing facilities, and inpatient rehabilitation facilities.
Beneficiary Summary File (Formerly known as Denominator file)	2012-2013	The Beneficiary Summary File contains demographic (e.g., age, gender, race/ethnicity) and enrollment information (e.g., original reason for enrollment, HMO status, Dual eligibility status) for each beneficiary enrolled in Medicare during a calendar year.
Inpatient Rehabilitation Facility Patient Assessment Instrument (IRF-PAI)	2012-2013	This file contains information related to: rehabilitation outcomes, functional status, mobility, cognitive status, case-mix groups, tier comorbidity status.

OBTAINING DATA SOURCE FILES

The Centers for Medicare and Medicaid Services (CMS) provides access to “research identifiable” data files including the IRF-PAI files listed previously. Requests for person-level Medicare data require the filing of an application, handled through Research Data Assistance Center (ResDAC). The files needed for the project had already been obtained and currently managed by the Center for Large Data Research and Data Sharing in Rehabilitation (CLRD). Thus, we did not need to seek separate permission to use this data for the proposed project.

MANAGEMENT AND STORAGE OF DATA

The research team has both the experience and the resources necessary to manage and store large datasets. The Division of Rehabilitation Science use both CMS and IRF-PAI data for several ongoing projects. The research team is part of the CLRD, a consortium of universities using large national data sets and headquartered at UTMB (Dr. Kenneth Ottenbacher – Principal Investigator). The data management core in the CLRD assisted in the management and analytics of the datasets that were utilized for this project.

STUDY DESIGN

This retrospective study involved secondary analyses of administrative claims data from the source files listed above.

SAMPLE SELECTION

The study selected beneficiaries receiving elective total hip or knee arthroplasty with a primary diagnosis of osteoarthritis. Specifically, patients who were directly admitted to IRF were selected. Table 2 provides ICD-9 procedure and diagnosis codes used for selection of study cohort.

Table 2: ICD-9 Procedure and diagnosis codes for eligible sample selection

Setting	Codes	Descriptor	Description
Acute Hospitals*	81.5	ICD9-Procedure Code	Total hip replacement
	81.5		Total knee replacement
Acute Hospitals*	715, 715.0, 715.0x, 715.2, 715.3, 715.4, 715.96	ICD9-Diagnosis Code	Osteoarthritis

* Acute hospitals include Critical Access Hospital (CAH)

INCLUSION AND EXCLUSION CRITERIA

Inclusion criteria

a) Medicare beneficiaries 65 years and older

b) Primary diagnosis of osteoarthritis

c) Underwent primary total hip or knee arthroplasty during the calendar years (CYs) 2012 and 2013

d) Admission to inpatient rehabilitation immediately following the acute hospital stay for the arthroplasty.

e) Living in the community prior to undergoing the primary elective arthroplasty procedure for hip or knee

f) Had a minimum of 3 days of IRF length of stay

Exclusion Criteria

After applying all the above inclusion criteria, we excluded those beneficiaries who had:

a) Undergone prior arthroplasty procedure on the same joint (excluded all revision procedures)

b) Undergone bilateral arthroplasty procedure (e.g., bilateral knee arthroplasties)

c) Undergone simultaneous arthroplasties of two or more joints (e.g., simultaneous THA and TKA) on the same or contralateral sides

d) An IRF stay longer than 30 days

e) IRF stay interrupted due to unplanned hospital admission (termed as program interruption)

f) Died during their IRF stay

The step-wise application of the above inclusion and exclusion criteria for deriving study samples has been demonstrated in Tables 3 and 4 below:

Table 3: Applying Study Criteria for Obtaining Eligible Study Sample, Overall Sample, and THA and TKA Analytical Samples for Aim-1 and Aim-3

	Inclusion/Exclusion Criteria	CY 2012	CY 2013	Total
Acute Phase	Medicare beneficiaries who underwent elective primary THA or TKA procedure (excluded joint replacements for fracture repairs, and simultaneous procedures of more than one joint)	526,625	564,037	1,090,662
	Beneficiaries who underwent THA or TKA at an acute or Critical Access hospital (CAH)	515,490	552,194	1,067,684
	Beneficiaries admitted to acute or CAH for THA or TKA	494,699	528,569	1,023,268
	Beneficiaries with underlying Osteoarthritis	466,682	499,133	965,815
	Beneficiaries with subsequent IRF admission within 3 days of discharge from acute stay	27,553	24,503	52,056

	Inclusion/Exclusion Criteria	CY 2012	CY 2013	Total
IRF Phase	Linking Above MedPAR File data with IRF-PAI File data	25,538	22,504	48,042
	Beneficiaries with index/initial IRF stay following THA or TKA	25,529	22,500	48,029
	Beneficiaries in the 'Unilateral Joint Replacement' Rehabilitation Impairment Category	24,273	21,361	45,634
	Beneficiaries with IRF-LOS less than 30 days	24,260	21,356	45,616
	Beneficiaries with IRF-LOS greater than 3 days	23,912	21,072	44,984
	Beneficiaries living in the community prior to THA or TKA	23,804	20,976	44,780
	Beneficiaries who survived entire IRF Stay (excluded: those who died during IRF stay)	23,452	20,973	44,425
	Beneficiaries who received initial rehabilitation for THA or TKA at IRF without program interruption (excluded: those who underwent unplanned acute hospital readmission before completion of IRF stay)	23,325	20,709	44,034
	Beneficiaries who had the Medicare Fee-For-Service coverage during entire IRF stay	21,265	18,556	39,821
	Beneficiaries of age between 65 -100 years	19,318	16,812	36,130
	Merging Above Linked data with the Elixhauser Master Database	18,754	16,341	35,095
Total Eligible Sample				**35,095**
Overall Analytical Sample (excluded: beneficiaries with unspecified or 'other' race/ethnicity from Total Eligible Sample)				**34,260**
THA Analytical Sample for Specific Aims 1 and 3 (Beneficiaries among Overall Analytical Sample who underwent THA)				**11,555**
TKA Analytical Sample for Specific Aims 1 and 3 (Beneficiaries among Overall Analytical Sample who underwent TKA)				**22,705**

Footnote: CY = calendar year

Table 4: Applying Study Criteria for Obtaining THA and TKA Analytical Samples for Aim-2

Step-wise criteria for derivation of THA and TKA Analytical Samples for the outcome of 30-day hospital readmission	**CY 2012**	**CY 2013**	**Total**
Breaking down overall analytical sample by year	18343	15917	34260
Cohort who were discharged from IRF by the end of November 2013	18343	14884	33227
Beneficiaries discharged to community after IRF Stay	17899	14544	32443
Excluding beneficiaries who died within these 30 days of discharge, and those who were transferred directly to acute hospital from IRF without returning to community	17736	14387	32123
Analytical sample for Aim-2			**32123**
THA Analytical Sample for Specific Aim 2 (Beneficiaries among above Analytical Sample who underwent THA)			10782
TKA Analytical Sample for Specific Aim 2 (Beneficiaries among above Analytical Sample who underwent TKA)			21341

MEASAURES

Primary Independent Variable: Obesity Status

Obesity was defined using the ICD-9-CM diagnosis codes associated with either acute or IRF stay as: normal weight, overweight, obesity, and morbid obesity. We used both files, MedPAR and IRF-PAI to identify those with overweight or obesity by using: a) the ICD-9-CM diagnosis codes from the MedPAR file and b) the comorbid conditions (ICD-9-CM codes) from the IRF-PAI. Those patients without any of these ICD-9-CM codes were classified as “normal weight”.

Findings from the Medicare Current Beneficiary Survey, a nationally representative survey of the health and health care experiences of Medicare beneficiaries, showed that the prevalence of obesity (BMI ≥ 30 Kg/m2) ranged from 15 to18% [64]. Cram and colleagues reported that the proportion of individuals with obesity receiving primary TKA has increased over the past two decades – from 4% in 1991 to 11.5% in 2010[62]. Table 5 provides a comprehensive list of obesity codes that were used for inclusion in the study.

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Table 5: List of codes defining Obesity

ICD9-CM Code	Description
278.0	Obesity, unspecified
278.0	Morbid obesity
278.0	Overweight
278.0	Obesity hypoventilation syndrome
V85.2x	Body mass index between 25-29
V85.3x	Body mass index between 30-39
V85.4x	Body mass index 40 and over

Outcome Variables

Rehabilitation Outcomes

a. *Discharge functional status*

Discharge functional status from IRF is measured by the Functional Independence Measure (FIM). The FIM is the patient-level assessment of the IRF-Patient Assessment Instrument (IRF-PAI). The FIM is comprised of 18 total items, divided into two domains: Motor and Cognition. The motor domain contains 13 items namely those on eating, bathing, grooming, dressing upper body, dressing lower body, toileting, sphincter control-bladder, sphincter control-bowel, bed/chair/wheelchair transfers, toilet transfer, tub/shower transfer, mobility, and stair climbing. The cognition domain is comprised of five items: comprehension, expression, social interaction, problem solving, and memory. All the items are scored using an ordinal scale from 1 to 7, where 1 = Total assistance, and 7 = Complete independence. The psychometric properties of the FIM have been extensively established in previous research [65].

For this study the discharge functional status was examined as discharge motor score and discharge cognition score - analyzed separately.

b. *Inpatient rehabilitation facility length of stay*

The IRF length of Stay (LOS) was computed as number of days from IRF admission date to IRF discharge date. The IRF Prospective Payment System (IRF-PPS) pre-allocates resources based on the Case Mix Group (CMG) assignment and presence of tiered comorbidity. For example, morbid obesity is considered as a tier 3 comorbidity and results in additional LOS at IRF as compared to patients without morbid obesity. Table 6 (next page), adapted from IRF Federal Register, provides differences in LOS for joint replacement CMGs[66].

c. *Community discharge*

Community discharge was considered as one of the positive (warranted) outcomes after IRF stay. We computed community discharge as a binary variable (Yes/No). Community discharge is operationally defined as discharge to any of the following settings after completion of IRF stay: home, board and care, transitional living, and assisted living residence[67].

Table 6: Inpatient Rehabilitation Facility Length of Stay for Joint Replacement Case Mix Groups based on Tiered Comorbidity status

Case Mix Group (CMG)	Case Mix Group Description	LOS Tier 1	LOS Tier 2	LOS Tier 3*	LOS Tier 0
0801	Admission FIM Motor Score >49.55	8	8	7	7
0802	Admission FIM Motor Score >37.05 and <49.55	10	10	9	9
0803	Admission FIM Motor Score >28.65 and <37.05 and Age >83.5	13	14	12	12
0804	Admission FIM Motor Score >28.65 and <37.05 and Age <83.5	11	12	11	10
0805	Admission FIM Motor Score >22.05 and <28.65	14	16	13	13
0806	Admission FIM Motor Score <22.05	15	18	16	15

*Note: Currently only Mobid Obesity is classified as Tier 3 comorbidity

Hospital Readmission

Among all the beneficiaries who were in the THA and TKA analytical samples described above for specific Aim 2 (Table 4 on page 28: for the outcome of hospital readmission), this study considered all 30-day all-cause acute care hospital readmissions from the time of discharge from IRF to community, and excluded direct transfers from IRF back to acute. This methodology was originally described by Ottenbacher and colleagues (2014) for calculating 30-day hospital readmissions[68].

Reason for Readmission

Among those readmitted, within each of the THA and TKA cohorts, reasons for readmission were identified and classified using MS-DRG codes as 'local or procedure-related', 'systemic' and 'unrealted'.

Mortality

All-cause mortality from the time of discharge from IRF for the duration of study period – through the end of CY 2013 was used.

Covariates

Age

Age of the beneficiary at the time of admission to IRF was used. This study used age as both a continuous variable and a categorical variable (66-74, 75-84, and 85 and above).

Gender

Male was the reference category.

Race/Ethnicity

Non-Hispanic White, non-Hispanic Black, and Hispanic were the race/ethnicities studied. Non-Hispanic White race/ethnicity was as the reference category.

Social Support

This covariate was created by combining the marital status variable and the living arrangement variables. Both the marital status and living arrangement variables are binary: married versus not married, and living with someone versus not living with someone. The binary variable of social support (yes versus no) was created by assigning a value of ‘yes’ for ‘married’ or ‘living with someone’; and a value of ‘no’ for ‘not married’ and ‘not living with someone’.

Disability Status

Disability status was computed using the Original Reason for Medicare Eligibility variable from the beneficiary summary file.

Medicare/Medicaid Dual Eligibility

This indicates eligibility for both Medicare and Medicaid.

Comorbidities

Three types of comorbidities indices were used: Elixhauser comorbid conditions, the CMS IRF Tier Comorbidity Status, and the Hospital Acquired Conditions (HAC).

Elixhauser comorbid conditions (EC)

These include 30 conditions. Twenty-nine out of the 30 Elixhauser comorbid conditions were used. The excluded Elixhauser comorbid condition namely Obesity is the primary independent variable for this study.

CMS IRF Tier Comorbidity Status

CMS IRF Tier Comorbidity Status: As mentioned previously IRF-PPS system pre-allocates higher resources (LOS) for presence of tiered comorbid conditions. For this study a binary variable (Tiered Comorbidity/No Tiered Comorbidity) was created using ICD-9 diagnosis codes associated with the IRF stay. Morbid obesity, which is a Tier 3 comorbid condition, was not included in these calculations, as it is part of the primary independent variable for the study.

Hospital Acquired Conditions (HAC)

A list of Hospital Acquired Conditions (HAC) created by the CMS, which can be used as a proxy for complications related to acute inpatient stay. These conditions include: blood incompatibility, pressure ulcers stages III and IV, Falls and Trauma, Catheter-Associated Urinary Tract Infection, Vascular Catheter-Associated Infection, Manifestation of Poor Glycemic Control, Surgical Site Infections, and Deep Venous Thrombosis[69].

DATA ANALYSES

Obesity Status

Obesity Status was the primary variable of interest. Prevalence of obesity for Medicare beneficiaries with THA or TKA using the ICD-9 diagnosis codes for obesity from both MedPAR and IRF-PAI files, was computed. Combined, this gave 30 fields of diagnosis codes to search from, to determine the prevalence of obesity as well as obesity categories.

Statistical analyses and testing of assumptions

All the adjusted models were preceded by descriptive statistics using ANOVA and Chi-square test – presented in the following chapter. For linear regression analyses, data normality was investigated using graphical methods such as histogram prior to all the analyses, and it was met for all continuous outcomes. For all logistic regression analyses, the Hosmer-Lemeshow test was used to check the assumption of goodness of fit.

For the outcome of 30-day hospital readmission, and mortality using cox proportional hazard regression models, the proportionality assumption for the primary independent variable, obesity status, was tested. This was done in two steps. First, obesity status was tested descriptively using the plots associated with survival analysis. Secondly, the proportionality of the interaction terms of obesity status with time was tested in the cox proportional hazard regression models. The time variable was readmission time for the outcome of 30-day readmission, and mortality time for the outcome of mortality.

All the chi-square values associated with the interaction terms among both the THA and TKA cohorts were statistically non-significant. Thus, there was no violation of the assumption of proportionality for any of the hazard models for the outcomes of 30day hospital readmission and mortality among both, the THA and TKA cohorts. All the data management and analyses were executed using SAS 9.4 analytical software.

Data analyses for testing hypotheses for each specific aim of the study

Aim1: To examine the association between obesity and rehabilitation outcomes after THA or TKA.

Hypotheses for studying the Specific Aim 1

1a. Patients with obesity will have poorer rehabilitation outcomes compared to those without obesity.

1b. Female patients with obesity will have greater proportion of undesirable rehabilitation outcomes than their male counterparts.

1c. Non-Hispanic Black and Hispanic patients with obesity will have greater proportion of undesirable rehabilitation outcomes than Non-Hispanic White patients with obesity.

For all the three hypotheses of aim 1, the outcome variables included: (i) discharge motor FIM score, (ii) discharge cognition FIM score, (iii) IRF LOS, and (iv) community discharge.

For the continuous variables namely discharge motor and discharge cognition FIM scores and IRF LOS, multivariable linear regression analyses were used. For the binary variable, namely community discharge, multivariable logistic regression analysis was used.

Aim 2: To examine the association of obesity with 30-day post-rehabilitation hospital readmission after total hip or total knee arthroplasty.

Hypotheses for studying the Specific Aim 2

2a. Patients with obesity will have higher risk for 30-day post-rehabilitation readmission complications, compared to those without obesity.

2b. The risk for 30-day post-rehabilitation hospital readmission associated with obesity will be greater in female patients compared to that in male patients.

2c. The risk for 30-day post-rehabilitation hospital readmission associated with obesity will be greater in Non-Hispanic Black and Hispanic patients compared to that in Non-Hispanic White patients.

For all the three hypotheses of aim 2, the outcome variable was 30-day all-cause hospital readmission following the date of discharge from IRF. Thirty-day hospital readmission being a binary variable, multivariable logistics regression was used. Time to hospital readmission was also examined using survival analysis (Cox proportional hazard models).

The primary independent variable for hypotheses 1a and 2a was obesity. The primary independent variables for hypotheses 1b and 2b were obesity and gender, and those for hypotheses 1c and 2c were obesity and race/ethnicity. Main and interaction effects were tested in hypotheses 1b, 1c, 2b and 2c.

Although not originally proposed in Specific Aim 2, this study also analyzed the association of obesity with the three-level outcome of reason for readmission, among each of THA and TKA cohorts, using multinomial logistic regression.

Aim 3: To examine the association between obesity and mortality following discharge from rehabilitation for total hip or total knee arthroplasty.

Hypotheses for studying the Specific Aim 3

3a. Patients with obesity will have higher risk for mortality, compared to those without obesity.

The outcome variable for aim 3 was mortality following IRF discharge.

Mortality being a categorical variable, multivariate logistics regression was used.

Time to death was also examined using survival analysis (Cox proportional hazard models). The primary independent variable for aim 3 was obesity.

CHAPTER 3

The Overall Sample

INTRODUCTION

This chapter describes the overall sample derived using the inclusion-exclusion criteria described in Chapter 2 (Methods). For this study the overall sample was stratified into the total hip arthroplasty (THA) and the total knee arthroplasty (TKA) cohorts. Each of these cohorts was analyzed separately for studying all the outcomes (for all the specific aims of the study). This stratification at the outset was done because the THA and TKA cohorts differed remarkably in their socio-demographic characteristics and health status (as noted in the next chapter: Chapter 4).

Each of the THA and TKA cohorts were further stratified into obesity categories namely: normal weight, overweight, obesity, and morbid obesity (Table 7). The criteria used for identifying obesity status categories have been explained in the Methods chapter.

Table 7: Frequencies and proportions for each obesity status category within the THA and TKA cohorts

	Total	Normal Weight	Overweight	Obesity	Morbid Obesity
THA	11,555	8,218 (71.1%)	210 (1.8%)	1,304 (11.3%)	1,823 (15.8%)
TKA	22,705	13,824 (60.9%)	373 (1.6%)	2,968 (13.1%)	5,540 (24.4%)
Overall Sample	34,260	22,042 (64.3%)	583 (1.7%)	4,272 (12.5%)	7,363 (21.5%)

Values represent number (percent). The percent values are row percent – proportion of each obesity category within the respective cohort.

It is apparent that the overweight category within each cohort was clearly under-coded (under-reported) and thus had very low numbers to be treated as a stand-alone category. The beneficiaries in the overweight category had demographic and health status variables that were more closely resembling those of the beneficiaries in the obesity category rather than those in the normal weight category. The overweight category was therefore merged with the obesity category. The three obesity categories used for this study are depicted in Table 8.

Table 8: Frequencies and proportions for the three obesity status categories used for this study

	Total	Normal Weight	Overweight and Obesity	Morbid Obesity
THA	11,555	8,218 (71.1%)	1,514 (13.1%)	1,823 (15.8%)
TKA	22,705	13,824 (60.9%)	3,341 (14.7%)	5,540 (24.4%)
Overall Sample	34,260	22,042 (64.3%)	4,855 (14.2%)	7,363 (21.5%)

Values represent number (percent). The percent values are row percent – proportion of each obesity category within the respective cohort.

DESCRIPTION OF THE OVERALL SAMPLE

The following descriptive statistics, for the overall sample, describe socio-demographic characteristics (numbers and percentages, and means and standard deviations), as well as variables and values representing the beneficiaries' health status, for both the THA and TKA cohorts. The variables representing health status include: disability status, admission and discharge motor and cognition FIM scores, FIM sub-component scores, and values representing prevalence of obesity and other comorbid conditions (Tier comorbidities, Elixhauser comorbidities and hospital acquired conditions).

Socio-demographic characteristics of the overall sample

There were 34260 beneficiaries in the overall sample. Of these 64.3% were in the normal weight, 14.2% were in the overweight-and-obesity, and 21.5% were in the morbid obesity category. Beneficiaries in the normal weight category were the oldest (mean age 78.4 years) and those in the morbid obesity category were the youngest (mean age 72.5 years). The proportion of individuals of age group 85 years-and-older was the highest among the beneficiaries in the normal weight category (22.8%) and the lowest among those with morbid obesity (2.9%) (Table 9).

The proportion of individuals of age group 65-74 years was the highest among the beneficiaries with morbid obesity (67.5%) and the lowest among those in the normal weight category (31.5%). Majority of the beneficiaries were women (70.2% on average) with the highest proportion of women being in the morbid obesity category and the lowest in the normal weight category (74.9% and 68.7% respectively). Majority were Non-Hispanic White (86.8% on average) and Hispanic was the smallest category (5.4% on average) (Table 9).

The highest proportion of Non-Hispanic White individuals was among the beneficiaries in the normal weight category (88.9%) and the lowest among those in the morbid obesity category (82.1%). In contrast, the highest proportion of Non-Hispanic Black individuals was among the beneficiaries in the morbid obesity category and the lowest was among those in the normal weight category (12.2% and 6.2% respectively). The highest proportion of Hispanic beneficiaries were in the overweight-obesity category (7.3%) (Table 9).

The highest proportion of beneficiaries with social support was within the morbid obesity category and the lowest was within the normal weight category (77.2% and 74% respectively). The proportion of beneficiaries with Medicare-Medicaid dual eligibility and those with disability status was the highest within the morbid obesity category (14.4% and 17.4% respectively). The IRF length of stay (IRF LOS) was the longest for those in the morbid obesity category (9.8 days). Beneficiaries in the normal weight category had the highest proportion of individuals receiving rehabilitation at an in-hospital rehabilitation unit (53.9%), and those in the overweight-and-obesity category had the highest proportion of individuals receiving rehabilitation at a free-standing IRF (54.6%) (Table 9).

Although the admission motor FIM score of the beneficiaries in the normal weight category was the highest (42.8), their discharge motor FIM (DC M-FIM) score was the lowest (70.8), compared to those in the other two obesity status categories. The admission and discharge cognition FIM (DC C-FIM) scores were the highest for beneficiaries in the morbid obesity category (27.9 and 32.1 respectively), compared to those in the other two obesity status categories (Table 9).

The proportion of individuals discharged to community was the highest among beneficiaries in the overweight-obesity category (93.5%), compared to those in the other two obesity status categories (Table 9).

Table 9: Socio-demographic characteristics of the overall sample

	Total	Normal weight	Overweight and Obesity	Morbid Obesity	p value
Sample Size (n)	34,260	22,042 (64.3%)	4,855 (14.2%)	7,363 (21.5%)	-
Age	76.7 (7.0)	78.4 (6.9)	75.7 (6.4)	72.5 (5.4)	<.001
Age Category 65-74 years 75-84 years 85+ years	 14,135 (41.3%) 14,387 (42.0%) 5,738 (16.7%)	 6,943 (31.5%) 10,084 (45.8%) 5,015 (22.7%)	 2,219 (45.7%) 2,127 (43.8%) 509 (10.5%)	 4,973 (67.5%) 2,176 (29.6%) 214 (2.9%)	<.001
Gender Men Women	 10,219 (29.8%) 24,041 (70.2%)	 6911 (31.3%) 15,131 (68.7%)	 1,458 (30%) 3,397 (70%)	 1,850 (25.1%) 5,513 (74.9%)	<.001
Race/ethnicity White Black Hispanic	 29,747 (86.8%) 2,672 (7.8%) 1,841 (5.4%)	 19,603 (89%) 1,374 (6.2%) 1,065 (4.8%)	 4,097 (84.4%) 402 (8.3%) 356 (7.3%)	 6,047 (82.1%) 896 (12.2%) 420 (5.7%)	<.001
*** Living with someone**	24,253 (70.8%)	15,348 (69.6%)	3,527 (72.7%)	5,378 (73%)	<.001
*** Married**	16,319 (47.6%)	10,240 (46.5%)	2,382 (49.1%)	3,697 (50.2%)	<.001
Social Support	25,654 (75%)	16,274 (74%)	3,710 (76.5%)	5,670 (77.2%)	<.001
Medicare-Medicaid Dual Eligibility	3,811 (11.1%)	2,108 (9.6%)	645 (13.3%)	1,058 (14.4%)	<.001
Disability Status	3,899 (11.4%)	2,005 (9.1%)	616 (12.7%)	1,278 (17.4%)	<.001
Hospital length of stay (days)	3.3 (1.6)	3.3 (1.6)	3.3 (1.6)	3.4 (1.7)	0.057
IRF length of stay (days)	9.6 (3.4)	9.6 (3.4)	9.6 (3.3)	9.8 (3.3)	<.001
IRF Type In-hospital Unit Free standing	 17677 (51.6%) 16583 (48.4%)	 11876 (53.9%) 10166 (46.1%)	 2202 (45.4%) 2653 (54.6%)	 3599 (48.9%) 3764 (51.1%)	<.001
Admission Motor FIM	42.4 (9.2)	42.8 (9.1)	42.3 (9.1)	41.3 (9.2)	<.001
Discharge Motor FIM	71.0 (9.5)	70.8 (9.7)	71.6 (9.0)	71.0 (9.5)	<.001
Admission Cognition FIM	27.5 (5.3)	27.3 (5.4)	27.5 (5.2)	27.9 (4.9)	<.001
Discharge Cognition FIM	31.6 (3.6)	31.4 (3.8)	31.8 (3.5)	32.1 (3.1)	<.001
Community discharge	31586 (92.1%)	20205 (91.7%)	4537 (93.5%)	6826 (92.7%)	<.001

Foot Notes: 1). Values represent: Number (Percent) / Mean (Standard Deviation). 2). * Missing values: Living with someone: 8.7%, married: 1.6%.

Comorbidities among the overall sample

Beneficiaries in the morbid obesity category had the highest proportion of individuals with a Tier comorbidity and those in the normal weight category had the lowest (71.9% and 17.4% respectively). The proportion of individuals with a Tier 3 comorbidity status was higher among beneficiaries in the morbid obesity category than those in the normal weight category (69. 8% and 14.6% respectively). Conversely, the proportion of individuals with a Tier 0 comorbidity status was lower among beneficiaries in the morbid obesity category than those in the normal weight category (28.1% and 82.7% respectively) (Table 10).

The highest total number of ECs (EC sum) was among beneficiaries with morbid obesity (3.2) and the lowest among those in the normal weight category (2.9). The ECs including, congestive heart failure, chronic pulmonary disease, renal failure, depression, hypertension, diabetes with and without chronic complications, comprised the highest proportion among beneficiaries in the morbid obesity category and the lowest among those in the normal weight category. The ECs namely, valvular disease, paralysis, neurological disorders, rheumatoid arthritis, coagulopathy, fluid and electrolyte disorders, and deficiency anemia and arrhythmia, comprised the highest proportion among beneficiaries in the normal weight category and the lowest among those with the morbid obesity (Table 10).

Table 10: Comorbidities among the overall sample

	Total	Normal weight	Overweight and Obesity	Morbid Obesity	p value
Tier Comorbidity	10,198 (29.8%)	3,824 (17.4%)	1,082 (22.3%)	5,292 (71.9%)	<.001
Tier Case Mix Group Tier 0 Tier 1 Tier 2 Tier 3	24,062 (70.2%) 171 (0.5%) 746 (2.2%) 9,281 (27.1%)	18,218 (82.6%) 113 (0.5%) 502 (2.3%) 3,209 (14.6%)	3,773 (77.8%) 30 (0.6%) 118 (2.4%) 934 (19.2%)	2,071 (28.1%) 28 (0.4%) 126 (1.7%) 5,138 (69.8%)	<.001
Hospital Acquired Conditions (HAC)	1,589 (4.6%)	962 (4.4%)	240 (4.9%)	387 (5.3%)	0.039
HAC: sum	0.1 (0.2)	0.0 (0.2)	0.1 (0.2)	0.1 (0.2)	0.029
Elixhauser comorbidities (EC): sum	3 (1.5)	2.9 (1.4)	3.1 (1.5)	3.2 (1.6)	<.001
EC: Congestive heart failure	2,260 (6.6%)	1,294 (5.9%)	319 (6.6%)	647 (8.8%)	<.001
EC: Valvular disease	1,682 (4.9%)	1,212 (5.5%)	225 (4.6%)	245 (3.3%)	<.001
EC: Pulmonary circulation disease	573 (1.7%)	348 (1.6%)	78 (1.6%)	147 (2%)	0.097
EC: Peripheral vascular disease	1,567 (4.6%)	1,022 (4.6%)	238 (4.9%)	307 (4.2%)	0.152
EC: Paralysis	573 (1.7%)	395 (1.8%)	86 (1.8%)	92 (1.3%)	0.061
EC: Other neurological disorders	2757 (8%)	1,936 (8.8%)	362 (7.5%)	459 (6.2%)	<.001
EC: Chronic pulmonary disease	6,187 (18.1%)	3,591 (16.3%)	905 (18.6%)	1,691 (23%)	<.001
EC: Hypothyroidism	8,294 (24.2%)	5,363 (24.3%)	1,119 (23%)	1,812 (24.6%)	0.116
EC: Renal failure	3,421 (10%)	1,979 (9%)	475 (9.8%)	967 (13.1%)	<.001
EC: Liver disease	206 (0.6%)	119 (0.5%)	29 (0.6%)	58 (0.8%)	0.186
EC: Peptic ulcer Disease x bleeding	9 (0.0%)	6 (0.0%)	2 (0.0%)	1 (0.0%)	0.7
EC: Acquired immune deficiency syndrome	9 (0.0%)	7 (0.0%)	0	2 (0.0%)	0.6
EC: Lymphoma	157 (0.5%)	118 (0.5%)	16 (0.3%)	23 (0.3%)	0.077
EC: Metastatic cancer	55 (0.2%)	41 (0.2%)	9 (0.2%)	5 (0.1%)	0.112
EC: Solid tumor w/o metastasis	265 (0.8%)	187 (0.9%)	34 (0.7%)	44 (0.6%)	0.155
EC: Rheumatoid arthritis/collagen vas	2,038 (5.9%)	1,410 (6.4%)	250 (5.2%)	378 (5.1%)	<.001
EC: Coagulopthy	1,486 (4.3%)	1,010 (4.6%)	200 (4.1%)	276 (3.8%)	0.071
EC: Weight loss	1,658 (4.8%)	909 (4.1%)	390 (8%)	359 (4.9%)	<.001
EC: Fluid and electrolyte disorders	5,675 (16.6%)	3,810 (17.3%)	789 (16.3%)	1,076 (14.6%)	<.001
EC: Chronic blood loss anemia	818 (2.4%)	542 (2.5%)	90 (1.9%)	186 (2.5%)	0.098
EC: Deficiency Anemias	13,258 (38.7%)	8,798 (39.9%)	1,857 (38.3%)	2,603 (35.4%)	<.001
EC: Psychoses	883 (2.6%)	539 (2.5%)	142 (2.9%)	202 (2.7%)	0.166
EC: Depression	5,879 (17.2%)	3,575 (16.2%)	870 (17.9%)	1,434 (19.5%)	<.001
EC: Hypertension	28,032 (81.8%)	17,743 (80.5%)	3,986 (82.1%)	6,303 (85.6%)	<.001
EC: Arrhythmias	6,129 (17.9%)	4,050 (18.4%)	841 (17.3%)	1,238 (16.8%)	0.056
EC: Diabetes w/o chronic complications	7,703 (22.5%)	4,010 (18.2%)	1,210 (24.9%)	2,483 (33.7%)	<.001
EC: Diabetes w/ chronic complications	2,065 (6%)	916 (4.2%)	377 (7.8%)	772 (10.5%)	<.001

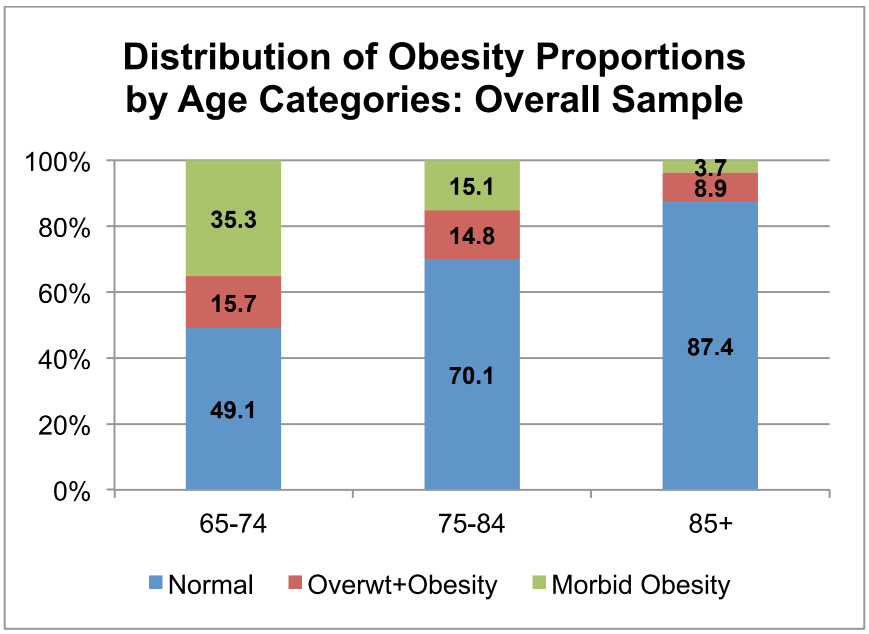
Foot Notes: 1). Values represent: number (percent). 2). The Elixhauser comorbidity namely Obesity is not taken into consideration. 3). The Tier 3 comorbidity namely Morbid Obesity is not taken into consideration. 3). The Elixhauser comorbidities namely drug abuse and alcohol abuse are not shown since there were no/zero cases for those conditions.

Obesity prevalence among the overall sample

The prevalence of morbid obesity and overweight-obesity were the highest among the Medicare beneficiaries in the 65 - 74 years' age group, and the lowest among those in the 85 years and older age group.

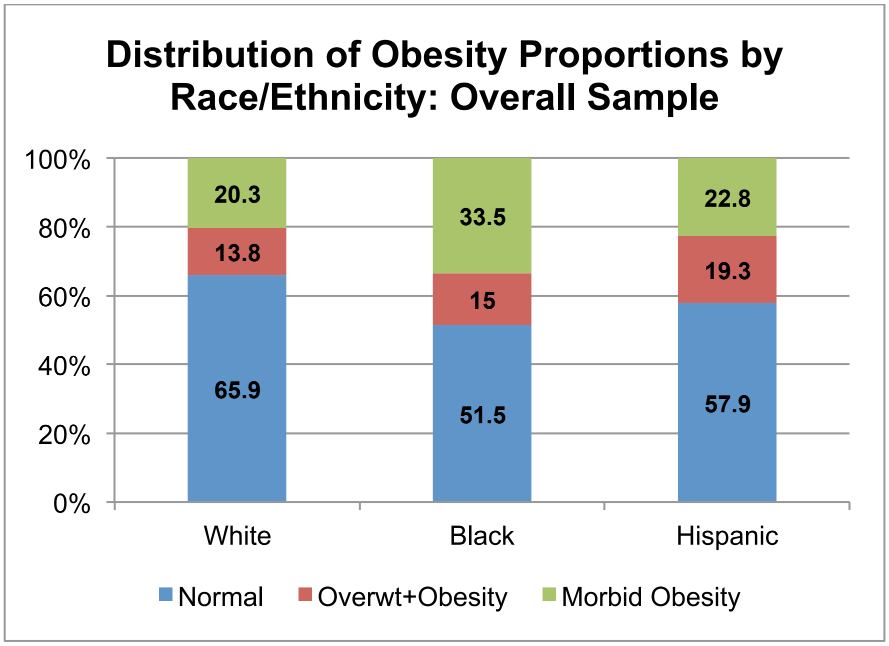
Similarly, the prevalence of normal weight was highest among beneficiaries in the 85 years and older age group, and the lowest among those in the 65-74 years' age group (Figure 8).

Figure 8: Distribution of obesity-status proportions by age categories among the overall sample



The prevalence of morbid obesity was the high among Non-Hispanic Black Medicare beneficiaries. The prevalence of overweight-obesity was high among Hispanic beneficiaries. Normal weight was more prevalent among Non-Hispanic White and the least among Non-Hispanic Black beneficiaries. Non-Hispanic White had the lowest prevalence of overweight-obesity and morbid obesity (Figure 9).

Figure 9: Distribution of obesity-status proportions by race/ethnicity among the overall sample



Functional status of the overall sample

For the FIM subcomponents of self-care, sphincter control, and transfers: a) beneficiaries in the normal weight category had the highest mean scores at admission and the lowest mean scores at discharge, in comparison to beneficiaries in the other two obesity categories; and b) beneficiaries in the morbid obesity category had the lowest mean scores at admission, and those in the over-weight obesity category had the highest mean scores at discharge (Table 11).

For the FIM subcomponent of locomotion: a). beneficiaries in the normal weight category had the highest mean score at admission and those in the overweight-obesity category had the highest mean score at discharge; and b). beneficiaries in the morbid obesity category had the lowest mean score at admission and discharge, in comparison to beneficiaries in the other two obesity-related categories (Table 11).

For the FIM subcomponents of communication and social cognition, at admission and discharge: a) beneficiaries in the morbid obesity category had the highest mean scores, and b) beneficiaries in the normal weight category had the lowest mean scores, in comparison with the other two obesity categories (Table 11).

Table 11: Total scores for FIM sub-components during IRF admission and discharge among the overall sample

Subgroups of FIM components	Overall	Normal weight	Over-weight and Obesity	Morbid Obesity	p-value
Admission Selfcare	22.4 (4.7)	22.6 (4.6)	22.4 (4.6)	22 (4.7)	<.001
Discharge Selfcare	34.7 (4.3)	34.6 (4.4)	35 (4.1)	35 (4.3)	<.001
Admission Sphincter Control	8.6 (3.1)	8.6 (3.1)	8.5 (3.1)	8.5 (3.2)	.055
Discharge Sphincter Control	11.5 (2.1)	11.5 (2.1)	11.6 (2.0)	11.5 (2.1)	.075
Admission Transfers	8.3 (2.8)	8.4 (2.7)	8.3 (2.8)	8 (2.8)	<.001
Discharge Transfers	15.7 (2.8)	15.6 (2.8)	15.9 (2.6)	15.7 (2.8)	<.001
Admission Locomotion	3.1 (1.5)	3.1 (1.5)	3 (1.5)	2.9 (1.4)	<.001
Discharge Locomotion	9.1 (2.8)	9.2 (2.8)	9.2 (2.7)	8.9 (2.9)	<.001
Admission Communication	11.4 (2.1)	11.3 (2.8)	11.4 (2.1)	11.5 (2.0)	<.001
Discharge Communication	12.9 (1.4)	12.8 (1.4)	12.9 (1.3)	13 (1.2)	<.001
Admission Social Cognition	16.1 (3.4)	16 (3.5)	16.1 (3.3)	16.4 (3.2)	<.001
Discharge Social Cognition	18.8 (2.5)	18.6 (2.6)	18.9 (2.4)	19.1 (2.1)	<.001

CHAPTER 4

Aim 1: Effect of Obesity on Rehabilitation Outcomes among Medicare Beneficiaries with Total Hip and Total Knee Arthroplasties

INTRODUCTION

This chapter presents the results of descriptive statistics and regression analyses examining the effect of obesity status on the rehabilitation outcomes among Medicare Beneficiaries with THA and THA during 2012 and 2013. The outcomes studied include discharge motor functional independence measure (DC M-FIM), discharge cognition functional independence measure (DC C-FIM), IRF length of stay (IRF LOS), and discharge to community following IRF stay.

The descriptive statistics describe, socio-demographic characteristics (in the form of numbers and percentages, and means and standard deviations), as well as variables and values representing the beneficiaries' health status, for both the THA and TKA cohorts. The variables representing health status include: disability status, admission and discharge motor and cognition FIM scores, FIM sub-component scores, and values representing prevalence of obesity and other comorbid conditions (Tier comorbidities, Elixhauser comorbidities and hospital acquired conditions), within each cohort.

Linear regression models were performed to test the association between obesity and functional outcomes and IRF LOS. Logistic regression analysis was used to test the association between obesity and community discharge. Three models were performed to test these associations. Model 1 included obesity status, age, gender, race/ethnicity, Medicare-Medicaid dual eligibility, disability status, length of stay (IRF LOS for functional outcomes and community discharge, hospital length of stay for IRF LOS), functional status (at admission for functional outcomes and IRF LOS, and at discharge for community discharge), and comorbidities (hospital acquired conditions, Tier comorbidities, and Elixhauser comorbidities). Model 2 included all the variables in Model 1 and interaction of obesity and race/ethnicity. Model 3 included all the variables in Model 1 and interaction of obesity and gender.

Secondary analyses were performed based on the results obtained from regression analyses to understand the association of obesity with the rehabilitation outcomes within each race/ethnicity sub-cohort in the THA and TKA samples.

RESULTS OF DESCRIPTIVE STATISTICS

Socio-demographic characteristics of the THA cohort

There was a total of 11555 beneficiaries in the THA cohort. Beneficiaries in the morbid obesity category were the youngest (mean age 73.2 years), had the highest proportion of Non-Hispanic Black race/ethnicity, social support, Medicare-Medicaid dual eligibility, and disability status, the longest IRF LOS, and the highest admission and discharge cognition FIM scores; compared to beneficiaries in the normal weight category. Beneficiaries in the morbid obesity category had the lowest proportion of Non-Hispanic White individuals, and the lowest admission motor FIM score; compared to those in the normal weight category (Table 12).

Table 12: Socio-demographic characteristics of THA cohort

	Total	Normal weight	Overweight and Obesity	Morbid Obesity	p value
Sample Size (n)	11,555 (100%)	8,218 (71.1%)	1,514 (13.1%)	1,823 (15.8%)	
Age	77.7 (7.1)	78.9 (7.1)	76.4 (6.6)	73.2 (5.8)	<.001
Age Category 65-74 years 75-84 years 85 years and above	 4,211 (36.4%) 4,937 (42.7%) 2,407 (20.8%)	 2,427 (29.5%) 3,673 (44.7%) 2,118 (25.8%)	 628 (41.5%) 680 (44.9%) 206 (13.6%)	 1,156 (63.4%) 584 (32.0%) 83 (4.6%)	<.001
Gender Men Women	3,636 (31.5%) 7,919 (68.5%)	2,595 (31.6%) 5,623 (68.4%)	484 (32%) 1,030 (68%)	557 (30.5%) 1,266 (69.5%)	0.7
Race/ethnicity White Black Hispanic	 10,392 (89.9%) 778 (6.7%) 385 (3.3%)	 7,499 (91.3%) 474 (5.8%) 68 (4.5%)	 1,342 (88.6%) 104 (6.9%) 68 (4.5%)	 1,551 (85.1%) 200 (11%) 72 (4%)	<.001
*** Living with someone**	7,964 (68.9%)	5,574 (67.8%)	1,078 (71.2%)	1,312 (72%)	0.025
*** Married**	5,342 (46.2%)	3,665 (44.6%)	718 (47.4%)	959 (52.6%)	<.001
*** Social Support**	8,469 (73.5%)	5,922 (72.2%)	1,147 (75.8%)	1,400 (77.1%)	<.001
Medicare-Medicaid Dual Eligibility	1,055 (9.1%)	656 (8%)	166 (11%)	233 (12.8%)	<.001
Disability	1,127 (9.8%)	662 (8.1%)	152 (10%)	313 (17.2%)	<.001
Hospital length of stay (days)	3.3 (1.6)	3.3 (1.6)	3.4 (1.7)	3.4 (1.6)	0.73
IRF length of stay (days)	10.0 (3.5)	9.9 (3.5)	10.1 (3.5)	10.3 (3.6)	<.001
IRF Type **In-Hospital Unit** **Free standing**	 6187 (53.5%) 5368 (46.5%)	 4534 (55.2%) 3684 (44.8%)	 710 (46.9%) 804 (53.1%)	 943 (51.7%) 880 (48.3%)	<.001
Admission Motor FIM	41.6 (8.9)	41.9 (8.9)	41.3 (9.0)	40.3 (9.0)	<.001
Discharge Motor FIM	69.8 (9.8)	69.7 (9.9)	70.3 (9.3)	69.8 (9.7)	0.0685
Admission Cognition FIM	27.3 (5.3)	27.2 (5.4)	27.4 (5.1)	27.9 (5.0)	<.001
Discharge Cognition FIM	31.5 (3.7)	31.3 (3.8)	31.8 (3.5)	32.1 (3.0)	<.001
Community discharge	10440 (90.4%)	7406 (90.1%)	1380 (91.2%)	1654 (90.7%)	0.43

Foot-notes: 1). Values represent: Number (Percent) / Mean (Standard Deviation). 2). *Living with Someone has 1248 (10.8%) missing values, *Married has 175 (1.5%) missing values, *Social Support has 26 (0.2%) missing values.3). the percent value for each of the three obesity-related categories in the (first) sample size row is row percent: proportion of the total. All other percent values in the table are column percent.

Comorbidities among the THA cohort

Beneficiaries with morbid obesity had the highest EC sum; the highest proportion of individuals with congestive heart failure, chronic pulmonary disease, renal failure, diabetes with and without chronic complications; compared to those in the normal weight category. Beneficiaries with morbid obesity had the lowest proportion of individuals with valvular disease, neurological disorders, fluid and electrolyte disorders, and deficiency anemias; compared to those in the normal weight category (Table 13).

Table 13: Comorbidities among THA cohort:

	Total	Normal weight	Overweight and Obesity	Morbid Obesity	*p* value
Tier Comorbidity	2,704 (23.4%)	1,196 (14.6%)	282 (18.6%)	1,226 (67.3%)	<.001
Tier Case Mix Group					
Tier 0	8,851 (76.6%)	7,022 (85.5%)	1,232 (81.4%)	597 (32.8%)	<.001
Tier 1	64 (0.6%)	51 (0.6%)	8 (0.5%)	5 (0.3%)	
Tier 2	274 (2.4%)	199 (2.4%)	44 (2.9%)	31 (1.7%)	
Tier 3	2,366 (20.5%)	946 (11.5%)	230 (15.2%)	1,190 (65.3%)	
Hospital Acquired Conditions (HAC)	500 (4.3%)	333 (4.1%)	80 (5.3%)	87 (4.8%)	0.172
HAC: sum	0.0 (0.2)	0.0 (0.2)	0.1 (0.2)	0.1 (0.2)	0.188
Elixhauser comorbidities (EC): sum	3.0 (1.5)	2.9 (1.5)	3.1 (1.6)	3.2 (1.6)	<.001
EC: Congestive heart failure	782 (6.8%)	512 (6.2%)	111 (7.3%)	159 (8.7%)	0.004
EC: Valvular disease	605 (5.2%)	465 (5.7%)	77 (5.1%)	63 (3.5%)	0.007
EC: Pulmonary circulation disease	164 (1.4%)	111 (1.4%)	26 (1.7%)	27 (1.5%)	0.6
EC: Peripheral vascular disease	584 (5.1%)	407 (5.0%)	94 (6.2%)	83 (4.6%)	0.0694
EC: Paralysis	158 (1.4%)	121 (1.5%)	15 (1.0%)	22 (1.2%)	0.4
EC: Other neurological disorders	890 (7.7%)	673 (8.2%)	100 (6.6%)	117 (6.4%)	0.085
EC: Chronic pulmonary disease	2,080 (18%)	1,368 (16.7%)	291 (19.2%)	421 (23.1%)	<.001
EC: Hypothyroidism	2,706 (23.4%)	1,927 (23.5%)	347 (22.9%)	432 (23.7%)	0.96
EC: Renal failure	1,070 (9.3%)	714 (8.7%)	146 (9.6%)	210 (11.5%)	0.007
EC: Liver disease	73 (0.6%)	51 (0.6%)	6 (0.4%)	16 (0.9%)	0.212
EC: Peptic ulcer Disease x bleeding	6 (0.1%)	5 (0.1%)	0	1 (0.1%)	0.627
EC: Acquired immune deficiency syndrome	5 (0.0%)	4 (0.1%)	0	1 (0.1%)	0.7
EC: Lymphoma	68 (0.6%)	54 (0.7%)	4 (0.3%)	10 (0.6%)	0.297
EC: Metastatic cancer	30 (0.3%)	25 (0.3%)	3 (0.2%)	2 (0.1%)	0.4
EC: Solid tumor w/out metastasis	109 (0.9%)	86 (1.1%)	10 (0.7%)	13 (0.7%)	0.254
EC: Rheumatoid arthritis/collagen vas	699 (6%)	527 (6.4%)	71 (4.7%)	101 (5.5%)	0.06

	Total	Normal weight	Overweight and Obesity	Morbid Obesity	*p* value
EC: Coagulopthy	479 (4.1%)	350 (4.3%)	73 (4.8%)	56 (3.1%)	0.060
EC: Weight loss	596 (5.2%)	345 (4.2%)	150 (9.9%)	101 (5.5%)	<.001
EC: Fluid and electrolyte disorders	1,947 (16.8%)	1,404 (17.1%)	280 (18.5%)	263 (14.4%)	0.043
EC: Chronic blood loss anemia	311 (2.7%)	220 (2.7%)	30 (2.0%)	61 (3.4%)	0.122
EC: Deficiency Anemias	4,669 (40.4%)	3,394 (41.3%)	611 (40.4%)	664 (36.4%)	0.006
EC: Psychoses	255 (2.2%)	174 (2.1%)	43 (2.8%)	38 (2.1%)	0.274
EC: Depression	1,840 (15.9%)	1,253 (15.3%)	271 (17.9%)	316 (17.3%)	0.070
EC: Hypertension	9,255 (80.1%)	6,488 (79%)	1,225 (80.9%)	1,542 (84.6%)	<.001
EC: Arrhythmias	2,073 (17.9%)	1,477 (18.0%)	277 (18.3%)	319 (17.5%)	0.9
EC: Diabetes w/o chronic complications	2,209 (19.1%)	1,316 (16.0%)	340 (22.5%)	553 (30.3%)	<.001
EC: Diabetes w/ chronic complications	524 (4.5%)	267 (3.3%)	84 (5.6%)	173 (9.5%)	<.001

Foot notes: 1). Values represent: Number (Percent). 2). The EC namely Obesity is not taken into consideration. 3). The Tier 3 comorbidity namely Morbid Obesity is not taken into consideration. 4). The number for both ECs: drug abuse and alcohol abuse was 0.

Obesity prevalence among the THA cohort

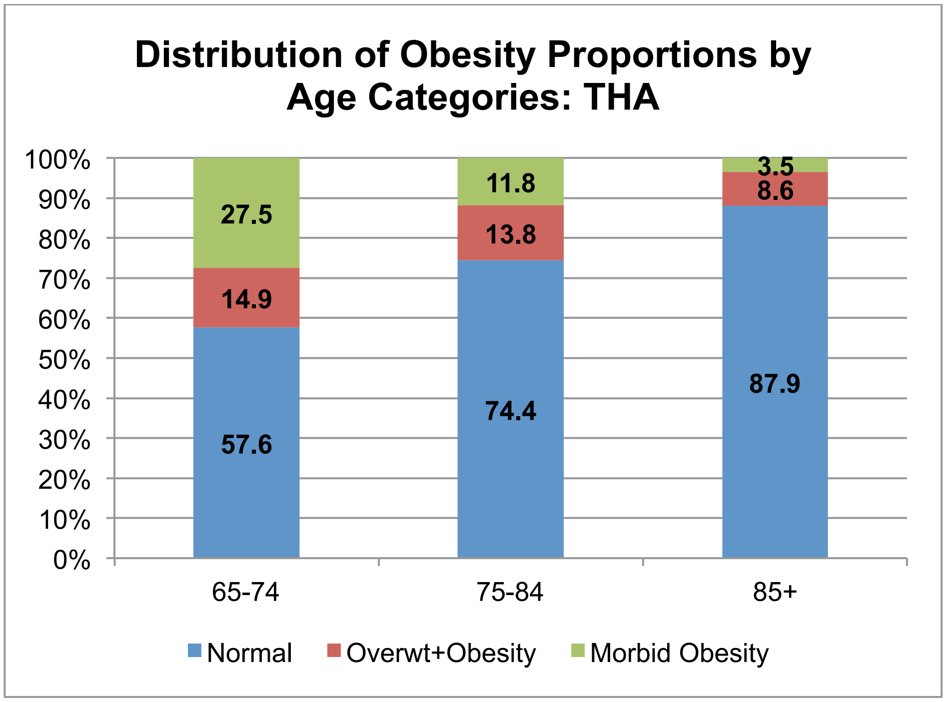
Overall obesity prevalence

Among the overall THA cohort, the prevalence of obesity was: 71.1% in the normal weight, 13.1% in the overweight-and-obesity, and 15.8% in the morbid obesity category.

Prevalence of obesity by age categories

Morbid obesity and overweight-obesity were the most prevalent among beneficiaries of age 65-74 years (27.5% and 14.9% respectively) and the least prevalent among those of age 85 years-and-older (3.5% and 8.6% respectively). Conversely, beneficiaries in the 85 years-and-older age group had the greatest proportion of individuals in the normal weight category and those in the 65-74 years' age group had the lowest (88% and 57.7% respectively) (Figure 10).

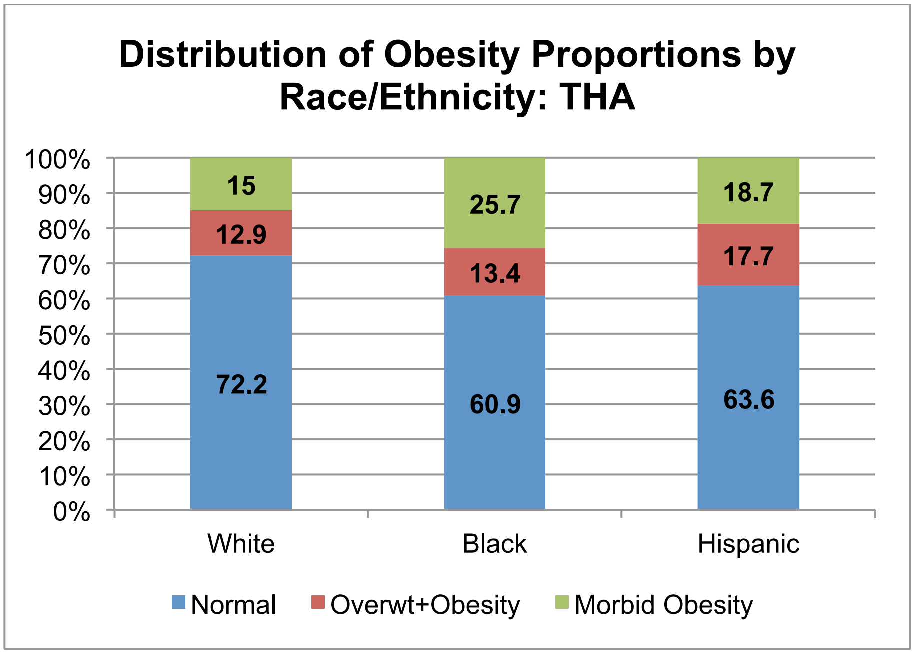
Figure 10: Prevalence of obesity status categories among the three age groups in the THA cohort



Prevalence of obesity by race/ethnicity

Non-Hispanic Black beneficiaries had the highest proportion of individuals with morbid obesity (25.7%) and Non-Hispanic White had the lowest (14.9%). Conversely, the proportion of individuals in the normal weight category was the highest among Non-Hispanic White beneficiaries (72.2%) and the lowest among Non-Hispanic Black (60.9%). Overweight-obesity was most prevalent among Hispanic beneficiaries and least among Non-Hispanic White (17.7% and 12.9% respectively) (Figure 11).

Figure 11: Prevalence of obesity status categories among the three race/ethnicity group groups in the THA cohort



Functional Status of the THA cohort

Beneficiaries in the normal weight category had the highest composite score in the self-care and transfers subcomponents at admission to IRF (22 and 8.2, respectively) and the lowest composite score in the same subcomponents at the time of discharge from IRF (34.1 and 15.3, respectively), as compared to those in the other two obesity status categories. The composite scores for admission transfers and locomotion subcomponents (8.1 and 3.0, respectively) were lower for beneficiaries in the overweight-and-obesity category compared to those in the normal weight category (8.2 and 3.2, respectively). However, the composite scores for the discharge transfer and locomotion subcomponents (15.5 and 9.0, respectively) were the highest for the beneficiaries in the overweight-and-obesity category compared to those in the normal weight and morbid obesity categories. Beneficiaries with morbid obesity had the highest composite scores for communication and social cognition, as compared to those in the normal weight and overweight-obesity categories, - both at admission and discharge (Table 14).

Table 14: Admission and discharge scores for FIM sub-components for Medicare beneficiaries for 2012 and 2013, who underwent inpatient rehabilitation for primary THA

Subgroups of FIM components	Overall	Normal weight	Overweight-Obesity	Morbid Obesity	p-value
Adm Self-care	21.9 (4.5)	22.0 (4.4)	21.8 (4.6)	21.4 (4.5)	<.001
DC Self-care	34.2 (4.5)	34.1 (4.5)	34.5 (4.1)	34.5 (4.4)	0.002
Adm Sphincter Control	8.5(3.2)	8.5 (3.1)	8.4 (3.1)	8.4 (3.2)	0.166
DC Sphincter Control	11.4 (2.2)	11.4 (2.2)	11.4 (2.1)	11.3 (2.2)	0.607
Adm Transfers	8.1 (2.7)	8.2 (2.7)	8.1 (2.7)	7.6 (2.7)	<.001
DC Transfers	15.4 (2.9)	15.3 (2.9)	15.5 (2.8)	15.4 (2.9)	0.112
Adm Locomotion	3.1 (1.5)	3.2 (1.5)	3.0 (1.4)	2.9 (1.3)	<.001
DC Locomotion	8.9 (2.8)	8.9 (2.8)	9.0 (2.8)	8.5 (3.0)	<.001
Adm Communication	11.3 (2.1)	11.3 (2.2)	11.4 (2.1)	11.5 (2.0)	0.013
DC Communication	12.8 (1.4)	12.8 (1.4)	12.9 (1.3)	13.0 (1.2)	<.001
Adm Social Cognition	16.0 (3.4)	15.9 (3.5)	16.0 (3.3)	16.4 (3.2)	<.001
DC Social Cognition	18.7 (2.5)	18.5 (2.6)	18.9 (2.4)	19.1 (2.1)	<.001

Foot notes: 1). Values represent: Mean (standard deviation). 2). FIM scores are recorded at admission (Adm) to IRF, during IRF stay and at discharge (DC). 3). Subcomponents are based on the guidelines in IRF-PAI manual. Each subcomponent score is sum of scores of individual items within that subcomponent.

Socio-demographic characteristics of the TKA cohort

There was a total of 22705 beneficiaries in the TKA cohort. Beneficiaries in the morbid obesity category were the youngest (mean age 72.2 years), and had the highest proportion of: women, individuals of Non-Hispanic Black race/ethnicity.

Beneficiaries in the morbid obesity category had the longest hospital and IRF LOS, social support, Medicare-Medicaid dual eligibility, and disability status when compared to beneficiaries in the normal weight category. Beneficiaries with morbid obesity also had the lowest admission motor FIM score, and the highest admission and discharge cognition FIM scores; compared to those in the normal weight category (Table 15).

Table 15: Socio-demographic characteristics of TKA cohort

	Total	**Normal weight**	**Overweight and Obesity**	**Morbid Obesity**	**p value**
Sample Size (n)	22,705 (100%)	13,824 (60.9%)	3,341 (14.7%)	5,540 (24.4%)	
Age	76.2 (6.8)	78.1 (6.8%)	75.3 (6.2)	72.2 (5.3)	<.001
Age Category 65-74 years 75-84 years 85 years and above	9,924 (43.7%) 9,450 (41.6%) 3,331 (14.7%)	4,516 (32.7%) 6,411 (46.4%) 2,897 (20.9%)	1,591 (47.6%) 1,447 (43.3%) 303 (9.1%)	3,817 (68.9%) 1,592 (28.7%) 131 (2.4%)	<.001
Gender Men Women	6,583 (29%) 16,122 (71%)	4,316 (31.2%) 9,508 (68.8%)	974 (29.1%) 2,367 (70.9%)	1,293 (23.3%) 4,247 (76.7%)	<.001
Race/ethnicity White Black Hispanic	19,355 (85.3%) 1,894 (8.3%) 1,456 (6.4%)	12,104 (87.6%) 900 (6.5%) 820 (5.9%)	2,755 (82.5%) 298 (8.9%) 288 (8.6%)	4,496 (81.2%) 696 (12.6%) 348 (6.3%)	<.001
*** Living with someone**	16,289 (71.7%)	9,774 (70.7%)	2,449 (73.3%)	4,066 (73.4%)	<.001
*** Married**	10,977 (48.4%)	6,575 (47.6%)	1,664 (49.8%)	2,738 (49.4%)	0.072
*** Social Support**	17,185 (75.7%)	1,0352 (75%)	2,563 (76.8%)	4,270 (77.3%)	0.016
Medicare- Medicaid Dual Eligibility	2,756 (12.1%)	1,452 (10.5%)	479 (14.3%)	825 (14.9%)	<.001
Disability	2,772 (12.2%)	1,343 (9.7%)	464 (13.9%)	965 (17.4%)	<.001
Hospital length of stay (days)	3.3 (1.6)	3.3 (1.5)	3.3 (1.6)	3.4 (1.7)	0.018
IRF length of stay (days)	9.4 (3.3)	9.4 (3.3)	9.4 (3.2)	9.6 (3.3)	<.001
IRF Type In-Hospital Unit Free standing	11,490 (50.6%) 11,215 (49.4%)	7,343 (53.1%) 6,482 (46.9%)	1,492 (44.7%) 1,849 (55.3%)	2,656 (47.9%) 2,884 (52.1%)	<.001
Admission Motor FIM	42.8 (9.3)	43.3 (9.2)	42.7 (9.1)	41.7 (9.3)	<.001
Discharge Motor FIM	71.6 (9.4)	71.5 (9.5)	72.2 (8.9)	71.4 (9.4)	<.001

	Total	Normal weight	Overweight and Obesity	Morbid Obesity	p value
Admission Cognition FIM	27.5 (5.3)	27.4 (5.4)	27.5 (5.2)	27.9 (5.0)	<.001
Discharge Cognition FIM	31.7 (3.6)	31.5 (3.8)	31.9 (3.5)	32.2 (3.2)	<.001
Community discharge	21,128 (93.1%)	12,799 (92.6%)	3,157 (94.5%)	5,172 (93.4%)	0.003

Foot-notes: 1). Values represent: Number (Percent) / Mean (Standard Deviation). 2). *Living with Someone has 1738 (7.7%) missing values, *Married has 382 (1.7%) missing values, and *Social Support has 42 (0.2%) missing values.

Comorbidities among the TKA cohort

Beneficiaries with morbid obesity had the highest EC sum, and the highest proportion of individuals with a Tier comorbidity 3 status, a hospital acquired condition, congestive heart failure, chronic pulmonary disease, renal failure, depression, hypertension, diabetes with and without chronic complications; compared to beneficiaries in the normal weight category. Beneficiaries with morbid obesity had the lowest proportion of individuals with a Tier 0 comorbidity status, valvular disease, paralysis, other neurological disorders, rheumatoid arthritis, fluid and electrolyte disorders, and deficiency anemias, coagulopathy, and arrhythmia; compared to those in the normal weight category (Table 16).

Table 16: Comorbidities among TKA cohort:

	Total	Normal weight	Overweight and Obesity	Morbid Obesity	*p* value
Tier Comorbidity	7,494 (33%)	2,628 (19.0%)	800 (23.9%)	4,066 (73.4%)	<.001
Tier Case Mix Group					<.001
Tier 0	15,211 (67%)	11,196 (81.0%)	2,541 (76.1%)	1,474 (26.6%)	
Tier 1	107 (0.5%)	62 (0.5%)	22 (0.7%)	23 (0.4%)	
Tier 2	472 (2.1%)	303 (2.2%)	74 (2.2%)	95 (1.7%)	
Tier 3	6,915 (30.5%)	2,263 (16.4%)	704 (21.1%)	3948 (71.3%)	
Hospital Acquired Conditions (HAC)	1,089 (4.8%)	629 (4.6%)	160 (4.8%)	300 (5.4%)	0.091
HAC: sum	0.1 (0.2)	0.1 (0.2)	0.1 (0.2)	0.1 (0.2)	0.0614
Elixhauser comorbidities (EC): sum	3.1 (1.5)	3.0 (1.5)	3.1 (1.5)	3.3 (1.6)	<.001
EC: Congestive heart failure	1,478 (6.5%)	782 (5.7%)	208 (6.2%)	488 (8.8%)	<.001
EC: Valvular disease	1,077 (4.7%)	747 (5.4%)	148 (4.4%)	182 (3.3%)	<.001
EC: Pulmonary circulation disease	409 (1.8%)	237 (1.7%)	52 (1.6%)	120 (2.2%)	0.126
EC: Peripheral vascular disease	983 (4.3%)	615 (4.5%)	144 (4.3%)	224 (4.0%)	0.6
EC: Paralysis	415 (1.8%)	274 (2.0%)	71 (2.1%)	70 (1.3%)	0.013
EC: Other neurological disorders	1,867 (8.2%)	1,263 (9.1%)	262 (7.8%)	342 (6.2%)	<.001
EC: Chronic pulmonary disease	4,107 (18.1%)	2,223 (16.1%)	614 (18.4%)	1,270 (22.9%)	<.001
EC: Hypothyroidism	5,588 (24.6%)	3,436 (24.9%)	772 (23.1%)	1,380 (24.9%)	0.114
EC: Renal failure	2,351 (10.4%)	1,265 (9.2%)	329 (9.9%)	757 (13.7%)	<.001
EC: Liver disease	133 (0.6%)	68 (0.5%)	23 (0.7%)	42 (0.8%)	0.0632
EC: Peptic ulcer Disease x bleeding	3 (0.0%)	1 (0.0%)	2 (0.1%)	0	0.067
EC: Acquired immune deficiency syndrome	4 (0.0%)	3 (0.0%)	0	1 (0.0%)	0.9
EC: Lymphoma	89 (0.4%)	64 (0.5%)	12 (0.4%)	13 (0.2%)	0.8
EC: Metastatic cancer	25 (0.1%)	16 (0.1%)	6 (0.2%)	3 (0.1%)	0.240
EC: Solid tumor w/out metastasis	156 (0.7%)	101 (0.7%)	24 (0.7%)	31 (0.6%)	0.6
EC: Rheumatoid arthritis/collagen vas	1339 (5.9%)	883 (6.4%)	179 (5.4%)	277 (5%)	0.004
EC: Coagulopthy	1,007 (4.4%)	660 (4.8%)	127 (3.8%)	220 (4.0%)	0.077
EC: Weight loss	1,062 (4.7%)	564 (4.1%)	240 (7.2%)	258 (4.7%)	<.001
EC: Fluid and electrolyte disorders	3,728 (16.4%)	2,406 (17.4%)	509 (15.2%)	813 (14.7%)	<.001
EC: Chronic blood loss anemia	507 (2.2%)	322 (2.3%)	60 (1.8%)	125 (2.3%)	0.216
EC: Deficiency Anemias	8,589 (37.8%)	5,404 (39.1%)	1,246 (37.3%)	1,939 (35.0%)	<.0010
EC: Psychoses	628 (2.8%)	365 (2.6%)	99 (3.0%)	164 (3.0%)	0.5
EC: Depression	4,039 (17.8%)	2,322 (16.8%)	599 (17.9%)	118 (20.2%)	<.001
EC: Hypertension	18,777 (82.7%)	11,255 (81.4%)	2,761 (82.6%)	4,761 (85.9%)	<.001
EC: Arrhythmias	4,056 (17.8%)	2,573 (18.6%)	564 (16.9%)	919 (16.6%)	0.011
EC: Diabetes w/o chronic complications	5,494 (24.2%)	2,694 (19.5%)	870 (26.0%)	1,930 (34.8%)	<.001
EC: Diabetes w/ chronic complications	1,541 (6.8%)	649 (4.7%)	293 (8.8%)	599 (10.8%)	<.001

Foot notes: 1). Values represent: Number (Percent). 2). The EC namely Obesity is not taken into consideration. 3). The Tier 3 comorbidity namely Morbid Obesity is not taken into consideration. 4). The number for both ECs: drug abuse and alcohol abuse was 0.

Obesity prevalence among the TKA cohort

Overall obesity prevalence

Among the overall TKA cohort 60.9% were in the normal weight, 14.7% were in the overweight-and-obesity, and 24.4% were in the morbid obesity category.

Prevalence of obesity by age categories

Morbid obesity and overweight-obesity were the most prevalent among beneficiaries of age 65-74 years (38.5% and 16% respectively) and the least prevalent among those of age 85 years-and-older (3.9% and 9.1% respectively). Conversely, beneficiaries in the 85 years-and-older age group had the greatest proportion of individuals in the normal weight category and those in the 65-74 years' age group had the lowest (87% and 45.5% respectively) (Figure 12 on next page).

Prevalence of obesity by race/ethnicity

Non-Hispanic Black beneficiaries had the highest proportion of individuals with morbid obesity (36.8%) and Non-Hispanic White had the lowest (23.2%). Conversely, the proportion of individuals in the normal weight category was the highest among Non-Hispanic White beneficiaries (62.5%) and the lowest among Non-Hispanic Black (47.5%). Overweight-obesity was most prevalent among Hispanic beneficiaries and least among Non-Hispanic White (19.8% and 14.2% respectively) (Figure 13).

Figure 12: Prevalence of the three obesity status categories among the three age groups in the TKA cohort:

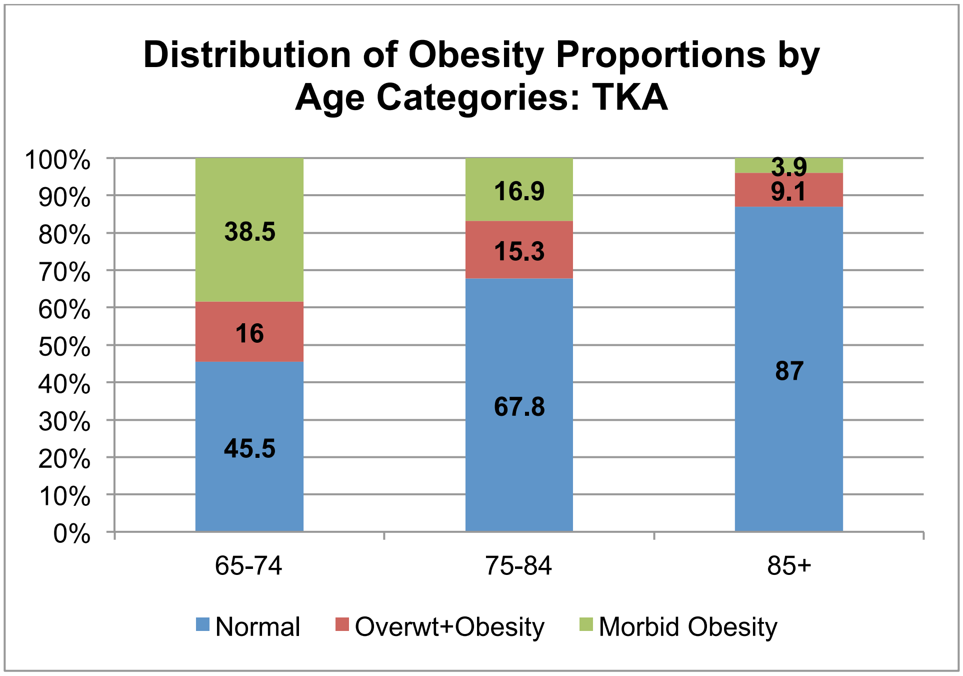
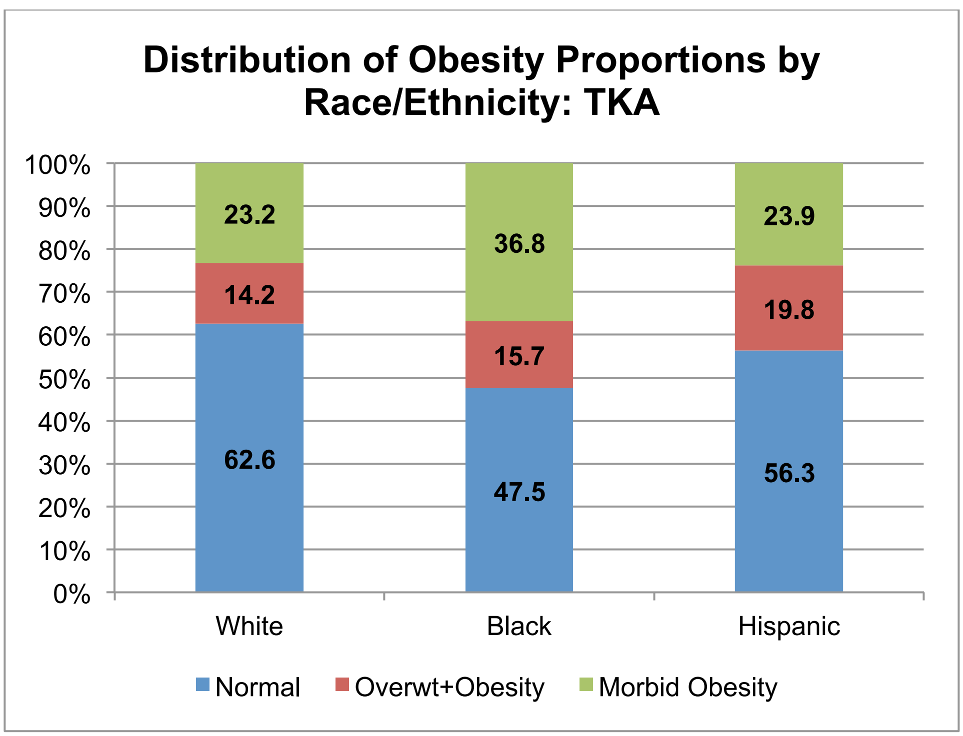


Figure 13: Prevalence of the three obesity status categories among the three race/ethnicity groups in the TKA cohort



Functional status of the TKA cohort

Beneficiaries in the normal weight category had the highest composite scores in the self-care, sphincter control, transfers and locomotion subcomponents at admission to IRF. Beneficiaries in the overweight-and-obesity category had the highest composite scores in the self-care, sphincter control, transfers and locomotion subcomponents at the time of discharge from IRF. Beneficiaries with morbid obesity had the highest composite scores for communication and social cognition, as compared to those in the normal weight and overweight-obesity categories, - both at admission and discharge (Table 17).

Table 17: Admission and discharge scores for FIM sub-components for TKA cohort

Subgroups of FIM components	Overall	Normal weight	Overweight-Obesity	Morbid Obesity	*p*-value
Adm Selfcare	22.7 (4.7)	22.9 (4.7)	22.6 (4.7)	22.2 (4.7)	<.001
DC Selfcare	35.0 (4.3)	34.9 (4.3)	35.2 (4.1)	35.1 (4.2)	0.002
Adm Sphincter Control	8.6 (3.1)	8.7 (3.1)	8.6 (3.1)	8.5 (3.2)	0.084
DC Sphincter Control	11.5 (2.1)	11.5 (2.1)	11.6 (2.0)	11.5 (2.1)	0.093
Adm Transfers	8.4 (2.8)	8.6 (2.8)	8.4 (2.8)	8.1 (2.9)	<.001
DC Transfers	15.8 (2.7)	15.8 (2.7)	16.0 (2.5)	15.8 (2.8)	<.001
Adm Locomotion	3.0 (1.5)	3.1 (1.5)	3.0 (1.5)	2.9 (1.4)	<.001
DC Locomotion	9.2 (2.7)	9.3 (2.7)	9.4 (2.6)	9.0 (2.8)	<.001
Adm Communication	11.4 (2.1)	11.3 (2.2)	11.4 (2.1)	11.5 (2.0)	<.001
DC Communication	12.9 (1.4)	12.8 (1.4)	12.9 (1.3)	13.0 (1.2)	<.001
Adm Social Cognition	16.2 (3.4)	16.0 (3.5)	16.2 (3.3)	16.4 (3.2)	<.001
DC Social Cognition	18.8 (2.4)	18.7 (2.5)	18.9 (2.3)	19.1 (2.2)	<.001

Foot notes: 1). Values represent: Mean (standard deviation). 2). FIM scores are recorded at admission (Adm) to IRF, during IRF stay and at discharge (DC). 3). Subcomponents are based on the guidelines in IRF-PAI manual. Each subcomponent score is sum of scores of individual items within that subcomponent.

RESULTS OF REGRESSION ANALYSES

Results for rehabilitation outcomes namely discharge motor FIM (DC M-FIM) (Table 18), discharge cognition FIM (DC C-FIM) (Table 19), IRF Length of Stay (LOS) (Table 20), and community discharge after IRF stay (Table 21) are described below.

Table 18: Linear Regression Models for DC M-FIM among THA and TKA cohorts

Independent Variable, Covariates, and Interaction Variables	**THA**			**TKA**		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Intercept	65 (1.2)*	65.1 (1.2)*	65 (1.2)*	64.8 (0.9)*	64.6 (0.9)*	64.7 (0.9)*
Obesity Status						
Normal weight	Reference	Reference	Reference	Reference	Reference	Reference
Overweight-Obesity	0.3 (0.2)	0.2 (0.3)	0.2 (0.4)	0.4 (0.2)^^	0.5 (0.2)^	0.3 (0.3)
Morbid Obesity	0.2 (0.3)	0.1 (0.3)	0.1 (0.4)	-0.1 (0.2)	0.0 (0.2)	0.1 (0.3)
Age	-0.2 (0.0)*	-0.2 (0.0)*	-0.2 (0.0)*	-0.2 (0.0)*	-0.2 (0.0)*	-0.2 (0.0)*
Gender						
Male	Reference	Reference	Reference	Reference	Reference	Reference
Female	0.2 (0.2)	0.2 (0.2)	0.1 (0.2)	1.1 (0.1)*	1.1 (0.1)*	1.1 (0.2)*
Race/ethnicity						
Non-Hispanic White	Reference	Reference	Reference	Reference	Reference	Reference
Non-Hispanic Black	-1.3 (0.3)*	-1.3 (0.4)^	-1.3 (0.3)**	-1.1 (0.2)*	-1.2 (0.3)*	-1.1 (0.2)*
Hispanic	0.1 (0.5)	-0.5 (0.6)	0.1 (0.5)	-0.3 (0.2)	0.3 (0.3)	-0.3 (0.2)
Medicare-Medicaid Dual Eligibility	-1.6 (0.3)*	-1.7 (0.3)*	-1.6 (0.3)*	-1.5 (0.2)*	-1.5 (0.2)*	-1.5 (0.2)*
Disability Status	-0.9 (0.3)**	-1.0 (0.3)**	-0.9 (0.3)**	-1.0 (0.2)*	-1.0 (0.2)*	-1.0 (0.2)*
Inpatient Rehabilitation Facility (IRF) Length of Stay	0.1 (0.0)*	0.1 (0.0)*	0.1 (0.0)*	0.2 (0.0)*	0.2 (0.0)*	0.2 (0.0)*
Type of IRF						
In-Hospital Unit	Reference	Reference	Reference	Reference	Reference	Reference
Freestanding	3.0 (0.2)*	3.0 (0.2)*	3.0 (0.2)*	2.9 (0.1)*	2.9 (0.1)*	2.9 (0.1)*
Admission Motor FIM	0.5 (0.0)*	0.5 (0.0)*	0.5 (0.0)*	0.4 (0.0)*	0.4 (0.0)*	0.4 (0.0)*
Tier Comorbidity	-1.0 (0.2)*	-1.0 (0.2)*	-1.0 (0.2)*	-0.7 (0.2)*	-0.7 (0.2)*	-0.7 (0.2)*
Hospital Acquired Conditions (HAC)	-2.2 (0.4)*	-2.2 (0.4)*	-2.2 (0.4)*	-1.9 (0.3)*	-1.9 (0.3)*	-1.9 (0.3)*
Congestive heart failure	-1.2 (0.3)**	-1.2 (0.3)**	-1.2 (0.3)**	-0.6 (0.2)^	-0.6 (0.2)^	-0.6 (0.2)^
Paralysis	-3.8 (0.7)*	-3.8 (0.7)*	-3.8 (0.7)*	-5.0 (0.4)*	-5.0 (0.4)*	-5.0 (0.4)*
Other neurological disorders	-2.1 (0.3)*	-2.1 (0.3)*	-2.1 (0.3)*	-1.7 (0.2)*	-1.7 (0.2)*	-1.7 (0.2)*
Hypothyroidism	0.5 (0.2)^	0.5 (0.2)^^	0.5 (0.2)^	0.4 (0.1)^	0.4 (0.1)^	0.4 (0.1)^
Renal failure	-1.4 (0.3)*	-1.4 (0.3)*	-1.4 (0.3)*	-0.5 (0.2)^	-0.5 (0.2)^	-0.5 (0.2)^
Rheumatoid arthritis	-0.9 (0.3)^	-0.9 (0.3)^	-0.9 (0.3)^	-	-	-
Fluid and electrolyte disorders	-0.9 (0.2)*	-0.9 (0.2)*	-0.9 (0.2)*	-0.7 (0.2)*	-0.7 (0.2)*	-0.7 (0.2)*
Psychoses	-2.2 (0.5)*	-2.2 (0.5)*	-2.2 (0.5)*	-2.5 (0.3)*	-2.5 (0.3)*	-2.5 (0.3)*
Depression	-0.7 (0.2)**	-0.7 (0.2)**	-0.7 (0.2)**	-0.6 (0.1)*	-0.6 (0.1)*	-0.6 (0.1)*
Arrhythmia	-0.9 (0.2)*	-0.9 (0.2)*	-0.9 (0.2)*	-0.4 (0.2)^	-0.4 (0.2)^	-0.4 (0.2)^

Independent Variable, Covariates, and Interaction Variables	THA			TKA		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Arrhythmia	-0.9 (0.2)*	-0.9 (0.2)*	-0.9 (0.2)*	-0.4 (0.2)^	-0.4 (0.2)^	-0.4 (0.2)^
Peripheral Vascular Dis.	-	-	-	-1.0 (0.3)**	-1.0 (0.3)**	-1.0 (0.3)**
Coagulopathy	-	-	-	-0.5 (0.3)^^	-0.5 (0.3)^^	-0.5 (0.3)^^
Diabetes w/o chronic complications	-	-	-	-0.5 (0.1)*	-0.5 (0.1)*	-0.5 (0.1)*
Interaction of Obesity and Race-Ethnicity (Model 2)						
Black and 'Overweight-Obesity'	-	0.7 (1.0)	-	-	0.0 (0.6)	-
Black and Morbid Obesity		-0.1 (0.8)			0.1 (0.4)	
Hispanic and 'Overweight-Obesity'		0.5 (1.2)			-1.2 (0.6)^^	
Hispanic and Morbid Obesity		2.7 (1.2)^^			-1.5 (0.5)^	
Interaction of Obesity and Gender (Model 3)						
Female and 'Overweight-Obesity'	-	-	0.1 (0.5)	-	-	0.2 (0.3)
Female and Morbid Obesity			0.1 (0.5)			-0.2 (0.3)
Variance (R-square)	0.3*	0.3*	0.3*	0.2*	0.2*	0.2*

Foot-notes: 1). Values represent: regression coefficient (Standard Error). 2). * = p<.0001, ** = p<.001, ^=p<.01 ^^=p<..05. 3). Values without any * or ^ have p>.05. 4). Reference category for categorical variables namely Tier comorbidity and HAC is 'No (condition absent)'. 5). Table displays only the statistically significant EC.

Discharge Motor Functional Independence Measure (DC M-FIM) among THA cohort

In *model 1*, each unit (year) increase in age was associated with a decrease of 0.2 in the DC M-FIM. Non-Hispanic Black Medicare beneficiaries scored 1.3 less than their Non-Hispanic White counterparts. Those with Medicare-Medicaid dual eligibility scored 1.6 less than those without, and those with disability scored 0.9 less than those without. Each unit (day) increase in IRF LOS was associated with an increase of 0.1 in DC M-FIM score. One unit of increase in the admission motor FIM score was associated with an increase of 0.5 in DC M-FIM score. DC M-FIM for beneficiaries receiving rehabilitation at a freestanding IRF was greater by 3.0 than those receiving rehabilitation at an in-hospital rehabilitation unit. The presence of a HAC, and that of a Tier comorbidity, was respectively associated with a decrease of 2.2 and 1.0, in the DC M-FIM score. The beneficiaries with the EC namely, paralysis, other neurological disorders, psychoses, depression, renal failure, congestive heart failure, fluid and electrolyte disorders, rheumatoid arthritis, and arrhythmia, had significantly lower DC M-FIM score compared to those without these EC. Hypothyroidism was the only EC that was associated with a significant increase in DC M-FIM score. The effects of all of the above comorbidities remained consistent in the models testing the interactions of obesity with race/ethnicity and gender (*models 2* and *3* respectively) (Table 18).

In *model 2*, a significant interaction effect was found between morbid obesity and Hispanic race/ethnicity ($p<.05$) for the outcome of DC M-FIM among the THA cohort. No significant interaction effect was found between obesity status and gender (Model 3) (Table 18).

DC M-FIM among TKA cohort

In *model 1* beneficiaries with overweight and obesity scored 0.4 more than those with normal weight. For each unit (year) increase in age DC M-FIM decreased by 0.2. Women scored 1.1 more than men. Non-Hispanic Black Medicare beneficiaries scored 1.1 less than their Non-Hispanic White counterparts. Those with Medicare-Medicaid dual eligibility scored 1.5 less than those without, and those with disability scored 1.0 less than those without. Each unit (day) increase in IRF LOS resulted in an increase of 0.2 units, and that in admission motor FIM resulted in 0.4 increase, respectively, in DC M-FIM score. DC M-FIM for beneficiaries receiving rehabilitation at a freestanding IRF was greater by 2.9 than those receiving rehabilitation at an in-hospital rehabilitation unit. The presence of a HAC, and that of a Tier comorbidity resulted in, 1.9 and 0.7 decrease in the DC M-FIM score, respectively. The beneficiaries with the EC namely paralysis, other neurological disorders, psychoses, depression, renal failure, congestive heart failure, fluid and electrolyte disorders, arrhythmia, peripheral vascular disease, coagulopathy, and diabetes without chronic complications, had significantly lower DC M-FIM score compared to those without these EC. Hypothyroidism was the only EC that was associated with a significant increase in DC M-FIM score (Table 18).

Significant interaction effect (Model 2) was found between Hispanic race/ethnicity and overweight/obesity, and between Hispanic race/ethnicity and morbid obesity ($p<.05$ and $p<.01$, respectively) for the outcome of DC M-FIM among the TKA cohort. No significant interaction effect was observed (Model 3) between gender and obesity status (Table 18).

Discharge Cognition Functional Independence Measure (DC C-FIM) among THA cohort

In *model 1,* the DC C-FIM score was greater by 0.6 among beneficiaries with morbid obesity, and by 0.3 among those with overweight and obesity, as compared to those in the normal weight category. For each unit (year) increase in age DC C-FIM decreased by 0.1. Women scored 0.3 greater than men. Hispanic beneficiaries scored 0.4 greater than their Non-Hispanic White counterparts. Beneficiaries with Medicare-Medicaid dual eligibility scored 0.8 less and those with disability scored 0.4 less, than those without the respective status. Beneficiaries receiving rehabilitation in a free-standing IRF scored 0.2 more than those receiving rehabilitation at an in-hospital unit. Each unit (day) increase in the length of IRF stay was associated with a decrease in DC C-FIM score by 0.0. Each unit increase in admission cognition FIM was associated with 0.1 increase in DC C-FIM. The presence of a HAC was associated with a decrease in DC C-FIM score by 0.8, and that of a Tier comorbidity with a decrease by 0.3. The effect of Non-Hispanic Black race/ethnicity as compared to Non-Hispanic White, was non-significant. Beneficiaries with congestive heart failure, other neurological disorders, weight loss, psychoses, and depression had significantly lower DC C-FIM score across all the three models, compared to those without these conditions. In *model 3*, paralysis, renal failure, fluid and electrolyte disorders, and chronic blood loss anemia, were also associated with significantly lower DC C-FIM scores (Table 19).

In *model 2*, the interaction effect of Hispanic race/ethnicity with overweight and obesity among the THA cohort for the outcome of DC C-FIM was significant ($p<.05$). In *model 3*, The interaction of gender and obesity status was non-significant (Table 19).

DC C-FIM among TKA cohort

In *model 1*, DC C-FIM score was greater by 0.2 and 0.1 respectively among beneficiaries with morbid obesity and over-weight-obesity, as compared to those in the normal weight category. For each unit (year) increase in age DC C-FIM decreased by 0.5. Women scored 0.3 greater than men. Hispanic beneficiaries scored 0.4 greater than their Non-Hispanic White counterparts. Beneficiaries with Medicare-Medicaid dual eligibility and those with disability scored 0.5 and 0.2 less respectively, than those without the respective status. Beneficiaries receiving rehabilitation in a free-standing IRF scored 0.7 more than those receiving rehabilitation at an in-hospital unit. Each unit (day) increase in the length of IRF stay resulted in decrease in DC C-FIM score by 0.0. Each unit increase in admission cognition FIM was associated with increase in DC C-FIM by 0.4. The presence of a HAC and a Tier comorbidity resulted in decrease in DC C-FIM score by 0.3 and 0.1 respectively. The effect of Non-Hispanic Black race/ethnicity as compared to Non-Hispanic White, was non-significant. The beneficiaries with the EC namely paralysis, other neurological disorders, psychoses, depression, renal failure, arrhythmia, and diabetes without complications, had significantly lower DC M-FIM score compared to those without these EC, across all three models. Beneficiaries with chronic pulmonary disease and hypothyroidism scored significantly higher than those without these EC (Table 19).

Table 19: Linear Regression Models for DC C-FIM

Independent Variable, Covariates, and Interaction Variables	THA			TKA		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Intercept	35.5 (0.5)*	26.2 (0.4)*	26.2 (0.4)*	25.4 (0.3)*	25.4 (0.3)*	25.4 (0.3)*
Obesity Status						
Normal weight	Reference	Reference	Reference	Reference	Reference	Reference
Overweight-Obesity	0.3 (0.1)**	0.2 (0.1)^^	0.3 (0.1)	0.1 (0.1)^^	0.2 (0.1)^	0.2 (0.1)^^
Morbid Obesity	0.6 (0.1)*	0.4 (0.1)**	0.5 (0.1)^	0.2 (0.1)**	0.2 (0.1)*	0.3 (0.1)^
Age	-0.1 (0.0)*	-0.1 (0.0)*	-0.1 (0.0)*	-0.5 (0.0)*	-0.1 (0.0)*	-0.1 (0.0)*
Gender						
Male	Reference	Reference	Reference	Reference	Reference	Reference
Female	0.3 (0.1)*	0.1 (0.1)	0.2 (0.1)^^	0.3 (0.0)*	0.3 (0.0)*	0.3 (0.1)*
Race/ethnicity						
Non-Hispanic White	Reference	Reference	Reference	Reference	Reference	Reference
Non-Hispanic Black	0.1 (0.1)	0.0 (0.1)	-0.1 (0.1)	-0.1 (0.1)	-0.1 (0.1)	-0.1 (0.1)
Hispanic	0.4 (0.2)^^	0.2 (0.2)	0.5 (0.2)^	0.4 (0.1)*	0.6 (0.1)*	0.4 (0.1)*
Medicare-Medicaid Dual Eligibility	-0.7 (0.1)*	-0.5 (0.1)*	--0.5 (0.1)*	-0.5 (0.1)*	-0.5 (0.1)*	-0.5 (0.1)*
Disability Status	-0.5 (0.1)*	-0.4 (0.1)*	-0.4 (0.1)*	-0.2 (0.1)^	-0.2 (0.1)*	-0.2 (0.1)^
Inpatient Rehabilitation Facility (IRF) Length of Stay	-0.0(0.0)^^	-0.0 (0.0)^	-0.0 (0.0)^	-0.0 (0.0)*	-0.0 (0.0)*	-0.0 (0.0)*
Type of IRF						
In-Hospital Unit	Reference	Reference	Reference	Reference	Reference	Reference
Freestanding	0.2 (0.1)^	0.6 (0.1)*	0.6 (0.1)*	0.7 (0.0)*	0.7 (0.0)*	0.7 (0.0)*
Admission Cognition FIM	0.1 (0.0)*	0.4 (0.0)*	0.4 (0.0)*	0.4 (0.0)*	0.4 (0.0)*	0.4 (0.0)*
Tier Comorbidity	-0.3 (0.1)^	-0.2 (0.1)^^	-0.2 (0.1)^^	-0.1 (0.1)^^	-0.1 (0.1)^^	-0.1 (0.1)^^
Hospital Acquired Conditions (HAC)	-0.8 (0.2)*	-0.8 (0.1)*	-0.8 (0.1)*	-0.3 (0.1)**	-0.3 (0.1)**	-0.3 (0.1)**
Congestive heart failure	-0.4 (0.1)^	-0.4 (0.1)^	-0.4 (0.1)^	-	-	-
Paralysis	-0.6 (0.3)^^	-	-	-1.0 (0.1)*	-1.0 (0.1)*	-1.0 (0.1)*
Other neurological disorders	-1.6 (0.1)*	-0.9 (0.1)*	-0.9 (0.1)*	-0.8 (0.1)*	-0.8 (0.1)*	-0.8 (0.1)*
Chronic Pulmonary Disease	-	-	-	0.1 (0.1)^^	0.1 (0.1)^^	0.1 (0.1)^^
Hypothyroidism	-	-	-	0.1 (0.1)^^	0.1 (0.1)^^	0.1 (0.1)^^
Renal failure	-0.3 (0.1)^^	-	-	-0.2 (0.1)^^	-0.2 (0.1)^^	-0.2 (0.1)^^
Weight Loss	-0.4 (0.1)^	-0.4 (0.1)^	-0.4 (0.1)^	-0.2 (0.1)^^	-0.2 (0.1)^^	-0.2 (0.1)^^
Fluid and electrolyte disorders	-0.3 (0.1)^	-	-	-0.1 (0.1)^^	-	-0.1 (0.1)^^
Chronic Blood Loss Anemia	-0.4 (0.2)^^	-	-	-	-	-
Deficiency Anemias	-	-0.1 (0.1)^^	-0.1 (0.1)^^	-	-	-
Psychoses	-1.9 (0.2)*	-0.9 (0.2)*	--0.9 (0.2)*	-0.8 (0.1)*	-0.9 (0.1)*	-0.9 (0.1)*
Depression	-0.7 (0.1)*	-0.4 (0.1)*	-0.4 (0.1)*	-0.4 (0.1)*	-0.4 (0.1)*	-0.4 (0.1)*
Arrhythmia	-	-	-	-0.2 (0.1)**	-0.2 (0.1)**	-0.2 (0.1)**
Diabetes w/o chronic complications	-	--0.2 (0.1)^^	-	-0.1 (0.1)^^	-0.1 (0.1)^^	-0.1 (0.1)^^
Diabetes w/ chronic complications	-	-	-	-	0.2 (0.1)	-
Interaction of Obesity and Race-Ethnicity (Model 2)	-		-	-		-
Black and 'Overweight-Obesity'		-0.0 (0.3)			0.1 (0.2)	
Black and Morbid Obesity		-0.2 (0.3)			-0.1 (0.2)	
Hispanic and 'Overweight-Obesity'		0.1 (0.4)^^			-0.6 (0.2)^	
Hispanic and Morbid Obesity		0.5 (0.4)			-0.2 (0.2)	

Independent Variable, Covariates, and Interaction Variables	THA			TKA		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Interaction of Obesity and Gender (Model 3)						
Female and 'Overweight-Obesity'	-	-	-0.1 (0.2)	-	-	-0.1 (0.1)
Female and Morbid Obesity			-0.2 (0.2)			-0.1 (0.1)
Variance (R-square)	0.2*	0.4*	0.4*	0.4*	0.4*	0.4*

Foot-notes: 1). Values represent: regression coefficient (Standard Error). 2). * = p<.0001, ** = p<.001, ^p<.01 ^^p<.05. 3). Values without any * or ^ have p>.05. 4). Reference category for categorical variables namely Tier comorbidity and HAC is 'No (condition absent)'. 5). Table displays only the statistically significant EC.

In *model 2*, the interaction effect of Hispanic race/ethnicity with overweight and obesity among the TKA cohort for the outcome of DC C-FIM was significant (p<.01). The effect of fluid electrolyte disorders was not significant; whereas diabetes with chronic complications was marginally significantly associated with 0.2 greater DC C-FIM score than those without the condition (p=0. 0.058) (Table 19).

The interaction of gender and obesity status, in *model 3*, was non-significant (Table 19).

Inpatient Rehabilitation Facility Length of Stay (IRF LOS) among THA cohort

In *model 1,* the beneficiaries with overweight and obesity had a longer IRF LOS by 0.2 than their counterparts with normal weight. Each year increase in age was associated with a 0.1 longer IRF LOS. Women had a longer IRF LOS than men by 0.5. Non-Hispanic Black beneficiaries had a longer IRF LOS by 0.6 compared to their Non-Hispanic White counterparts. Beneficiaries with disability had a longer IRF LOS by 0.3 as compared to those without disability. Each unit (day) increase in hospital LOS was associated with a longer IRF LOS by 0.1. Beneficiaries receiving rehabilitation at a free-standing IRF had a shorter IRF LOS than those receiving rehabilitation at an in-hospital unit by 0.3. Each unit increase in admission motor FIM score was associated with a shorter IRF LOS by 0.2. Beneficiaries with a Tier comorbidity had a longer IRF LOS than those without by 0.6. Beneficiaries with paralysis, other neurological disorders, chronic pulmonary disease, liver disease, weight loss, fluid and electrolyte disorders, deficiency anemias, depression, arrhythmias and diabetes without chronic complications had significantly longer IRF LOS across all the three models, compared to those without these EC. Beneficiaries with paralysis and liver disease had the highest increase in IRF LOS of more than a day (1.4 and 1.2 respectively) as compared to those without these EC. In *models 2 and 3*, the interaction effects of obesity with race/ethnicity and gender respectively were not significant (Table 20).

Table 20: Linear Regression Models for IRF length of stay

Independent Variable, Covariates, and Interaction Variables	**THA**			**TKA**		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Intercept	9.7 (0.4)*	9.8 (0.4)*	9.8 (0.4)*	11.2 (0.3)*	11.1 (0.3)*	11.2 (0.3)*
Obesity Status						
Normal weight	Reference	Reference	Reference	Reference	Reference	Reference
Overweight-Obesity	0.2 (0.1)^^	0.2 (0.1)^^	0.2 (0.2)	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)
Morbid Obesity	0.2 (0.1)	0.1 (0.1)	0.1 (0.2)	-0.1 (0.1)	-0.1 (0.1)	-0.2 (0.1)
Age	0.1 (0.0)*	0.1 (0.0)*	0.1 (0.0)*	0.1 (0.0)*	0.1 (0.0)*	0.1 (0.0)*
Gender						
Male	Reference	Reference	Reference	Reference	Reference	Reference
Female	0.5 (0.1)*	0.5 (0.1)*	0.5 (0.1)*	0.2 (0.0)*	0.2 (0.0)**	0.1 (0.1)^^
Race/ethnicity						
Non-Hispanic White	Reference	Reference	Reference	Reference	Reference	Reference
Non-Hispanic Black	0.6 (0.1)*	0.6 (0.1)*	0.6 (0.1)*	0.7 (0.1)*	0.8 (0.1)*	0.7 (0.1)*
Hispanic	0.3 (0.2)	0.2 (0.2)	0.3 (0.2)	0.3 (0.1)^	0.2 (0.1)^^	0.3 (0.1)^
Medicare-Medicaid Dual Eligibility	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)	0.3 (0.1)*	0.3 (0.1)*	0.3 (0.1)*
Disability Status	0.3 (0.1)**	0.3 (0.1)**	0.3 (0.1)**	0.3 (0.1)*	0.3 (0.1)*	0.3 (0.1)*
Inpatient Rehabilitation Facility (IRF) Length of Stay	0.1 (0.0)**	0.1 (0.0)**	0.1 (0.0)**	0.0 (0.0)^	0.0 (0.0)^	0.0 (0.0)^
Type of IRF						
In-Hospital Unit	Reference	Reference	Reference	Reference	Reference	Reference
Freestanding	-0.3 (0.1)*	-0.3 (0.1)*	-0.3 (0.1)*	-0.5 (0.0)*	-0.5 (0.0)*	-0.5 (0.0)*
Admission Motor FIM	-0.2 (0.0)*	-0.2 (0.0)*	-0.2 (0.0)*	-0.2 (0.0)*	-0.2 (0.0)*	-0.2 (0.0)*
Tier Comorbidity	0.6 (0.1)*	0.6 (0.1)*	0.6 (0.1)*	0.6 (0.1)*	0.6 (0.1)*	0.6 (0.1)*
Hospital Acquired Conditions (HAC)	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)
Paralysis	1.4 (0.2)*	1.4 (0.2)*	1.4 (0.2)*	1.1 (0.1)*	1.1 (0.1)*	1.1 (0.1)*
Other neurological disorders	0.5 (0.1)*	0.5 (0.1)*	0.5 (0.1)*	0.4 (0.1)*	0.4 (0.1)*	0.4 (0.1)*
Chronic Pulmonary Disease	0.2 (0.1)^^	0.2 (0.1)^^	0.2 (0.1)^^	0.1 (0.1)^^	0.1 (0.1)^^	0.1 (0.1)^^
Renal Failure	-	-	-	0.3 (0.1)*	0.3 (0.1)*	0.3 (0.1)*
Liver Disease	1.3 (0.4)**	1.3 (0.4)**	1.3 (0.4)**	-	-	-
Weight Loss	0.3 (0.1)^^	0.3 (0.1)^^	0.3 (0.1)^^	0.4 (0.1)*	0.4 (0.1)*	0.4 (0.1)*
Fluid and electrolyte disorders	0.3 (0.1)*	0.3 (0.1)*	0.3 (0.1)*	0.2 (0.1)^	0.2 (0.1)^	0.2 (0.1)^
Chronic Blood Loss Anemia	-	-	-	0.3 (0.1)^^	0.3 (0.1)^^	0.3 (0.1)^^

Independent Variable, Covariates, and Interaction Variables	THA			TKA		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Deficiency Anemias	0.1 (0.1)^^	0.1 (0.1)^^	0.1 (0.1)^^	-	-	-
Psychoses	-	-	-	0.5 (0.1)*	0.5 (0.1)*	0.5 (0.1)*
Depression	0.3 (0.1)^	0.2 (0.1)^	0.2 (0.1)^	0.2 (0.1)*	0.2 (0.1)*	0.2 (0.1)*
Arrhythmia	0.2 (0.1)^^	0.2 (0.1)^^	0.2 (0.1)^^	-	-	-
Diabetes w/o chronic complications	0.2 (0.1)^	0.2 (0.1)^	0.2 (0.1)^	-	-	-
Interaction of Obesity and Race-Ethnicity (Model 2)	-		-	-		-
Black and 'Overweight-Obesity'		-0.3 (0.3)			-0.1 (0.2)	
Black and Morbid Obesity		0.2 (0.3)			-0.3 (0.2)^^	
Hispanic and 'Overweight-Obesity'		-0.0 (0.4)			0.1 (0.2)	
Hispanic and Morbid Obesity		0.3 (0.4)			0.0 (0.2)	
Interaction of Obesity and Gender (Model 3)	-	-		-	-	
Female and 'Overweight-Obesity'			0.0 (0.2)			0.0 (0.1)
Female and Morbid Obesity			0.1 (0.2)			0.1 (0.1)
Variance (R-square)	0.3*	0.3*	0.3*	0.3*	0.3*	0.3*

Foot-notes: 1). Values represent: regression coefficient (Standard Error). 2). * = p<.0001, ** = p<.001, ^p<.01 ^^p<.05. 3). Values without any * or ^ have p>.05. 4). Reference category for categorical variables namely Tier comorbidity and HAC is 'No (condition absent)'. 5). Table displays only the statistically significant EC.

IRF LOS among TKA cohort

In *model 1,* each year increase in age was associated with a 0.06 longer IRF LOS. Women had a longer IRF LOS than men by 0.2. Non-Hispanic Black beneficiaries had 0.7, and Hispanic beneficiaries had 0.3, longer IRF LOS as compared to their Non-Hispanic White counterparts. Beneficiaries with Medicare-Medicaid dual eligibility and those with disability had a longer IRF LOS by 0.3 as compared to those without the respective status. Each unit (day) increase in hospital LOS was associated with a longer IRF LOS by 0.0. Beneficiaries receiving rehabilitation at a free-standing IRF had a shorter IRF LOS than those receiving rehabilitation at an in-hospital unit by 0.5. Each unit increase in admission motor FIM score was associated with a shorter IRF LOS by 0.2 (Table 20).

Beneficiaries with a Tier comorbidity had a longer IRF LOS than those without by 0.6. Beneficiaries with paralysis, other neurological disorders, chronic pulmonary disease, renal failure, weight loss, fluid and electrolyte disorders, chronic blood loss anemia, psychoses, and depression, had significantly longer IRF LOS across all the three models, compared to those without these EC. Beneficiaries with paralysis had the highest increase in IRF LOS of more than a day (1.1) as compared to those without (Table 20).

In *model 2 (testing the interaction of obesity and race/ethnicity)*, the interaction of Non-Hispanic Black race/ethnicity with morbid obesity was significant for the outcome of IRF LOS ($p<.05$) (Table 20). The interaction effects of obesity with gender in *model 3* was not significant (Table 20).

Community Discharge among THA cohort

In *model 1*, the odds of community discharge were 1% lower with each year of increase in age. Women had 37% greater odds of being discharged to the community as compared to men. Beneficiaries with social support had nearly 15 times higher odds of being discharged to the community as compared to those without. Beneficiaries with a Tier comorbidity had 22% lower odds of community discharge compared to those without. Each unit increase in DC M-FIM score increased the odds of community discharge by 17%. Beneficiaries with deficiency anemia and arrhythmia had 18% and 23% lower odds of discharge to community respectively compared to those without these ECs. The interaction effects between obesity and race/ethnicity (*model 2*) and obesity and gender (*model 3*) on the likelihood of community discharge were not significant (Table 21).

Table 21: Logistic Regression Models for Community Discharge

Independent Variable, Covariates, and Interaction Variables	THA			TKA		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Obesity Status Normal weight Overweight-Obesity Morbid Obesity	Reference 0.8 (0.6-1.1) 1.0 (0.7-1.2)	Reference 0.8 (0.6-1.1) 1.0 (0.7-1.3)	Reference 0.9 (0.5-1.4) 1.2 (0.8-2.0)	Reference 1.1 (0.9-1.4) 1.1 (0.9-1.4)	Reference 1.1 (0.9-1.4) 1.0 (0.9-1.3)	Reference 1.0 (0.7-1.4) 1.3 (0.9-1.9)
Age	1.0 (1.0-1.0)	1.0 (1.0-1.0)	1.0 (1.0-1.0)	1.0 (1.0-1.0)	1.0 (1.0-1.0)	1.0 (1.0-1.0)
Gender Male Female	Reference 1.4 (1.1-1.7)	Reference 1.4 (1.1-1.7)	Reference 1.5 (1.2-1.8)	Reference 1.2 (1.0-1.4)	Reference 1.2 (1.0-1.4)	Reference 1.2 (1.0-1.5)
Race/ethnicity Non-Hispanic White Non-Hispanic Black Hispanic	Reference 1.1 (0.8-1.6) 1.0 (0.6-1.7)	Reference 1.2 (0.7-1.8) 0.9 (0.5-1.7)	Reference 1.2 (0.8-1.6) 1.0 (0.6-1.7)	Reference 1.3 (1.0-1.7) 1.4 (1.0-1.9)	Reference 1.1 (0.8-1.6) 1.3 (0.9-2.0)	Reference 1.3 (1.0-1.7) 1.4 (1.0-1.9)
Medicare-Medicaid Dual Eligibility	1.3 (1.0-1.7)	1.3 (1.0-1.7)	1.3 (1.0-1.7)	1.1 (0.9-1.4)	1.1 (0.9-1.4)	1.1 (0.9-1.4)
Disability Status	1.1 (0.8-1.5)	1.1 (0.8-1.5)	1.1 (0.8-1.5)	0.9 (0.7-1.1)	0.9 (0.7-1.1)	0.9 (0.7-1.1)
Social Support	**14.6 (12.0-17.6)**	**14.6 (12.1-17.6)**	**14.6 (12.0-17.6)**	**12.2 (10.5-14.2)**	**12.2 (10.5-14.2)**	**12.2 (10.5-14.2)**
Inpatient Rehabilitation Facility (IRF) Length of Stay	1.0 (1.0-1.0)	1.0 (1.0-1.0)	1.0 (1.0-1.0)	1.0 (1.0-1.0)	1.0 (1.0-1.0)	1.0 (1.0-1.0)
Type of IRF In-Hospital Unit Freestanding	Reference 1.1 (1.0-1.3)	Reference 1.1 (1.0-1.3)	Reference 1.1 (1.0-1.3)	Reference 1.0 (0.9-1.2)	Reference 1.0 (0.9-1.2)	Reference 1.0 (0.9-1.2)
Discharge Motor FIM	1.2 (1.2-1.2)	1.2 (1.2-1.2)	1.2 (1.2-1.2)	1.2 (1.2-1.2)	1.2 (1.2-1.2)	1.2 (1.2-1.2)
Tier Comorbidity	0.8 (0.6-1.0)	0.8 (0.6-1.0)	0.8 (0.6-1.0)	0.9 (0.7-1.0)	0.9 (0.7-1.0)	0.9 (0.7-1.0)
Hospital Acquired Conditions (HAC)	1.1 (0.8-1.6)	1.1 (0.8-1.6)	1.1 (0.8-1.6)	1.1 (0.8-1.5)	1.1 (0.8-1.5)	1.1 (0.8-1.5)
EC: Valvular Disease	1.5 (1.1-2.2)	1.5 (1.1-2.2)	1.5 (1.1-2.2)	-	-	-
EC: Pulmonary Circulation Disease	-	-	-	0.6 (0.4-0.9)	0.6 (0.4-0.9)	0.6 (0.4-0.9)
EC: Liver Disease	-	-	-	-	-	-
EC: Coagulopathy	1.6 (1.0-2.4)	1.6 (1.0-2.4)	1.6 (1.0-2.4)	-	-	-
EC: Deficiency Anemia	0.8 (0.7-1.0)	0.8 (0.7-1.0)	0.8 (0.7-1.0)	-	-	-
EC: Arrhythmia	0.8 (0.6-1.0)	0.8 (0.6-1.0)	0.8 (0.6-1.0)	0.8 (0.7-0.9)	0.8 (0.7-0.9)	0.8 (0.7-0.9)
EC: Diabetes without chronic complications	-	-	-	0.8 (0.7-1.0)	0.8 (0.7-1.0)	0.8 (0.7-1.0)
Interaction of Obesity and Race-Ethnicity (Model 2) Black and 'Overweight- Obesity' Black and Morbid Obesity Hispanic and 'Overweight-Obesity' Hispanic and Morbid Obesity	-	1.0 (0.4-2.8) 0.9 (0.4-2.1) 2.1 (0.5-8.6) 0.7 (0.2-2.6)	-	-	1.1 (0.5-2.3) 1.6 (0.9-2.7) 0.9 (0.4-2.0) 1.2 (0.6-2.6)	-
Interaction of Obesity and Gender (Model 3) Female and 'Overweight-Obesity' Female and Morbid Obesity	-	-	1.0 (0.6-1.7) 0.7 (0.4-1.2)	-	-	1.2 (0.8-1.9) 0.8 (0.6-1.2)

Foot-notes: 1). Values represent: Odds Ratio (95% Confidence Interval [CI]) 2). Reference category for categorical variables namely Tier comorbidity and HAC is 'No (condition absent).

Community Discharge among TKA cohort

In *model 1*, the odds of community discharge were 1% lower with each year of increase in age. Women had 19% greater odds of being discharged to the community as compared to men. Non- Hispanic Black beneficiaries had 29% higher odds of being discharged to the community as compared to their Non-Hispanic White counterparts. Beneficiaries with social support had more than 12 times higher odds of being discharged to the community as compared to those without. Each unit increase in DC M-FIM score increased the odds of community discharge by 17%. Beneficiaries with pulmonary circulation disease, arrhythmia, and diabetes without complications had 44%, 21%, and 19% lower odds of community discharge respectively, as compared to those without these ECs. (Table 21). No significant interaction effects between obesity and race/ethnicity (*model 2*), and obesity and gender (*model 3*) were found (Table 21).

RESULTS OF STRATIFIED ANALYSES

For all the significant interactions between obesity and race/ethnicity, the following stratified analyses was conducted to compare and contrast the three obesity status categories within each of the three race/ethnicity categories. These analyses were conducted separately for the THA and TKA cohorts. For these secondary analyses comorbidities were excluded from the covariates. The results of these analyses are described in the following tables and figures.

Stratification of each of THA and TKA cohort based on race/ethnicity

Table 22: Sizes of sub-cohorts based on race/ethnicity among THA and TKA cohorts

Race/Eth. / Cohort	Non-Hispanic White	Non-Hispanic Black	Hispanic	Total
THA	10,392	778	385	11,555
TKA	19,355	1,894	1,456	22,705
Total	29,747	2,672	1,841	34,260

Summary of stratified analyses for DC M-FIM within each of Non-Hispanic White, Non-Hispanic Black, and Hispanic race/ethnicities among THA cohort

Within each of the Non-Hispanic White, Non-Hispanic Black race/ethnicity sub-cohorts, obesity status was not significantly associated with any change in DC M-FIM score in reference to the normal weight category. Within the Hispanic sub-cohort, however, morbid obesity was significantly associated with higher DC M-FIM score. (Table 23 and Figure 14).

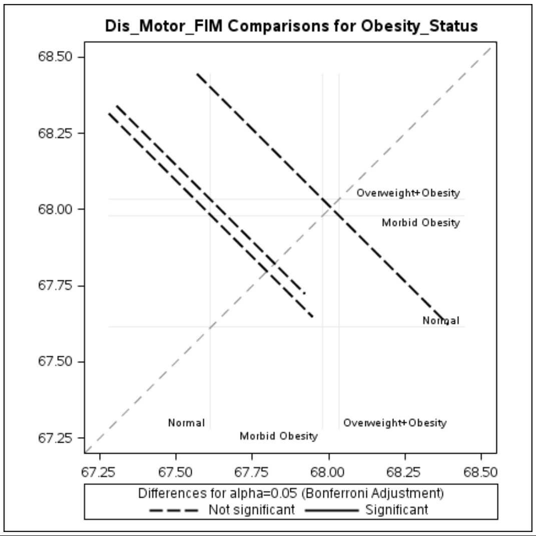
Table 23: Linear Regression for DC M-FIM within each race/ethnicities among THA cohort

	Non-Hispanic White (n=10,392)	**Non-Hispanic Black** (n=778)	**Hispanic** (n=385)
Intercept	69.2 (1.2)*	68.4 (5.0)*	66.7 (6.5)*
Age	-0.2 (0.0)*	-0.3 (0.1)*	-0.2 (0.1)^^
Gender Male Female	Reference 0.5 (0.2)^	Reference 0.3 (0.8)	Reference -1.8 (1.1)
Obesity_Status Normal Overweight+Obesity Morbid Obesity	Reference 0.4 (0.3) 0.4 (0.3)	Reference 1.0 (1.0) 0.2 (0.9)	Reference 1.4 (1.3) 3.2 (1.4)^^
Medicare-Medicaid Dual Eligibility	-2.3 (0.4)*	-1.5 (0.8)	-2.7 (1.0)^
Disability	-1.7 (0.3)*	-0.9 (0.9)	-0.5 (1.5)
TierCM	-1.5 (0.2)*	-1.1 (0.8)	-1.8 (1.2)
Adm_Motor_FIM	0.4 (0.0)*	0.5 (0.0)*	0.4 (0.1)*
IrfLOS	0.1 (0.0)^	0.1 (0.1)	0.3 (0.2)

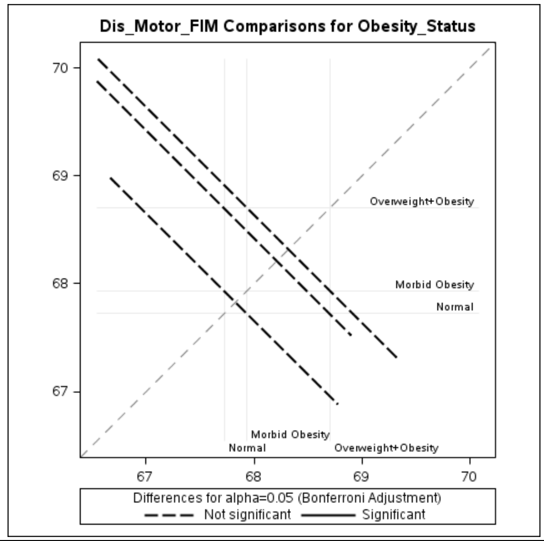
Values represent parameter estimate and standard error. * = $p<.0001$, ^ = $p<.01$, ^^ = $p<.05$. Values without * or ^ are not statistically significant. Variance (R-square) = 0.2 ($p<.0001$) (Whites); 0.2 ($p<.0001$) (Blacks); 0.2 ($p<.0001$) (Hispanics).

Figure 14: Association between obesity and DC M-FIM scores within each race/ethnicity among THA cohort

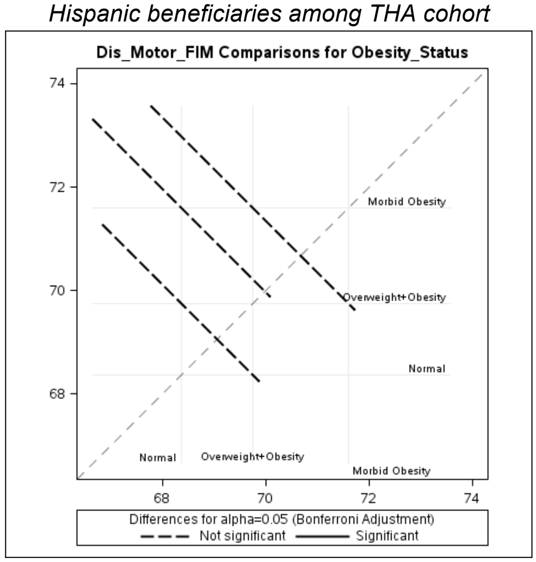
Non-Hispanic White beneficiaries among THA cohort



Non-Hispanic Black beneficiaries among THA cohort



Hispanic beneficiaries among THA cohort



Summary of stratified analyses for DC M-FIM within each race/ethnicity among TKA cohort

Within the Non-Hispanic White sub-cohort, DC M-FIM score of beneficiaries with overweight-obesity was significantly higher compared to that of those in the normal weight category. Within the Non-Hispanic Black race/ethnicity sub-cohort, obesity status was not significantly associated with any change in DC M-FIM score. Within the Hispanic sub-cohort, morbid obesity was associated with lower DC M-FIM score. (Table 24 and Figure 15).

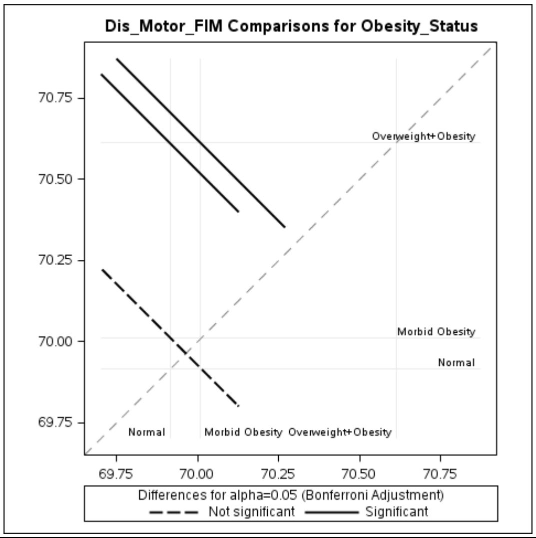
Table 24: Linear Regression for DC M-FIM within each race/ethnicities among TKA cohort

	Non-Hispanic White (n=19355)	**Non-Hispanic Black** (n=1894)	**Hispanic** (n=1456)
Intercept	67.8 (0.9)*	73.3 (3.1)*	72.2 (3.5)*
Age	-0.2 (0.0)*	-0.3 (0.0)*	-0.3 (0.0)*
Gender			
Male	Reference	Reference	Reference
Female	1.3 (0.1)*	2.6 (0.5)*	0.6 (0.5)
Obesity_Status			
Normal	Reference	Reference	Reference
Overweight+Obesity	0.7 (0.2)*	0.6 (0.6)	-0.3 (0.6)
Morbid Obesity	0.1 (0.2)	-0.0 (0.5)	-1.3 (0.6)^^
Medicare-Medicaid Dual Eligibility	-1.7 (0.2)*	-2.2 (0.4)*	-2.1 (0.5)*
Disability	-1.5 (0.2)*	-1.8 (0.5)**	-0.6 (0.6)
TierCM	-0.7 (0.2)*	-0.9 (0.5)	-1.2 (0.5)^^
Adm_Motor_FIM	0.4 (0.0)*	0.4 (0.0)*	0.4 (0.0)*
IrfLOS	0.1 (0.0)*	-0.1 (0.1)	0.2 (0.1)^^

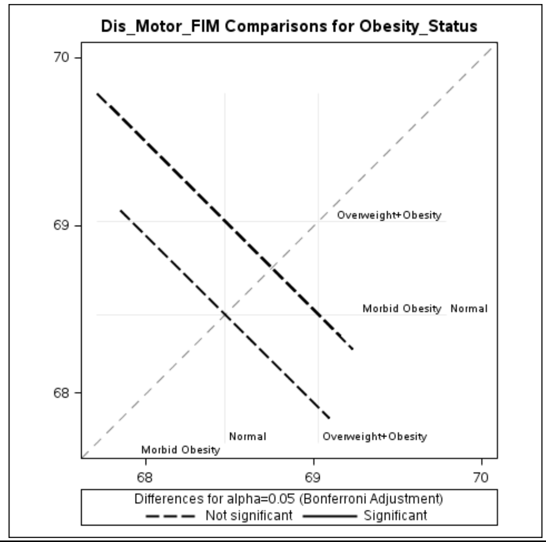
Values represent parameter estimate (regression coefficient) and standard error. * = p<.0001, ^ = p<.01, ^^ = p<.05. Values without * or ^ are not statistically significant. Variance (R-square) = 0.2 (p<.0001) (Whites); 0.2 (p<.0001) (Blacks); 0.2 (p<.0001) (Hispanics).

Figure 15: Association between obesity and DC M-FIM scores within each race/ethnicity among TKA cohort

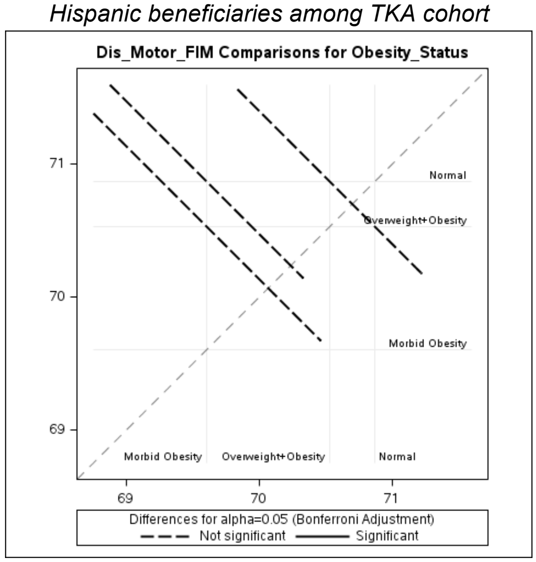
Non-Hispanic White beneficiaries among TKA cohort



Non-Hispanic Black beneficiaries among TKA cohort



Hispanic beneficiaries among TKA cohort



Summary of stratified analyses for DC C-FIM within each race/ethnicity among THA cohort

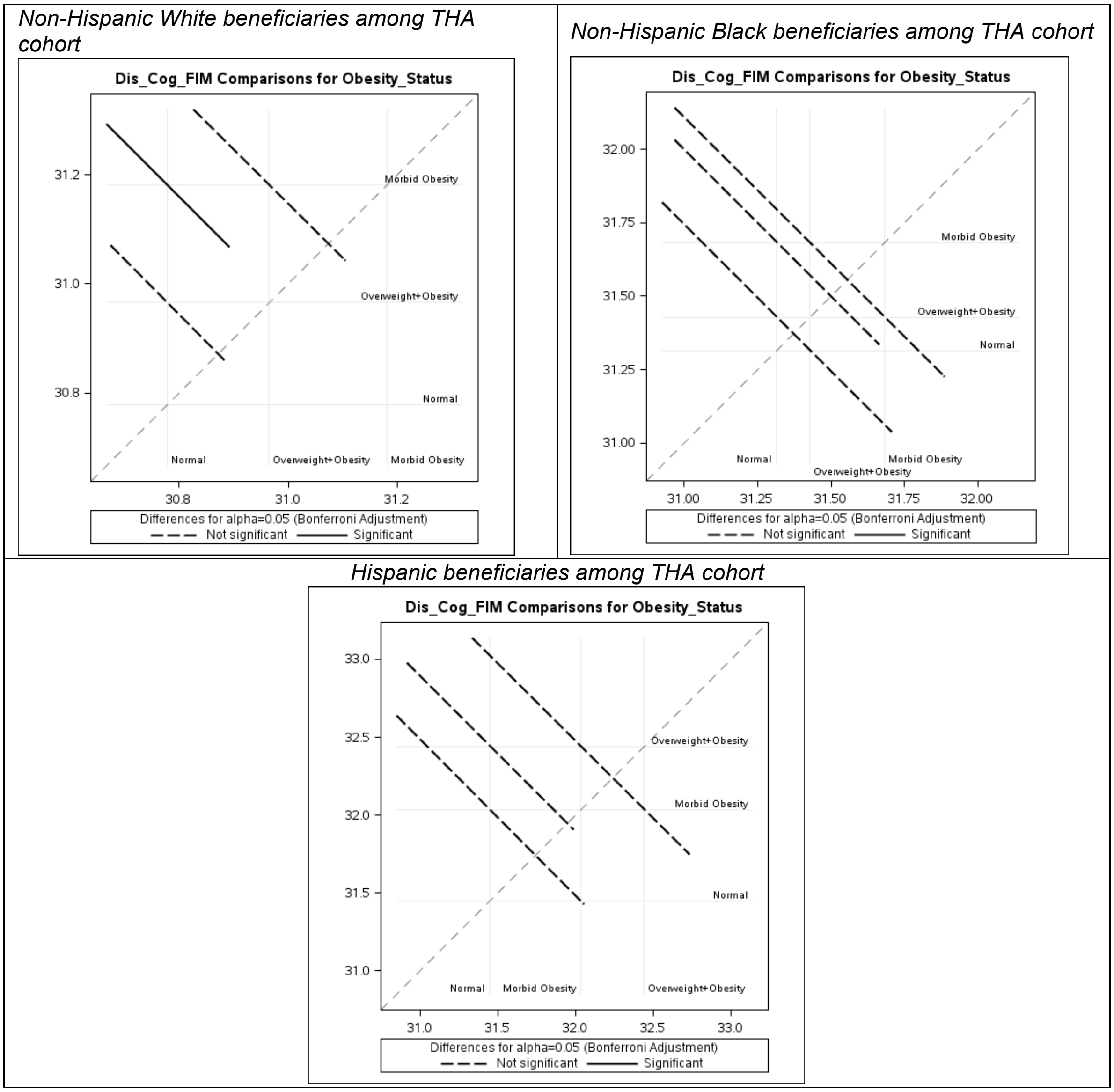
Within each of the Non-Hispanic Black and Hispanic race/ethnicity sub-cohorts, obesity status was not significantly associated with any change in DC C-FIM score in reference to the normal weight category. Within the Non-Hispanic White sub-cohort, morbid obesity was highly significantly associated with higher DC C-FIM score. Overweight-obesity was also associated with higher DC C-FIM score (Table 25 and Figure 16).

Table 25: Linear Regression for DC C-FIM within each race/ethnicities among THA cohort

	Non-Hispanic White (n=10,392)	**Non-Hispanic Black** (n=778)	**Hispanic** (n=385)
Intercept	26.9 (0.4)*	23.6 (1.6)*	25.4 (2.4)*
Age	-0.1 (0.0)*	-0.0 (0.0)^^	-0.3 (0.3)
Gender			
Male	Reference	Reference	Reference
Female	0.2 (0.1)^^	0.2 (0.3)	-0.3 (0.4)
Obesity_Status			
Normal	Reference	Reference	Reference
Overweight+Obesity	0.2 (0.1)^^	0.1 (0.3)	1.0 (0.4)
Morbid Obesity	0.4 (0.1)*	0.4 (0.3)	0.6 (0.5)
Medicare-Medicaid Dual Eligibility	-0.7 (0.1)*	-0.8 (0.3)^	0.2 (0.4)
Disability	-0.6 (0.1)*	-0.2 (0.3)	-0.3 (0.5)
TierCM	-0.3 (0.1)**	-0.4 (0.3)	0.4 (0.4)
Adm_Motor_FIM	0.4(0.0)*	0.4 (0.0)*	0.3 (0.0)*
IrfLOS	-0.0 (0.0)*	-0.0 (0.0)	-0.1 (0.1)

Values represent parameter estimate (regression coefficient) and standard error. * = $p<.0001$, **= $p<.001$, ^ = $p<.01$, ^^ = $p<.05$. Values without * or ^ are not statistically significant. Variance (R-square) = 0.4 ($p<.0001$) (Whites); == 0.4 ($p<.0001$) (Blacks); = 0.3 ($p<.0001$) (Hispanics).

Figure 16: Association between obesity and DC C-FIM scores within each race/ethnicity among THA cohort



Summary of stratified analyses for DC C-FIM within each race/ethnicity among TKA cohort

Within the Non-Hispanic White sub-cohort, DC C-FIM score of beneficiaries with overweight-obesity and those with morbid obesity were significantly higher compared to the DC C-FIM score of beneficiaries in the normal weight category. Within each of the Non-Hispanic Black and Hispanic race/ethnicity sub-cohorts, obesity status was not significantly associated with any change in DC C-FIM score (in reference to DC C-FIM score for the normal weight category) (Table 26 and Figure 17).

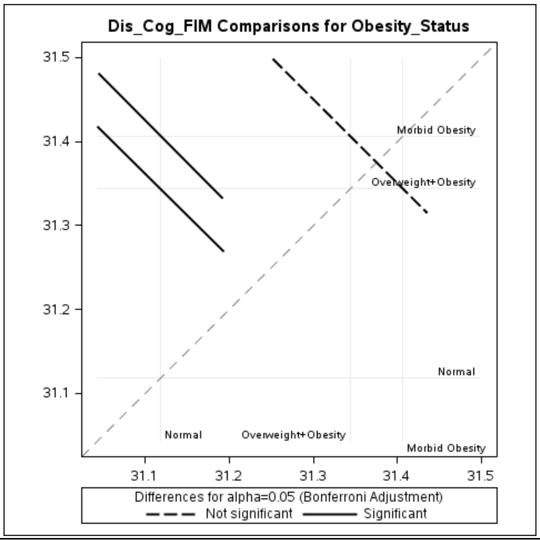
Table 26: Linear regression for DC C-FIM within each race/ethnicities among TKA cohort

	Non-Hispanic White (n=19355)	**Non-Hispanic Black** (n=1894)	**Hispanic** (n=1456)
Intercept	25.7 (0.3)*	26.8 (1.0)*	29.9 (1.2)*
Age	-0.1 (0.0)*	-0.1 (0.0)*	-0.1 (0.0)*
Gender			
Male	Reference	Reference	Reference
Female	0.4 (0.1)*	0.3 (0.2)	0.2 (0.2)
Obesity_Status			
Normal	Reference	Reference	Reference
Overweight+Obesity	0.2 (0.1)**	0.1 (0.2)	0.0 (0.2)
Morbid Obesity	0.3 (0.1)*	0.3 (0.2)	-0.3 (0.2)
Medicare-Medicaid Dual Eligibility	-0.7 (0.1)*	-0.6 (0.2)**	-0.2 (0.2)
Disability	-0.3 (0.1)**	-0.4 (0.2)^	-0.4 (0.2)
TierCM	-0.1 (0.1)	-0.1 (0.2)	-0.1 (0.2)
Adm_Motor_FIM	0.4 (0.0)*	0.4 (0.0)*	0.3 (0.0)*
IrfLOS	-0.1 (0.0)*	-0.1 (0.0)^	-0.0 (0.0)

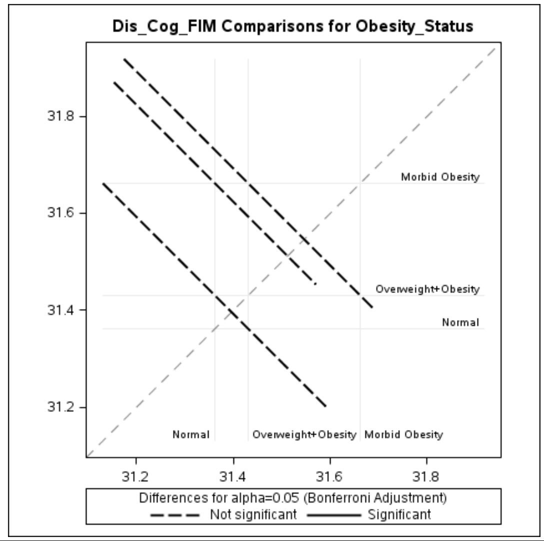
Values represent parameter estimate (regression coefficient) and standard error. * = p<.0001, **=p<.001,^ = p<.01, ^^ = p<.05. Values without * or ^ are not statistically significant. Variance (R-square) = 0.3 (p<.0001) (Whites); = 0.4 (p<.0001) (Blacks); = 0.3 (p<.0001) (Hispanics).

Figure 17: Association between obesity and DC C-FIM scores within each race/ethnicity among TKA cohort

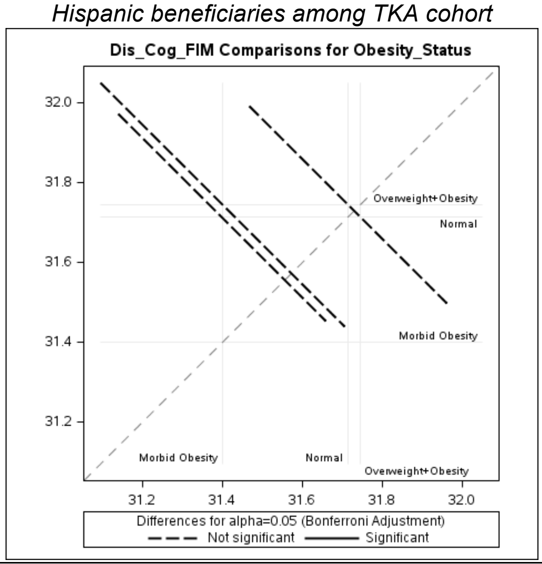
Non-Hispanic White beneficiaries among TKA cohort



Non-Hispanic Black beneficiaries among TKA cohort



Hispanic beneficiaries among TKA cohort



Summary of stratified analyses for IRF LOS within each race/ethnicity among TKA cohort

Within each of the Non-Hispanic White and Hispanic race/ethnicity sub-cohorts, obesity status was not significantly associated with any change in IRF LOS in reference to the normal weight category. Within the Non-Hispanic Black sub-cohort, morbid obesity was associated with shorter IRF LOS (Table 27 and Figure 18).

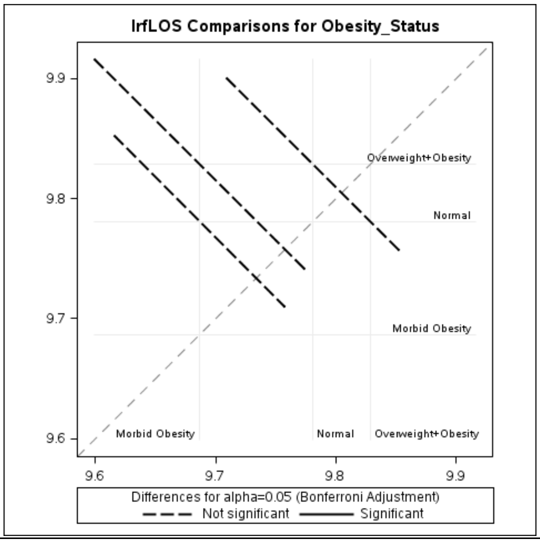
Table 27: Linear regression for IRF LOS within each race/ethnicities among TKA cohort

	Non-Hispanic White (n=19355)	**Non-Hispanic Black** (n=1894)	**Hispanic** (n=1456)
Intercept	10.6 (0.3)*	14.3 (1.0)*	11.3 (1.0)*
Age	0.1 (0.0)*	0.0 (0.0)^	0.1 (0.0)*
Gender			
Male	Reference	Reference	Reference
Female	0.2 (0.0)**	0.0 (0.2)	-0.1 (0.2)
Obesity_Status			
Normal	Reference	Reference	Reference
Overweight+Obesity	0.1 (0.1)	-0.1 (0.2)	0.1 (0.2)
Morbid Obesity	-0.1 (0.1)	-0.4 (0.2)^^	0.1 (0.2)
Medicare-Medicaid Dual Eligibility	0.4 (0.1)*	0.2 (0.1)	0.5 (0.1)**
Disability	0.5 (0.1)*	0.3 (0.2)^^	0.2 (0.2)
TierCM	0.7 (0.1)*	0.5 (0.2)^	0.4 (0.2)^
Adm_Motor_FIM	-0.2 (0.0)*	-0.2 (0.0)*	-0.1 (0.0)*

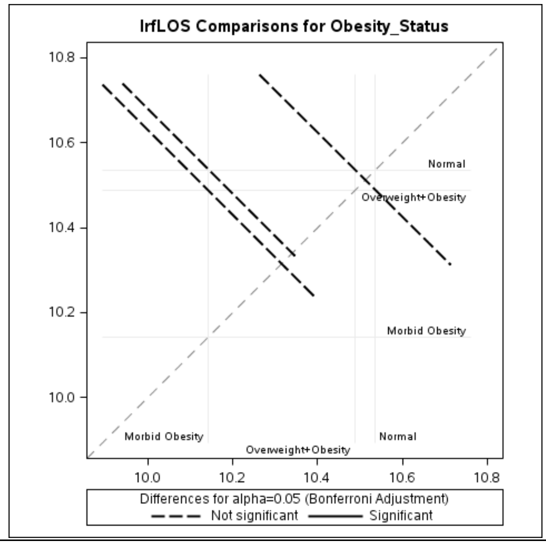
Values represent parameter estimate (regression coefficient) and standard error. * = p<.0001, **=p<.001,^ = p<.01, ^^ = p<.05. Values without * or ^ are not statistically significant. Variance (R-square) = 0.3 (p<.0001) (Whites); 0.3 (p<.0001) (Blacks); 0.3 (p<.0001) (Hispanics).

Figure 18: Association between obesity and IRF LOS within each race/ethnicity among TKA cohort

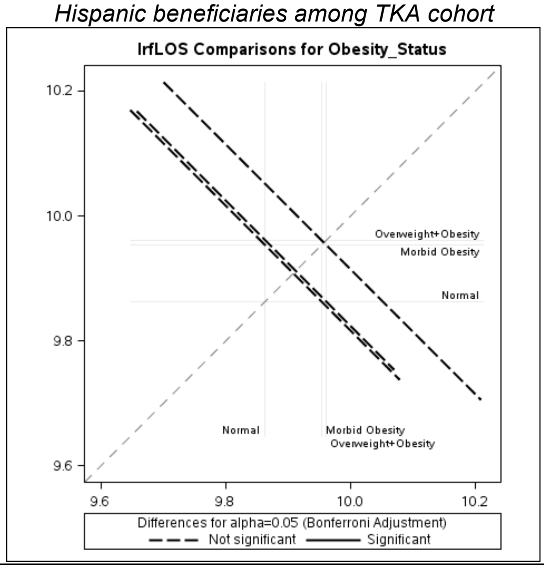
Non-Hispanic White beneficiaries among TKA cohort



Non-Hispanic Black beneficiaries among TKA cohort



Hispanic beneficiaries among TKA cohort



SUMMARY OF FINDINGS FOR EFFECT OF OBESITY ON REHABILITATION OUTCOMES

Discharge Motor FIM among THA cohort

- Obesity was not significantly associated with the outcome of discharge motor FIM.

- The interaction effect between Hispanic race/ethnicity and morbid obesity was significant for the outcome of discharge motor FIM. Upon performing stratified analysis:
    - Hispanic beneficiaries with morbid obesity had significantly higher discharge motor FIM as compared to Hispanic beneficiaries in the normal weight category.
- The interaction effect between obesity and gender was not significant for the outcome of discharge motor FIM.

Discharge Cognition FIM among THA cohort

- Overweight-obesity and morbid obesity were significantly associated with higher discharge cognition FIM.
- The interaction effect between Hispanic race/ethnicity and overweight-obesity was significantly associated with the outcome of discharge cognition FIM. Upon performing stratified analysis:
    - Non-Hispanic White beneficiaries with overweight-obesity and Non-Hispanic White beneficiaries with morbid obesity had significantly higher discharge cognition FIM as compared to Non-Hispanic White beneficiaries in the normal weight category.
- The interaction effect between obesity and gender was not significant for the outcome of discharge cognition FIM.

IRF length of stay among THA cohort

- Overweight-obesity was significantly associated with longer IRF length of stay.
- The interaction effect between obesity and race/ethnicity was not significant for the outcome of IRF length of stay.

- The interaction effect between obesity and gender was not significant for the outcome of IRF length of stay.

Community Discharge among THA cohort

- Obesity was not significantly associated with the outcome of community discharge.
- The interaction effect between obesity and race/ethnicity was not significant for the outcome of community discharge.
- The interaction effect between obesity and gender was not significant for the outcome of community discharge.

Discharge Motor FIM Among TKA cohort

- Overweight-obesity was significantly associated with higher discharge motor FIM.
- Each of the interaction effects, - between Hispanic race/ethnicity and overweight-obesity, and, between Hispanic race/ethnicity and morbid obesity, was significant for the outcome of discharge motor FIM. Upon performing stratified analysis:
  - Hispanic beneficiaries with morbid obesity had significantly lower discharge motor FIM as compared to Hispanic beneficiaries in the normal weight category.
  - Non-Hispanic White beneficiaries with overweight-obesity had significantly higher discharge motor FIM as compared to Non-Hispanic White beneficiaries in the normal weight category.
- The interaction of obesity and gender was not significantly associated with the outcome of discharge motor FIM.

Discharge Cognition FIM among TKA cohort

- Overweight-obesity and morbid obesity were significantly associated with higher discharge cognition FIM.

- The interaction effect between Hispanic race/ethnicity and overweight-obesity was significant for the outcome of discharge cognition FIM. Upon performing stratified analysis:
    - Non-Hispanic White beneficiaries with overweight-obesity and Non-Hispanic White beneficiaries with morbid obesity had significantly higher discharge cognition FIM as compared to those in the normal weight category.
- The interaction effect between obesity and gender was not significant for the outcome of discharge cognition FIM.

IRF length of stay among TKA cohort

- Obesity was not significantly associated with the outcome of IRF length of stay.
- The interaction effect between Hispanic race/ethnicity and morbid obesity was significant for the outcome of IRF length of stay.
- Upon performing stratified analysis:
    - Non-Hispanic Black beneficiaries with morbid obesity had significantly shorter IRF length of stay as compared to Non-Hispanic Black beneficiaries in the normal weight category.
    - Interaction effect between obesity and gender was not significant for the outcome of IRF length of stay.

Community Discharge among TKA cohort

- Obesity was not associated with the outcome of community discharge.
- The interaction effects, between obesity and race/ethnicity, and between obesity and gender, were not significant for the outcome of community discharge.

CHAPTER 5

Aim 2: Effect of Obesity on 30-day Hospital Readmission among Medicare Beneficiaries with Total Hip or Total Knee Arthroplasties

INTRODUCTION

This chapter presents the results of descriptive statistics, logistic regression analysis examining the association of obesity status with the likelihood of 30-day hospital readmission after IRF discharge, and survival analysis examining differences between obesity categories with respect to time to readmission, among Medicare Beneficiaries with THA or TKA during 2012 and 2013. The reasons for readmission were examined and classified as procedure-related or local complications, systemic complications, or unrelated reasons.

The descriptive statistics involve the stratification of the overall sample as well as each of the THA and TKA cohorts based on beneficiaries who experienced a 30-day readmission after IRF discharge versus those who did not. Socio-demographic characteristics (in the form of numbers and percentages, and means and standard deviations), as well as variables and values representing the beneficiaries' health status including: disability status, discharge motor FIM scores, and values representing prevalence of obesity and other comorbid conditions (Tier comorbidities, Elixhauser comorbidities and hospital acquired conditions), have been described. T-tests and chi-square statistics were used to determine differences in the above variables based on readmission status (occurred versus did not occur).

Logistic regression analysis was used to test the association between obesity and 30-day post-IRF hospital readmission. The adjusted main effects model included obesity status, age, gender, race/ethnicity, Medicare-Medicaid dual eligibility, disability status, social support, IRF length of stay, IRF admission and discharge functional status (DC M-FIM and DC C-FIM), type of IRF (freestanding versus in-hospital unit), discharge to community, and comorbidities (hospital acquired conditions, Tier comorbidities, hospital acquired conditions, and Elixhauser comorbidities [EC]). EC with prevalence lower than 1% were excluded. The obesity-race/ethnicity interaction model and the obesity-gender interaction model tested the association of respective interaction effect in addition to obesity and all the above covariates, with the likelihood of 30-day readmission.

Survival analysis was performed to determine the time to 30-day readmission, and comparisons were made between the survival curves for the three obesity-related categories. The unit used for time to 30-day hospital readmission was 10 days for plotting the Kaplan-Myer curves. Cox proportionality was tested in the main effects model (adjusting for all covariates) as well as in models testing differential effects of obesity by race/ethnicity and gender, to obtain the respective hazard ratios for 30-day hospital readmission. Because of low number of events, Non-Hispanic Black and Hispanic race/ethnicities were combined into one category: Non-White for the purpose of these subgroup analyses.

Among the beneficiaries in each of the THA and TKA cohorts who experienced readmission, reasons for readmissions were determined using medical severity diagnosis related group (MS-DRG) code and classified as local/procedure-related, systemic, and unrelated reasons. Multinomial logistic regression, adjusting for all covariates, was conducted for studying the association of obesity status with reason for readmission.

RESULTS OF DESCRIPTIVE STATISTICS

Readmissions by socio-demographic characteristics and comorbidities among the THA cohort

There were 10782 beneficiaries in the THA cohort. The proportion among the cohort who were readmitted was 5.1%. Among the obesity status categories in the readmitted sub-cohort, readmissions were the highest for beneficiaries with morbid obesity: 6.6% and the lowest for those in the normal weight category: 4.6%. Readmissions were high among beneficiaries with Medicare-Medicaid dual eligibility, disability, a Tier comorbidity, and a HAC: 7%, 6.2%, 6.8% and 9.6% respectively. Readmissions were also high among beneficiaries with EC – the highest being among those with metastatic cancer, congestive heart failure, renal failure, and diabetes with complications: 14.3%, 8.9%, 7.8% and 7.0%, respectively. Comparing between race/ethnicity categories, readmissions were highest among Non-Hispanic Black beneficiaries (5.3%) and lowest among Hispanic beneficiaries (4.7%). Readmissions were slightly higher among women (5.1%) compared to men (5%).

Readmissions by socio-demographic characteristics and comorbidities among the TKA cohort

There were 21341 beneficiaries in the TKA cohort. The proportion among the cohort who were readmitted was 5.1%. Among the obesity status categories in the readmitted sub-cohort, readmissions were the highest in beneficiaries with morbid obesity: 5.5% and the lowest in those with overweight and obesity: 4.9%. Readmissions were high among beneficiaries with Medicare-Medicaid dual eligibility, disability, a Tier comorbidity, and a HAC: 7.2%, 6.3%, 6.6% and 7.9% respectively. Readmissions were also high among beneficiaries with EC – the highest being among those with lymphoma, paralysis, congestive heart failure, psychoses, valvular disease, renal failure, and arrhythmia: 11.1%, 8.4%, 8.3%, 7.7%, 7.3%, 7.2, and 7.2% respectively. Comparing between race/ethnicity categories, readmissions were highest among Non-Hispanic Black beneficiaries (6.1%) and lowest among Non-Hispanic White beneficiaries (5%). Readmissions were slightly lower among women (4.9%) compared to men (5.5%).

Socio-demographic characteristics and comorbidities of beneficiaries who experienced 30-day hospital readmission among the THA cohort

Beneficiaries who were readmitted had significantly higher number of HAC and EC, and significantly higher prevalence of congestive heart failure, chronic pulmonary disease, renal failure, metastatic cancer, arrhythmia, and diabetes with chronic complications; compared to beneficiaries who were not readmitted (Table 28).

Table 28: Socio-demographic characteristics and comorbidities for 30-day hospital readmission among THA and TKA cohorts

	THA		TKA	
Experienced 30-day Readmission	**Yes**	**No**	**Yes**	**No**
Sample Size [n]	546	10,236	1,087	20,254
Obesity Status				
Normal weight	355 (65.0%)^	7,296 (71.3%)^	652 (59.9%)	12,355 (61%)
Overweight and Obesity	79 (14.5%)	1,352 (13.2%)	154 (14.2%)	2,989 (14.8%)
Morbid Obesity	112 (20.5%)	1,588 (15.5%)	281 (25.9%)	4,910 (24.2%)
Age	78.4 (7.3)	77.6 (7.1)	77.0 (7.0)^	76.2 (6.8)^
Gender				
Men	169 (30.9%)	3,215 (31.4%)	337 (31.0%)	5,775 (28.5%)
Women	377 (69.1%)	7,021 (68.6%)	750 (69.0%)	14,479 (71.5%)
Race/ethnicity				
White	491 (89.9%)	9,210 (90%)	907 (83.4%)	17,276 (85.3%)
Black	38 (7%)	684 (6.7%)	109 (10.0%)	1,685 (8.3%)
Hispanic	17 (3.1%)	342 (3.3%)	71 (6.5%)	1,293 (6.4%)
*** Living with someone**	371 (68%)	7,303 (71.4%)	778 (71.6%)*	14,909 (73.6%)*
*** Married**	235 (43.0%)	4,782 (46.7%)	513 (47.2%)*	9,804 (48.4%)*
*** Social Support**	388 (71.3%)	7,633 (74.7%)	828 (76.2%)	15,483 (76.5%)
Medicare-Medicaid Dual Eligibility	68 (12.5%)^	904 (8.8%)^	185 (17.0%)*	2,394 (11.8%)*
Disability	65 (11.9%)	983 (9.6%)	163 (15.0%)^	2,421 (12%)^
IRF length of stay (days)	10.8 (3.8)*	10.0 (3.4)*	10.5 (3.6)*	9.4 (3.2)*
IRF Type				
In-Hospital Unit	291 (53.3%)	5,479 (53.5%)	533 (49.0%)	10,309 (50.9%)
Free standing	255 (46.7%)	4,757 (46.5%)	554 (51%)	9,945 (49.1%)
Community Discharge	490 (89.7%)^	9,550 (93.3%)^	1,003 (92.3%)*	19,335 (95.5%)*
Admission Motor FIM	40.2 (9.1)**	41.9 (8.8)**	39.9 (9.8)*	43.2 (9.1)*
Discharge Motor FIM	67.7 (10.7)*	70.6 (8.8)*	68.6 (10.4)*	72.2 (8.4)*
Admission Cognition FIM	26.7 (5.4)^^	27.5 (5.2)^^	26.3 (5.9)*	27.7 (5.2)*
Discharge Cognition FIM	31.0 (4.1)**	31.6 (3.5)**	30.8 (4.2)	31.9 (3.4)
Tier Comorbidity	168 (30.8%)*	2,295 (22.4%)*	457 (42.0%)*	6,475 (32%)*
Tier Case Mix Group				
Tier 0	378 (69.2%)*	7,941 (77.6%)*	630 (58%)*	13,779 (68.0%)*
Tier 1	7 (1.3%)	47 (0.5%)	10 (0.9%)	86 (0.4%)
Tier 2	20 (3.7%)	221 (2.2%)	51 (4.7%)	387 (1.9%)
Tier 3	141 (25.8%)	2,027 (19.8%)	396 (36.4%)	6,002 (29.6%)
Hospital Acquired Conditions (HAC)	45 (8.2%)*	424 (4.1%)*	78 (7.2%)*	914 (4.5%)*
HAC: sum	0.1 (0.3)*	0.0 (0.2)*	0.1 (0.3)**	0.1 (0.2)**
Elixhauser comorbidities (EC): sum	3.3 (1.6)*	2.9 (1.5)*	3.5 (1.6)*	3.0 (1.5)*
EC: Congestive heart failure	63 (11.5%)*	649 (6.3%)*	111 (10.2%)*	1,226 (6.1%)*

	THA		TKA	
Experienced 30-day Readmission	**Yes**	**No**	**Yes**	**No**
EC: Valvular disease	36 (6.6%)	524 (5.1%)	73 (6.7%)^	933 (4.6%)^
EC: Pulmonary circulation disease	12 (2.2%)	133 (1.3%)	25 (2.3%)	346 (1.7%)
EC: Peripheral vascular disease	37 (6.8%)	502 (4.9%)	59 (5.4%)	853 (4.2%)
EC: Paralysis	7 (1.3%)	134 (1.3%)	32 (2.9%)^	349 (1.7%)^
EC: Other neurological disorders	49 (9%)	766 (7.5%)	116 (10.7%)^	1,629 (8.0%)^
EC: Chronic pulmonary disease	122 (22.3%)^	1,800 (17.6%)^	244 (22.5%)*	3,581 (17.7%)*
EC: Hypothyroidism	132 (24.2%)	2,400 (23.5%)	267 (24.6%)	4,974 (24.6%)
EC: Renal failure	76 (13.9%)*	897 (8.8%)*	156 (14.4%)*	2,013 (9.9%)*
EC: Liver disease	4 (0.7%)	60 (0.6%)	8 (0.7%)	114 (0.6%)
EC: Peptic ulcer Disease x bleeding	0	6 (0.1%)	0	3 (0.0%)
EC: Acquired immune deficiency syndrome	1 (0.2%)	4 (0.0%)	1 (0.1%)^^	2 (0.0%)^^
EC: Lymphoma	4 (0.7%)	61 (0.6%)	9 (0.8%)^^	72 (0.4%)^^
EC: Metastatic cancer	4 (0.7%)^^	24 (0.2%)^^	1 (0.1%)	23 (0.1%)
EC: Solid tumor w/out metastasis	5 (0.9%)	98 (1%)	7 (0.6%)	139 (0.7%)
EC: Rheumatoid arthritis/collagen vas	38 (7%)	616 (6.0%)	75 (6.9%)	1193 (5.9%)
EC: Coagulopthy	23 (4.2%)	424 (4.1%)	61 (5.6%)	892 (4.4%)
EC: Weight loss	22 (4.0%)	528 (5.2%)	54 (5%)	954 (4.7%)
EC: Fluid and electrolyte disorders	103 (18.9%)	1683 (16.4%)	218 (20.1%)**	3,249 (16.0%)**
EC: Chronic blood loss anemia	22 (4.0%)	262 (2.6%)	24 (2.2%)	454 (2.2%)
EC: Deficiency Anemias	226 (41.4%)	4,126 (40.3%)	417 (38.4%)	7,658 (37.8%)
EC: Psychoses	11 (2.0%)	219 (2.1%)	45 (4.1%)^	538 (2.7%)^
EC: Depression	94 (17.2%)	1,619 (15.8%)	225 (20.7%)^	3,533 (17.4%)^
EC: Hypertension	454 (83.2%)	8,189 (80.0%)	902 (83%)	16,743 (82.7%)
EC: Arrhythmias	130 (23.8%)**	1,777 (17.4%)**	270 (24.8%)*	3,496 (17.3%)*
EC: Diabetes w/o chronic complications	115 (21.1%)	1,941 (19%)	281 (25.9%)	4,870 (24%)
EC: Diabetes w/ chronic complications	34 (6.2%)^^	451 (4.4%)^^	102 (9.4%)**	1,312 (6.5%)**

Foot-notes: 1). Values represent: Number (Percent%) / Mean (Standard Deviation). 2). The percent(%) values demonstrate proportions within each of the sub-cohorts based on readmission status (column percent) among the overall sample, THA and TKA cohorts. 3). *Married, *Living with someone, and *Social Support have missing values, among each of the THA and TKA cohorts. These have been depicted in a table in the appendix. 4) * = p<.0001, ** = p<.001, ^p<.01 ^^p<.05 demonstrate degree of statistically significant differences among those readmitted versus not. 5). Values without any * or ^ have p>.0.05

Beneficiaries who were readmitted had significantly lower motor and cognition FIM scores at IRF admission and discharge, and a significantly smaller proportion of individuals discharged to community, compared to beneficiaries who were not readmitted. Significantly greater proportion of beneficiaries had Medicare-Medicaid dual eligibility, a Tier comorbidity, and a HAC, among those who were readmitted compared to those who were not readmitted. Beneficiaries who were readmitted had a significantly higher proportion of individuals with Tier 1, -2, and -3, case mix groups, and a significantly lower proportion of Tier 0 case mix group; as compared to those who were not (Table 28).

Socio-demographic characteristics and comorbidities of beneficiaries who experienced 30-day hospital readmission among the TKA cohort

Beneficiaries who were readmitted were significantly older, had significantly higher IRF LOS, higher number of HAC and EC, and a significantly higher prevalence of congestive heart failure, paralysis and other neurological disorders, chronic pulmonary disease, renal failure, acquired immune deficiency syndrome, lymphoma, fluid and electrolyte disorders, psychoses, depression, arrhythmia, and diabetes with chronic complications; compared to beneficiaries who were not readmitted. Beneficiaries who were readmitted had significantly lower admission motor and cognition FIM and DC M-FIM scores, compared to those not readmitted. Significantly greater proportion of beneficiaries who were readmitted had a disability, Medicare-Medicaid dual eligibility, a Tier comorbidity, and a HAC; compared to those who were not. Beneficiaries who were readmitted had a significantly higher proportion of individuals with Tier 1, -2, and -3, case mix groups, and a significantly lower proportion of Tier 0 case mix group; as compared to those who were not (Table 28).

RESULTS OF MULTIVARIABLE LOGISTIC REGRESSION ANALYSES

Results among THA cohort for 30-day post-IRF readmission

Morbid obesity (in comparison with normal weight) was associated with 38% increase in odds for 30-day hospital readmission in the main effects model. The odds for readmission increased, by 72% with the presence of a HAC; by: 60%, 34%, 32%, 27% and 26% respectively with each of the ECs namely chronic blood loss, congestive heart failure, renal failure, arrhythmia, chronic pulmonary disease; and by 2% with every additional day longer length of IRF stay (IRF LOS), and 2% with each year increase in age. The odds of readmission were lower by 2% with each unit increase in DC M-FIM (Table 29).

The interaction effects of obesity and race/ethnicity, and obesity and gender, were not significantly associated with difference in the odds of readmission (Table 29).

Table 29: Logistic Regression Models for 30-day post IRF hospital readmission among THA cohort

Independent Variable, Covariates, and Interaction Variables	Model for testing main effects adjusted for all covariates	Model for testing interaction effect of obesity and race/ethnicity	Model for testing interaction effect of obesity and gender
Obesity Status			
Normal weight	Reference	Reference	Reference
Overweight and Obesity	1.2 (1.0-1.6)	1.2 (0.9-1.6)	1.3 (0.8-2.0)
Morbid Obesity	1.4 (1.1-1.8)	1.4 (1.0-1.8)	1.3 (0.9-2.1)
Age	1.0 (1.0-1.0)	1.0 (1.0-1.0)	1.0 (1.0-1.0)
Gender			
Male	Reference	Reference	Reference
Female	1.0 (0.8– 1.3)	1.0 (0.8– 1.3)	1.0 (0.8– 1.3)
Race/ethnicity			
Non-Hispanic White	Reference	Reference	Reference
Non-Hispanic Black	1.0 (0.7-1.4)	0.8 (0.5-1.3)	1.0 (0.7-1.4)
Hispanic	0.8 (0.5-1.4)	0.9 (0.5-1.7)	0.8 (0.5-1.4)
Social Support	1.1 (0.9-1.4)	1.1 (0.9-1.4)	1.1 (0.9-1.4)
Medicare-Medicaid Dual Eligibility	1.3 (1.0-1.7)	1.3 (1.0-1.7)	1.3 (1.0-1.7)
Disability Status	1.2 (0.9-1.6)	1.2 (0.9-1.6)	1.2 (0.9-1.6)
IRF Length of Stay	1.0 (1.0-1.1)	1.0 (1.0-1.1)	1.0 (1.0-1.1)
Type of IRF			
In-Hospital Unit	Reference	Reference	Reference
Freestanding	1.1 (0.9-1.3)	1.1 (0.9-1.3)	1.1 (0.9-1.3)
Discharge Motor FIM	0.9 (0.9-0.9)	0.9 (0.9-0.9)	0.9 (0.9-0.9)
Tier Comorbidity	1.1 (0.9-1.5)	1.1 (0.9-1.5)	1.1 (0.9-1.5)
Hospital Acquired Condition (HAC)	1.7 (1.2-2.4)	1.7 (1.2-2.4)	1.7 (1.2-2.4)
EC: Congestive Heart Failure	1.3 (1.0-1.8)	1.4 (1.0-1.8)	1.4 (1.0-1.8)
EC: Chronic Pulmonary Disease	1.3 (1.0-1.6)	1.3 (1.0-1.6)	1.3 (1.0-1.6)
EC: Renal Failure	1.3 (1.0-1.7)	1.3 (1.0-1.7)	1.3 (1.0-1.7)
EC: Chronic Blood Loss	1.6 (1.0-2.5)	1.6 (1.0-2.5)	1.6 (1.0-2.5)
EC: Arrhythmia	1.3 (1.0-1.6)	1.3 (1.0-1.6)	1.3 (1.0-1.6)

Independent Variable, Covariates, and Interaction Variables	Model for testing main effects adjusted for all covariates	Model for testing interaction effect of obesity and race/ethnicity	Model for testing interaction effect of obesity and gender
Interaction of Obesity & Race-Ethnicity			
Black & Overweight-Obesity	-	1.6 (0.6-4.2)	-
Black & Morbid Obesity		1.5 (0.7-3.2)	
Hispanic & Overweight-Obesity		1.3 (0.4-4.4)	
Hispanic & Morbid Obesity		0.7 (0.2-2.6)	
Interaction of Obesity & Gender			
Female & Overweight-Obesity	-	-	1.3 (0.8-2.0)
Female & Morbid Obesity			1.3 (0.9-2.1)

Foot-notes: 1). Values represent: Odds Ratio (95% Confidence Interval [CI]) 2). Reference category for categorical variables namely Tier comorbidity and HAC is 'No (condition absent)'. 3). Table displays statistically significant EC. 4). In all the adjusted models, the EC with less than 1% prevalence were excluded. 4) Lower limit of 95% CI for IRF LOS & significant ECs, rounded to 1.0 however have values slightly greater than 1.0.

Results among TKA cohort for 30-day post-IRF readmission

In all of the model (main effects, obesity-race/ethnicity interaction model, and the obesity-gender interaction model), the odds of readmission increased by: 1% with every year increase in age, 36% with the presence of Medicare-Medicaid dual eligibility, 40% with the presence of the EC: arrhythmia, 33% with EC: valvular disease, 25% with EC: chronic pulmonary disease, and 17% with EC: fluid electrolyte disorder (Table 30).

In the adjusted and obesity-gender interaction model the odds of readmission increased by 29% in the presence of a Tier comorbidity, and decreased by 3% with every unit increase in DC M-FIM. These associations were similar in the obesity-race/ethnicity interaction model with the respective odds ratios values being 28% and 2%. The interaction effects of obesity and race/ethnicity, and obesity and gender, were not significant. Obesity status was not significantly associated with a change in the odds of readmission among the TKA cohort (Table 30).

Table 30: Logistic Regression Models for 30-day post IRF hospital readmission among TKA cohort

Independent Variable, Covariates, and Interaction Variables	Model for testing main effects adjusted for all covariates	Model for testing interaction effect of obesity and race/ethnicity	Model for testing interaction effect of obesity and gender
Obesity Status			
Normal weight	Reference	Reference	Reference
Overweight and Obesity	1.0 (0.8-1.2)	1.1 (0.8-1.5)	1.0 (0.7-1.4)
Morbid Obesity	0.9 (0.8-1.1)	1.0 (0.8-1.4)	1.0 (0.7-1.3)
Age	1.0 (1.0-1.0)	1.0 (1.0-1.0)	1.0 (1.0-1.0)
Gender			
Male	Reference	Reference	Reference
Female	1.0 (0.8-1.1)	1.0 (0.8-1.1)	1.0 (0.8-1.2)
Race/ethnicity			
Non-Hispanic White	Reference	Reference	Reference
Non-Hispanic Black	1.1 (0.9-1.3)	1.0 (0.9-1.3)	1.1 (0.9-1.3)
Hispanic	0.9 (0.7-1.2)	1.1 (0.9-1.3)	0.9 (0.7-1.2)
Social Support	1.0 (0.8-1.1)	1.0 (0.8-1.1)	1.0 (0.8-1.1)
Medicare-Medicaid Dual Eligibility	1.4 (1.1-1.7)	1.4 (1.1-1.6)	1.4 (1.1-1.7)
Disability Status	1.1 (0.9-1.3)	1.1 (0.9-1.3)	1.1 (0.9-1.3)
IRF Length of Stay	1.1 (1.0-1.1)	1.1 (1.0-1.1)	1.1 (1.0-1.1)
Type of IRF			
In-Hospital Unit	Reference	Reference	Reference
Freestanding	1.2 (1.0-1.3)	1.2 (1.0-1.3)	1.2 (1.0-1.3)
Discharge Motor FIM	0.9 (0.9-0.9)	0.9 (0.9-0.9)	0.9 (0.9-0.9)
Tier Comorbidity	1.3 (1.1-1.5)	1.3 (1.1-1.5)	1.3 (1.1-1.5)
Hospital Acquired Condition (HAC)	1.4 (1.1-1.8)	1.4 (1.1-1.8)	1.4 (1.1-1.8)
EC: Valvular Disease	1.3 (1.0-1.7)	1.3 (1.0-1.7)	1.3 (1.0-1.7)
EC: Chronic Pulmonary Disease	1.3 (1.1-1.5)	1.3 (1.1-1.5)	1.3 (1.1-1.5)
EC: Fluid and Electrolyte Disorder	1.2 (1.0-1.4)	1.2 (1.0-1.4)	1.2 (1.0-1.4)
EC: Arrhythmia	1.4 (1.2-1.6)	1.4 (1.2-1.6)	1.4 (1.2-1.6)
Interaction of Obesity & Race-Ethnicity	-		-
Black & Overweight-Obesity		0.7 (0.3-1.3)	
Black & Morbid Obesity		1.1 (0.7-1.7)	
Hispanic & Overweight-Obesity		0.7 (0.4-1.4)	
Hispanic & Morbid Obesity		0.6 (0.3-1.0)	
Interaction of Obesity & Gender	-	-	
Female & Overweight-Obesity			1.0 (0.7-1.4)
Female & Morbid Obesity			1.0 (0.7-1.3)

Foot-notes: 1). Values represent: Odds Ratio (95% Confidence Interval [CI]) 2). Reference category for categorical variables namely Tier comorbidity and HAC is 'No (condition absent)'. 3). Table displays statistically significant EC. 4). In all the adjusted models, the EC with less than 1% prevalence were excluded.

RESULTS OF SURVIVAL ANALYSIS FOR TIME TO 30-DAY READMISSION

Based on the log-rank test, the differences in the time to readmission among the three obesity-related categories were significant among the THA cohort (p = 0.0028) (Figure 19) but not among the TKA cohort (p = 0.4783) (Figure 20).

Figure 19: Time to 30-day readmission among beneficiaries by obesity-related categories within the THA cohort (Kaplan Maier Survival Plot)

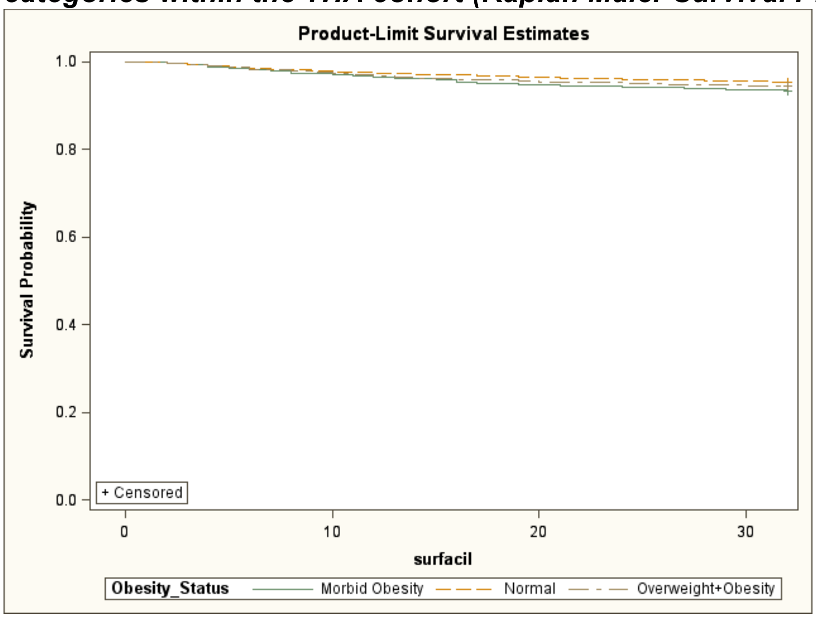
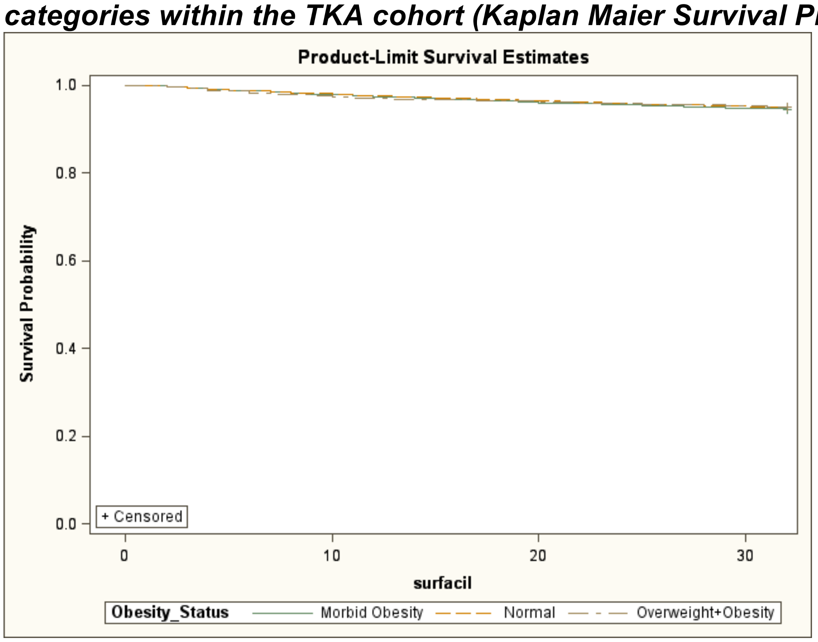


Figure 20: Time to 30-day readmission among beneficiaries by obesity-related categories within the TKA cohort (Kaplan Maier Survival Plot)



RESULTS OF COX REGRESSION ANALYSES

Results of Cox proportional hazard models among THA cohort for the risk of 30-day hospital readmission

Morbid obesity was significantly associated with 40% greater risk for 30-day hospital readmission, in the main effect model as well as in the models testing the interaction effects between obesity status and race/ethnicity (Non-White, reference = White) between obesity status and gender. Because of low number of events, Non-Hispanic Black and Hispanic race/ethnicities were combined into one category: Non-white for the obesity-race/ethnicity interaction effect analysis. The interaction effect between morbid obesity and Non-White was significant for the risk of 30-day hospital readmission. The interaction effect between overweight/obesity and race/ethnicity was non-significant for the risk of 30-day readmission. The interaction effect between morbid obesity and gender was significant for the risk of 30-day hospital readmission. The interaction effect between overweight/obesity and gender was non-significant for the risk of 30-day readmission (Table 31).

Table 31: Cox proportional hazard models for risk of 30-day post-IRF readmission among THA cohort

Independent Variable, Covariates, and Variables for Sub-group Analyses	**Model testing Main Effects**	**Model testing interaction effect of obesity and race/ethnicity**	**Model testing the interaction effect of obesity and gender**
Obesity Status			
Normal weight	Reference	Reference	Reference
Overweight and Obesity	1.2 (1.0-1.6)	1.2 (1.0-1.6)	1.3 (1.0-1.6)
Morbid Obesity	1.4 (1.1-1.8)	1.4 (1.1-1.8)	1.4 (1.1-1.8)
Gender			
Male	Reference	Reference	Reference
Female	1.0 (0.9-1.3)	1.0 (0.9-1.3)	1.0 (0.9-1.3)
Race/ethnicity			
Non-Hispanic White	Reference	Reference	Reference
Non-Hispanic Black	1.0 (0.7-1.3)	1.0 (0.7-1.3)	1.0 (0.7-1.3)
Hispanic	0.8 (0.5-1.4)	0.8 (0.5-1.4)	0.8 (0.5-1.4)

Independent Variable, Covariates, and Interaction Terms	Model testing Main Effects	Model testing effect of obesity and race/ethnicity	Model testing effect of obesity and gender
Discharge Motor FIM	0.9 (0.9-0.9)	0.9 (0.9-0.9)	0.9 (0.9-0.9)
Hospital Acquired Condition (HAC)	1.7 (1.2-2.3)	1.7 (1.2-2.3)	1.7 (1.2-2.3)
EC: Congestive Heart Failure	1.3 (1.0-1.8)	1.3 (1.0-1.8)	1.3 (1.0-1.8)
EC: Chr. Pulmonary Disease	1.2 (1.0-1.5)	1.2 (1.0-1.5)	1.2 (1.0-1.5)
EC: Renal Failure	1.3 (1.0-1.7)	1.3 (1.0-1.7)	1.3 (1.0-1.7)
EC: Chronic Blood Loss	1.5 (1.0-2.4)	1.5 (1.0-2.4)	1.5 (1.0-2.4)
EC: Arrhythmias	1.3 (1.0-1.6)	1.3 (1.0-1.6)	1.3 (1.0-1.6)
Obesity by Race-Ethnicity			
Overweight-Obesity for Non-White	-	0.8 (0.6-1.0)	-
Morbid Obesity for Non-White		1.4 (1.1-1.8)	
Obesity by Gender			
Overweight-Obesity for Female	-	-	0.8 (0.6-1.0)
Morbid Obesity for Female			1.4 (1.1-1.8)

Values represent Hazard Ratio (95% confidence limits). Although all models were adjusted for all the covariates, only the statistically significant hazard ratios have been reported in addition to the values for obesity status, gender, race/ethnicity, and the interaction effect terms. The lower limit values of the 95% CI for the ECs listed are rounded to 1.0, but are slightly greater in value than 1.0.

Results of Cox proportional hazard models among TKA cohort for the risk of 30-day hospital readmission

Obesity status, gender, and race/ethnicity main effects were not significantly associated with the risk of 30-day hospital readmission. Because of the low number of events, Non-Hispanic Black and Hispanic race/ethnicities were combined into one category: Non-white for the interaction effect analysis. The interaction effect obesity and race/ethnicity and between obesity and gender were not significant for the risk of 30-day hospital readmission (Table 32).

Table 32: Cox proportional hazard models for the risk of 30-day post-IRF readmission among TKA cohort

Independent Variable, Covariates, and Variables for Sub-group Analyses	Model testing Main Effects	Model testing effect of obesity by race/ethnicity	Model testing effect of obesity by gender
Obesity Status			
Normal weight	Reference	Reference	Reference
Overweight-Obesity	1.0 (0.8-1.2)	1.0 (0.8-1.2)	1.0 (0.8-1.2)
Morbid Obesity	1.0 (0.8-1.1)	1.0 (0.8-1.1)	1.0 (0.8-1.1)
Gender			
Male	Reference	Reference	Reference
Female	1.0 (0.8-1.1)	1.0 (0.8-1.1)	1.0 (0.8-1.1)
Race/ethnicity			
Non-Hispanic White	Reference	Reference	Reference
Non-Hispanic Black	1.0 (0.8-1.3)	1.0 (0.8-1.3)	1.0 (0.8-1.3)
Hispanic	0.9 (0.7-1.2)	0.9 (0.7-1.2)	0.9 (0.7-1.2)
Medicare-Medicaid Dual Eligibility	1.4 (1.2-1.6)	1.4 (1.1-1.6)	1.4 (1.1-1.6)
Discharge Motor FIM	0.9 (0.9-0.9)	0.9 (0.9-0.9)	0.9 (0.9-0.9)
IRF Length of Stay	1.0 (1.0-1.1)	1.0 (1.0-1.1)	1.0 (1.0-1.1)
Type of IRF			
In-Hospital Unit	Reference	Reference	Reference
Freestanding	1.2 (1.0-1.3)	1.2 (1.0-1.3)	1.2 (1.0-1.3)
Tier Comorbidity	1.3 (1.1-1.5)	1.3 (1.1-1.5)	1.3 (1.1-1.5)
Hospital Acquired Condition (HAC)	1.3 (1.1-1.7)	1.3 (1.1-1.7)	1.3 (1.1-1.7)
EC: Chornic Pulmonary Disease	1.2 (1.1-1.4)	1.2 (1.1-1.4)	1.2 (1.1-1.4)
EC: Fluid and electrolyte disorders	1.2 (1.0-1.4)	1.2 (1.0-1.4)	1.2 (1.0-1.4)
EC:Arrhythmias	1.4 (1.2-1.6)	1.4 (1.2-1.6)	1.4 (1.2-1.6)
Obesity by Race-Ethnicity			
Overweight-Obesity for Non-White	-	1.0 (0.8-1.2)	-
Morbid Obesity for Non-White		1.0 (0.8-1.1)	
Obesity with Gender			
Overweight-Obesity for Female	-	-	1.0 (0.8-1.2)
Morbid Obesity for Female			1.0 (0.8-1.1)

Values represent Hazard Ratio (95% confidence limits). Although all models were adjusted for all the covariates, only the statistically significant hazard ratios have been reported in addition to the values for obesity status, gender, race/ethnicity, and the differential effects terms. The lower limit value of the 95% CI for the EC: Fluid and electrolyte disorders is rounded to 1.0, but is slightly greater in value than 1.0.

REASONS FOR 30-DAY POST-IRF HOSPITAL READMISSION

The reason for each of the 30-day post-IRF readmissions (condition or procedure), that occurred among the beneficiaries in each of the THA and TKA cohorts, was categorized either as systemic complication, local/procedure-related complication, or an unrelated reason. This classification was done based on existing literature[70] and on the basis of clinical reasoning under the guidance of the chair of the advisory committee, Dr. Soham al Snih, MD PhD. Chi-square statistic was calculated for the reason for readmission and obesity status categories. Multinomial logistic regression was performed with the three-level outcome of reason for readmission ('unrelated' reason being the reference category), and with obesity status as the independent variable. For each of THA and TKA cohorts, the frequencies of the DRG codes for systemic (Tables 33 and 36), local/procedure-related (Table 34 and 37) and unrelated reasons (Table 35 and 38) have been tabulated below.

Reasons for readmission among the THA cohort

Table 33: Systemic complications (conditions and procedures) that occurred following primary THA

Number	DRG code Number	DRG code descriptor	Frequency	Percent
1	392	ESOPHAGITIS, GASTROENT & MISC DIGEST DISORDERS W/O MCC	17	3.1%
2	603	CELLULITIS W/O MCC	12	2.2%
3	908	OTHER O.R. PROCEDURES FOR INJURIES W CC		
4	561	AFTERCARE, MUSCULOSKELETAL SYSTEM & CONNECTIVE TISSUE W/O CC/MCC	11	2%
5	292	HEART FAILURE & SHOCK W CC		
6	378	G.I. HEMORRHAGE W CC		
7	176	PULMONARY EMBOLISM W/O MCC	10	1.8%
8	872	SEPTICEMIA W/O MV 96+ HOURS W/O MCC		
9	690	KIDNEY & URINARY TRACT INFECTIONS W/O MCC	9	1.6%
10	909	OTHER O.R. PROCEDURES FOR INJURIES W/O CC/MCC		
11	470	MAJOR JOINT REPLACEMENT OR REATTACHMENT OF LOWER EXTREMITY W/O MCC	8	1.5%
12	373	MAJOR GASTROINTESTINAL DISORDERS & PERITONEAL INFECTIONS W/O CC/MCC		
13	300	PERIPHERAL VASCULAR DISORDERS W CC	7	1.3%
14	641	NUTRITIONAL & MISC METABOLIC DISORDERS W/O MCC		
15	683	RENAL FAILURE W CC	6	1.1%
16	309	CARDIAC ARRHYTHMIA & CONDUCTION DISORDERS W CC	5	0.9%
17	312	SYNCOPE & COLLAPSE		
18	194	SIMPLE PNEUMONIA & PLEURISY W CC		
19	313	CHEST PAIN		

Number	DRG code Number	DRG code descriptor	Frequency	Percent
20	556	SIGNS & SYMPTOMS OF MUSCULOSKELETAL SYSTEM & CONN TISSUE W/O MCC	3	0.5%
21	559	AFTERCARE, MUSCULOSKELETAL SYSTEM & CONNECTIVE TISSUE W MCC	2	0.4%
22	486	KNEE PROCEDURES W PDX OF INFECTION W CC	1	0.2%
23	491	BACK & NECK PROC EXC SPINAL FUSION W/O CC/MCC		
24	494	LOWER EXTREM & HUMER PROC EXCEPT HIP,FOOT,FEMUR W/O CC/MCC		
26	502	SOFT TISSUE PROCEDURES W/O CC/MCC		
27	515	OTHER MUSCULOSKELET SYS & CONN TISS O.R. PROC W MCC		
28	554	BONE DISEASES & ARTHROPATHIES W/O MCC	1	0.2%
29	534	FRACTURES OF FEMUR W/O MCC		
30	563	FX, SPRN, STRN & DISL EXCEPT FEMUR, HIP, PELVIS & THIGH W/O MCC		
31	593	SKIN ULCERS W CC		
32	605	TRAUMA TO THE SKIN, SUBCUT TISS & BREAST W/O MCC		
33	880	ACUTE ADJUSTMENT REACTION & PSYCHOSOCIAL DYSFUNCTION		
34	963	OTHER MULTIPLE SIGNIFICANT TRAUMA W MCC		
35	674	OTHER KIDNEY & URINARY TRACT PROCEDURES W CC		
36	684	RENAL FAILURE W/O CC/MCC		
37	698	OTHER KIDNEY & URINARY TRACT DIAGNOSES W MCC		
38	699	OTHER KIDNEY & URINARY TRACT DIAGNOSES W CC		
39	700	OTHER KIDNEY & URINARY TRACT DIAGNOSES W/O CC/MCC		
40	626	THYROID, PARATHYROID & THYROGLOSSAL PROCEDURES W CC		
41	640	NUTRITIONAL & MISC METABOLIC DISORDERS W MCC		
42	644	ENDOCRINE DISORDERS W CC		
43	645	ENDOCRINE DISORDERS W/O CC/MCC		
44	813	COAGULATION DISORDERS		
45	881	DEPRESSIVE NEUROSES		
45	881	DEPRESSIVE NEUROSES		

Table 34: Local or Procedure-related complications (conditions and procedures) that occurred following primary THA

Number	DRG code Number	DRG code descriptor	Frequency	Percent
1	467	REVISION OF HIP OR KNEE REPLACEMENT W CC	38	7%
2	863	POSTOPERATIVE & POST-TRAUMATIC INFECTIONS W/O MCC	27	4.9%
3	857	POSTOPERATIVE OR POST-TRAUMATIC INFECTIONS W O.R. PROC W CC	17	3.1%
4	468	REVISION OF HIP OR KNEE REPLACEMENT W/O CC/MCC	12	2.2%
5	466	REVISION OF HIP OR KNEE REPLACEMENT W MCC	9	1.6%
6	920	COMPLICATIONS OF TREATMENT W CC		
7	481	HIP & FEMUR PROCEDURES EXCEPT MAJOR JOINT W CC	7	1.3%
8	921	COMPLICATIONS OF TREATMENT W/O CC/MCC	4	0.7%
9	464	WND DEBRID & SKN GRFT EXC HAND, FOR MUSCULO-CONN TISS DIS W CC	3	0.5%
10	853	INFECTIOUS & PARASITIC DISEASES W O.R. PROCEDURE W MCC		
11	856	POSTOPERATIVE OR POST-TRAUMATIC INFECTIONS W O.R. PROC W MCC		
12	858	POSTOPERATIVE OR POST-TRAUMATIC INFECTIONS W O.R. PROC W/O CC/MCC		
13	549	SEPTIC ARTHRITIS W CC	2	0.4%
14	862	POSTOPERATIVE & POST-TRAUMATIC INFECTIONS W MCC		
15	498	LOCAL EXCISION & REMOVAL INT FIX DEVICES OF HIP & FEMUR W CC/MCC	1	0.2%
16	919	COMPLICATIONS OF TREATMENT W MCC		

Table 35: Unrelated Conditions and procedures that occurred following THA

Number	DRG code Number	DRG code descriptor	Frequency	Percent
1	747	VAGINA, CERVIX & VULVA PROCEDURES W/O CC/MCC	1	0.2%
2	810	MAJOR HEMATOL/IMMUN DIAG EXC SICKLE CELL CRISIS & COAGUL W/O CC/MCC		
3	840	LYMPHOMA & NON-ACUTE LEUKEMIA W MCC		
4	885	PSYCHOSES		
5	982	EXTENSIVE O.R. PROCEDURE UNRELATED TO PRINCIPAL DIAGNOSIS W CC		
6	988	NON-EXTENSIVE O.R. PROC UNRELATED TO PRINCIPAL DIAGNOSIS W CC		

Reasons for 30-day post-IRF readmission among the TKA cohort

Table 36: Systemic complications (conditions and procedures) that occurred following primary TKA

Number	DRG code Number	DRG code descriptor	Frequency	Percent
1	392	ESOPHAGITIS, GASTROENT & MISC DIGEST DISORDERS W/O MCC	48	4.4%
2	470	MAJOR JOINT REPLACEMENT OR REATTACHMENT OF LOWER EXTREMITY W/O MCC	47	4.3%
3	603	CELLULITIS W/O MCC	41	3.8%
4	683	RENAL FAILURE W CC	25	2.3%
5	176	PULMONARY EMBOLISM W/O MCC	24	2.2%
6	908	OTHER O.R. PROCEDURES FOR INJURIES W CC	23	2.1%
7	641	NUTRITIONAL & MISC METABOLIC DISORDERS W/O MCC	22	2%
8	378	G.I. HEMORRHAGE W CC	19	1.7%
9	560	AFTERCARE, MUSCULOSKELETAL SYSTEM & CONNECTIVE TISSUE W CC	18	1.7%
10	292	HEART FAILURE & SHOCK W CC		
11	690	KIDNEY & URINARY TRACT INFECTIONS W/O MCC		
12	309	CARDIAC ARRHYTHMIA & CONDUCTION DISORDERS W CC		
13	872	SEPTICEMIA W/O MV 96+ HOURS W/O MCC	16	1.5%
14	909	OTHER O.R. PROCEDURES FOR INJURIES W/O CC/MCC	15	1.4%
15	372	MAJOR GASTROINTESTINAL DISORDERS & PERITONEAL INFECTIONS W CC		
16	312	SYNCOPE & COLLAPSE		
17	310	CARDIAC ARRHYTHMIA & CONDUCTION DISORDERS W/O CC/MCC	13	1.2%
18	948	SIGNS & SYMPTOMS W/O MCC		
19	301	PERIPHERAL VASCULAR DISORDERS W/O CC/MCC		
20	871	SEPTICEMIA W/O MV 96+ HOURS W MCC	12	1.1%
21	291	HEART FAILURE & SHOCK W MCC	11	1%
22	300	PERIPHERAL VASCULAR DISORDERS W CC	11	1%
23	69	TRANSIENT ISCHEMIA		
24	308	CARDIAC ARRHYTHMIA & CONDUCTION DISORDERS W MCC		
26	556	SIGNS & SYMPTOMS OF MUSCULOSKELETAL SYSTEM & CONN TISSUE W/O MCC	10	0.9%
27	287	CIRCULATORY DISORDERS EXCEPT AMI, W CARD CATH W/O MCC	9	0.8%
28	194	SIMPLE PNEUMONIA & PLEURISY W CC		
29	193	SIMPLE PNEUMONIA & PLEURISY W MCC	8	0.7%
30	554	BONE DISEASES & ARTHROPATHIES W/O MCC		
31	502	SOFT TISSUE PROCEDURES W/O CC/MCC		
32	689	KIDNEY & URINARY TRACT INFECTIONS W MCC		
33	247	PERC CARDIOVASC PROC W DRUG-ELUTING STENT W/O MCC	7	0.6%
34	195	SIMPLE PNEUMONIA & PLEURISY W/O CC/MCC		
35	552	MEDICAL BACK PROBLEMS W/O MCC		
36	902	WOUND DEBRIDEMENTS FOR INJURIES W CC		
37	903	WOUND DEBRIDEMENTS FOR INJURIES W/O CC/MCC		
38	293	HEART FAILURE & SHOCK W/O CC/MCC		
39	684	RENAL FAILURE W/O CC/MCC		
40	204	RESPIRATORY SIGNS & SYMPTOMS		
41	379	G.I. HEMORRHAGE W/O CC/MCC	6	0.6%
42	313	CHEST PAIN		
43	394	OTHER DIGESTIVE SYSTEM DIAGNOSES W CC		
44	373	MAJOR GASTROINTESTINAL DISORDERS & PERITONEAL INFECTIONS W/O CC/MCC		
45	562	FX, SPRN, STRN & DISL EXCEPT FEMUR, HIP, PELVIS & THIGH W/O MCC	5	0.5%
46	175	PULMONARY EMBOLISM W MCC		
47	907	OTHER O.R. PROCEDURES FOR INJURIES W MCC		
48	501	SOFT TISSUE PROCEDURES W CC		
49	682	RENAL FAILURE W MCC		
50	391	ESOPHAGITIS, GASTROENT & MISC DIGEST DISORDERS W MCC		
51	390	G.I. OBSTRUCTION W/O CC/MCC		
52	243	PERMANENT CARDIAC PACEMAKER IMPLANT W CC	4	0.4%
53	149	DYSEQUILIBRIUM		
54	561	AFTERCARE, MUSCULOSKELETAL SYSTEM & CONNECTIVE TISSUE W/O CC/MCC		
55	65	INTRACRANIAL HEMORRHAGE OR CEREBRAL INFARCTION W CC		
56	87	TRAUMATIC STUPOR & COMA, COMA <1 HR W/O CC/MCC	3	0.3%
57	559	AFTERCARE, MUSCULOSKELETAL SYSTEM & CONNECTIVE TISSUE W MCC		
58	493	LOWER EXTREM & HUMER PROC EXCEPT HIP,FOOT,FEMUR W CC		

Number	DRG code Number	DRG code descriptor	Frequency	Percent
59	252	OTHER VASCULAR PROCEDURES W MCC	3	0.3%
60	253	OTHER VASCULAR PROCEDURES W CC		
61	389	G.I. OBSTRUCTION W CC		
62	57	DEGENERATIVE NERVOUS SYSTEM DISORDERS W/O MCC		
63	74	CRANIAL & PERIPHERAL NERVE DISORDERS W/O MCC		
64	92	OTHER DISORDERS OF NERVOUS SYSTEM W CC		
65	329	MAJOR SMALL & LARGE BOWEL PROCEDURES W MCC		
66	386	INFLAMMATORY BOWEL DISEASE W CC		
67	581	OTHER SKIN, SUBCUT TISS & BREAST PROC W/O CC/MCC		
68	864	FEVER OF UNKNOWN ORIGIN		
69	440	DISORDERS OF PANCREAS EXCEPT MALIGNANCY W/O CC/MCC		
70	439	DISORDERS OF PANCREAS EXCEPT MALIGNANCY W CC	2	0.2%
71	100	SEIZURES W MCC		
72	227	CARDIAC DEFIBRILLATOR IMPLANT W/O CARDIAC CATH W/O MCC		
73	645	ENDOCRINE DISORDERS W/O CC/MCC		
74	93	OTHER DISORDERS OF NERVOUS SYSTEM W/O CC/MCC		
75	638	DIABETES W CC		
77	494	LOWER EXTREM & HUMER PROC EXCEPT HIP,FOOT,FEMUR W/O CC/MCC		
78	249	PERC CARDIOVASC PROC W NON-DRUG-ELUTING STENT W/O MCC		
79	251	PERC CARDIOVASC PROC W/O CORONARY ARTERY STENT OR AMI W CC		
80	870	SEPTICEMIA W MV 96+ HOURS		
81	917	POISONING & TOXIC EFFECTS OF DRUGS W MCC	2	0.2%
82	280	ACUTE MYOCARDIAL INFARCTION, DISCHARGED ALIVE W MCC		
83	283	ACUTE MYOCARDIAL INFARCTION, EXPIRED W MCC		
84	286	CIRCULATORY DISORDERS EXCEPT AMI, W CARD CATH W MCC		
85	315	OTHER CIRCULATORY SYSTEM DIAGNOSES W CC		
86	357	OTHER DIGESTIVE SYSTEM O.R. PROCEDURES W CC		
87	371	MAJOR GASTROINTESTINAL DISORDERS & PERITONEAL INFECTIONS W MCC		
88	698	OTHER KIDNEY & URINARY TRACT DIAGNOSES W MCC		
89	699	OTHER KIDNEY & URINARY TRACT DIAGNOSES W CC		

Table 37: Local or Procedure-related complications (conditions and procedures) that occurred following primary TKA

Number	DRG code Number	DRG code descriptor	Frequency	Percent
1	863	POSTOPERATIVE & POST-TRAUMATIC INFECTIONS W/O MCC	32	2.9%
2	486	KNEE PROCEDURES W PDX OF INFECTION W CC	24	2.2%
3	857	POSTOPERATIVE OR POST-TRAUMATIC INFECTIONS W O.R. PROC W CC	13	1.2%
4	488	KNEE PROCEDURES W/O PDX OF INFECTION W CC/MCC	12	1.1%
5	921	COMPLICATIONS OF TREATMENT W/O CC/MCC		
6	467	REVISION OF HIP OR KNEE REPLACEMENT W CC	11	1%
7	464	WND DEBRID & SKN GRFT EXC HAND, FOR MUSCULO-CONN TISS DIS W CC	9	0.8%
8	481	HIP & FEMUR PROCEDURES EXCEPT MAJOR JOINT W CC	8	0.7%
9	468	REVISION OF HIP OR KNEE REPLACEMENT W/O CC/MCC	7	0.6%
10	482	HIP & FEMUR PROCEDURES EXCEPT MAJOR JOINT W/O CC/MCC	6	0.6%
11	920	COMPLICATIONS OF TREATMENT W CC		
12	487	KNEE PROCEDURES W PDX OF INFECTION W/O CC/MCC	4	0.4%
13	480	HIP & FEMUR PROCEDURES EXCEPT MAJOR JOINT W MCC	3	0.3%
14	862	POSTOPERATIVE & POST-TRAUMATIC INFECTIONS W MCC		
15	496	LOCAL EXCISION & REMOVAL INT FIX DEVICES EXC HIP & FEMUR W CC		
16	463	WND DEBRID & SKN GRFT EXC HAND, FOR MUSCULO-CONN TISS DIS W MCC	2	0.2%
17	856	POSTOPERATIVE OR POST-TRAUMATIC INFECTIONS W O.R. PROC W MCC		
18	550	SEPTIC ARTHRITIS W/O CC/MCC		
19	485	KNEE PROCEDURES W PDX OF INFECTION W MCC		

Table 38: Unrelated Conditions and procedures that occurred following primary TKA

Number	DRG code Number	DRG code descriptor	Frequency	Percent
1	192	CHRONIC OBSTRUCTIVE PULMONARY DISEASE W/O CC/MCC	8	0.7%
2	203	BRONCHITIS & ASTHMA W/O CC/MCC	5	0.5%
3	639	DIABETES W/O CC/MCC		
4	694	URINARY STONES W/O ESW LITHOTRIPSY W/O MCC		
5	812	RED BLOOD CELL DISORDERS W/O MCC		
6	202	BRONCHITIS & ASTHMA W CC/MCC	4	0.4%
7	167	OTHER RESP SYSTEM O.R. PROCEDURES W CC	2	0.2%
8	417	LAPAROSCOPIC CHOLECYSTECTOMY W/O C.D.E. W MCC		
9	607	MINOR SKIN DISORDERS W/O MCC		
10	669	TRANSURETHRAL PROCEDURES W CC		

Reasons for 30-day post-IRF readmission based on obesity-status among the THA cohort

Table 39 presents number and proportion of local, systemic and unrelated reasons for readmission in each of the three obesity-related categories among the THA cohort.

Table 39: Frequencies of reasons for readmission among the THA cohort by obesity status

Reason for Readmission	Obesity Status n (%)			Total n (%)
	Normal Weight	Overweight and Obesity	Morbid Obesity	
Local	79 (22.3%)	17 (21.5%)	45 (40.2%)	141 (25.8%)
Systemic	133 (37.5%)	30 (38%)	33 (29.5%)	196 (35.9%)
Unrelated	143 (40.3%)	32 (40.5%)	34 (30.4%)	209 (38.3%)
Total	355 (100%)	79 (100%)	112 (100%)	546 (100%)

Table 40 summarizes the results of multinomial logistic regression in both the unadjusted and adjusted models among the THA cohort.

Table 40: Multinomial Logistic Regression for Reason for among THA cohort

Obesity Status (Reference: Normal weight)	**Reason for Readmission – Unadjusted Model (Reference: Unrelated)**		**Reason for Readmission – Adjusted Model (Reference: Unrelated)**	
	Systemic	**Local**	**Systemic**	**Local**
Overweight and Obesity	1.0 (0.6-1.8)	1.0 (0.5-1.8)	1.0 (0.6-1.9)	0.9 (0.4-1.8)
Morbid Obesity	1.0 (0.6-1.8)	**2.4 (1.4-4.0)**	0.9 (0.5-1.6)	**2.1 (1.1-4.0)**

Values represent odds ratio and 95% Wald confidence interval

Figures 21 and 22 depict the odds ratios for reasons for readmission in the unadjusted and adjusted models respectively, among the THA cohort.

Figure 21: Odds ratio estimates for systemic and local complication among THA cohort (unadjusted model)

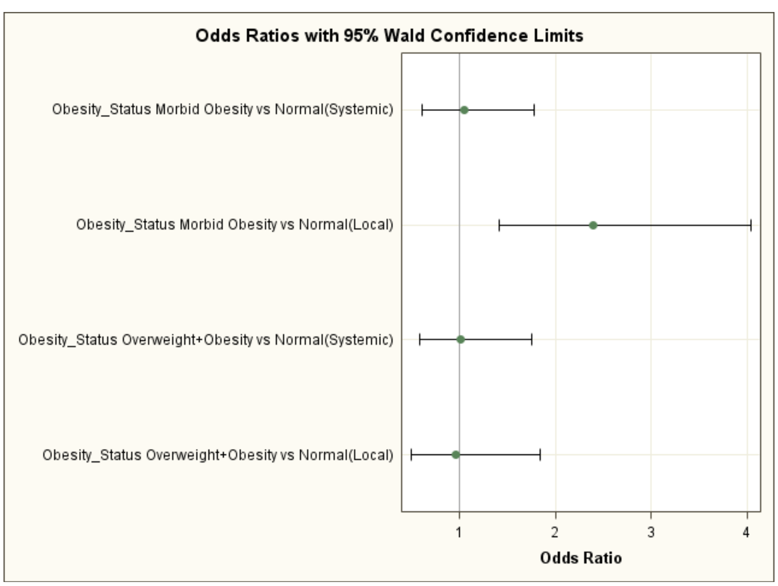
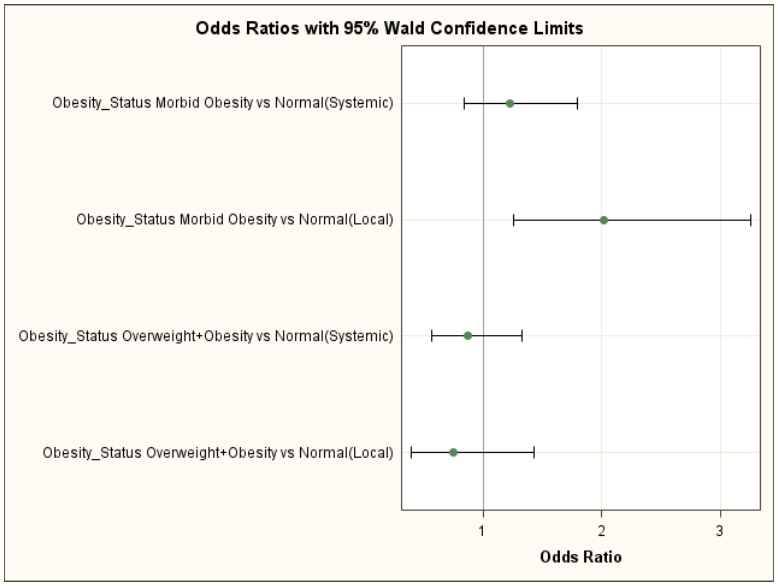


Figure 22: Odds ratio estimates for systemic and local complication among TKA cohort (unadjusted model)



Reasons for 30-day post-IRF readmission based on obesity-status among the TKA cohort:

Table 41 presents number and proportion of local, systemic and unrelated reasons for readmission in each of the three obesity-related categories among the TKA cohort.

Table 41: Frequencies of reasons for readmission among the TKA cohort by obesity status

Reason for Readmission	Obesity Status n (%)			Total n (%)
	Normal Weight	Overweight and Obesity	Morbid Obesity	
Local	84 (12.9%)	17 (11.0%)	57 (20.3%)	158 (14.5%)
Systemic	434 (66.6%)	101 (65.6%)	179 (63.7%)	714 (65.7%)
Unrelated	134 (20.6%)	36 (23.4%)	45 (16.0%)	215 (19.8%)
Total	652 (100%)	154 (100%)	281 (100%)	1087 (100%)

Table 42 summarizes the results of multinomial logistic regression in both the unadjusted and adjusted models among the TKA cohort.

Table 42: Multinomial Logistic Regression for Reason for Readmission based on Obesity Status among the TKA cohort

Obesity Status (Reference: Normal weight)	**Reason for Readmission – Unadjusted Model (Reference: Unrelated)**		**Reason for Readmission – Adjusted Model (Reference: Unrelated)**	
	Systemic	**Local**	**Systemic**	**Local**
Overweight and Obesity	0.9 (0.6-1.3)	0.8 (0.4-1.4)	0.9 (0.6-1.4)	0.8 (0.4-1.5)
Morbid Obesity	1.2 (0.8-1.8)	**2.0 (1.3-3.3)**	1.3 (0.8-2.0)	**2.0 (1.1-3.6)**

Values represent odds ratio and 95% Wald confidence interval

Summary of Multinomial Logistic Regression for Reason-for-Readmission among the THA and TKA cohorts

Among those readmitted in both the THA (Table 41) and TKA (Table 42) cohorts, morbid obesity was found to be significantly associated with 'local' reasons for readmission. This was true in the unadjusted and adjusted (accounting for all covariates) models. No other associations of obesity status (and other covariates) and the type of reasons for readmission (systemic versus local) were significant.

SUMMARY OF FINDINGS FOR ASSOCIATION OF OBESITY WITH 30-DAY HOSPITAL READMISSION

Thirty-Day Hospital Readmission Among THA cohort

- Morbid obesity was significantly associated with greater risk for 30-day hospital readmission.
- In the Logistic models, the interaction effects between obesity status and race/ethnicity, and between obesity status and gender, were not significant for the outcome of 30-day hospital readmission. However, in the Cox models, the

interaction effect between morbid obesity and race/ethnicity (Non-White versus White) and between morbid obesity and gender were significantly associated with greater risk for 30-day hospital readmission.

- Time to 30-day hospital readmission was significantly different between the three obesity-related categories.

Reason for readmission among beneficiaries in the THA cohort who experienced a 30-day hospital readmission

- Morbid obesity was significantly associated with greater odds for readmission because of ‘local’ or ‘procedure-related’.

Thirty-Day Hospital Readmission Among TKA cohort

- Obesity status was not significantly associated with the outcome of 30-day post-IRF hospital readmission.
- No significant interaction effect between obesity status and race/ethnicity and between obesity status and gender was found for the outcome of 30-day hospital readmission.
- Time to 30-day hospital readmission was not significantly different between the three obesity-related categories.

Reason for readmission among beneficiaries in the TKA cohort who experienced a 30-day hospital readmission

- Morbid obesity was significantly associated with greater odds readmission because of ‘local’ or ‘procedure-related’.

CHAPTER 6

Aim 3: Effect of Obesity on Mortality among Medicare Beneficiaries with Total Hip or Total Knee Arthroplasties

INTRODUCTION

This chapter presents the results of descriptive statistics, survival analysis examining differences between obesity categories, with respect to time to death, as well as cox proportional hazard models for the outcome of mortality, among Medicare Beneficiaries who underwent THA or TKA during 2012 and 2013. For the purpose of all the statistical analyses in this chapter, all mortality that occurred through end of calendar year 2013, for the entire analytical samples of THA and TKA, was included.

The descriptive statistics involved the stratification of each of the THA and TKA cohorts based on beneficiaries who died versus survived after IRF discharge through the end of calendar year 2013. Socio-demographic characteristics (in the form of numbers and percentages, and means and standard deviations), as well as variables and values representing the beneficiaries' health status including: disability status, discharge motor FIM scores, prevalence of obesity and other comorbid conditions (Tier comorbidities, Elixhauser comorbidities and hospital acquired conditions), have been described. T-tests and chi-square statistics were used to determine differences in the above variables based on mortality status (died versus survived).

Survival analysis was performed to determine the time to death, and comparisons were made between the survival curves for the three obesity-related categories. The unit used for time to death was 200 days for the purpose of plotting the Kaplan-Myer curves.

Main and interaction effects were tested using Cox proportional regression analysis. Because of low number of events, Non-Hispanic Black and Hispanic race/ethnicities were combined into one category: Non-White for the purpose of testing the interaction effect of obesity status and race/ethnicity.

RESULTS OF DESCRIPTIVE STATISTICS

Mortality by socio-demographic characteristics and comorbidities among the THA cohort

There were 11,555 beneficiaries in the THA cohort. The proportion among the cohort who died was 2.7%. Mortality was highest among beneficiaries in the normal weight category (3%) and lowest among those in the morbid obesity category 1.9%. The proportion of beneficiaries who died among those with a HAC, a Tier comorbidity, Medicare-Medicaid dual eligibility, and disability; was 6.6%, 4.2%, 2.8%, and 2.7% respectively. Mortality was also high among beneficiaries with EC – the highest being among those with metastatic cancer (23.3%) congestive heart failure (7.5%), renal failure (7%), pulmonary circulation disease (6.1%), lymphoma (5.9%), solid tumor without metastasis (5.5%), arrhythmia (5.1%), peripheral vascular disease (5%), and chronic pulmonary disease (4.6%). Comparing between race/ethnicity categories, mortality was highest among Non-Hispanic White beneficiaries (2.8%) and lowest among Hispanic beneficiaries (0.8%). Mortality was higher among men (3.7%) compared to women (2.2%). Mortality was also slightly higher among beneficiaries discharged from an in-hospital rehabilitation unit 3%) compared to that among beneficiaries discharged from a free-standing IRF (2.4%).

Mortality by socio-demographic characteristics and comorbidities among the TKA cohort

The TKA cohort size was 22,705 beneficiaries. The proportion of mortality among the cohort was 2.1%. Deaths were highest among beneficiaries in the normal weight category (2.3%) and the least among those in the morbid obesity category (1.8%). Mortality among those with a HAC, Tier comorbidity, a disability, and Medicare-Medicaid dual eligibility, was 2.8%, 2.7%, 2.2%, and 2.2% respectively. Mortality was high among beneficiaries with EC namely metastatic cancer (12%), lymphoma (7.9%), pulmonary circulation disease (5.4%), congestive heart failure (5%), and renal failure (4.7%). The proportion of mortality was highest among Non-Hispanic White beneficiaries (2.2%) and lowest among Hispanic beneficiaries (0.9%). Mortality was higher among men (3.4%) compared to women (1.6%). Beneficiaries discharged from in-hospital rehabilitation unit had higher mortality (2.5%) compared to those discharged from a free-standing IRF (1.7%).

Socio-demographic characteristics and comorbidities of beneficiaries who died among the THA cohort

Beneficiaries who died had a significantly higher proportion of individuals in the normal weight category and significantly lower proportions of individuals in the ‘overweight and obesity’ and the morbid obesity categories, as compared to beneficiaries who survived (Table 43).

Table 43: Socio-demographic characteristics and comorbidities for mortality among the THA and TKA cohorts

Cohort	THA		TKA	
Mortality status	**Died**	**Survived**	**Died**	**Survived**
Sample Size [n]	311	11,244	476	22,229
Obesity Status				
Normal weight	245 (78.8%)^	7,973 (70.9%)^	312 (65.6%)	13,512 (60.8%)
Overweight and Obesity	32 (10.3%)	1,482 (13.2%)	62 (13%)	3,279 (14.8%)
Morbid Obesity	34 (10.9%)	1,789 (15.9%)	102 (21.4%)	5,438 (24.5%)
Age	81.0 (7.2)*	77.6 (7.1)*	79.2 (7.2)	76.2 (6.8)
Gender				
Men	136 (43.7%)*	3,500 (31.1%)*	226 (47.5%)*	6,357 (28.6%)*
Women	175 (56.3%)	7,744 (68.9%)	250 (52.5%)	15,872 (71.4%)
Race/ethnicity				
White	291 (93.6%)^^	10,101 (89.8%)^^	426 (89.5%)^	18,929 (85.2%)^
Black	17 (5.5%)	761 (6.8%)	37 (7.8%)	1857 (8.4%)
Hispanic	3 (1%)	382 (3.4%)	13 (2.7%)	1443 (6.5%)
*** Living with someone**	190 (61.1%)*	7,774 (69.1%)*	278 (58.4%)*	16,011 (72%)*
*** Married**	136 (43.7%)	5,206 (46.3%)	208 (43.7%)	10,769 (48.5%)
*** Social Support**	222 (71.6%)	8,247 (73.5%)	331 (69.8%)^	16,854 (76%)^
Medicare-Medicaid Dual Eligibility	30 (9.7%)	1,025 (9.1%)	60 (12.6%)	2,696 (12.1%)
Disability	30 (9.7%)	1,097 (9.8%)	61 (12.8%)	2,711 (12.2%)
IRF length of stay (days)	11.2 (4.0)*	10.0 (3.5)*	10.3 (3.8)*	9.4 (3.3)*
IRF Type				
In-Hospital Unit	183 (58.8%)	6,004 (53.4%)	288 (60.5%)*	11,202 (50.4%)*
Free standing	128 (41.2%)	5,240 (46.6%)	188 (39.5%)	11,027 (49.6%)
Community Discharge	236 (75.9%)*	10,204 (90.8%)*	358 (75.2%)*	20,770 (93.4%)*
Admission Motor FIM	37.7 (9.7)*	41.7 (8.9)*	38.9 (10.1)*	42.9 (9.2)*
Discharge Motor FIM	61.5 (14.0)*	70.0 (9.5)*	63.2 (14.1)*	71.7 (9.1)*
Admission Cognition FIM	25.06 (6.0)*	27.4 (5.3)*	25.3 (5.8)*	27.6 (5.3)*
Discharge Cognition FIM	29.0 (5.4)*	31.6 (3.6)*	29.6 (4.8)*	31.8 (3.6)*
Tier Comorbidity	114 (36.7%)*	2,590 (23%)*	202 (42.4%)*	7,292 (32.8%)*
Tier Case Mix Group				
Tier 0	197 (63.3%)*	8,654 (77%)*	274 (57.6%)*	14,937 (67.2%)*
Tier 1	11 (3.5%)	53 (0.5%)	6 (1.3%)	101 (0.5%)
Tier 2	13 (4.2%)	261 (2.3%)	14 (2.9%)	458 (2.1%)
Tier 3	90 (28.9%)	2,276 (20.2%)	182 (38.2%)	6,733 (30.3%)
Hospital Acquired Condition (HAC)	33 (10.6%)*	467 (4.2%)*	30 (6.3%)	1,059 (4.8%)
HAC: sum	0.1 (0.3)*	0.0 (0.2)*	0.1 (0.3)	0.1 (0.2)
Elixhauser comorbidities (EC): sum	3.9 (1.7)*	2.9 (1.5)*	3.7 (1.7)*	3.0 (1.5)*
EC: Congestive heart failure	59 (19%)*	723 (6.4%)*	74 (15.6%)*	1,404 (6.3%)*
EC: Valvular disease	22 (7.1%)	583 (5.2%)	32 (6.7%)^^	1,045 (4.7%)^^
EC: Pulmonary circulation disease	10 (3.2%)^	154 (1.4%)^	22 (4.6%)*	387 (1.7%)*
EC: Peripheral vascular disease	29 (9.3%)**	555 (4.9%)**	37 (7.8%)**	946 (4.3%)**
EC: Paralysis	5 (1.6%)	153 (1.4%)	13 (2.7%)	402 (1.8%)
EC: Other neurological disorders	31 (10%)	859 (7.6%)	42 (8.8%)	1825 (8.2%)
EC: Chronic pulmonary disease	96 (30.9%)*	1,984 (17.6%)*	113 (23.7%)^	3,994 (18%)^
EC: Hypothyroidism	72 (23.2%)	2,634 (23.4%)	108 (22.7%)	5,480 (24.7%)
EC: Renal failure	75 (24.1%)*	995 (8.9%)*	111 (23.3%)*	2,240 (10.1%)*
EC: Liver disease	2 (0.6%)	71 (0.6%)	3 (0.6%)	130 (0.6%)
EC: Peptic ulcer Disease w/o bleeding	0	6 (0.1%)	0	3 (0.0%)
EC: Acquired immune deficiency syndrome	0	5 (0.0%)	0	4 (0.0%)
EC: Lymphoma	4 (1.3%)	64 (0.6%)	7 (1.5%)**	82 (0.4%)**
EC: Metastatic cancer	7 (2.3%)*	23 (0.2%)*	3 (0.6%)**	22 (0.1%)**
EC: Solid tumor without metastasis	6 (1.9%)	103 (0.9%)	6 (1.3%)	150 (0.7%)
EC: Rheumatoid arthritis/ collagen vascular disease	17 (5.5%)	682 (6.1%)	25 (5.3%)	1314 (5.9%)
EC: Coagulopthy	21 (6.8%)^^	458 (4.1%)^^	28 (5.9%)	979 (4.4%)
EC: Weight loss	26 (8.4%)^	570 (5.1%)^	19 (3.99%)	1,043 (4.7%)
EC: Fluid and electrolyte disorders	65 (20.9%)	1,882 (16.7%)	111 (23.3%)*	3,617 (16.3%)*
EC: Chronic blood loss anemia	11 (3.5%)	300 (2.7%)	13 (2.7%)	494 (2.2%)

Cohort	THA		TKA	
Mortality status	**Died**	**Survived**	**Died**	**Survived**
EC: Deficiency Anemias	148 (47.6%)^	4,521 (40.2%)^	187 (39.3%)	8,402 (37.8%)
EC: Psychoses	7 (2.3%)	248 (2.2%)	19 (3.99%)	609 (2.7%)
EC: Depression	71 (22.8%)**	1,769 (15.7%)**	81 (17.0%)	3,958 (17.8%)
EC: Hypertension	246 (79.1%)	9,009 (80.1%)	402 (84.5%)	18,375 (82.7%)
EC: Arrhythmias	105 (33.8%)*	1,968 (17.5%)*	145 (30.5%)*	3,911 (17.6%)*
EC: Diabetes w/o chronic complications	68 (21.9%)	2,141 (19.0%)	132 (27.7%)	5,362 (24.1%)
EC: Diabetes w/ chronic complications	21 (6.8%)	503 (4.5%)	46 (9.7%)	1,495 (6.7%)

Foot-notes: 1). Values represent: Number (Percent%) / Mean (Standard Deviation). 2). The percent (%) values demonstrate proportions within each of the sub-cohorts based on mortality status (column percent) among the overall sample, THA and TKA cohorts. 3). *Married, *Living with someone, and *Social Support have missing values, among each of the THA and TKA cohorts. 4) * = p<.0001, ** = p<.001, ^p<.01 ^^p<.05 demonstrate degree of statistically significant differences among those who died versus survived. 5). Values without any * or ^ have p>.05.

Beneficiaries who died were significantly older, had significantly lower proportions of women, Non-Hispanic Black and Hispanic race/ethnicities, individuals discharged to the community, and lower motor and cognition FIM scores at IRF admission and discharge, as compared to beneficiaries who survived. Beneficiaries who died had significantly longer length of IRF stay, greater proportion of individuals with a Tier comorbidity, with significantly greater numbers of Tier 1, 2 and 3 case-mix groups, with a HAC, with greater number of HAC and EC, and a greater proportion of individuals with the EC: congestive heart failure, pulmonary circulation disease, peripheral vascular disease, chronic pulmonary disease, renal failure, metastatic cancer, coagulopathy, chronic weight loss, deficiency anemia, depression and arrhythmia, as compared to beneficiaries who survived (Table 43).

Socio-demographic characteristics and comorbidities of beneficiaries who died among the TKA cohort

A significantly higher proportion of beneficiaries who died were men, Non-Hispanic White, had a longer IRF length of stay, had greater proportion of individuals discharged from an in-hospital rehabilitation unit, significantly greater proportion of individuals with a Tier comorbidity, individuals with significantly higher number of EC, and significantly higher proportions of the EC: congestive heart failure, valvular disease, pulmonary circulation disease, peripheral vascular disease, chronic pulmonary disease, renal failure, lymphoma, metastatic cancer, fluid and electrolyte disorder, and arrhythmia; as compared to beneficiaries who survived. Beneficiaries who died had a significantly lower proportion of individuals in the Tier 0 case mix group category, significantly lower proportion of individuals with social support, discharged to community, with significantly lower motor and cognition FIM scores at IRF admission and discharge; as compared to beneficiaries who survived (Table 43).

SURVIVAL ANALYSIS FOR TIME TO DEATH AFTER IRF DISCHARGE

Kaplan-Myer Survival Curves for the outcome of mortality among the THA and TKA cohorts

Based on the log-rank test, time to death was significantly different (p = 0.0094) between the three obesity-related categories among the THA cohort (Figure 23). The log-rank test for TKA cohort was not significant (p = 0.1087) (Figure 24).

Figure 23: Kaplan-Myer curve for the outcome of mortality (Time to death - by obesity status) among THA cohort

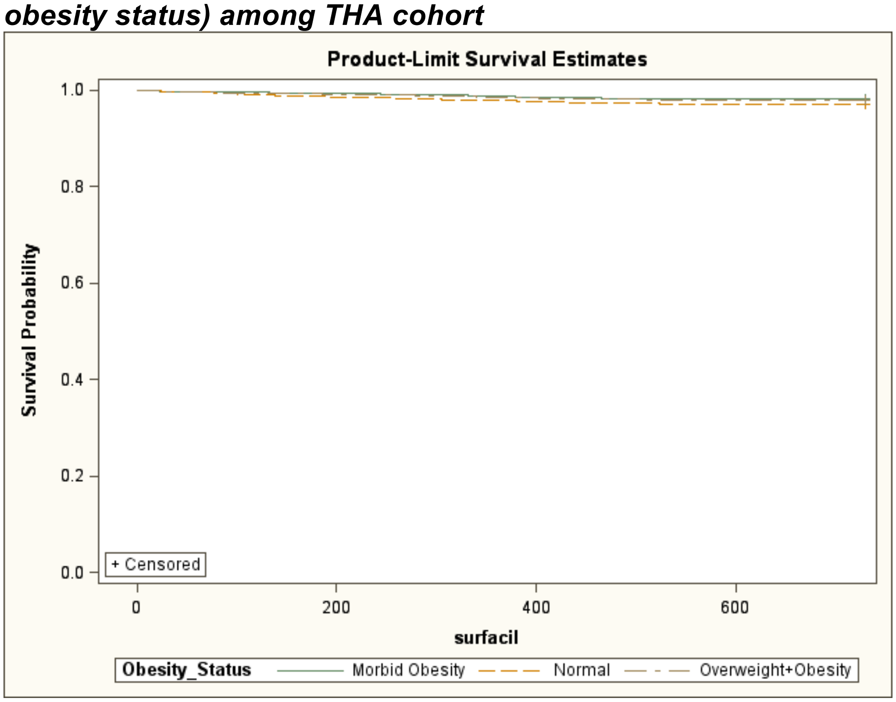
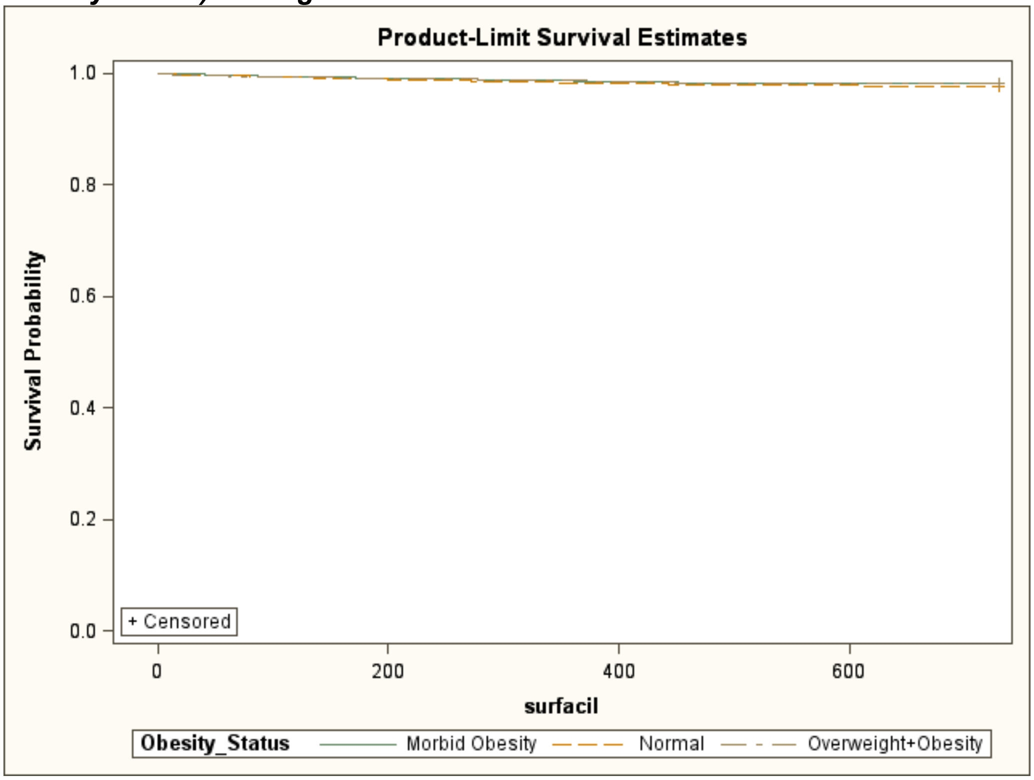


Figure 24: Kaplan-Myer curve for the outcome of mortality (Time to death - by obesity status) among TKA cohort



RESULTS OF COX PROPORTIONALITY REGRESSION ANALYSES

Results of Cox Regression Models for mortality after IRF discharge among THA cohort

Morbid obesity was significantly associated with a 40% lower risk for mortality. Each year increase in age was associated with 4 % increase in risk of mortality. Female gender was associated with 30% lower risk of mortality. Although not significant Non-Hispanic Black and Hispanic race/ethnicities were associated with lower risk for mortality compared to Non-Hispanic White. Every unit increase in discharge motor FIM was associated with a 10% lower risk for mortality. The presence of Tier comorbidity and HAC were associated with 50% and 80% higher risk for mortality, respectively. The presence of ECs namely chronic pulmonary disease and renal failure were each associated with twice as greater a risk for mortality as compared to the absence of these

ECs. The presence of EC namely metastatic cancer was associated with nearly 12 times greater risk for mortality (Table 44).

Because of low number of events, Non-Hispanic Black and Hispanic race/ethnicities were combined into one category: Non-white for the interaction effect analysis. The interaction effects of morbid obesity and race/ethnicity (Non-White) and morbid obesity and of morbid obesity and gender were also significantly associated with lower risk of mortality (Table 44).

Table 44: Cox Proportional Hazard Models for mortality after IRF discharge among THA cohort

Independent Variable, Covariates, and Interaction Variables	Model for testing main effects, adjusting for all covariates	Model for testing interaction effect between obesity and race/ethnicity	Model for testing interaction effect between obesity and gender
Obesity Status			
Normal weight	Reference	Reference	Reference
Overweight and Obesity	0.8 (0.5-1.1)	0.8 (0.5-1.1)	0.8 (0.5-1.1)
Morbid Obesity	0.6 (0.4-0.9)	0.6 (0.4-0.9)	0.6 (0.4-0.9)
Age	1.0(1.0-1.1)	1.0(1.0-1.1)	1.0(1.0-1.1)
Gender			
Male	Reference	Reference	Reference
Female	0.7 (0.5-0.9)	0.7 (0.5-0.9)	0.7 (0.5-0.9)
Race/ethnicity			
Non-Hispanic White	Reference	Reference	Reference
Non-Hispanic Black	0.8 (0.5-1.4)	0.8 (0.5-1.4)	0.8 (0.5-1.4)
Hispanic	0.3 (0.1-1.0)	0.3 (0.1-1.0)	0.3 (0.1-1.0)
Discharge Motor FIM	0.9 (0.9-0.9)	0.9 (0.9-0.9)	0.9 (0.9-0.9)
Tier Comorbidity	1.5 (1.1-1.9)	1.5 (1.1-1.9)	1.5 (1.1-1.9)
Hospital Acquired Conditions (HAC)	1.8 (1.2-2.5)	1.8 (1.2-2.5)	1.8 (1.2-2.5)
EC: Congestive Health Failure	1.6 (1.2-2.2)	1.6 (1.2-2.2)	1.6 (1.2-2.2)
EC: Chronic Pulmonary Disease	2.0 (1.5-2.5)	2.0 (1.5-2.5)	2.0 (1.5-2.5)
EC: Renal Failure	2.0 (1.5-2.6)	2.0 (1.5-2.6)	2.0 (1.5-2.6)
EC: Metastatic Cancer	11.9 (5.5-25.6)	11.9 (5.5-25.6)	11.9 (5.5-25.6)
EC: Depression	1.5 (1.2-2.0)	1.5 (1.2-2.0)	1.5 (1.2-2.0)
EC: Arrhythmias	1.5 (1.1-1.9)	1.5 (1.1-1.9)	1.5 (1.1-1.9)
Obesity status by Race-Ethnicity	-		-
Overweight-Obesity for Non-White		1.3 (0.9-1.9)	
Morbid Obesity for Non-White		0.6 (0.4-0.9)	
Obesity status by Gender	-	-	
Overweight-Obesity for Female			1.3 (0.9-1.9)
Morbid Obesity for Female			0.6 (0.4-0.9)

Values represent Hazard Ratio (95% confidence limits). Although all models were adjusted for all the covariates, only the statistically significant hazard ratios have been reported in addition to the values for obesity status, gender, race/ethnicity, and the differential effects terms. The hazard ratio value and the lower limit value of the 95% CI for the covariate age are rounded to 1.0, but are slightly greater in value than 1.0.

Results of Cox Regression Models for mortality after IRF discharge among TKA cohort

Obesity status was not significantly associated with risk for mortality. Every one year increase in age was associated with a 4% higher risk for mortality. Female gender was associated with 40% lower risk for mortality. Hispanic race/ethnicity was associated with 60% lower risk for mortality. Although not significant, Non-Hispanic Black race/ethnicity demonstrates a protective effect for the outcome of risk for mortality. Each unit increase in discharge motor FIM score was associated with a 10% lower risk for mortality (Table 45).

The presence of the ECs lymphoma and metastatic cancer were respectively associated with 4 and 6 times higher risk for mortality. The presence of each of the ECs namely pulmonary circulation disorder, renal failure, congestive heart failure, arrhythmias, and chronic pulmonary disease, were associated with a 70%, 60%, 40%, 40% and 30% increased risk for mortality, respectively. Receiving rehabilitation at a free-standing IRF compared to an in-hospital unit was associated with 20% lower risk for mortality. Because of low number of events, Non-Hispanic Black and Hispanic race/ethnicities were combined into one category: Non-white for the interaction effect analysis. The interaction effect between obesity status and race/ethnicity (for Non-White) and obesity status and gender, were not significantly associated with the risk for mortality (Table 45).

Table 45: Cox Proportional Hazard Models for mortality after IRF discharge among TKA cohort

Independent Variable, Covariates, and Interaction Variables	Model for testing main effects, adjusting for all covariates	Model for testing interaction effect between obesity and race/ethnicity	Model for testing interaction effect between obesity and gender
Obesity Status			
Normal weight	Reference	Reference	Reference
Overweight and Obesity	1.0 (0.8-1.3)	1.0 (0.8-1.3)	1.0 (0.8-1.3)
Morbid Obesity	0.9 (0.7-1.2)	0.9 (0.7-1.2)	0.9 (0.7-1.2)
Age	1.0 (1.0-1.1)	1.0 (1.0-1.1)	1.0 (1.0-1.1)
Gender			
Male	Reference	Reference	Reference
Female	0.6 (0.5-0.7)	0.6 (0.5-0.7)	0.6 (0.5-0.7)
Race/ethnicity			
Non-Hispanic White	Reference	Reference	Reference
Non-Hispanic Black	0.8 (0.6-1.2)	0.8 (0.6-1.2)	0.8 (0.6-1.2)
Hispanic	0.4 (0.3-0.7)	0.4 (0.3-0.7)	0.4 (0.3-0.7)
Discharge Motor FIM	0.9 (0.9-0.9)	0.9 (0.9-0.9)	0.9 (0.9-0.9)
Type of IRF			
In-hospital Unit	Reference	Reference	Reference
Free-standing	0.8 (0.7-0.9)	0.8 (0.7-0.9)	0.8 (0.7-0.9)
EC: Congestive Heart Failure	1.4 (1.1-1.8)	1.4 (1.1-1.8)	1.4 (1.1-1.8)
EC: Pulmonary Circulation Disorder	1.7 (1.1-2.7)	1.7 (1.1-2.7)	1.7 (1.1-2.7)
EC: Chronic Pulmonary Disease	1.3 (1.1-1.6)	1.3 (1.1-1.6)	1.3 (1.1-1.6)
EC: Renal Failure	1.6 (1.3-2.1)	1.6 (1.3-2.1)	1.6 (1.3-2.1)
EC: Lymphoma	4.4 (2.1-9.4)	4.4 (2.1-9.4)	4.4 (2.1-9.4)
EC: Metastatic Cancer	5.7 (1.8-17.9)	5.7 (1.8-17.9)	5.7 (1.8-17.9)
EC: Arrhythmias	1.4 (1.1-1.7)	1.4 (1.1-1.7)	1.4 (1.1-1.7)
Obesity status by Race-Ethnicity			
Overweight-Obesity for Non-White	-	1.0 (0.8-1.3)	-
Morbid Obesity for Non-White		0.9 (0.7-1.2)	
Obesity status by Gender			
Overweight-Obesity for Female	-	-	1.0 (0.8-1.3)
Morbid Obesity for Female			0.9 (0.7-1.2)

Values represent Hazard Ratio (95% confidence limits). Although all models were adjusted for all the covariates, only the statistically significant hazard ratios have been reported in addition to the values for obesity status, gender, race/ethnicity, and the differential effects terms. The hazard ratio value and the lower limit value of the 95% CI for the covariate age are rounded to 1.0, but are slightly greater in value than 1.0.

SUMMARY OF FINDINGS FOR THE OUTCOME OF MORTALITY

Mortality Among THA cohort

- Morbid obesity was significantly associated with lower risk for mortality.
- Time to death was significantly different between the three obesity-related categories.

Mortality Among TKA cohort

- Obesity was not significantly associated with risk for mortality.
- Time to death was not significantly different between the three obesity-related categories.

CHAPTER 7

Discussion

This study investigated the effect of obesity on the rehabilitation outcomes namely discharge motor FIM, discharge cognition FIM, IRF length of stay; association of obesity with the rehabilitation outcome of community discharge, with 30-day hospital readmissions, with reasons for readmission, and with mortality; among Medicare beneficiaries with osteoarthritis, who underwent primary THA or primary TKA, during 2012 and 2013. Based on evidence from existing literature, this study hypothesized that obesity in general, will adversely affect the above outcomes after IRF stay. However, the outcomes of this study differed based on the type of joint replacement procedure: THA or TKA, as well as based on the category of the obesity status: overweight-obesity or morbid obesity.

Among the THA cohort, overweight-obesity and morbid obesity did not significantly affect discharge motor FIM. Among the TKA cohort, overweight-obesity was significantly associated with higher discharge motor FIM compared to the normal weight category. Among both the THA and TKA cohorts, overweight-obesity and morbid obesity were significantly associated with higher discharge cognition FIM. Among the THA cohort, overweight-obesity was significantly associated with longer IRF LOS. Obesity status did not affect the IRF LOS, among the TKA cohort. Obesity was not significantly associated with differences in the likelihood of community versus non-community discharge upon completion of IRF stay, among both the THA and TKA cohorts.

Among the THA cohort, morbid obesity was significantly associated with greater odds and risks for 30-day post-IRF hospital readmission. This association was not significant among the TKA cohort. Among both the THA and TKA cohorts, interaction effects of obesity status with race/ethnicity, and obesity status with gender, were not significantly associated with differences in the odds for 30-day post-IRF hospital readmission. However, differential effects of obesity status by race/ethnicity (Non-White versus White) and by gender were significantly associated with greater risk for 30-day hospital readmission. Time to readmission was significantly different between the three obesity-related categories within the THA cohort, but not within the TKA cohort. Among the beneficiaries who experienced 30-day post-IRF hospital readmission in both the THA and TKA cohorts, morbid obesity was significantly associated with greater odds for the reason for readmission being ‘local’ or ‘procedure-related’. Among both the THA and TKA cohorts, risk for mortality, and time to death, did not differ significantly between the three obesity-related categories.

Based on evidence from existing literature, it was hypothesized that the adverse effect of obesity will be greater among Non-Hispanic Black and Hispanic beneficiaries as compared to Non-Hispanic White beneficiaries. This was tested by modeling three-by-three interaction effects (with the ‘normal weight’ being the reference category for obesity status, and Non-Hispanic White being the reference category for race/ethnicity). It was also hypothesized that the adverse effect of obesity will be greater among women as compared to men.

Among the Hispanic beneficiaries who underwent THA, morbid obesity was significantly associated with higher discharge motor FIM as compared to the normal weight category. Among the Non-Hispanic White beneficiaries who underwent THA, overweight-obesity and morbid obesity were significantly associated with higher discharge cognition FIM as compared the normal weight category. The Interaction of obesity and race/ethnicity was not significantly associated with the outcome of IRF length of stay among the THA cohort.

Among the Hispanic beneficiaries who underwent TKA, morbid obesity was significantly associated with lower discharge motor FIM as compared to the normal weight category. Among the Non-Hispanic White beneficiaries, overweight-obesity was significantly associated with higher discharge motor FIM scores as compared to the normal weight category. The interaction effect between Hispanic race/ethnicity and overweight-obesity was significant for lower discharge cognition FIM. The interaction effect between Hispanic race/ethnicity and morbid obesity was significant for shorter IRF length of stay. Non-Hispanic Black beneficiaries with morbid obesity had significantly shorter IRF length of stay as compared to Non-Hispanic Black beneficiaries in the normal weight category.

For the THA cohort, morbid obesity was found to be significantly associated with greater risk for 30-day hospital readmission. On the other hand, morbid obesity was found to have a protective effect for the outcome of mortality in the THA cohort. The time to 30-day readmission and time to death were found to be significantly different between the three obesity-related categories in the THA cohort, but not in the TKA cohort. Since the effects of obesity status on the outcomes studied differed between the THA and TKA cohorts, Table 46 in Appendix provides the descriptive characteristics of the two cohorts with respect to age, gender and race/ethnicity.

OBESITY AND OUTCOMES

Discharge Motor and Cognition FIM

Overall, the findings of this study were similar to those of Vincent and colleagues (2007) who also found that FIM scores were higher for individuals with overweight and moderate obesity, as compared to those without obesity and those with severe obesity [71]. This study showed that beneficiaries with overweight-obesity had higher functional status at time of IRF discharge compared to beneficiaries in the normal weight category, following both THA and TKA. This concurs with the study by Dere and colleagues (2014) which showed that overweight and obesity among women with osteoarthritis who underwent knee replacement did not have any negative effects on functional recovery [72]. Overweight-obesity and morbid obesity were found to be associated with higher cognition FIM scores at time of IRF discharge, among both the THA and TKA cohorts in this study. These findings contradict those of Vincent and Vincent (2012) who reported that severe obesity was associated with lower cognition FIM [73].

This study also found that Hispanic beneficiaries with morbid obesity who underwent THA had higher DC M-FIM scores whereas those who underwent TKA had lower DC M-FIM scores. Similarly, Hispanic beneficiaries with overweight-obesity who underwent THA had higher DC C-FIM scores whereas those who underwent TKA had lower DC C-FIM scores. These are unique findings. No other study has demonstrated - examining differences in motor and cognition FIM scores based on obesity status and type of joint replacement procedure among individuals of Hispanic race/ethnicity.

IRF Length of Stay

This study found that beneficiaries with overweight-obesity who underwent THA have longer IRF LOS. The interaction of Non-Hispanic Black race/ethnicity and morbid obesity was associated with a shorter IRF LOS. These findings seem to contrast with that of the study by Vincent and colleagues (2007) who found the exact opposite – IRF LOS being shorter for overweight and moderate obesity and longer for severe obesity. However, in the stratified analyses, similar to findings of Vincent and colleagues (2007), this study also found that Non-Hispanic White beneficiaries with morbid obesity had significantly longer IRF LOS [71].

Thirty-day Hospital Readmission

Morbid obesity was significantly associated with greater risk for 30-day hospital readmission among the THA cohort. This is in agreement with the findings of the meta-analysis by Haverkamp and colleagues (2011) [74] who concluded that obesity negatively affected the outcome of hospital readmission following hip replacement.

Reasons for Readmission

Among those who experienced 30-day hospital readmission within both the THA and TKA cohorts, beneficiaries with morbid obesity had higher likelihood for the reason for readmission being a local or procedure-related complication. Ramkumar and colleagues conducted a systematic review and meta-analysis to examine reasons for readmission following THA and TKA (2015). Although not having examined the effect of obesity, the authors found that for THA the primary reason for readmission was "joint specific" and that for TKA was surgical-site infection [70]. Both of the 'joint-specific' and surgical-site infection' reasons were grouped under local/procedure-related complication in our study.

Mortality among the THA cohort

In this study, morbid obesity was found to be associated with a lower risk for mortality among the THA cohort. Although not statistically significant, overweight-obesity also had a protective effect for the outcome of risk for mortality. This is in agreement with previous studies that have shown that overweight and obesity were associated with a lower risk for mortality after hip replacement surgery[75 76].

As stated earlier, although morbid obesity was found to be significantly associated with the adverse event of readmission in the THA cohort, it had a protective effect for the outcome of mortality. This is in concurrence with the 'obesity paradox' – the paradoxical protective effect of obesity status on survival after development of chronic comorbid conditions studied by several investigators [77-80]. Similar to the finding of our study, Huddleston and colleagues (2012), who also studied the effect of obesity on adverse events specifically among Medicare beneficiaries with obesity undergoing THA, found that although experiencing an adverse health event such as an illness was associated with an increased length of hospital stay and with an increased likelihood of readmission, it was not associated with an increased likelihood of mortality [81].

CONCLUSION

This is a unique study contributing valuable scientific information regarding: 1. differences in rehabilitation outcomes based on obesity status; 2. the time to readmission following discharge into the community from inpatient rehabilitation; 3. the reasons for readmission; 4. the time to death, 5. risk for mortality, and, 6. the differential effects of obesity status by race/ethnicity and by gender on the above outcomes; among individuals undergoing elective primary THA and TKA procedures and receiving rehabilitation at an IRF.

This study provides unique granularity compared to existing studies – giving new insights on the effect of obesity status on outcomes within different race/ethnicities. This is the first study that has evaluated the association of obesity with reasons for readmission among Medicare beneficiaries who underwent THA or TKA. Having utilized large data, this study makes significant contribution with respect to sound findings given the large sample size, in comparison to other studies in the existing body of research literature.

This is also a timely study identifying potential gaps in care that may be contributing to adverse outcomes which increase burden of care and healthcare costs; given the bundling of payment for care improvement Initiative for joint replacement procedures, known as the Comprehensive Care for Joint Replacement, effective April 2016, for reducing healthcare costs and improving quality of care and health outcomes in this population [82] Given that the THA and TKA procedures studied are elective procedures, knowing the potential risk for post-operative death would aid in the decision-making processing of opting to undergo the procedure. This study attempted to quantify the risk of death in the post-operative period, after receiving rehabilitation for the joint replacement procedure at an IRF.

LIMITATIONS

During the year 2012, only 8.1% of all Medicare beneficiaries who underwent primary THA and 7.4% of all those who underwent primary TKA, received rehabilitation at an IRF immediately following the respective procedure. These proportions were even lower for the year 2013: 6.8% for THA and 6.5% for TKA (Table 47 in Appendix). During the study period of 2012 and 2013, substantially greater proportions of Medicare beneficiaries were discharged directly to skilled nursing facilities (SNFs) after THA (32.6% and 30.8% respectively) and TKA (31.8% and 30.8% respectively) (Table 47). Being a greater proportion of the total, Medicare beneficiaries receiving rehabilitation at SNFs are more likely to demonstrate closer resemblance to the overall population of all beneficiaries undergoing the joint replacements, as compared to those receiving rehabilitation at an IRF.

As mentioned earlier in the Background chapter, the 75%/60% rule by the CMS required specific criteria of intensive rehabilitation needs for the beneficiaries to qualify for receiving rehabilitation at an IRF as opposed to other post-acute settings such as a SNF[45]. It is likely that more severely involved and medically complex joint replacement patients may be sent to IRF as opposed to a SNF, for receiving specialized medical services, rehabilitation nursing, and intensive rehabilitation services. DeJong and colleagues (2009) have noted that patients admitted to IRF after primary elective hip or knee joint replacement, had lower functional status and greater number of comorbid conditions as compared to those admitted to SNF[83]. At the same time, the converse may also be true. Given the three hours a day of intensive rehabilitation provided at an IRF, the individual, determined to need to inpatient rehabilitation services after the joint replacement procedure, would need to have the physical and functional capability to potentially tolerate the extensive therapy at an IRF. This may be one of the factors for discharge planning by the interdisciplinary team of healthcare professionals at the acute hospital phase.

Therefore, individuals receiving rehabilitation at an IRF may present a different clinical picture with respect to severity of illness and overall health status. Some reports showed that patients sent to SNF after primary joint replacement had greater number of comorbidities as compared to those sent to IRF[84 85]. Although the study by DeJong and colleagues (2009) and the report by Buntin and colleagues (2005) contradicted with respect to the comparison of the number of comorbid conditions between those discharged to IRF versus SNF, they both agreed that patients admitted to IRF after primary hip or knee joint replacement are younger than those who get admitted to SNF[83 84].

The distributions/proportions of the Medicare beneficiaries in the three obesity-related categories among the THA and TKA analytical samples, and among those who received rehabilitation at an IRF for THA and for TKA, were not representative of the respective distribution/proportion among all Medicare beneficiaries who underwent hip and knee joint replacement procedures during the study period. These distributions have been highlighted in bold in Table 48 in the Appendix. This classification into the three obesity-related categories (normal weight, overweight-obesity, and morbid obesity) was done applying the same operational definitions for the as those used for this study. The proportion of morbid obesity among the TKA analytical sample was twice as that among all Medicare beneficiaries who underwent TKA (24.4% and 12% respectively). This was also true among Medicare beneficiaries who underwent THA with the respective proportions of beneficiaries with morbid obesity being 15.8% and 8% (Table 48).

The number of patients being admitted to IRF after primary elective lower extremity joint replacements has been steading declining. The beginning of this decline is concurrent with the prediction of commencement of the IRF prospective payment system in 2001 and enforcement of the same in 2002 (Figures 25 and 26 in Appendix). Illustration 7 (Appendix) demonstrates the downward trend of all IRF admissions covered by Medicare. This drop in the number of Medicare cases admitted occurred as a result of the enforcement of the 75%/60% rule. This decrease in the number of cases was the most drastic in the 'replacement of lower extremity joint' rehabilitation impairment category (RIC): from 55,000 cases in 2006 to 31,425 cases in 2010 – a decrease by 43%[44].

All of the above-stated facts in the limitations section allude to the selection bias that the analytical samples of THA and TKA used for this study are subject to. The THA and TKA analytical samples are therefore unlikely to be representative of the overall population of Medicare beneficiaries who undergo primary elective hip or knee joint replacement. Thus, the generalizability of the findings of this study is limited.

Medicare data is administrative claims data. In addition to overweight category, obesity category may also have been under-recorded. The limitation/bias resulting from underestimation was controlled for in two ways: a. Linking of data from more than one source file which enabled capturing the maximum possible coding for obesity categories; and b. Overweight category was grouped with the obesity category by utilizing sensitivity analyses. Overweight-obesity grouped together however impeded the ability to understand how each of the two combined categories plays an individual role in relation to the outcomes of interest. Underweight beneficiaries, if any, were categorized within the normal weight category. This may have modified the true effects of normal weight on the outcomes of interest. Morbid obesity, however, is expected to have been adequately coded given the fact that morbid obesity is a Tier 3 comorbidity that qualifies the

Medicare beneficiary who underwent primary elective THA or TKA to receive rehabilitation services at an IRF.

FUTURE RESEARCH IMPLICATIONS

Beneficiaries with overweight-obesity fared relatively better than beneficiaries in the normal weight category. It would be interesting in future to examine how these results would differ when overweight can be analyzed as a stand-alone category. Investigating whether individuals in each of the overweight and obesity categories fare better in functional outcomes than those in the normal weight category, may throw light on whether a "new normal" reference category has emerged. Further analyzing differences in outcomes by gender within each race/ethnicity and obesity category would be insightful to get a deeper understanding of how different individuals fare after elective joint replacement procedures.

For this study beneficiaries in the morbid obesity were younger relative to those in the other two obesity-related categories. Thus, it is not a surprise that morbid obesity, overall, was associated with higher cognitive functions and had a protective effect for the long-term outcome of mortality among the THA cohort. It is an assumption that the beneficiaries with morbid obesity in this study may have been relatively healthier as compared to all Medicare beneficiaries with morbid obesity who received primary elective hip or knee joint replacement during the study period – based on all the facts elaborated in the limitations section. Thirdly, the difference in discharge cognition scores, although statistically significant, may not be clinically meaningful. Set parameters for clinically meaningful differences are currently lacking. Future studies to understand the clinical meaningfulness of these differences and how comorbidities play a role in driving these differences will be useful.

It is disconcerting, though, that morbid obesity need more intensive care – indicated by longer hospital and IRF LOS, have lower motor functions, have a greater risk for 30-day readmission, and have higher likelihood of experiencing complications related to the joint replacement procedure. It is imperative therefore, to conduct longer prospective studies in the future to compare their long-term health outcomes with individuals with normal weight, overweight and obesity. Although community discharge did not differ based on obesity status, following cohorts prospectively for longer periods may enable understanding how obesity affects sustainability of community residential status.

Future studies to investigate whether the health status of individuals with morbid obesity differs between different race/ethnicities would be beneficial. Also, it would be useful to investigate if differences in readmissions are attributable to any disparities existing in follow-up following discharge and/or access to needed care. It is important to study the outcome of mortality prospectively for individuals undergoing elective lower extremity joint replacements – especially in relation to health status trajectories following hospital readmissions. Given the clarity of mortality as the end-point, accurately quantifying the risk for mortality over a longer period of follow-up and the effect of the interplay of obesity and other comorbid conditions on this outcome will be important to determine for the end users as well as the healthcare providers.

The effect of age, gender, race/ethnicity, functional status and comorbid conditions, were found to have significance, when studying the outcomes of 30-day readmission and mortality. In agreement with what's stated in the literature, increased age was associated with increased risk for mortality among both the THA and TKA cohorts, and female gender had a protective effect for the risk for mortality among the TKA cohort[75 76]. Also, as found in previous studies, higher discharge motor FIM was associated with lower risks, for 30-day hospital readmission[86], and for mortality[76]. In concurrence with the 'Hispanic paradox', Hispanic race/ethnicity had a significant protective effect for the outcome of risk for mortality cohort among the TKA cohort[87]. Although the risk for mortality associated with comorbid condition of metastatic cancer was nearly 12 times higher in the THA cohort and nearly 6 times higher in the TKA cohort, the prevalence of the condition was low (0.3% among the THA cohort and 0.1% among the TKA cohort). These factors need further studies in the future to understand their effect on the risk for mortality among individuals undergoing THA and TKA. The primary focus of the current study, however, was to examine the effect of obesity on the above stated outcomes (in addition to rehabilitation outcomes) after inpatient rehabilitation for THA or TKA.

Part of the reasons that may be driving the difference in IRF rehabilitation service utilization following lower extremity joint replacement by individuals with morbid obesity, is the fact that not all geographic regions in the US have the option of choosing rehabilitation at an IRF over that at a skilled nursing facility. Some facility-level factors also determine discharge to IRF versus SNF such as a co-located or preferred sub-provider of post-acute services[88]. It will be insightful to investigate in the future how the availability of post-acute care options is related to the proportion of individuals with morbid obesity who receive rehabilitation at IRF after hip and knee joint replacements, after adjusting for differences in health status.

Effective April 1, 2016, performance-based payments, rewards and penalties have been through the Comprehensive Care for Joint Replacement – a bundled payment initiative by the CMS for hip and knee joint replacements. As part of this initiative, hospitals are held accountable to provide coordinated care to beneficiaries by working with various post-acute provider settings including IRF, SNF and home health agencies[89]. Future research on how this payment reform impacts outcomes after joint replacement will be valuable. Resources would need to be wisely allocated for the close medical attention and intensive rehabilitation that beneficiaries with morbid obesity need following joint replacement in order to mitigate adverse and burdensome outcomes on the healthcare dollar such as readmissions and procedure-related complications.

CLINICAL IMPLICATIONS

Given the finding that morbid obesity is associated with increased risk for adverse outcomes such as readmissions and procedure-related complications, it will be valuable to adopt a clinical risk management approach in which risk factors for post-operative complications are managed by providing greater vigilance and closer monitoring for signs of potential adverse events and providing a longer follow-up. This will not only improve the quality of care provided, but will also ensure improved health outcomes and over the long run, reduced spending of the healthcare dollar.

Rehabilitation services can play a preventive role for secondary complications by a. enabling and empowering individuals with morbid obesity to take charge of their health status providing the necessary health education and increasing awareness of impact of obesity on their health; and b. take steps towards improving health of those with morbid obesity by providing them with the necessary interventions, support and resources for weight reduction pre-operatively, which will help reduce the risk of long-term adverse health outcomes.

HEALTH POLICY IMPLICATIONS

Reports on findings of studies such as the current one, will inform policy makers regarding the importance of appropriate allocation of resources beyond the acute care phase for the beneficiaries with morbid obesity to best benefit from the coordinated care model enforced.

APPENDIX

Table – 46: Descriptive characteristics of the THA and TKA cohorts

	Normal weight		Overweight-Obesity		Morbid Obesity	
	THA	TKA	THA	TKA	THA	TKA
Age	78.9 (7.1)	78.1 (6.8%)	76.4 (6.6)	75.3 (6.2)	73.2 (5.8)	72.2 (5.3)
Age Category						
65-74 years	2,427 (29.5%)	4,516 (32.7%)	628 (41.5%)	1,591 (47.6%)	1,156 (63.4%)	3,817 (68.9%)
75-84 years	3,673 (44.7%)	6,411 (46.4%)	680 (44.9%)	1,447 (43.3%)	584 (32.0%)	1,592 (28.7%)
85+ years	2,118 (25.8%)	2,897 (20.9%)	206 (13.6%)	303 (9.1%)	83 (4.6%)	131 (2.4%)
Gender						
Men	2,595 (31.6%)	4,316 (31.2%)	484 (32%)	974 (29.1%)	557 (30.5%)	1,293 (23.3%)
Women	5,623 (68.4%)	9,508 (68.8%)	1,030 (68%)	2,367 (70.9%)	1,266 (69.5%)	4,247 (76.7%)
Race/ethnicity						
White	7,499 (91.3%)	12,104 (87.6%)	1,342 (88.6%)	2,755 (82.5%)	1,551 (85.1%)	4,496 (81.2%)
Black	474 (5.8%)	900 (6.5%)	104 (6.9%)	298 (8.9%)	200 (11%)	696 (12.6%)
Hispanic	68 (4.5%)	820 (5.9%)	68 (4.5%)	288 (8.6%)	72 (4%)	348 (6.3%)

Table – 47: Distribution of Medicare beneficiaries for 2012 and 2013, based on discharge destination from acute hospital stay for primary THA or primary TKA

Discharge Destination	THA		TKA	
	2012	2013	2012	2013
Death	119 (0.1%)	110 (0.1%)	265 (0.1%)	244 (0.1%)
Home with Home Health	52,540 (36.9%)	59,850 (38.8%)	1,21,636 (37.5%)	1,33,826 (38.8%)
Home	28,705 (20.1%)	33,159 (21.5%)	67,658 (20.9%)	74,910 (21.7%)
IRF	11,604 (8.1%)	10,525 (6.8%)	24,145 (7.4%)	22,404 (6.5%)
Long term care hospital	147 (0.1%)	179 (0.1%)	361 (0.1%)	321 (0.1%)
Other	2,884 (2.0%)	2,955 (1.9%)	6,954 (2.1%)	7,085 (2.1%)
Skilled Nursing Facility	46,476 (32.6%)	47,456 (30.8%)	1,03,188 (31.8%)	1,06,109 (30.8%)

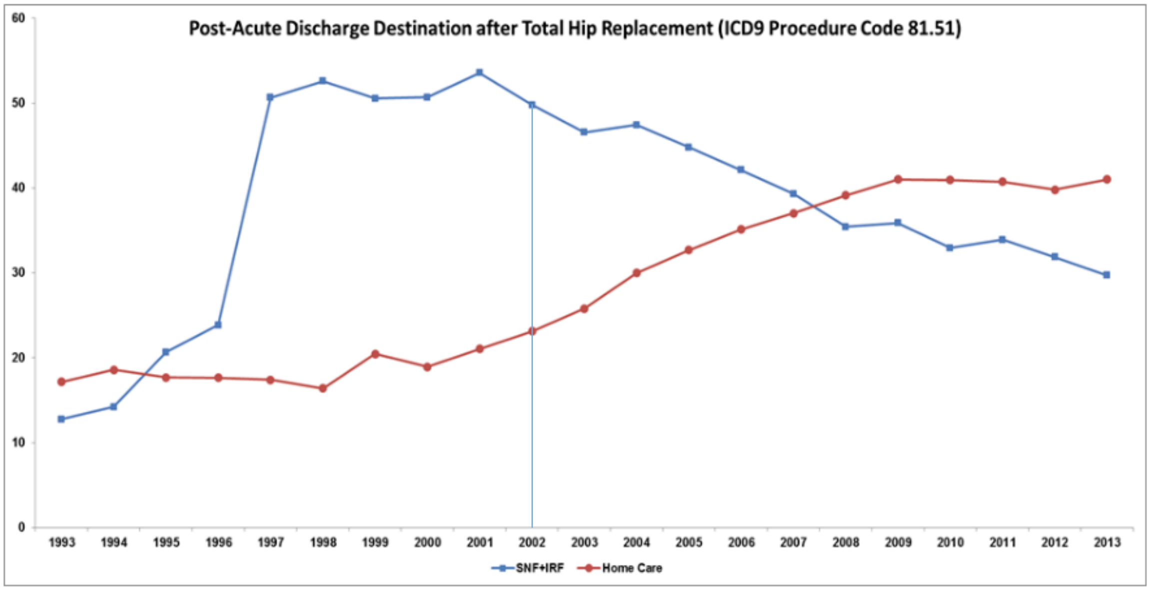
Values represent: number (column percent)

Table 48: Proportion of Medicare Beneficiaries who underwent primary Hip or Knee Joint Replacement during 2012 and 2013 in the three Obesity-related Categories

	Normal weight	**Overweight-Obesity**	**Morbid Obesity**	**Total**
THA – all Row percent	2,49,050 **83.9%**	23,916 **8.1%**	23,743 **8%**	2,96,709 100%
THA – IRF Percent (of THA-all Total) Row percent (of THA-IRF Total) Column Percent (of THA-all obesity category)	18,043 6.1% **81.5%** 7.2%	1,754 0.6% **8%** 16%	*2,332* 0.8% **10.5%** 9.8%	22,129 7.5%
THA – Analytical Sample Row percent (of THA – Anal. Sample Total)	8,218 **71.1%**	1,514 **13.1%**	1,823 **15.8%**	11,555 3.9%
TKA – all Row percent	5,26,300 **78.7%**	62,592 **9.3%**	80,214 **12%**	6,69,106 100%
TKA – IRF Percent (of TKA-all Total) Row percent (of TKA-IRF Total) Column Percent (of TKA-all obesity category)	34,724 5.2% **74.6%** 6.6%	4,442 0.7% **9.6%** 15.4%	7,383 1.1% **15.9%** 9.2%	46,549 7%
TKA – Analytical Sample Row percent (of TKA – Anal. Sample Total)	13,824 **60.9%**	3,341 **14.7%**	5,540 **24.4%**	22,705 3.4%

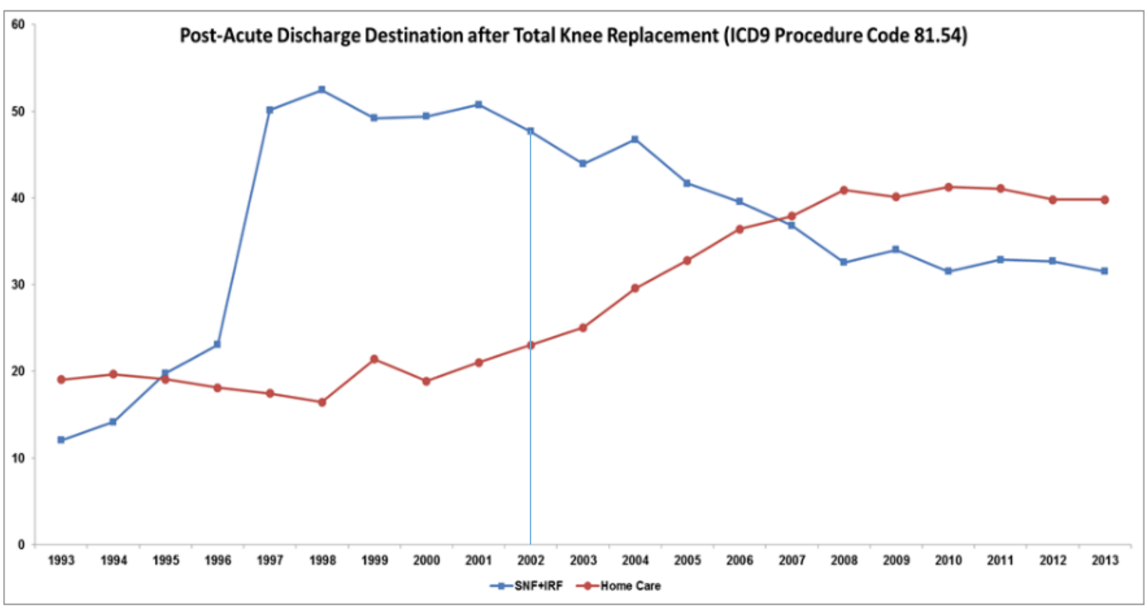
Footnote: THA-all = all Medicare beneficiaries who underwent THA during 2012 and 2013; TKA-all = all Medicare beneficiaries who underwent TKA during 2012 and 2013. THA-IRF = all Medicare beneficiaries who received rehabilitation at IRF following THA during 2012 and 2013. TKA-IRF = all Medicare beneficiaries who received rehabilitation at IRF following TKA during 2012 and 2013. Total column has frequency and column percent of the respective (THA-all/TKA-all) grand total

Figure 25: Directional change in trends in discharge destination, following acute hospital stay for elective primary THA, in concurrence with implementation of the 75% rule



Footnote: The blue vertical line marks the time point of the 75% rule implementation. Source: Trends data extracted using Hcup.Net Online portal using ICD9-CM procedure code 81.5 (total hip replacement)

Figure 26: Directional change in trends in discharge destination, following acute hospital stay for elective primary TKA, in concurrence with implementation of the 75% rule



Footnote: The blue vertical line marks the time point of the 75% rule implementation. Source: Trends data extracted using Hcup.Net Online portal using ICD9-CM procedure code 81.54 (total knee replacement)

Illustration 7: Downward trend in IRF admissions of all cases covered by Medicare

REFERENCES

1. Galuska DA1 SM, Pamuk E, Siegel PZ, Byers T. Trends in overweight among US adults from 1987 to 1993: a multistate telephone survey. *Am J Public Health* 1996;86(12):1729-35.

2. The World health Organization Global Infobase: Global Comparable Estimaes of Prevalence of Overweight and Obesity. 2011.

3. Cynthia L. Ogden MDC, Brian K. Kit, Katherine M. Flegal Prevalence of Childhood and Adult Obesity in the United States, 2011-2012. *Journal of American Medical Association* 2014;311(8):806-14.

4. Y Claire Wang KM, Tim Marsh, Steven L Gortmaker, Martin Brown. Health and economic burden of the projected obesity trends in the USA and the UK. *Lancet* 2011;378:815-25.

5. Centers for Disease Control and Prevention: Overweight and Obesity - Obesity Facts. 2014.

6. Flegal KM CM, Kit BK, Ogden CL. Prevalence of obesity and trends in the distribution of body mass index among US adults. *JAMA* 2012;307:491-97.

7. Prevalence of Obesity Among Adults and Youth: United States, 2011–2014 2015 [updated November 2015. Available from: http://www.cdc.gov/nchs/products/databriefs/db219.htm accessed September 2016.

8. National Cancer Institute: Obesity and Cancer Risk 2014 [Available from: http://www.cancer.gov/cancertopics/factsheet/Risk/obesity.

9. Centers for Disease Control and Prevention: Osteoarthritis. 2014.

10. Osteoarthritis [webpage]. 2014 [updated May 2014. Available from: http://www.cdc.gov/arthritis/basics/osteoarthritis.htm accessed December 12, 2014 2014.

11. Lawrence RC FD, Helmick CG, Arnold LM, Choi H, Deyo RA, Gabriel S, Hirsch R, Hochberg MC, Hunder GG, Jordan JM, Katz JN, Kremers HM., and Frederick Wolfe. Estimates of the prevalence of arthritis and other rheumatic conditions in the United States - Part II. *Arthritis and Rheumatism* 2008;58(1):26-35.

12. Bolen J SL, Hootman JM, Helmick CG, Theis K, Murphy LB, et al. Differences in the prevalence and impact of arthritis among racial/ethnic groups in the United States, National Health Interview Survey, 2002, 2003, and 2006. *Prev Chronic Dis* 2010;7(10):1-5.

13. Prevalence of doctor-diagnosed arthritis and arthritis-attributable activity limitation--United States, 2010-2012 [Online Report]. 2013 [updated November 08, 2013.

869-73]. Available from: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6244a1.htm accessed 44 62.

14. Adipose Tissue and Adipokines in Health and Disease. In: Fantuzzi G, ed. 2nd Ed. ed: Springer Science & Business 2014.

15. M. S. Epidemiology of risk factors for osteoarthritis: systemic factors. *Curr Opin Rheumatol* 2001;13:447-51.

16. Hart DJ ST. The relationship of obesity, fat distribution and osteoarthritis in women in the general population: the Chingford Study. *J Rheumatol* 1993;20:331-35.

17. GS. H. Inflammation and metabolic disorders. *Nature* 2006;444:860-67.

18. RM. A. Obesity punches above its weight in osteoarthritis. *Nat Rev Rheumatol* 2011;7:65-68.

19. Dumond H PN, Terlain B, Mainard D, Loeuille D, Netter P et al. . Evidence for a key role of leptin in osteoarthritis. *Arthritis Rheum* 2003;48:3118-29.

20. L. S. Local factors in osteoarthritis. *Curr Opin Rheumatol* 2001;13:441-46.

21. Mundermann A DC, Andriacchi TP. Secondary gait changes in patients with medial compartment knee osteoarthritis: increased load at the ankle, knee, and hip during walking. *Arthritis Rheum* 2005;52:2835-44.

22. Felson DT GJ, Niu J, Zhang Y, Hunter DJ. The effect of body weight on progression of knee osteoarthritis is dependent on alignment. *Arthritis Rheum* 2004;50:3904-09.

23. Sharma L LC, Cahue S, Dunlop DD. The mechanism of the effect of obesity in knee osteoarthritis: the mediating role of malalignment. *Arthritis Rheum* 2000;43:568-75.

24. Wearing SC HE, Byrne NM, Steele JR, Hills AP. Musculoskeletal disorders associated with obesity: a biomechanical perspective. *Obes Rev* 2006;7:239-50.

25. Margaret Shih JMH, Judy Kruger, Charles G. Helmick. Physical activity in men and women with arthritis National Health Interview Survey, 2002. *Am J Prev Med* 2006;30(5):385–93.

26. Dillon CF RE, Gu Q, Hirsch R. . Prevalence of knee osteoarthritis in the United States: arthritis data from the Third National Health and Nutrition Examination Survey 1991–1994. *J Rheumatol* 2006;33(11):2271-79.

27. Buckwalter JA SC, Brown T. The impact of osteoarthritis. *Clin Orthoped Rel Res* 2004;427S:S6-S15.

28. Srikanth VK FJ, Zhai G, Winzenberg TM, Hosmer D, Jones G. A meta-analysis of sex difference prevalence, incidence and severity of osteoarthritis. *Osteoarthritis Cartilage* 2005;13:769-81.

29. Derman PB FP, David G,. The Role of Overweight and Obesity in Relation to the More Rapid Growth of Total Knee Arthroplasty Volume Compared with Total Hip Arthroplasty Volume. *J Bone Joint Surg Am* 2014;96(11):922 -28.

30. Mayo Clinic: Osteoarthritis 2014 [Available from: http://www.mayoclinic.org/diseases-conditions/osteoarthritis/basics/treatment/con-20014749.

31. Ethgen O BO, Richy F, Dardennes C, Reginster JY. Health-related quality of life in total hip and total knee arthroplasty. A qualitative and systematic review of the literature. *J Bone Joint Surg Am* 2004;86-A(5):963-74.

32. Waimann CA F-MR, Cantor SB, Lopez-Olivo MA, Zhang H, Landon GC, Siff SJ, Suarez-Almazor ME. Cost-effectiveness of total knee replacement: a prospective cohort study. *Arthritis Care Res (Hoboken)* 2014;66(4):592-9.

33. Shan L SB, Graham D, Saxena A. Total hip replacement: a systematic review and meta-analysis on mid-term quality of life. *Osteoarthritis Cartilage* 2014 22(3):389-406.

34. Centers for Disease Control and Prevention: Fast Stats - Inpatient Surgery. 2014.

35. Franklin J IT, Englund M, Lohmander LS. Sex differences in the association between body mass index and total hip or knee joint replacement resulting from osteoarthritis. *Annals of the Rheumatic Diseases* 2008;68(4):536-40. [published Online First: May 26, 2008]

36. Tayne S MC, Smith EL, Mackey WC. Predictive risk factors for 30-day readmissions following primary total joint arthroplasty and modification of patient management. *Journal of Arthroplasty* 2014;29(10):1938-42.

37. Mahomed NN BJ, Katz JN Baron JA, Wright J, Losina E. Epidemiology of total knee replacements in the United States Medicare population. *J Bone Joint Surg Am* 2005;84(9):702-11.

38. CDC: Racial disparities in total knee replacement among Medicare enrollees--United States, 2000–2006. *MMWR* 2009;58(6):133-8.

39. Kurtz S MF, Ong K, Chan N, Lau E, Hlapern M. Prevalence of primary and revision total hip and knee arthroplasty in the United States from 1990 through 2002. *J Bone Joint Surg Am* 2005;87(7):1487-97.

40. AHRQ publishes statistics on hospital stays among obese adults and children and hospital stays for hip and knee replacement 2012 [updated December 2012. Available from: http://archive.ahrq.gov/news/newsletters/research-activities/12dec/1212RA37.html2013.

41. H.CUPnet National and regional estimates on hospital use for all patients from the HCUP National (Nationwide) Inpatient Sample (NIS) 2015 [updated 2015. Available from: http://hcupnet.ahrq.gov/HCUPnet.jsp?Id=64272F5913D7A11F&Form=MAINSEL

&JS=Y&Action=%3E%3ENext%3E%3E&_MAINSEL=National Statistics accessed May 2015.

42. Westby MD BA, Backman CL. Expert consensus on best practices for post-acute rehabilitation after total hip and knee arthroplasty: a Canada and United States Delphi Study. *Arthritis Care and Research* 2014;66(3):411-23.

43. Beeuwkes Buntin M HCC, Escarce JJ. Effects of Payment Changes on Trends in Post-Acute Care. *Health Services Research* 2009;44(4):1188-210.

44. Utilization Trends in Inpatient Rehabilitation - Update through Q2 2011. 2016 [updated 2011. Available from: http://www.aha.org/content/11/11nov-irfmoranrpt.pdf accessed October 2016.

45. Inpatient Rehabilitation Facility Prospective Payment System 2015 [updated September 2015. Available from: https://www.cms.gov/Outreach-and-Education/Medicare-Learning-Network-MLN/MLNProducts/downloads/InpatRehabPaymtfctsht09-508.pdf accessed October 2016.

46. Patel VP WM, Sehgal B, Preston C, DeWal H, Di Cesare PE. Factors associated with prolonged wound drainage after primary total hip and knee arthroplasty. *The Journal of bone and joint surgery American volume* 2007;89:33-38.

47. Belmont PJ GG, Waterman BR, Bader JO, Schoenfeld AJ. Thirty-Day Postoperative Complications and Mortality Following Total Knee Arthroplasty: Incidence and Risk Factors among a National Sample of 15,321 Patients. *J Bone Joint Surg Am* 2014;96:20-6.

48. Wallace G JA, Prieto-Alhambra D, de Vries F, Arden NK, Cooper C. The effect of body mass index on the risk of post-operative complications during the 6 months following total hip replacement or total knee replacement surgery. *Osteoarthritis and Cartilage* 2014;22:918e27.

49. Schwarzkopf R1 TS, Adwar SJ, Liublinska V, Slover JD. Postoperative complication rates in the "super-obese" hip and knee arthroplasty population. *The Journal of Arthroplasty* 2012;27(3):397-401.

50. Werner BC EC, Carothers JT, Browne JA. Primary Total Knee Arthroplasty in Super-obese Patients: Dramatically Higher Postoperative Complication Rates Even Compared to Revision Surgery. J Arthroplasty, 2014; 14:00947-4.

51. Jain NB1 GU, Pietrobon R, Bond TK, Higgins LD. Comorbidities increase complication rates in patients having arthroplasty. *Clinical Orthopaedics and Related Research* 2005;435:232-8.

52. Brown TD1 EJ, Pedersen DR1, Callaghan JJ2. Impingement and Dislocation in Total HIP Arthroplasty: Mechanisms and Consequences. *The Iowa orthopaedic journal* 2014;34:1-15.

53. Judge A AN, Cooper C, Kassim, Javaid M, Carr AJ, Field RE, Dieppe PA. Predictors of outcomes of total knee replacement surgery. *Rheumatology (Oxford)* 2012;10(10):1804-13.

54. Amin AK PJ, Cook RE, Brenkel IJ. Does obesity influence the clinical outcome at five years following total knee replacement for osteoarthritis? *J Bone Joint Surg Br* 2006;3(3):335-40.

55. Bordini B SS, Cremonini S, Viceconti M, De Palma R, Toni A. Relationship between obesity and early failure of total knee prostheses. *BMC Musculoskeletal Disorders* 2009;10(29).

56. Jamsen E PM, Eskelinen A, Lehto MU. Comorbid diseases as prdictors of survival of primary total hip and knee replacements: a nationwide register-based study of 96754 opertions on patients with primary osteoarthritis. *AnnRheumDis* 2013;12(1):1975-82.

57. AAOS Clinical Practice Guidelines. Published guildelines for surgical management/arthroplasty for osteoarthritis of knee [Available from: http://www.orthoguidelines.org/guideline-detail?id=1291 accessed March 2016.

58. Ledford CK RTR, Appleton Jr. JS, Butler RJ, Wellman SS, Attarian DE, Queen RM, Bolognesi MP. Percent body fat more associated with perioperative risks after total joint arthroplasty than body mass index. *J Arthropl* 2014;29 Suppl. 2:150–54.

59. Bradley BM GS, Stewart KJ, Higgins GA, Hockings M, Isaac DL. The effect of obesity and increasing age on operative time and length of stay in primary hip and knee arthroplasty. *J Arthroplasty* 2014;29(10):1906-10.

60. Abdel MP AM, Lee Y, Lyman S, Della Valle AG. All-Cause in-hospital complications and urinary tract infections increased in obese patients undergoing total knee arthroplasty. *J Arthropl* 2014;29:1430-34.

61. Cram P LX, Kaboli PJ, Vaughan-Sarrazin MS, Cai X, Wolf BR, Li, Y. Clinical Characteristics and Outcomes of Medicare Patients Undergoing Total Hip Arthroplasty, 1991-2008. *JAMA* 2011 305(15):1560-67.

62. Cram P LX, Kates SL, Singh JA, Li Y, Wolf BR. Total knee arthroplasty volume, utilization, and outcomes among Medicare beneficiaries, 1991-2010. *JAMA* 2012;308:1227-36.

63. Verbrugge LM JA. The Disablement Process. *Soc Sci Med* 1994;38(1):1-14.

64. Definitions of terms and variables 2014 [updated 2014. Available from: https://www.cms.gov/Research-Statistics-Data-and-Systems/Research/MCBS/Data-Tables-Items/2013CNP.html?DLPage=1&DLEntries=10&DLSort=0&DLSortDir=descending accessed April 2016.

65. Ottenbacher KJ HY, Granger CV, Fiedler RC. The reliability of the functional independence measure: a quantitative review. *Arch Phys Med Rehabil* 1996;77(12):1226-32.

66. Medicare Program Inpatient Rehabilitation Facility Prospective Payment System for Federal fiscal year 2016: A Rule by Centers for Medicare and Medicaid Services 2015 [Available from: https://www.gpo.gov/fdsys/pkg/FR-2015-08-06/pdf/2015-18973.pdf accessed April 2016.

67. The Continuity Assessment Record and Evaluation (CARE) tool. 2015 [updated January 2015. Available from: https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/Post-Acute-Care-Quality-Initiatives/Downloads/CARE-Discharge-Assessment-Tool.pdf accessed April 2016.

68. Ottenbacher KJ KA, Graham JE, Kuo YF, Deutsch A, Reistetter TA, Al Snih A, Granger CV. Thirty-Day Hospital Readmission Following Discharge From Postacute Rehabilitation in Fee-for-Service Medicare Patients. *JAMA* 2014;311(6):604-14.

69. Final List of Hospital Acquired Conditions for fiscal years 2013 through 2015. 2016 [Available from: https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/HospitalAcqCond/Downloads/FY_2013_Final_HACsCodeList.pdf accessed April 2016.

70. Ramkumar PN CC, Harris JD, Athiviraham A, Harrington MA, White DL, Berger DH, Naik AD, Li LT. Causes and rates of unplanned readmissions afer elective primary total joint arthroplasty: a systematic review and meta-analysis. *The Americal Journal of Orthopedics* 2015 44(9):397-405.

71. Vincent HK WJ, Vincent KR. Effect of obesity on inpatient rehabilitation outcomes after total hip arthroplasty.*Obesity* 2007;15(2):522-30.

72. Dere D PN, Soy Bugdaci D, Tekdos Demircioglu D. Effect of body mass index on functional recovery after total knee arthroplasty in ambulatory overweight or obese women with osteoarthritis. *Acta Orthop Traumatol Turc* 2014;48 (2):117-21.

73. Vincent HK VK. Obeisty and inpatient rehabilitation outcomes following knee arthroplasty: a multicenter study. *Obesity* 2012;16(1):130-36.

74. Haverkamp D KM, Somford MP, Albers GH, van der Vis HM. Obesity in total hip arthroplast-does it really matter? A meta-analysis. *Acta Orthopedica* 2011;82(4):417-22.

75. Hunt LP B-SY, Clark EM, et al. Ninety-day mortality after 409,096 total hip replacements for osteoarthritis National Joint Registry for England and Wales: a retrospective analysis. *Lancet* 2013;382:1097-104.

76. Jämsen E PT, Eskelinen A, et al. Predictors of mortality following primary hip and knee replacement in the aged. A single-center analysis of 1,998 primary hip and knee replacements for primary osteoarthritis. *Acta Orthop* 2013;84:44-53.

77. Curtis JP SJ, Wang Y, et al. The obesity paradox: body mass index and outcomes in patients with heart failure. *Arch Intern Med* 2005;165:55-61.

78. Haass M KD, Anand IS, et al. Body mass index and adverse cardiovascular outcomes in heart failure patients with preserved ejection fraction: results from the Irbesartan in Heart Failure with Preserved Ejection Fraction (I-PRESERVE) trial. *Circ Heart Fail* 2011;4:324–31.

79. Bakaeen FG CD. The obesity paradox and cardiac surgery: are we sending the wrong message? *Ann Thorac Surg* 2011;92(4):1153.

80. Stamou SC NM, Stiegel RM, et al. . Effect of body mass index on outcomes after cardiac surgery: is there an obesity paradox? *Ann Thorac Surg* 2011;91:42-47.

81. Huddleston JI WY, Uquillas C, Herndon JH, Maloney WJ. Age and obesity are risk factors for adverse events after total hip arthroplasty. *Clin Orthop Relat Res* 2012;470:490-96.

82. Bundled Payments for Care Improvement (BPCI) Initiative 2016 [updated July 2016. Available from: https://innovation.cms.gov/initiatives/bundled-payments/ accessed September 2016.

83. DeJong G, Tian, W., Smout, R.J. et al. Use of rehabilitation and other health care services by patients with joint replacement after discharge from skilled nursing and inpatient rehabilitation facilities. *Arch Phys Med Rehabil* 2009;90:1297-305.

84. Buntin MB, Partha, D., Escarce, J.J., Hoverman, C., Paddock, S., and Sood, N. Comparison of Medicare spending and outcomes of beneficiaries with lower extremity joint replacements. . RAND Health, Arlington, 2005.

85. Gage B, Morley, M., Spain, P., and Ingber, M. . Examining post acute care relationships in an integrated hospital system. 2009 [Available from: https://aspe.hhs.gov/pdf-report/examining-post-acute-care-relationships-integrated-hospital-system accessed October 2016.

86. Hoyer E ND, Atanelov L, Knox, B, Friedman M, Brotman DJ. Association of impaired functional status at hospital discharge and subsequent rehospitalization. *Journal of Hospital Medicine* 2014;9(5):277-82.

87. Franzini L1 RJ, Keddie AM. Understanding the Hispanic paradox. *Ethn Dis* 2001;11(3):496-518.

88. Buntin MB DGA, Paddock S, Saliba D, Totten M, Escarce JJ. How Much Is Postacute Care Use Affected by Its Availability? *Health Services Research* 2005;40(2):413-34.

89. CMS finalizes bundled payment initiative for hip and knee replacements 2015 [updated November 2015. Available from: http://www.hhs.gov/about/news/2015/11/16/cms-finalizes-bundled-payment-initiative-hip-and-knee-replacements.html accessed October 2016.

Vita

Kshitija Kulkarni was born on October 3, 1978 to Kranti and Ashok Kulkarni, in the city of Ahmednagar, state of Maharashtra, India. Kshitija completed her schooling up to junior college level in Ahmednagar through 1996. She completed her Bachelor of Science in Occupational Therapy from Government Medical College, Nagpur University, located in the city of Nagpur, Maharashtra, in the year 2000. Kshitija worked as an occupational therapist, in the city of Pune, Maharashtra, until June 2002 in outpatient Hand and Neurorehabilitation Clinic, and the outpatient setting (for Children with Sensory Integration Disorders) and acute inpatient setting (for children and adults with neurological impairments) of the Pune Institute of Neurology. She also provided home health visits for her patients discharged from acute care (adults with Parkinson's disease, stroke; and children with medically fragile conditions such as hydrocephalus).

Kshitija came to United States in 2002 to pursue the Advanced Professional Master of Science degree program in Occupational Therapy at the State University of New York, Buffalo, NY. Since the completion of her MS in 2005 through 2009, Kshitija worked in Pittsburgh, PA and for a year in Houston, TX, as an occupational therapist, with adult population in various clinical settings including acute hospitals, sub-acute and transitional care units, inpatient rehabilitation units, and skilled nursing and long-term care facilities. She moved to Texas in 2010, and worked as an occupational therapist at an inpatient rehabilitation facility through 2011.

Kshitija joined University of Texas Medical Branch, at Galveston, TX (UTMB), in Spring of 2012 in the doctoral program in Rehabilitation Science, at the Division of Rehabilitation Sciences. She enrolled in the Master of Public Health program, at the Department of Preventive Medicine and Community Health in Fall 2014. Kshitija is graduating from both her PhD in Rehabilitation Sciences and her MPH programs in Fall

2016. In addition to being a full-time student Kshitija also works as an adjunct faculty/instructor in the Department of Occupational Therapy at UTMB.

Kshitija is mostly known by the nick-name ‘Kay’. She first met her husband, Dr. Amol Karmarkar, in 1996, in Nagpur, India. They got married in 2004 in Buffalo, NY. Their first child, Aarya Karmarkar, was born in Pittsburgh, PA, on October 12, 2009. Their second child, Parth Karmarkar, was born in Houston, TX, on December 12, 2011. Kshitija, her husband, and their two children, live in League City, TX.