Race Differences in Functional Outcomes and Physical Therapy Utilization after Total Knee Arthroplasty

by

Allyn Michele Bove

B.S., Biology and B.S., Health Sciences, Duquesne University, 2007

Doctor of Physical Therapy, Columbia University 2010

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This dissertation was presented

by

Allyn Michele Bove

It was defended on

January 29, 2020

and approved by

Leslie R.M. Hausmann, Associate Professor, Department of Medicine, Division of General Internal Medicine, University of Pittsburgh

Sara R. Piva, Associate Professor, Department of Physical Therapy, University of Pittsburgh

Jennifer S. Brach, Professor, Department of Physical Therapy, University of Pittsburgh

Allen Lewis, Dean and Professor, SUNY Downstate Health Sciences University

Dissertation Director: G. Kelley Fitzgerald, Professor and Associate Dean, Department of Physical Therapy, University of Pittsburgh

Race Differences in Functional Outcomes and Physical Therapy Utilization after Total Knee Arthroplasty

Allyn Michele Bove, PT, DPT

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It is well-known that race disparities exist in the utilization of total knee arthroplasty (TKA). Some studies have suggested there are also race disparities in short-term outcome measures following TKA. Current research is lacking regarding whether disparities exist in functional outcomes following TKA, and if the amount or type of post-operative physical therapy (PT) plays a role in any such disparity.

The aims of this dissertation study include: (1) to determine if race is a significant predictor of functional outcome following TKA; (2) to determine if there are race differences in post-acute PT utilization following TKA; and (3) to qualitatively explore race differences in satisfaction with the rehabilitation experience following TKA. To accomplish these aims, we prospectively recruited 104 black/African-American and white/Caucasian non-Hispanic individuals scheduled to undergo unilateral TKA. Participants completed pre-operative and twelve weeks post-operative questionnaires regarding their physical function, reported information regarding PT received across several settings, and investigators reviewed participants' outpatient PT records following TKA.

We found that race was not an important independent predictor of patient-reported function after TKA. White participants reported slightly better function at both the pre- and post-operative time points, but these differences were not statistically significant. When examining

post-acute PT utilization, we observed a non-significant trend that black and white participants tended to receive PT in different settings, but the overall amount of post-acute PT received was similar between the groups. In focus groups exploring participants' experience with rehabilitation following TKA, participants largely reported positive views of their PT experience despite some barriers to completing post-operative rehabilitation. There were minor differences in the TKA experience described by white and black participants.

This is the first study to examine *both* PT utilization and functional outcomes in a sample of individuals undergoing TKA. This work adds to the literature regarding the role of race in physical function and rehabilitation use after TKA, but continued gaps in the literature exist. Future studies should use large data sets containing both functional measurements and rehabilitation utilization on a diverse group of patients to fully illuminate the relationships between demographic factors, rehabilitation use, and functional outcomes following TKA.

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Preface

I would like to thank several individuals involved in this research project, beginning with my dissertation committee. I am very grateful to my committee chair, Dr. G. Kelley Fitzgerald, for serving as an excellent mentor, teacher, and encourager over the past several years. I cannot thank him enough for taking me on as his doctoral student and for allowing me the freedom to pursue research interests both within and outside of his own interests. I was fortunate to meet Dr. Leslie Hausmann during my first week as a Ph.D. student, and I am thankful that she was willing to mentor an eager but very "green" doctoral student who was dedicated to studying health disparities. I am grateful to Drs. Sara Piva and Jennifer Brach for not only their mentorship in my dissertation project, but also for setting an excellent example of strong female leadership within the profession of physical therapy. Finally, I thank Dr. Allen Lewis for supporting me throughout my early doctoral education and for his endless optimism as I (slowly) trudged through the dissertation phase of the program. In addition to my committee, several other individuals' work was essential to the success of this project. I thank Dr. Brian Klatt and his staff for their essential help with recruitment for the study. Several current and former Doctor of Physical Therapy students assisted with recruitment and follow-up, including Dr. Nikki DiSalvio, Dr. Rachel Troxell, and Erin Dong.

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I am endlessly grateful to my family and friends for their support throughout my journey to a Ph.D. I met my husband Kevin when I was only one month into my doctoral studies. We have now been married for five years, and his support for my education and career knows no bounds. My parents, George and Suni Susko, are both first-generation college graduates who taught me that working hard and pursuing my educational goals was the key to unlocking my potential. While both of my parents will insist that I never required their urging to pursue academic endeavors, their encouragement was more important than they know. My remaining family and friends (both Suskos/Cliteses and Boves/Strangs) have been tremendous throughout this process, and I appreciate their support. I also appreciate that they eventually learned that it would be better to stop asking if I am ever going to graduate.

1.0 Specific Aims

Osteoarthritis affects more than 30 million Americans and results in more than $127 billion annually in direct and indirect health care costs.[1] The knee is the most commonly symptomatic osteoarthritic joint, and TKA is currently the only effective treatment for end-stage knee osteoarthritis.[1] It is estimated that the number of total knee arthroplasty (TKA) surgeries performed annually in the United States will quadruple by the year 2050.[2]

Studies have highlighted race disparities in short-term outcome measures following TKA, such as complication rates and receipt of immediate post-acute rehabilitation care.[3-5] Current research is lacking regarding potential race or ethnic disparities in *functional* outcomes following TKA. While disparities in the provision of physical therapy (PT) services and functional outcomes have been studied in other populations such as stroke and spinal cord injury,[6-8] similar research with respect to TKA does not exist. The goal of the proposed research is to compare functional outcomes and factors relating to the provision of PT services across races. This information is key to a better understanding of functional outcome disparities following TKA. We sought to accomplish the following aims:

1.1 Specific Aim 1

To determine if race predicts functional outcome following total knee arthroplasty (TKA). We prospectively recruited non-Hispanic white and non-Hispanic black or African-

American patients scheduled for TKA surgery in Allegheny County. (Note: From this point forward, the word "black" shall refer to anyone who self-identified as non-Hispanic black and/or African-American.) Via self-report measures, we collected data on functional status pre-operatively and at three months post-operatively. For those still receiving formal physical therapy in an outpatient or other setting at three months post-operatively, outcomes were collected again following discharge from the PT episode of care.

Hypothesis 1: Race will significantly predict self-reported functional outcome, and black participants will achieve significantly poorer functional outcomes at three months post-operative compared to white participants.

1.2 Specific Aim 2

To determine if there are race differences in PT service utilization following TKA. Via self-report, we obtained data regarding use of inpatient post-acute rehabilitation care and home PT. Following discharge from all formal PT services, we conducted a chart review to measure parameters related to outpatient PT services for those who received outpatient PT.

Hypothesis 2: Black participants will have significantly lower *total* utilization of PT services post-operatively compared to white participants.

1.3 Specific Aim 3

To explore race differences in satisfaction with rehabilitation following TKA. A series of semi-structured focus group discussions were conducted with white and black participants to explore levels of satisfaction with the location, duration, and intensity of PT following TKA.

Hypothesis 3: Black participants will report more feelings of dissatisfaction with rehabilitation or barriers to rehabilitation than white participants.

This research fills a gap in the literature regarding disparities in *functional* outcomes following TKA. It also helps to bring the field of PT research up to date with other disciplines that have already been conducting research regarding race disparities related to joint replacement surgery. If disparities in functional outcomes and PT service utilization are observed, the findings from Aims 1 and 2 will lay the groundwork for future research that will seek to reduce these disparities. Aim 3 is second-generation disparities work, which aids in elucidating possible reasons for any found disparity and allow generation of hypotheses regarding potential ways to intervene upon a disparity.

2.0 Background & Significance

2.1 Burden of Knee OA and TKA in the United States

Osteoarthritis (OA) is a joint disorder characterized by chronic breakdown of cartilage, resulting in stiffness, pain, and functional limitations. The knee is the most commonly affected joint; knee OA will affect nearly one half of all adults in their lifetime.[1] Knee OA is among the 25 most common causes of global years lived with disability (YLDs).[9] The causes of OA are multifactorial; contributing factors include age, prior injury, genetics, and joint mechanics. With recent increases in the incidence of obesity and traumatic knee injuries among United States adults, it is expected that the prevalence of knee OA, especially in those under age 65, will continue to increase.[10] No treatments have been shown to reverse the cartilage destruction that occurs in osteoarthritic joints. This often leads a person with knee OA to a lengthy and expensive path of attempting various nonsurgical and surgical treatments. The lifetime direct and indirect medical costs for a person with knee OA have been estimated at more than $140,000 US dollars.[10] Currently, the only effective treatment for end-stage knee osteoarthritis is elective TKA surgery.[1] TKA involves the surgical removal of any remaining cartilage as well as the ends of the tibia and femur bones, then implanting a joint prosthesis consisting of metal “bones” and plastic “cartilage”. In the United States, more than half of adults with knee osteoarthritis will eventually undergo a total knee replacement.[11,12]

More than four percent of adults over the age of 50 in the United States currently have a total knee replacement.[12] In 2004, the aggregate hospital costs for TKA surgery topped $6.3 billion. Over the preceding decade, the average selling price for prosthetic joint implants increased 132%. These statistics contribute to a growing gap between cost and reimbursement.[13] As the costs of medical devices and hospitalizations began to increase, there was a concern whether TKA surgery is cost-effective. An economic analysis of various treatment strategies for end-stage knee OA showed that immediate TKA resulted in greater quality of life improvement than delaying TKA with or without other conservative interventions.[14] While the majority of studies on the cost-effectiveness or societal cost of TKA surgery have focused on retired people, TKA has also been shown to be cost-effective in younger people with end-stage OA.[15] In fact, improved employment status and earnings from those who receive TKA is greater than the societal cost of having the surgery; thus, both the patient and his/her employer benefits from the employee's receipt of TKA surgery.[16]

The lifetime prevalence of knee OA is approximately 45% in the United States.[17] TKA surgery is associated with substantial improvements in physical function and quality of life; therefore, equitable access to TKA for all of those who need it is extremely important.

2.2 TKA Outcomes and Need for Post-Operative Rehabilitation

Outcomes following TKA surgery are overwhelmingly positive; 85% of TKA recipients report being satisfied with the results, and 90% experience a rapid and significant improvement

in pain, function, and quality of life.[18,19] Nearly all patients who undergo TKA can expect that the implanted knee joint prosthesis will last for well beyond a decade.[20] Patient-reported function typically improves greatly following knee replacement surgery. Both the Knee Society Score, a measure of pain, range of motion, and stability; and the SF-36, a measure of health-related quality of life (HRQoL), have been shown to improve by more than 100% by 12 months post-operatively.[21] For most patients, the vast majority of improvement in physical function occurs during the first 12 weeks post-operatively; little improvement is expected beyond 26 weeks.[22]

Intensive post-operative PT is necessary to maximize functional outcomes. A systematic review recently determined that more comprehensive, higher-intensity PT is needed well beyond the acute post-operative hospitalization period in order to maximize functional outcomes following total joint replacement.[23,24] This may be even more important for patients of racial and ethnic minority groups, given that minority patients tend to exhibit poorer functional status at the time of surgery compared to white majority patients, and poorer pre-operative function predicts poorer post-operative outcomes.[25-27]

2.3 Documented Race Disparities in TKA Rates in the United States

2.3.1 Identifying the Disparity

Several early studies demonstrated that those of black race and/or Hispanic ethnicity were significantly less likely than non-Hispanic whites to receive TKA surgery. A landmark 2003 study conducted by researchers from the Dartmouth Atlas of Health Care demonstrated that

non-Hispanic white males received TKA at a rate 40% higher than Hispanic males and 162% higher than non-Hispanic black males.[28] Similar but less drastic results were observed for women. While the Dartmouth Atlas project typically focuses on identifying regional variations in the delivery of health services, this study found that rates of TKA were significantly lower for blacks than whites in nearly every hospital referral region in the United States.

The epidemiological methods of early studies were criticized for including all elderly people in the denominator, which may introduce bias if there is a between-group difference in the prevalence or severity of knee OA. In response, Jones and colleagues demonstrated that even when only including patients with diagnosed knee OA who had been referred for specialty care, rates of TKA were still 28% lower in black patients within the Veterans Affairs health care system compared to non-Hispanic whites after adjusting for age, sex, and medical comorbidities.[29]

Steel and colleagues demonstrated that race disparities in TKA are not due to a difference in need.[30] Using data from the Health and Retirement Study, the need for TKA was characterized by difficulty walking, joint pain/stiffness/edema, and actively receiving treatment for OA, as well as the absence of contraindications for TKA surgery. Two years later, the survey assessed whether those "in need" actually received TKA surgery. The odds ratio for receipt of TKA for blacks compared to whites was 0.47 [95% CI 0.26-0.83]. This discrepancy was not explained by other variables such as access to care, medical comorbidities, employment status, disability status, or living alone.[30]

Hospital characteristics were also hypothesized to explain the differences in receipt of TKA. Chen and colleagues used the Nationwide Inpatient Sample from 2002-2007 from the Health

Care Utilization Project to examine this relationship. They found that, while hospital admission source and hospital characteristics explain some of the difference in TKA utilization rates, black patients received TKA at lower rates even after controlling for these variables.[31] Using similar Nationwide Inpatient Sample data, Bang and colleagues found that race disparities persist independently of age and income.[25]

These early studies demonstrated that the race disparity in use of TKA is widespread and consistent across Medicare, Veterans Affairs, and private insurance populations. In fact, a study by Wilson and colleagues specifically analyzed data from several different sources and concluded that the disparity in TKA utilization is consistent at all income levels and all insurance statuses.[32] According to the CDC, the race disparity in TKA rates between white and black patients is still growing. Data from 2000 indicated a gap of 37 percentage points between whites and blacks, which prompted a Healthy People 2010 initiative to reduce race disparities in TKA rates.[33] However, by 2006, the gap grew to 39 percentage points.[17] Despite this failure of the Healthy People 2010 initiative, this topic was excluded from the Healthy People 2020 campaign.

2.3.2. Understanding the Disparity

Studies have repeatedly found that black patients are less likely than whites to express a willingness to undergo total joint replacement surgery because of differences in fear as well as expectations regarding pain and prognosis.[34-37] A few studies have noted that black patients perceive fewer benefits and greater risks associated with TKA surgery compared to whites.[38,39] Ang and colleagues also showed that black and white patients report similar perceptions of pain

and functional limitation related to knee OA, after adjusting for disease severity.[40] This led to the conclusion that the observed disparities in TKA utilization rates cannot be explained by differing perception of symptoms. In addition, studies by Weng and Ibrahim demonstrated that black patients' expectations for recovery and willingness to undergo TKA significantly improved after the use of a video decision aid with or without brief counseling; thus, much of the difference in expectations and willingness might be attributed to insufficient patient education regarding the procedure.[41,42] This hypothesis was supported in a recent study by Kwoh and colleagues, which found that black patients' willingness to undergo the surgery is influenced by having a better understanding of the surgical procedure, expecting a shorter hospital length of stay, and believing that the post-operative pain would be lower.[43] These authors also found that improved knowledge of TKA procedure decreased the disparity between white and black patients' willingness to undergo the surgery.

Lack of knowledge regarding the TKA procedure is an interesting line of inquiry when investigating disparities in the knee OA and TKA population. A recent study by Parks concluded that patients' decision-making is influenced by the experience of other people that they know.[44] Because TKA surgery is known to be successful and satisfactory to 85-90% of recipients,[19] it is likely that knowing someone who has undergone TKA would result in greater willingness to undergo the surgery. However, Ibrahim and colleagues found that black patients are significantly less likely than white patients to know a family member or friend who has undergone TKA.[45] Thus, it is understandable that black patients tend to have poorer expectations for TKA and would be less likely to consider it as an attractive treatment option. Patients' expectations regarding TKA

surgery is an extremely important topic to understand, because research has also shown that patients' preoperative expectations may correlate with improved patient-reported outcomes and improved patient satisfaction following TKA.[46,47]

Several studies have examined the role of physician attitude and patient-provider interaction on rates of TKA. Hausmann and colleagues observed that the odds of an orthopaedic surgeon recommending a patient for joint replacement surgery in the Veterans Affairs system was 0.46 for black veterans compared to white veterans (95% confidence interval [0.26, 0.83]; however, this was no longer statistically significant after adjusting for patient preference.[48] By analyzing audio-recordings of discussions of OA treatment options between patients and orthopaedic surgeons, these authors also found that black patients' visits included less discussion of the biomedical aspects of osteoarthritis and TKA surgery, but that all other items of discussion were quite similar for black and white patients.[49] A more recent study found that family and internal medicine physicians display a strong implicit preference for white patients over black patients with knee OA and associated the phrase "medically cooperative" with hypothetical white patients significantly more frequently than similar hypothetical black patients.[50] The physicians in this study agreed that their subconscious bias could play a role in their decision to refer a patient for an orthopaedic surgical consult.

2.4 Race Disparities Among Those Receiving Total Joint Arthroplasty

Most of the research surrounding outcomes following joint arthroplasty are not specifically related to rehabilitation; instead, they tend to focus on rates of complications or adverse events. A 2012 study analyzed more than 600,000 admissions for TKA at more than 3,000 hospitals nationwide. Hospitals were placed into quality categories based upon frequency of adverse events. Next, more than 91,000 admissions for primary TKA across 2,842 hospitals were examined for these adverse events. Overall, black patients were significantly more likely to receive TKA at a low-quality hospital (OR 1.28, 95% CI 1.18-1.41) after adjusting for diagnosis and for demographic, socioeconomic, and geographic variables.[3]

Two other studies highlight the impact of hospital choice on race disparities following TKA. Losina showed that racial minorities are more likely to receive TKA at a hospital with relatively low surgical volume, while another recent study showed that minority patients are more likely to have a longer hospital length of stay after the procedure.[51,52] A more recent study by Zhang and colleagues confirmed this trend.[54] Cram and colleagues showed that complication rates following TKA are significantly lower in high-volume hospitals (OR for high-volume compared to low-volume 0.64, 95% CI 0.56-0.75).[54] However, although black patients are more likely to undergo TKA in a low-volume hospital, more recent research concluded that hospital volume alone does not explain the race differences in post-operative complications or readmissions.[55]

A study conducted within the Veterans Affairs system found that black patients receiving TKA had higher rates of infection-related (RR 1.42, 95% CI 1.06-1.90) and non-infection-related (RR 1.5, 95% CI 1.08-2.1) complications within 30 days following primary TKA.[56] Similar results were noted in a recent study that found that black patients across a national database were more likely to experience any post-operative complication ($p = .007$) and some specific complications, including deep vein thrombosis ($p < .001$) and pulmonary embolism ($p < .001$).[57]

While the previously mentioned studies suggest that race plays a role in recovery from TKA, they do not provide information on the potential role of rehabilitation services in determining patient outcomes or race disparities in outcomes. Using data from the Health Care Utilization Project's State Inpatient Databases for four states (Arizona, Florida, New Jersey, and Wisconsin), Freburger and colleagues investigated the relationship between race and the use of post-acute inpatient rehabilitation services following TKA. While they found that geographic location and insurance status modify the relationship between these two variables, they noted that in most cases, racial minorities were discharged to facilities that usually offer less intensive rehabilitation care.[4] However, variables related to the actual delivery of PT services at these facilities was not studied.

A similar study specifically examined patients who received TKA in hospitals in Pennsylvania. They found that black patients were more likely to be discharged to both inpatient rehabilitation and skilled nursing facilities than their white counterparts. While this may seem like a potentially positive step because it means that they may have been receiving more hours of rehabilitation in those facilities than patients who were discharged home, patients discharged

to inpatient facilities also had significantly higher odds of being readmitted to the hospital within one month (30-day readmission odds ratio: 7.76 for patients in inpatient rehabilitation, 2.01 for patients in skilled nursing facilities).

Little research has been conducted on long-term outcomes following TKA. Dy and colleagues recently demonstrated that black race is associated with an increased risk of revision within ten years of primary TKA (HR 1.39, 95% CI 1.29-1.49) after adjusting for insurance status, income, and level of education.[46] This study involved more than 300,000 patients in New York and California over an 8-year period.

A recent study identified black race as an independent risk factor for a surgical manipulation under anesthesia due to insufficient post-operative range of motion or excessive stiffness.[58] While this doesn't directly imply that race disparities in rehabilitation use or success exist, manipulation under anesthesia is typically recommended when a patient is unable to obtain sufficient range of motion despite participating in post-operative physical therapy. It is unclear whether there are physiological differences between members of different races that may relate to the disparity in manipulations, such as differential scarring of connective tissue.

Very little research has examined race differences in long-term *functional* outcomes following TKA. One retrospective study noted lower Knee Society Scores for black patients who received TKA compared to white patients at two years post-operatively.[59] The Knee Society Score consists primarily of range of motion, stability, and alignment variables; it includes only three questions about function.[60] Another study noted that minority patients were more likely to report dissatisfaction or general functional limitations after surgery, but this study combined all

racial and ethnic minority patients into a single group and did not adjust for pre-operative functional status.[61]

One large retrospective study explored race differences in long-term function after TKA. Lavernia and colleagues performed a study of 1749 patients who had received either total hip or total knee arthroplasty studied self-reported pain, function, and well-being several years after surgery.[62] Overall, differences were observed for pain, function, and well-being even after adjusting for baseline values; generally, black race and Hispanic ethnicity were associated with poorer outcomes. No measures of the type, amount, or content of post-operative rehabilitation were included in this study, so it is unclear whether differences in the rehabilitation process may have contributed to the differences in outcomes. While this study certainly supports potential race disparities after TKA, the results may be affected by the fact the study was retrospective in nature, includes data from only one surgeon, and had highly variable follow-up time ranging from 2 to 16 years post-operatively. [62]

2.5 Disparities in PT Utilization and Outcomes in Other (Non-TKA) Populations

Relatively few published studies have focused on race disparities in PT utilization and outcomes. In fact, a conference was held in 2013 with representatives from historically black colleges and universities in the United States with the purpose of developing a research agenda to study health disparities related to rehabilitation.[63] While this conference was preliminary in nature, using a modified Delphi technique the attendees agreed that rehabilitation providers

must collaborate to increase formal research into disparities present amongst populations of people seeking rehabilitation care.

It has been reported that, among community-dwelling adults with Medicare, outpatient rehabilitation service utilization for any purpose or health condition is generally lower amongst black patients.[64] A recent study examined whether this is true amongst people with self-reported arthritis.[65] They found that minority race/ethnicity and lower socioeconomic status both made it less likely that a patient would access outpatient rehabilitation services, and that the effect of race/ethnicity persisted for black patients even after adjusting for socioeconomic variables.[65] However, this study included any participant in the Medical Expenditure Panel Survey (MEPS) who self-reported a diagnosis of arthritis; it did not specifically examine patients with confirmed knee osteoarthritis.

Several studies of race disparities related to rehabilitation utilization have focused on differences in rates of discharge from acute care hospitals to inpatient rehabilitation facilities. These studies have found that racial minorities are less likely to receive inpatient rehabilitation following spinal cord injury and traumatic brain injury.[66,67]

A 1992 study followed community-dwelling elderly individuals for one year and tracked use of outpatient rehabilitation services. Overall, 15% of the sample used physical or occupational therapy over the year, but use of rehabilitation was significantly lower amongst racial minorities.[68] This study, however, did not examine any particular explanations for the differences in rehabilitation service utilization. Similar race differences in PT utilization were found in a sample of people with Parkinson's disease.[69]

Few studies have examined race differences in rehabilitation outcomes or variables related to the delivery of specific rehabilitation services. Ellis and colleagues found that, within the Veterans Affairs system, black patients with stroke were actually more likely than white patients with stroke to receive PT and OT services.[7] However, this study did not examine the role of disease-specific variables that may have explained this difference and did not have data to investigate whether any participants were receiving PT or OT services outside the VA system. Another study examined functional status at discharge from inpatient rehabilitation hospitals amongst people with moderate or severe stroke. They found that black patients with severe stroke had significantly poorer function at discharge than white patients with severe stroke, but this difference was not significant when the specific PT and OT interventions that had been provided were added to the model. This study also identified several types of interventions within PT and OT sessions that varied significantly between races, but not all were necessarily related to an increase or decrease in function.[6] At first glance, this study appears to indicate that the content of rehabilitation may be important to understanding the disparity; however, specific details regarding best practices or ideal content of rehabilitation sessions would be difficult to glean from this particular study.

Very little research regarding rehabilitation disparities focuses on orthopaedic conditions. In 2000, Harada and colleagues examined 187,990 hospital admissions for hip fractures and found that, compared to white patients, black patients were approximately 30% less likely to receive PT in the hospital or in inpatient rehabilitation facilities following hip fracture (OR for "no PT" 1.30, 95% CI 1.18-1.43).[70] Disparities relating to PT for orthopaedic conditions beyond the

acute care hospital phase or discharge destination have not been studied, highlighting the need for increased research into potential disparities in delivery of post-acute PT services.

2.6 Gaps in Literature Regarding Race Disparities in Outcomes Following TKA

Overall, literature regarding race and ethnic disparities in outcomes following TKA is not comprehensive. Published studies have focused on more intermediate outcomes such as complication rates or post-operative discharge destination without regard to *functional* outcomes OR outcomes following access to formal rehabilitation services. PT is lagging behind other health care professions in conducting research to identify health care disparities, but evidence from database studies suggests that there may be race/ethnic disparities in functional outcomes following total joint replacement. These disparities may be directly related to overall utilization of PT services post-operatively. It is imperative to identify disparities in functional outcomes and whether utilization of PT is a contributing factor, in order to design and test interventions aimed at reducing any found disparity.

2.7 Theoretical Model Informing Current Research Study

In 2006, Kilbourne and colleagues introduced a conceptual framework specifically designed to promote health disparities research.[71] These authors organize health disparities research into three phases.

The first phase involves the detection of disparities, which is more complex than it may initially seem.[71] First, the researcher must define a particular health disparity, which Kilbourne and colleagues define as an observable difference that is both clinically and statistically significant. A disparity may not be measured only as an observed difference in a health outcome or utilization of any particular health care intervention, but also as a difference in the *quality* of the care provided. Quality of care may be considerably more challenging to measure but has great implications for intervention at the level of the practitioner or health care system. Also included in the first phase of health disparities research is the identification of vulnerable populations; defined as subpopulations that are "at risk of poor physical psychological, and/or social health because of differences in underlying social status owing to race/ethnicity, gender, and so on". The final piece of the first phase of disparities research involves determining how to reliably and validly measure the disparity. Much of the published disparities research in TKR utilization has used Medicare data or the Nationwide Inpatient Sample to provide information regarding surgical rates within various demographic categories; these data are readily available to the researcher. However, if a researcher wanted to study variables such as quality of care or outcomes from rehabilitation, it would be considerably more difficult to determine how to access these data and measure them in a consistent and valid manner.

Once a disparity has been detected, the second phase of research involves understanding the factors that lead to the disparity.[71] These factors may be at the level of the patient, e.g. race/ethnicity, education, health literacy, biology, or patient preferences. As discussed previously, patient preferences have been shown to play a contributing role in the race/ethnic

disparities in TKR utilization. Kilbourne and colleagues note that is important to differentiate between preferences that are truly grounded in culture versus those that are due to "modifiable perceptions or even misleading information". In addition to patient factors, health care provider factors such as bias or competing professional demands may also contribute to a health care disparity. In addition, health care system factors such as institutional policies, culture, and financing may contribute to disparities. A health care system that provides minimal charity care or does not accept Medicaid or medical assistance is unlikely to provide adequate care for patients of low socioeconomic status, who are disproportionately racial minorities. Interestingly, Kilbourne's model also includes the intersection of patient factors and provider factors into the *clinical encounter*, and states that the quality of patient-provider communication likely plays a role in health disparities. For example, a patient who visits a provider who takes the time to build rapport with a patient and to explain risks associated with surgery or the complexities of the rehabilitation process may be more willing to consider surgery than a provider who spends minimal time with patients and expects the patient to do his/her own research regarding the surgical risks and prognosis.

Finally, the third phase of health disparities research involves reducing or eliminating disparities.[71] This includes not only the development and implementation of interventions to address a disparity, but also the evaluation of the intervention to determine its efficacy. Both quantitative and qualitative data are important in evaluating the success of an intervention. While quantitative data allow calculation of the difference between the majority and minority or underserved population being studied, the nature of quantitative data often limits the ability of

participants to expand upon their thoughts or feelings. Qualitative data collection allows the participant to provide more comprehensive answers. Often, patterns gleaned from qualitative data collection (e.g. many participants who were separately interviewed identifying the same problem or issue) provide a deeper understanding of quantitative information and help to develop hypotheses for future research studies.

The state of research into potential disparities in *functional* outcomes and/or PT delivery following TKA is in its infancy; thus, current research efforts must be focused on detection (Phase I projects). Reliable, valid measures must be used to determine whether a race disparity in functional outcomes or PT utilization exists among those who have recently underwent TKA. The proposed study aims to answer this question. Aims 1 and 2 are Phase I (detection) studies designed to identify potential disparities in functional outcomes and PT utilization between white and black patients undergoing TKA. If a disparity is found in PT utilization or functional outcomes, future research should focus first on identifying the root causes of the disparity and later on designing and implementing interventions to reduce or eliminate the disparity. Aim 3 of the proposed study is a qualitative project that may generate hypotheses regarding potential reasons for the disparity and lead to future Phase II (understanding) projects to more clearly understand why such a disparity exists.

2.8 Overall Significance & Innovation of the Present Study

This project is innovative in several ways. To our knowledge, it will be the first study of potential race disparities in *functional* outcomes in a sample consisting only of those receiving TKA. It will also be the first study to examine potential race/ethnic disparities in PT utilization measures in a population of participants who have undergone TKA. Finally, the present study will be the first *prospective* investigation into race disparities related to TKA and the provision of PT services and the first to use qualitative methods to illuminate potential reasons for any found disparity.

This study builds upon prior research identifying disparities in immediate post-operative outcomes following TKA by asking the question of whether functional outcomes are different between black and non-Hispanic white patients (Aim 1), and whether PT delivery differs and may play a role in any disparity in outcome (Aims 2 and 3). This Phase I research study (as classified using the Kilbourne model) will provide a framework for future studies to identify the root causes of any found disparities and to design and implement interventions to reduce or eliminate them. Studies designed to test interventions to reduce disparities in *any* population of people utilizing PT services have not been published to date.

3.0. AIM 1: Does Race Predict Functional Outcome Following Knee Arthroplasty?

3.1 Introduction

Nearly half of all adults will experience knee osteoarthritis (OA) in their lifetime, and knee OA is among the most common causes of disability in the world.[1,9] Currently, the only effective treatment for end-stage knee osteoarthritis is elective total knee arthroplasty (TKA) surgery.[1] In the US, more than half of adults with knee OA will eventually undergo TKA.[11,12]

Outcomes following TKA surgery are generally quite positive – between 85-90% of TKA recipients report satisfaction with the results and significant improvements in pain, physical function, and quality of life.[18,19] Thus, it is important that this successful surgery be available to all those in need. However, race disparities in TKA utilization are well-documented.

Countless studies have demonstrated that those of black race are significantly less likely than non-Hispanic whites to undergo TKA surgery.[17,25,28-33,40] Although demographic variables such as age, income, and insurance status can explain some of the variability in TKA rates, the disparity persists even after adjusting for all of these factors. However, despite ample research regarding race disparities in rates of TKA surgery, relatively little research exists regarding disparities in functional outcomes among those who have actually received TKA surgery.

Several studies have found that black patients tend to receive TKA at lower-quality hospitals, at hospitals that perform fewer TKAs in general, and are more likely to experience post-operative complications and hospital readmissions than white patients.[3,51,52,54,56,57] Therefore, it

is reasonable to ask whether black patients may also have a longer course of recovery or more difficulty with functional mobility after TKA surgery.

Unfortunately, research regarding race disparities in *functional* outcomes following TKA is scant. One recent study identified black race as a risk factor for manipulation under anesthesia following TKA, which may point to general difficulty in the post-operative recovery process.[58] Another study noted decreased Knee Society Scores for black patients following TKA, which indicates poorer performance on variables such as range of motion, stability, and alignment.[59] In general, one study found that racial minority patients were more likely to report general functional limitations following TKA, but the study grouped all racial and ethnic minority patients into a single group, making it difficult to parse out how function differed between specific groups.[61] One study did examine long-term function after TKA in a large sample of patients who had received either total knee or total hip arthroplasty.[62] Lavernia and colleagues found that black race and Hispanic ethnicity were generally associated with poorer outcomes following lower extremity arthroplasty surgery.[62]

Overall, there is a lack of research regarding the role of race in functional outcomes following TKA surgery. To that end, the purpose of the present study was to determine whether black/African-American race is an independent predictor of physical function following TKA.

3.2 Methods

3.2.1 Design Overview

This study employed a prospective observational cohort study design.

3.2.2. Setting and Participants

All study procedures took place at the University of Pittsburgh School of Health and Rehabilitation Sciences, Department of Physical Therapy. Participants were recruited from a variety of sources, including advertisements in five local hospital-based orthopaedic surgeons' offices, one private practice orthopaedic surgeon's office, referrals from a local research participant registry, and mailed advertisements. All surgeons who distributed advertisements were from within the University of Pittsburgh Medical Center (UPMC) system, but participants who were reached via the research registry and mailed advertisements were not limited to the UPMC system.

We screened potential participants via telephone for eligibility using an IRB-approved script (Appendix 1). Eligible and interested participants were then provided with a copy of the informed consent document via e-mail or postal mail. The principal investigator or research assistant telephoned the potential participant after they were given ample time to read the consent document, reviewed it with them, and answered any questions prior to the potential participant deciding whether to consent to participate in the study.

Participants were included in the study if they were scheduled for a primary unilateral TKA and identified as either white/Caucasian or black/African-American race and non-Hispanic ethnicity. Participants of other races and Hispanic ethnicity were not included, as there is a very low proportion of residents of those racial/ethnic groups locally and we would lack the statistical power to draw any meaningful conclusions about disparities in those populations. Additionally, eligible participants were English-speaking (to complete study questionnaires). Potential participants were excluded if they were scheduled for simultaneous bilateral TKA or a revision TKA (as the post-operative recovery process is quite different than that of unilateral and primary TKA) or if they failed to receive their scheduled unilateral TKA.

3.2.3. Research Procedures

Prior to undergoing TKA surgery, participants completed paper-based pre-operative questionnaires that were sent by research staff via e-mail (in PDF format and needed to be printed to complete the form) or by postal mail. Instructions for completion were included when the forms were distributed, and research staff was available by telephone or e-mail to answer questions about how to complete the forms. After undergoing surgery, study personnel kept in touch with the patient regarding their progress through rehabilitation via monthly telephone or e-mail follow-ups, but did not provide any intervention or medical/rehabilitation advice. Three months after surgery, participants completed paper-based post-operative questionnaires. We chose to collect follow-up questionnaires at the three-month post-operative time point because

prior research has demonstrated that the vast majority of improvement in physical function occurs in the first 12 weeks following surgery.[22]

Participants were not required to seek physical therapy care in any particular setting or from any particular care provider; these decisions were left entirely to the patient and the surgeon/other providers caring for them. Study personnel collected data regarding the settings (e.g. skilled nursing facility, home health, outpatient) in which patients received physical therapy but did not provide recommendations or opinions regarding physical therapy care.

3.2.4 Outcomes and Follow-Up

Pre-operatively, we collected demographic information including patient age, race, ethnicity, marital status, level of education, income, health insurance status, body mass index, and medical comorbidities using the Functional Comorbidity Index.[72] We also asked participants to self-report the name of their surgeon and hospital in which they would receive TKA.

The primary outcome for this study was the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). This self-reported outcome measure is designed to assess pain, stiffness, and physical function in people with knee OA and has been shown to be reliable, valid, and responsive in individuals with knee OA and those undergoing TKA.[73-77] For this study, we used the original 5-point Likert scale version of the WOMAC.[78] We used WOMAC questionnaires to calculate a total WOMAC score (with scores ranging from 0-96, with higher scores indicating worse symptoms) as well as pain and physical function subscale scores.

WOMAC questionnaires were completed pre-operatively and at three months post-operatively. Participants who were still actively in physical therapy at the three-month time point waited to complete the final WOMAC questionnaire until immediately following discharge from physical therapy, because it was more likely that a participant still receiving physical therapy would not yet have reached a plateau in their physical function.

3.2.5 Data Analysis

To calculate the target sample size, we used means and standard deviations of WOMAC scores for black/African-American and white/Caucasian patients with knee OA, as described by Allen et al.[79] We assumed a moderate race difference at follow-up with effect size of r = .15 between black and white participants and used this assumption to guide a multivariable regression model. We set alpha at .05, power at 80%, and determined that 103 participants were needed to determine if race significantly predicts post-operative WOMAC. Common convention is to recruit 10-15 participants per predictor, which would have required a sample of 70-105 participants using seven predictors (baseline WOMAC, age, sex, insurance status, income, hospital, and surgeon). Therefore, we aimed to recruit 105 participants. To aid in recruitment by more closely mirroring local racial demographics, we aimed to recruit participants at a 2:1 ratio of white:black participants.

The primary research question in this study is whether race is a significant predictor of outcome (post-operative WOMAC score) following TKA. To explore this question, we first

performed correlation and association analyses to determine if each potential covariate (listed in the previous paragraph) was significantly related to both race and follow-up WOMAC score. When examining the relationship of potential covariates to follow-up WOMAC score, we treated WOMAC score as a continuous variable. Depending on whether the potential covariate was continuous, ordinal, or nominal data, we performed Pearson product-moment correlations, Spearman rank-order correlations, and point biserial analyses, respectively. When examining the association of potential covariates to race, we used point biserial analyses or chi-squared analysis depending on upon whether the covariate was continuous (e.g. age) or categorical (e.g. sex). Post-hoc, we performed additional analyses to determine if the presence of any medical comorbidities (in the Functional Comorbidity Index) were significantly related to both race and follow-up WOMAC score.

After performing correlation analyses, we next performed a series of linear regression analyses. In Model 1, we first performed a simple linear regression analysis to look at the raw predictive value of race with respect to post-operative WOMAC score. Next, we performed three different hierarchical linear regression analyses to adjust for covariates, using the information gleaned in the correlation analyses described above. Because prior literature has consistently shown a strong correlation between pre-operative and post-operative function, we decided *a priori* to adjust for pre-operative WOMAC score in our regression model. Therefore, Model 2 reflects the predictive value of race on post-operative function after adjusting for pre-operative function. In Models 3 and 4, we added the covariates that correlation analyses indicated were important: In Model 3, we adjusted for pre-operative WOMAC score and all covariates that were

significantly correlated to *both* race *and* post-operative WOMAC score. In model 4, we adjusted for pre-operative WOMAC score and all covariates that were significantly correlated to *either* race *or* post-operative WOMAC score. In Models 2-4, we adjusted for covariates in the first step of the regressions. In the second step, race was added to determine the additional predictive value of race on post-operative WOMAC score. SPSS Statistics data analysis software (SPSS version 25; IBM, Inc.) was used for all data analysis.

3.2.6 Role of the Funding Source

This study was supported by Promotion of Doctoral Studies I and II awards from the Foundation for Physical Therapy Research and by a Pilot Award from the University of Pittsburgh Rehabilitation Institute. Neither funding source was involved in study design, study procedures, data analysis, or developing the manuscript.

3.3 Results

We enrolled 105 participants in the study, but one participant dropped out prior to completing any questionnaires because they chose to cancel their planned TKA surgery. All remaining participants (n = 104) completed baseline (pre-operative) questionnaires, and 96 completed follow-up (post-operative) questionnaires, for a dropout rate of 7.6%. Of the eight participants who were lost to follow-up, six were white and two were black.

Baseline participant characteristics are described in **Table 1**. The majority of participants were female, and the mean participant age was approximately 64 years old. On average, white participants were more likely to be married or in a domestic partnership, had higher educational attainment, and reported higher household income compared to black participants. For participants of both races, the most common health insurance was Medicare, followed by private/commercial insurance. The most common medical comorbidities were arthritis, obesity, upper gastrointestinal disease, degenerative disc disease, and visual impairment. Participants received TKA surgeries at 17 different hospitals from 29 different orthopaedic surgeons.

Pre-operatively, white participants had better global WOMAC scores (mean = 50.5, SD = 15.1) than black participants (mean 54.1, SD 13.4; **Table 1**). This magnitude of difference remained consistent at follow-up. White participants' mean post-operative WOMAC was 20.4 (SD 16.6), compared to black participants' mean WOMAC of 25.2 (SD 12.4), a 5% between-group difference in relation to the maximum possible score of 96. This does not meet the threshold of a clinically important difference of at least 6% as described by Angst et al.[85]

Table 1: Baseline Participant Demographic & Clinical Characteristics by Race

	White/Caucasian, n = 75	Black/African-American, n = 29
Sex, n (%)		
Male	28 (37.3%)	9 (31.0%)
Female	47 (62.7%)	20 (69.0%)
Age, mean (SD)	64.3 (8.4)	65.2 (6.2)
Marital Status, n (%)		
Married/Domestic Partner	57 (76.0%)	8 (27.6%)
Divorced/Separated	7 (9.3%)	10 (34.5%)
Widowed	5 (6.7%)	8 (27.6%)
Single, never married	6 (8.0%)	3 (10.3%)
Highest Educational Level Completed, n (%)		
Less than High School	0 (0.0%)	1 (3.4%)
High School	33 (44.0%)	23 (79.3%)
College	20 (26.6%)	4 (13.8%)
Post-Graduate Degree	22 (29.3%)	1 (3.4%)
Annual Household Income (in United States dollars), n (%)		
<25,000	8 (10.7%)	11 (37.9%)
25,000-<50,000	16 (21.3%)	17 (58.6%)
50,000-<100,000	28 (37.3%)	1 (0.0%)
100,000+	20 (26.7%)	0 (0.0%)
No response	3 (4.0%)	1 (3.4%)
Health Insurance, n (%)		
Medicare	36 (48.0%)	16 (55.2%)
Medicaid	1 (1.3%)	1 (3.4%)
Dual Medicare/Medicaid	4 (5.3%)	3 (10.3%)
Private	33 (44.0%)	8 (37.6%)
Veterans	1 (1.3%)	0 (0.0%)
No insurance	0 (0.0%)	1 (3.4%)
Comorbidities, n (%)		
Arthritis	75 (100.0%)	28 (96.6%)
Osteoporosis	16 (21.3%)	1 (3.4%)
Asthma	9 (12.0%)	6 (20.7%)
Lung disease	4 (5.3%)	1 (3.4%)
Angina	0 (0.0%)	0 (0.0%)
Congestive heart failure	8 (10.7%)	2 (6.9%)
Myocardial infarction	8 (10.7%)	1 (3.4%)
Neurological disease	4 (5.3%)	0 (0.0%)
Stroke or transient ischemic attack	2 (2.7%)	0 (0.0%)
Peripheral vascular disease	4 (5.3%)	2 (6.9%)
Diabetes I or II	3 (4.0%)	6 (20.7%)
Upper gastrointestinal disease	29 (38.7%)	11 (37.9%)
Depression	9 (12.0%)	7 (24.1%)
Anxiety/panic disorder	10 (13.3%)	0 (0.0%)
Visual impairment	19 (25.3%)	6 (20.7%)
Hearing impairment	9 (12.0%)	1 (3.4%)
Degenerative Disc Disease	18 (24.0%)	12 (41.4%)

Obesity: 44 (58.7%)	44 (58.7%)	16 (55.2%)
Pre-Operative WOMAC Score, mean (SD)	50.5 (15.1)	54.1 (13.4)

Continuous variables are reported as mean (standard deviation). Categorical variables are reported as n (percent). SD = standard deviation; WOMAC = Western Ontario and McMaster Arthritis Index

Prior to conducting bivariate Pearson correlation analyses, we performed a logarithmic transformation on the variable "post-operative WOMAC" due to a violation of the assumption of normality. The transformation was successful at bringing the data into a normal distribution. All other statistical assumptions were met.

The correlation matrix is in **Table 2**. Several variables were significantly correlated to either post-operative WOMAC score or race. Variables related to post-operative WOMAC at the criterion of $p < .10$ included sex ($r = .274$, $p = .007$), pre-operative WOMAC ($r = .331$, $p = .001$), household income ($r = .179$, $p = .088$), and surgeon ($r = .186$, $p = .069$). Variables significantly related to race included marital status ($r = .403$, $p < .001$), educational attainment ($r = .420$, $p < .001$), and household income ($r = .543$, $p < .001$). Household income was the only potential covariate that correlated to both race *and* post-operative WOMAC score at a threshold of $p < .10$.

In post-hoc analyses, we found that two medical comorbidities significantly correlate to both the predictor and the outcome variables. Presence of diabetes (type I or II) was correlated to race ($r = .268$, $p = .008$) and post-operative WOMAC ($r = .266$, $p = .006$). Degenerative disc disease was also correlated to both race ($r = .205$, $p = .045$) and post-operative WOMAC ($r = .172$, $p = .081$).

Table 2. Bivariate Correlation Matrix

		WOMAC Post	Age	Sex	Race	Marital	Education	Income	Insurance	Hospital	Surgeon
WOMAC Post	**r**										
	p										
Age	**r**	.006									
	p	.952									
Sex	**r**	.274**	.069								
	p	.007	.488								
Race	**r**	.185	.053	.059 [a]							
	p	.071	.593	.552							
Marital	**r**	.018	.080	.209* [a]	.403** [a]						
	p	.863	.419	.033	.000						
Education	**r**	.135	.066	.033 [a]	.420** [a]	.234* [a]					
	p	.189	.507	.738	.000	.017					
Income	**r**	.179	.202*	.028 [a]	.543** [a]	.534** [a]	.572** [a]				
	p	.088	.044	.783	.000	.000	.000				
Insurance	**r**	.022	.547**	.143 [a]	.091 [a]	.026 [a]	.026 [a]	.250* [a]			
	p	.835	.000	.147	.360	.793	.791	.012			
Hospital	**r**	.118	.049	.197* [a]	.031 [a]	.071 [a]	.024 [a]	.053 [a]	.032		
	p	.254	.624	.045	.754	.475	.807	.601	.749		
Surgeon	**r**	.186	.094	.335** [a]	.044 [a]	.022 [a]	.058 [a]	.064 [a]	.188	.622**	
	p	.069	.342	.001	.660	.827	.557	.524	.056	.000	
WOMAC Pre	**r**	.331**	.025	.219*	.109	.110	.156	.282**	.063	.015	.094
	p	.001	.804	.026	.270	.268	.114	.005	.523	.883	.341

*WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index; r = Pearson correlation coefficient; p = p-value for correlation coefficient. WOMAC Pre indicates pre-operative WOMAC score and WOMAC Post indicates post-operative WOMAC score. ** denotes statistically significant results. [a] denotes chi-squared analyses (not correlation analyses).*

Table 3 shows the results of regression analyses. The unadjusted linear regression model (Model 1) demonstrated that race was not a statistically significant predictor of post-operative WOMAC score ($p = .071$, adjusted $R^2 = .024$). After adjusting for baseline WOMAC score (Model 2), the overall model fit was statistically significant ($p = .001$), but the R^2 remained small (adjusted $R^2 = .12$), and R^2 change when adding race into the model was very small (.02). Similar results were observed in Model 3, adjusting for baseline WOMAC score, household income, and presence of diabetes and/or degenerative disc disease; $p = .008$, adjusted $R^2 = .11$). In this model, the R^2 change when adding race into the model was even smaller (.01). Finally, we expanded the model to adjust for additional sociodemographic variables including sex, marital status, educational attainment, household income, and surgeon (Model 4). Again, the overall model fit was statistically significant ($p = .004$), but the adjusted R^2 change was only .167 and R^2 change when adding race into the model was .01.

Overall model fit was strongest for Model 4, but it still indicates that all of the sociodemographic and clinical factors only account for a relatively small proportion (approximately 17%) of the variability in follow-up WOMAC scores. Beta coefficients and 95% confidence intervals are included in Table 3 but are difficult to interpret because the outcome variable (follow-up WOMAC score) had to be transformed to satisfy the normality assumption prior to running regression analyses.

Table 3. Regression Models: Race as a Predictor of Follow-Up WOMAC Score after Adjusting for Sociodemographic and Clinical Factors

	Model 1 β (95% CI)	Model 2 β (95% CI)	Model 3 β (95% CI)	Model 4 β (95% CI)
Variable				
Race (black)	.72 (-.07, 1.51)	.62 (-.13, 1.37)	.22 (-.75, 1.18)	.22 (-.74, 1.17)
Baseline WOMAC	--	.04 (.02, .06)	.03 (.002, .06)	.02 (-.01, .05)
Annual Income	--	--	-.10 (-.52, .33)	-.34 (-.85, .17)
Presence of DM	--	--	.89 (-.43, 2.20)	.82 (-.46, 2.11)
Presence of DD	--	--	.48 (-.33, 1.29)	.54 (-.26, 1.34)
Sex (female)	--	--	--	.87 (.04, 1.69)
Marital status (married or cohabitating)	--	--	--	-.29 (-.59, .001)
Level of Education (college degree or higher)	--	--	--	.02 (-.26, .30)
Surgeon	--	--	--	.02 (-.02, .06)
Overall Model Fit				
F (df)	3.32 (1, 94)	7.24* (2, 93)	3.34* (5,86)	3.02* (9,82)
R^2	.03	.14	.16	.25
Adjusted R^2	.02	.12	.11	.17
R^2 change from race term	.02	.02	.01	.01

*β = Beta coefficient; 95% CI = 95% confidence interval; WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index; DM = diabetes mellitus (type 1 or 2); DDD = degenerative disc disease; df = degrees of freedom in regression models. * denotes statistical significance of overall model fit at $p < .05$*

3.4 Discussion

In the present study, we found that race was not predictive of post-operative WOMAC score following total knee arthroplasty. This held true when conducting an unadjusted regression model and after adjusting for demographic and clinical variables that were related to race and/or post-operative WOMAC.

At baseline, race was moderately correlated to other demographic variables, including marital status, educational attainment, and household income. Because these are demographic traits that we anticipated would correlate with each other, we first looked at the predictive value of race alone, prior to building models that adjusted for additional demographic traits. However, in all models, race was not associated with the outcome. Similarly, two medical comorbidities (diabetes and degenerative disc disease) were significantly correlated to both race and post-operative WOMAC score. However, adding these variables into the regression models did not result in substantial changes to the results. Even our best-fit model found that, after adjusting for all relevant demographic and clinical variables, race only explained approximately 17% of the variance in post-operative WOMAC.

There is a paucity of research investigating race disparities in functional outcomes after TKA surgery, but some studies have identified black race as a risk factor for other negative outcomes such as manipulation under anesthesia and lower Knee Society Scores (indicating poorer range of motion, stability, and/or alignment.)[58,59] Based upon that research, it is reasonable to hypothesize that patient-reported function may also be lower amongst black patients status post TKA. However, our findings do not support that hypothesis.

We did not ask specific questions regarding manipulations under anesthesia or measure variables included in the Knee Society Score outcome measure, so we cannot assess whether our findings support the prior studies that have noted race as a predictor of those outcomes.

In our study, black patients' pre-operative WOMAC scores indicated slightly worse function than white patients'. This small between-group difference persisted at follow-up. The overall amount of post-operative improvement was similar between groups. One may presume that the magnitude of change would be larger amongst black participants, because there was greater room for improvement from baseline to follow-up, but we did not observe that in this sample. Regardless, we adjusted for baseline function in our analyses to account for any confounding effects that baseline WOMAC score may have had.

Our findings conflict with those of Lavernia and colleagues, who noted that both black race and Hispanic ethnicity were associated with poorer outcomes on several different measures of function and quality of life after TKA.[62] In that single-surgeon study, black patients were younger and had different pre-operative diagnoses than white patients, which was not the case in our study. Similar to our study, total WOMAC scores were higher (indicating worse symptoms) in black patients pre-operatively. In the present study, the difference was not clinically significant (between-group difference of 3.6 points in total average pre-operative WOMAC), but the difference was larger and clinically significant among participants in the Lavernia study (between-group difference of 8.6 points in total average pre-operative WOMAC). However, although the Lavernia study utilized a much larger overall sample size (n = 1010 patients with TKA), approximately 90% of the sample was white.[62] Our study involved a much smaller sample size (n

= 104), but the race breakdown was more equitable (28% black and 72% white), and we investigated a larger number of demographic factors (such as insurance status, household income, and educational attainment). Both the present study (Pittsburgh) and the Lavernia study (Miami) involved patients from a single urban geographic region, and it is possible that black/white disparities in function following TKA may simply differ by location.

Prior research has shown that black patients undergoing TKA have poorer short-term outcomes such as post-operative complications and hospital readmissions. In this study, we did not measure hospital readmissions because our focus was on measuring functional recovery. We did measure post-operative complications, but there were relatively few complications in the sample, so we lacked the statistical power to detect a difference between black and white participants. However, one may presume that post-operative complications or additional hospital stays would prolong functional recovery following TKA. Therefore, corresponding to prior literature describing the functional recovery trajectory following TKA, we assessed follow-up function at three months post-operatively in participants who had completed all physical therapy at that point.[22] There was only one participant who was still actively in physical therapy at three months post-operatively, and we waited to assess follow-up function until the participant was discharged from physical therapy. It is possible that function continued to change or improve beyond the three-month time point, but we designed our study to capture post-operative function at a time when participants would have achieved close to their maximal function.

Future research should investigate potential race disparities in long-term functional outcome following TKA using validated measures of physical function over a longer period of time (one year or longer) and using patients from a wider geographic region. In addition, future research should use large data sets that will allow researchers the statistical power to detect differences between many different races and ethnicities, rather than simply white and black patients undergoing TKA.

3.4.1 Limitations

The primary limitation of our study is the relatively small sample size. Although we recruited the number of participants that were necessary per our power analysis, we were powered to detect a moderate or larger relationship between race and functional outcomes. It is possible that a relationship exists that was not detected in this study.

Additionally, in our sample, there were significant relationships between race and other demographic variables such as income, marital status, and educational attainment. It is possible that, by adjusting for these variables in our regression model, we masked part of the effect of race on outcome. However, this is unlikely for two reasons. First, in the model where we only adjusted for income (because it was the only demographic variable related to both race *and* WOMAC scores), the R^2 change when adding race into the model was still quite low. Second, average WOMAC scores were similar between white and black patients at both baseline and follow-up, so it is unlikely that our statistical methods masked a difference in function between groups of patients because there was not a substantial difference present.

To investigate the relationship between race and functional outcomes, we used a patient-reported outcome measure. We did not collect performance-based measures of physical function. It is possible that the relationship between race and performance-based measures of function is different than the relationship we found between race and WOMAC scores, a patient-reported measure of function.

Finally, the racial and ethnic demographics of the geographic region where our study was conducted only allowed us to compare black and white patients undergoing TKA. Therefore, we cannot generate any conclusions regarding functional outcomes in patients of other races and ethnicities.

Overall, our findings did not support our hypothesis that race would be a strong predictor of post-operative functional recovery after TKA. However, due to our relatively small sample size and limited geographic variability of our sample, further investigation is warranted.

3.5 Conclusion

In this sample of 104 participants who underwent TKA, race was not a substantial independent predictor of post-operative functional outcomes. Additional larger studies with more racially diverse patient samples are needed to confirm or deny the relationship between race and functional recovery following TKA.

4.0. AIM 2: Does Physical Therapy Service Utilization Differ By Race Following Total Knee Arthroplasty?

4.1 Introduction

Total knee arthroplasty (TKA) is a successful elective surgery for individuals with end-stage knee osteoarthritis (OA). TKA is effective at improving physical function and quality of life, and cost-effective in both older and younger adults.[14-16,18,19,21]

Following TKA surgery, intensive post-operative physical therapy is necessary to maximize functional outcomes. A systematic review recently determined that comprehensive, high-intensity physical therapy is needed for months beyond the acute post-operative hospitalization period in order to maximize functional outcomes following total joint replacement.[23,24] Intensive post-operative physical therapy may be even more important for patients of racial and ethnic minority groups, given that minority patients tend to exhibit poorer functional status at the time of surgery compared to white patients, and poorer pre-operative function predicts poorer post-operative outcomes.[25-27]

Substantial research has demonstrated race disparities in utilization of TKA: white non-Hispanic patients with knee OA are more likely to undergo TKA than patients of other races and/or Hispanic ethnicity.[17,25,27-50] While there are dozens of studies published on race disparities in the use of TKA, relatively little research has focused on whether such disparities persist among those who actually receive TKA surgery.

Several studies have identified race as a predictor of receiving TKA in a low-quality hospital or a hospital with lower surgical volume, of experiencing short- and long-term complications such as infection or revision TKA surgery, and of hospital readmissions.[51-58] However, little research has examined the role of physical therapy and rehabilitation services in any possible disparities. Freburger and colleagues demonstrated that racial minority patients are more likely to be discharged to facilities that offer less intensive rehabilitation care.[4] However, the impact of this on patients' functional outcomes was not studied. A retrospective single-surgeon study by Lavernia and colleagues identified long-term differences in pain and function after TKA for black and Hispanic patients compared to white patients.[62] However, this study did not include any measure of the type, amount, or content post-operative rehabilitation patients received, so it is unclear whether differences in the rehabilitation process may have contributed to the differences in outcomes.

Overall, current literature suggests that there may be both short- and long-term race disparities affecting the clinical outcome of individuals who have undergone TKA surgery. However, there is a lack of knowledge regarding whether differences in the provision of physical therapy exist and play a role in any such disparities. Therefore, the purpose of this study was to investigate whether there are race differences in the provision of post-operative physical therapy services received following elective TKA surgery.

4.2 Methods

4.2.1 Design Overview

This study employed a prospective observational cohort study design.

4.2.2 Setting and Participants

All study procedures took place at the University of Pittsburgh School of Health and Rehabilitation Sciences, Department of Physical Therapy. Participants were recruited from a variety of sources, including advertisements in local orthopaedic surgeons' offices, referrals from a local research participant registry, and mailed advertisements. We screened potential participants via telephone for eligibility using an IRB-approved script (Appendix 1). Eligible and interested participants were then provided with a copy of the informed consent document via e-mail or postal mail. The principal investigator or research assistant then telephoned the potential participant after they were given ample time to read the consent document, reviewed the document with them, and answered any questions prior to the potential participant deciding whether to consent to participate in the study.

Participants were included in the study if they were scheduled for a primary unilateral TKA and identified as either white/Caucasian or black/African-American race and non-Hispanic ethnicity. Participants of other races and Hispanic ethnicity were not included, as there is a very low proportion of residents of those racial/ethnic groups locally and we would lack the statistical power to draw any meaningful conclusions about disparities in those populations.

Additionally, eligible participants were English-speaking (to complete study questionnaires). Potential participants were excluded if they were scheduled for simultaneous bilateral TKA or a revision TKA, because the post-operative recovery processes for bilateral and revision TKAs are quite different than those of unilateral and primary TKAs. Participants were also excluded if they failed to receive their scheduled primary unilateral TKA.

4.2.3 Research Procedures

Prior to undergoing TKA surgery, participants completed pre-operative questionnaires. After undergoing surgery, study personnel kept in touch via monthly telephone or e-mail contacts with the participant regarding their progress through rehabilitation, but did not provide any intervention or medical/rehabilitation advice. Three months after surgery, participants completed post-operative questionnaires. We chose to collect follow-up questionnaires that three months post-operatively because prior research has demonstrated that the vast majority of improvement in physical function occurs in the first 12 weeks following surgery.[22] If a participant was still actively in physical therapy treatment at the three-month time point, we waited to complete post-operative questionnaires until immediately upon discharge from formal physical therapy services.

Participants were not required to seek physical therapy care in any particular setting or from any particular care provider; these decisions were left entirely to the patient and their health care team. Study personnel collected data regarding the settings (e.g. skilled nursing

facility, home health, outpatient) in which patients received physical therapy but did not provide recommendations or opinions regarding physical therapy care.

4.2.4 Outcomes and Follow-Up

The primary outcome for this study is the total number of hours of post-acute care physical therapy received by each participant, calculated as the sum of the amount of time spent in home health physical therapy, acute inpatient rehabilitation physical therapy, skilled nursing facility or subacute inpatient physical therapy, and outpatient physical therapy. Upon enrollment, participants were given an informational sheet describing the self-reported items that would be asked of each participant at follow-up, as well as a form to document these variables as they occur to minimize reporting bias.

Pre-operatively, we collected demographic information including patient age, sex, race, ethnicity, marital status, level of education, income, health insurance status, body mass index, and medical comorbidities using the Functional Comorbidity Index.[72] We asked participants to self-report the name of their surgeon and hospital in which they would be receiving TKA surgery. Participants also completed a pre-operative Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). The WOMAC tool measures pain, stiffness, and physical function and has been shown to be reliable, valid, and responsive in individuals with knee OA and TKA.[73-77] We used the 5-item Likert scale version of the WOMAC, which contains 24 items and a scoring range of 0-96, with higher scores indicating poorer self-reported pain, function, and stiffness.

At three months post-operatively, participants completed another WOMAC questionnaire. In addition, they completed a survey regarding their post-operative recovery trajectory, including hospital length of stay (number of nights), occurrence of any post-operative complications, and type of TKA received (cemented vs. non-cemented). Participants also self-reported the number of nights stayed in any inpatient rehabilitation facility following discharge from the acute care hospital, as well as the number of visits from home health physical therapy. Finally, participants were asked to report the name and location of any outpatient physical therapy facility they attended. Study personnel then worked with the participant to obtain a copy of their outpatient physical therapy records to record the number of outpatient physical therapy visits, duration of physical therapy care, number of units for each procedural code billed at each session (typically 1 billing unit represents approximately 15 minutes of treatment), and the number of units/minutes billed at each outpatient physical therapy visit.

Following review of participant self-reported information and review of outpatient physical therapy records, the total amount of time spent in each phase of post-operative physical therapy was calculated as follows:

- Acute rehabilitation: self-reported length of stay (days) x 90 minutes PT/day
    - *Rationale: Acute rehabilitation guidelines require 3 total hours of rehabilitation per day on at least 5 days per week; most facilities split this into 90 minutes physical and 90 minutes occupational therapy.*[80-82]
- Skilled nursing facility (SNF) or subacute rehabilitation facility: self-reported length of stay (days) x 45 minutes PT/day

- *Rationale: While there is some variability in time spent in PT at SNFs by health insurer and particular SNF, the average is 90 minutes per day of total therapy, including 45 minutes occupational therapy and 45 minutes PT.*[80-82]

- Home PT: self-reported number of visits by home care therapist x 60 minutes/ visit
    - *Rationale: While there is no set amount of time required for a home care PT visit, most agencies schedule visits for 60 minutes of treatment time due to a common convention related to Medicare guidelines.*[83] *In addition, published research indicates that PTs spend approximately 74 minutes per home PT visit with a patient with an orthopaedic condition; however, after subtracting average travel time calculated in this study, this number would be 61 minutes.*[84]
- Outpatient PT: total minutes (from billing/CPT code sheet, sum of all outpatient PT visits).
- **Summary outcome measure of TOTAL amount of PT received:**

    (acute rehabilitation minutes + SNF minutes + home PT minutes + outpatient PT minutes) ÷ 60

    This will provide a total number of HOURS of post-acute care PT received, rounded to the nearest 10th of an hour. This is the most accurate way

to create a single variable representing all PT received following TKA, due to differences in the ways that PT utilization is measured across different locations.

4.2.5 Data Analysis

To calculate sample size, we assumed a 2-tailed t-test with alpha = .05, 80% power, and a moderate effect size of 0.5 for the difference in total physical therapy utilization between white and black participants. To aid in recruitment by more closely mirroring the racial demographics of our city, we also assumed a 2:1 ratio of white:black participants. Using these variables, we calculated that complete data would be needed from 144 participants.

The primary research question in this study is whether the total amount of post-acute care physical therapy received is different between black/African-American and white/ Caucasian participants. To investigate this question, we performed an independent samples t-test comparing the mean total number of hours of physical therapy between the two groups. Additionally, we performed independent t-tests to compare utilization of specific physical therapy settings (skilled nursing facility, acute inpatient rehabilitation, home health, and outpatient) between groups to gain more information about differences in utilization.

In a post-hoc analysis, we compared each participant's pre-operative and three-month post-operative WOMAC score to determine the proportion of participants meeting the criteria to be classified as "responders" using OARSI-OMERACT criteria. These criteria include

(1) improvement in pain or physical function of at least 50% and an absolute change of at least 20 mm on a 100-mm scale; or (2) improvement of at least 20% with an absolute change of at least 10 mm on a 100-mm scale in two of the following three categories: pain, physical function, and patients' global assessment.

4.2.6 Role of the Funding Source

This study was supported by Promotion of Doctoral Studies I and II awards from the Foundation for Physical Therapy Research and by a Pilot Award from the University of Pittsburgh Rehabilitation Institute. Neither funding source was involved in study design, study procedures, data analysis, or developing the manuscript.

4.3 Results

In this manuscript, we report preliminary results from 104 participants. We originally planned to recruit 144 participants, but recruitment proved to be difficult. It is challenging to reach patients scheduled for TKA before they undergo surgery, as the time between scheduling and undergoing surgery is often a short window (2-4 weeks). Because Aim 1 is considered the primary aim of the study, we decided to perform statistical analyses and report results when we reached the recruitment target for Aim 1.

Baseline participant demographic and clinical characteristics, split by race, are described in **Table 4**. Both white and black participants' average age was in the mid-sixties, and there was a similar sex split between both groups with approximately double the number of women participants than men in each group. White participants reported overall higher levels of educational attainment and larger annual household incomes.

Comorbidities differed somewhat between groups. White participants were substantially more likely to have osteoporosis, hearing impairments, and anxiety or panic disorders. Black participants were more likely to have asthma, diabetes mellitus, depression, and degenerative disc disease. Other comorbidities were similar between groups.

Compared to white participants, black participants' pre-operative total WOMAC scores were similar. Black participants' scores were slightly higher at baseline (indicating more pain and stiffness and/or poorer physical function), but this difference was not clinically or statistically significant.

Table 4: Baseline Participant Demographic & Clinical Characteristics By Race

	White/Caucasian, n = 75	Black/African-American, n = 29
Sex, n (%)		
Male	28 (37.3%)	9 (31.0%)
Female	47 (62.7%)	20 (69.0%)
Age, mean (SD)	64.3 (8.4)	65.2 (6.2)
Marital Status, n (%)		
Married/Domestic Partner	57 (76.0%)	8 (27.6%)
Divorced/Separated	7 (9.3%)	10 (34.5%)
Widowed	5 (6.7%)	8 (27.6%)
Single, never married	6 (8.0%)	3 (10.3%)
Highest Educational Level Completed, n (%)		
Less than High School	0 (0.0%)	1 (3.4%)
High School	33 (44.0%)	23 (79.3%)
College	20 (26.6%)	4 (13.8%)
Post-Graduate Degree	22 (29.3%)	1 (3.4%)
Annual Household Income (in United States dollars), n (%)		
<25,000	8 (10.7%)	11 (37.9%)
25,000-<50,000	16 (21.3%)	17 (58.6%)
50,000-<100,000	28 (37.3%)	1 (0.0%)
100,000+	20 (26.7%)	0 (0.0%)
No response	3 (4.0%)	1 (3.4%)
Health Insurance, n (%)		
Medicare	36 (48.0%)	16 (55.2%)
Medicaid	1 (1.3%)	1 (3.4%)
Dual Medicare/Medicaid	4 (5.3%)	3 (10.3%)
Private	33 (44.0%)	8 (37.6%)
Veterans	1 (1.3%)	0 (0.0%)
No insurance	0 (0.0%)	1 (3.4%)
Comorbidities, n (%)		
Arthritis	75 (100.0%)	28 (96.6%)
Osteoporosis	16 (21.3%)	1 (3.4%)
Asthma	9 (12.0%)	6 (20.7%)
Lung disease	4 (5.3%)	1 (3.4%)
Angina	0 (0.0%)	0 (0.0%)
Congestive heart failure	8 (10.7%)	2 (6.9%)
Myocardial infarction	8 (10.7%)	1 (3.4%)
Neurological disease	4 (5.3%)	0 (0.0%)
Stroke or transient ischemic attack	2 (2.7%)	0 (0.0%)
Peripheral vascular disease	4 (5.3%)	2 (6.9%)
Diabetes I or II	3 (4.0%)	6 (20.7%)
Upper gastrointestinal disease	29 (38.7%)	11 (37.9%)
Depression	9 (12.0%)	7 (24.1%)
Anxiety/panic disorder	10 (13.3%)	0 (0.0%)
Visual impairment	19 (25.3%)	6 (20.7%)
Hearing impairment	9 (12.0%)	1 (3.4%)
Degenerative Disc Disease	18 (24.0%)	12 (41.4%)

Obesity: 44 (58.7%)	44 (58.7%)	16 (55.2%)
Pre-Operative WOMAC Score, mean (SD)	50.5 (15.1)	54.1 (13.4)

Continuous variables are reported as mean (standard deviation). Categorical variables are reported as n (percent). SD = standard deviation; WOMAC = Western Ontario and McMaster Arthritis Index

Table 5 reports post-operative clinical characteristics by race. White participants were more likely to report complications (20.0% complication rate for white patients vs. 6.9% complication rate). The most commonly reported complications were manipulation under anesthesia (n = 5) and deep vein thrombosis or pulmonary embolism (n = 4). Post-operative WOMAC scores indicated that black participants' scores remained higher than white participants, but the post-operative between-group difference was overall very similar to the baseline (pre-operative) difference.

Table 5: Post-Surgical Characteristics By Race

	White/Caucasian, n = 75	Black/African-American, n = 29
Surgical Complications		
Yes, n (%)	15 (20.0%)	2 (6.9%)
• Yes, Wound Infection (n)	• 2	• 0
• Yes, DVT/PE (n)	• 4	• 0
• Yes, Manipulation (n)	• 4	• 1
• Yes, Other Complication (n)	• 7	• 1
No, n (%)	52 (69.3%)	25 (86.2%)
Unknown, n (%)	8 (10.7%)	2 (6.9%)
Post-Operative WOMAC, mean (SD)	20.4 (16.6)	25.2 (12.4)

Continuous variables are reported as mean (standard deviation). Categorical variables are reported as n (percent). SD = standard deviation; WOMAC = Western Ontario and McMaster Arthritis Index (higher scores = worse symptoms); DVT = Deep Venous Thrombosis; PE = Pulmonary Embolism

Post-operative physical therapy utilization is described in **Table 6**. All participants who completed follow-up questionnaires reported receiving acute care/hospital physical therapy, and hospital length of stay was nearly identical. No participant in either group reported being discharged to acute inpatient rehabilitation after their hospital stay.

Table 6: Post-Acute Physical Therapy Utilization by Race

	White/Caucasian, n = 75	Black/African-American, n = 29	p-value (between-group difference)
Hospital/Acute Care: Received PT?	Yes: 75 (92.0%) No: 0 (0.0%) Unknown: 0 (8.0%)	Yes: 27 (93.1%) No: 0 (0.0%) Unknown: 2 (6.9%)	.863
Hospital Length of Stay	2.3 days (SD 0.8)	2.3 days (SD 0.8)	.872
Discharged to SNF?	Yes: 13 (17.3%) No: 56 (74.7%) Unknown: 6 (8.0%)	Yes: 8 (27.6%) No: 19 (65.5%) Unknown: 2 (6.9%)	.250
Length of stay in SNF	12.6 days (SD 6.8)	11.0 days (SD 2.3)	.446
Hours of SNF PT Received	1.52 (SD 0.46)	2.44 (SD 0.76)	.490
Received Home Health PT?	Yes: 52 (69.3%) No: 17 (22.7%) Unknown: 6 (8.0%)	Yes: 26 (89.7%) No: 1 (3.4%) Unknown: 2 (6.9%)	.018*
Number of home PT visits	4.7 visits (SD 3.4)	6.2 visits (SD 3.4)	.051
Hours of Home Health PT Received	4.6 (SD 0.44)	6.2 (SD 0.66)	.051
Received Outpatient PT?	Yes: 66 (88.0%) No: 3 (4.0%) Unknown: 6 (8.0%)	Yes: 24 (82.8%) No: 3 (10.3%) Unknown: 2 (6.9%)	.218
Duration of Outpatient PT Care	56.8 days (SD 30.0)	71.2 days (SD 37.7)	.056
Number of outpatient PT visits	17.1 visits (SD 8.6)	16.1 visits (SD 9.0)	.629
Hours of Outpatient PT Received	19.22 (SD 1.55)	14.08 (SD 1.54)	.055
Total Hours of Post-Acute PT Received	25.4 (SD 1.7)	22.8 (SD 1.9)	.360

*Continuous variables are reported as mean (standard deviation). Categorical variables are reported as n (percent). SD = standard deviation; PT = Physical Therapy; SNF = Skilled Nursing Facility. * indicates statistically significant results.*

4.3.1 Skilled Nursing Facility Physical Therapy

A substantial minority of participants in both groups were discharged to skilled nursing facilities for rehabilitation. More black participants (27.6%) than white participants (17.3%) were discharged to skilled nursing facilities, **Table 6**). When comparing the full cohort of black participants to the full cohort of white participants, neither the length of stay ($p = .446$) nor the number of hours of physical therapy received ($p = .490$) in skilled nursing facilities was statistically significant between groups.

4.3.2 Home Health Physical Therapy

A majority of participants in both groups reported receiving home health physical therapy, but a statistically significantly larger proportion of black participants received home health ($\chi^2 = 5.58$, $p = .018$). The number of visits received was also higher amongst black participants (average of 6.2 visits), than white participants (average of 4.7 visits), but this difference did not reach statistical significance ($p = .051$, **Table 6**).

4.3.3. Outpatient Physical Therapy

A large majority of participants in both groups received outpatient physical therapy (88.0% of white participants and 82.8% of black participants). The duration of care was shorter for white participants (mean of 56.8 days) than black participants (mean of 71.2 days), but this difference was not significant ($p = .056$, **Table 6**).

Although black participants averaged longer duration of care in outpatient physical therapy, on average they actually received one fewer visit (mean of 17.1 visits vs. 16.1 visits, p = .629) and more than five fewer hours of outpatient physical therapy (mean of 19.22 hours vs. 14.08 hours, p = .055). This means that black participants overall had less intensive outpatient physical therapy, although neither between-group difference was significant.

4.3.4 Total Post-Acute Physical Therapy Received

The bottom of **Table 6** showed the aggregate hours of post-acute physical therapy received. The mean between-group difference was 2.6 hours, indicating that black participants averaged 156 fewer minutes of physical therapy care than white participants. This difference was not statistically significant (p = .360).

4.4 Discussion

In the present study, black participants received an average of 2.6 fewer hours of total post-acute physical therapy following TKA than white participants. This difference was not statistically significant. Minor differences were present across treatment settings, with black participants overall receiving more skilled nursing facility and home health physical therapy, but less outpatient and total physical therapy. Differences in the home health and outpatient settings trended toward significance, and our preliminary analyses likely suffered from a lack of statistical power to detect between-group differences.

At both the pre-operative and three-month post-operative measurement points, white participants' total WOMAC score was slightly better than those of black participants'. At follow-up, the between-group global WOMAC difference was 4.8 points (on a 96-point scale), or 5% of the maximal score. Research by Angst and colleagues has suggested that differences greater than 6% of the maximal WOMAC score are clinically important in individuals with lower extremity osteoarthritis, so the between-group difference in the present study does not meet the threshold for clinical importance.[85] In addition, the proportion of participants who would be classified as responders using OARSI-OMERACT criteria is very similar (72.0% of white participants and 72.4% of black participants), which further supports the lack of a clinically important difference in function between black and white patients.[86]

However, physical therapists should still consider this information when treating patients who have undergone TKA. A 4-point difference between two patients' global WOMAC scores could indicate that one patient experiences slightly more pain or difficulty on several functional tasks or substantially more pain or difficulty with one or two tasks. Physical therapists should therefore examine patients' self-reported outcome measures to screen for pain or difficulty with specific movements or tasks and tailor their treatment plan to address tasks that are particularly problematic. Physical therapists in the outpatient setting are typically the final rehabilitation provider giving care to patients status post TKA, so they are uniquely positioned to help "close the gap" in post-operative pain and function and maximize outcomes for all patients.

In a prior study by Freburger and colleagues, 55% of patients were discharged home following total hip or knee arthroplasty surgery.[4] This is a much smaller proportion than in the

present study, in which 72-80% of participants were discharged home. This may reflect differences in the samples, because the present study included only patients receiving TKA whereas Freburger and colleagues included data from both knee and hip replacement recipients and did not report results separately by joint. Alternately, this may reflect regional variation in post-acute care patterns following joint replacement surgery. Finally, this difference may reflect the time during which the data were collected. The Freburger study used a sample from 2005 and 2006; the present study included data from 2015-2019.

In order to fully expose any existing race disparities in post-acute physical therapy utilization following total knee arthroplasty, comprehensive data from a large sample of patients is needed. The present study included all practice settings following the acute care hospital (inpatient rehabilitation, skilled nursing facility, home health, and outpatient) but contained a small sample from a single geographic region. Prior work has investigated disparities in discharge destination following the hospital stay, but did not track participants through their entire rehabilitation trajectory. Future work should utilize large data sets to track patients' physical therapy utilization throughout all practice settings and explore the role of the various settings in functional recovery following total knee arthroplasty.

Overall, participants in our sample achieved similar functional outcomes on the WOMAC following TKA and received similar amounts of post-acute physical therapy. These results may support the assertion that, when provision of rehabilitation is similar, disparities in function are not present. If this holds true in additional studies, the solution to resolving any found disparities

in function following TKA may be to ensure equivalent access to and provision of post-acute rehabilitation services.

4.4.1 Limitations

This study has several limitations. Most importantly, these results are based upon a preliminary analysis of 104 participants. Our original power analysis indicated that complete data would be needed from 144 participants to detect moderate between-group differences in physical therapy utilization. Therefore, it is possible that we are committing a type II error by lacking the statistical power to detect such a difference. Further data collection and analyses are needed on a larger sample of participants to increase statistical power and improve confidence in our findings. In addition, future studies should use better recruitment methods to ensure enrollment targets can be achieved. Patient registries and data repositories are more widely available today than they were when this study was designed, and these should be used to the greatest extent possible when conducting future studies.

This study was conducted within a relatively small geographic region. Participants in the study received their TKAs from 29 different surgeons at 17 different hospitals, which should enhance generalizability. However, it is possible that physical therapy utilization patterns observed in this study are different from those in other geographic areas or the United States as a whole. Of the 104 participants, 55 received their TKAs in urban hospitals, 47 in suburban hospitals, and only 2 in rural hospitals. It is particularly likely that physical therapy

utilization patterns are different in rural areas where access to care is a greater challenge than urban and suburban areas.

Recall bias may be a concern, because participants were asked to self-report their length of stay in skilled nursing facilities and the number of home physical therapy visits they received. We attempted to minimize the effects of recall bias by providing participants with a handout pre-operatively that detailed the information they would be asked to report post-operatively. We also reminded them to track these metrics when we contacted them for monthly telephone and/or e-mail follow-ups. The large majority of total physical therapy services delivered were in the outpatient setting. Recall bias is not a concern for these data, because we gathered these data directly from each participant's outpatient physical therapy chart.

It is also possible that our estimations of physical therapy received in skilled nursing facility and home health settings may not be accurate. We estimated the length of each home health physical therapy visit and average length of daily physical therapy visits in skilled nursing facilities based upon published norms,[80-84] but practice patterns may have varied within the actual facilities/agencies providing care to the participants in our study.

4.5 Conclusion

Physical therapy utilization across skilled nursing facilities, home health, and outpatient clinics did not significantly differ between white and black participants following total knee arthroplasty. Additional research is needed, using larger sample sizes, to determine whether race disparities in physical therapy utilization are present in this population.

5.0. AIM 3: Exploring Race Differences in Satisfaction with Rehabilitation Following Total Knee Arthroplasty

5.1 Introduction

Osteoarthritis (OA), a joint disorder characterized by chronic and irreversible breakdown of cartilage, is among the most prevalent and most expensive disorders affecting adults in the United States.[1,9,10,13] The knee is the most commonly affected joint, and more than half of adults with knee OA will opt to undergo total knee arthroplasty (TKA) surgery.[1,11,12] Generally, outcomes following TKA surgery are excellent, with 85% of TKA recipients reporting overall satisfaction with the results and approximately 90% reporting substantial improvements in pain and function.[18,19] To achieve maximal results, post-operative rehabilitation is necessary.[23,24]

Studies have shown that significant race differences exist in both the utilization of TKA surgery and short-term outcomes following TKA.[3,5,17,25,27-32,51-59] Both the odds of undergoing TKA and the outcomes following TKA generally favor non-Hispanic white/ Caucasian patients over those of minority race or Hispanic ethnicity. This has the ability to negatively affect the post-operative rehabilitation process in multiple ways. First, it has been shown that patients of minority races tend to be functioning more poorly at the time of surgery, and poorer pre-operative function is predictive of poorer post-operative outcomes.[25-27] Second, higher complication rates among minority patients means that these patients must spend more time and energy fighting infections or venous

thromboembolisms in the immediate post-operative recovery period, thus having less time and energy to fully focus on participating in physical therapy. Finally, it has been shown that black patients tend to have lower expectations for recovery for TKA, and lower pre-operative expectations may correlate with poorer outcomes and satisfaction following surgery.[46,47] In order to maximize patient outcomes, it is important to understand how existing disparities may affect and involve the provision of rehabilitation services.

Very little research exists regarding the patient experience in post-operative rehabilitation following TKA, or patient satisfaction with rehabilitation services. However, there is some research to suggest that race differences in the rehabilitation process are present. Studies have shown that patients of minority race may be discharged from the hospital to different types of rehabilitation providers compared to white patients and may be more likely to report general dissatisfaction after TKA surgery.[4,61] In a general (not TKA-specific) population of older adults with Medicare, outpatient rehabilitation service utilization tends to be lower for black patients than their white counterparts.[64,68] Another study found that this pattern was also true for patients with self-reported OA.[65]

To our knowledge, there is no research that explores the patients' perspective of post-operative physical therapy and rehabilitation following TKA and whether it may play a role in any race disparities that exist in this population. To explore race differences in the rehabilitation experience and satisfaction with physical therapy following TKA, we conducted a series of focus group discussions with white and black participants to explore their opinions regarding the location, duration, and intensity of physical therapy they received after TKA.

5.2 Methods

5.2.1 Design Overview

This study employed a qualitative focus group study design.

5.2.2. Setting and Participants

All study procedures took place at the University of Pittsburgh School of Health and Rehabilitation Sciences, Department of Physical Therapy. Participants were recruited from a variety of sources, including advertisements in local orthopaedic surgeons' offices, referrals from a local research participant registry, and mailed advertisements. All participants were participating in a larger study investigating race differences in physical therapy utilization and functional outcomes following TKA. At the time of consent (pre-operatively), participants indicated their interest in being invited to a focus group.

We screened potential participants in the larger study via telephone for eligibility using an IRB-approved script (Appendix 1). Eligible and interested participants were then provided with a copy of the informed consent document via e-mail or postal mail. The principal investigator or research assistant then telephoned the potential participant after they were given ample time to read the consent document, reviewed the document with them, and answered any questions prior to the potential participant deciding whether to consent to participate in the study.

Participants were included in the study if they were scheduled for primary unilateral TKA and identified as white/Caucasian or black/African-American race and non-Hispanic ethnicity. Participants of other races and Hispanic ethnicity were not included, as there is a very low proportion of residents of those racial/ethnic groups locally and we would lack the statistical power to draw meaningful conclusions about disparities in those populations. Additionally, eligible participants were English-speaking (to participate in focus groups with an English-speaking moderator). Potential participants were excluded if they were scheduled for simultaneous bilateral or revision TKA (as the post-operative recovery is quite different than that of unilateral primary TKA) or if they failed to receive the scheduled TKA.

5.2.3. Research Procedures

Participants were recruited and enrolled in this study prior to undergoing TKA, but focus groups were not conducted until at least three months after each participant's surgery. Grounded theory approach was used, which asks the researcher to develop theory from the data that are collected.[87] Rather than beginning with a hypothetical theory and seeking data to support it, we collected the data first and developed the theory as the data were analyzed.

When inviting participants to focus groups, we used both electronic mail and postal mail invitations. At first, we invited any participants who underwent TKA and had completed formal physical therapy. After a few groups were conducted, we began to shift our recruitment

strategy to theoretical sampling, which helps to ensure that we can gain information from participants whose experiences may inform the developing theory. For example, if an earlier focus group suggested that perhaps participants who were retired from full-time work would experience greater satisfaction with physical therapy, we would seek more participants who were retired to more fully explore that theory in later focus groups.

To maximize comfort of all participants to express their beliefs and opinions, we held separate focus groups for white and black participants.[88] In addition, this allowed us to explore racial or cultural issues specific to each group. For each focus group session, we sought to recruit six to eight participants.[89-91]

Each focus group was held in a conference room at the Physical Therapy Clinical and Translational Research Center at the University of Pittsburgh. The room was quiet and had a long oval table which allowed participants and the moderator to see each other at all times. One research team member (PI: A. Bove, a white woman), who has been extensively trained in moderating focus groups, served as the group moderator, while another research team member (either R. Troxell, a white woman, or E. Dong, an Asian woman) served as note-taker. Two electronic recording devices (Sony IC Recorder, ICD-UX533, Sony, Inc., Tokyo, Japan) were placed in the center of the table; one was used to create a transcript of the recording and the second was used only as a backup in case of failure of the first device or difficulty understanding someone's speech on the first recording.

During the focus group session, the facilitator took caution to refrain from any teaching, counseling, or offering of any personal perspectives on the topics being discussed. The facilitator offered an opening statement to describe the purpose of the focus groups and the reasons for taking notes and recording the session. The need for confidentiality was also discussed. The facilitator stressed that each focus group participant should not hesitate to state opinions or feelings regardless of whether they think that others (including the research team) may not share those opinions.

Following the opening statement and an ice-breaker question, a series of short and direct but open-ended questions were offered to facilitate discussion. Questions were designed to introduce the topic, then steer the group toward the most important questions for the session. The primary areas of concern included questions regarding barriers and facilitators to accessing physical therapy after surgery, opinions regarding their physical therapist(s) and their treatment of the patient, opinions regarding the amount of physical therapy that was received after surgery, and overall satisfaction with the post-operative rehabilitation process. Race was not specifically mentioned in the questions, but all participants were consented into the study and knew that the overall purpose of the study was to identify race differences related to TKA surgery. The specific questions asked can be found in **Figure 1.**

- Introductory question: used to initially introduce the topic.
    - "Did you all participate in some form of physical therapy after your knee replacement surgery?"
        - Follow-up question: Where did you receive physical therapy?
- Transition questions: designed to steer the group toward the key questions for the session
    - "In general, how do you view physical therapists and the physical therapy process?"
- Key questions: the primary areas of concern
    - "What barriers, if any, did you experience in accessing physical therapy after your surgery?"
    - "Did anything make it easier for you to access physical therapy following your total knee replacement?"
    - "Did you feel that your physical therapist(s) treated you the way you want to be treated?"
        - If "no", follow-up question: "Can you elaborate on that?" "In what ways did you feel that your physical therapist let you down?"
        - If "yes", follow-up question: "In what ways?" "Can you expand upon that?"
    - "Do you feel that you received enough physical therapy, too little, or too much?"
        - If "too little" or "too much", follow-up question: "Why did you feel it was too little/too much?"
    - "Overall, how satisfied were you with your physical therapy experience following your knee replacement?"
        - Follow-up question: "What would have made you more satisfied with your physical therapy?"

Ending question: ensuring all necessary information has been brought out

- "Is there anything else that you'd like to say regarding your rehabilitation following your total knee replacement?"

Figure 1. Focus Group Questions

5.2.4 Outcomes and Follow-Up

Following each focus group, the recordings were transcribed verbatim, except for participants' names being changed to random numbers and any patient-identifying information being removed from the transcript and replaced with "xxxxxxx". Transcripts were first reviewed by the transcriptionist, then by the moderator. While listening to the recordings, corrections were made to correct transcription errors and add information regarding emotion, tone of speech, etc. to make the intent of the language more clear. After transcripts were reviewed multiple times for accuracy, the files were destroyed to protect participant confidentiality.

5.2.5 Data Analysis

There is no precise method for sample size calculation when conducting focus groups using grounded theory methodology. We hypothesized that two to three groups of six to eight participants each would be needed in each demographic group (white/ Caucasian and black/African-American) to achieve thematic saturation, but we were open to hosting as many sessions as necessary to ensure that all relevant themes had been identified.

Two members of the research team (PI A. Bove, and E. Dong) served as coders for the qualitative data. First, level I coding involved attaching conceptual labels to phrases or topics that begin to appear multiple times in the raw data. Next, level II coding included reexamining these topics and beginning to group them into categories and subcategories. Finally, level III coding involved isolating "core categories", which are concepts found frequently within the

transcripts that can be linked to other categories as theories are developed. Coding was performed independently but concurrently by both coders. After each round of coding was complete, the coders met to review cases of disagreement or requiring clarification. Discrepancies were resolved by discussion. A third person was available to consult for instance where simple discussion was not successful at resolving discrepancies.

Thematic saturation was determined to be reached when no additional or new themes emerged after coding and analyzing data from a focus group session. At that point, no further focus groups were held.

Agreement between coders was assessed within Atlas.TI using Krippendorff's alpha statistic. The alpha coefficient was selected over a kappa statistic because Krippendorff's alpha coefficient is more appropriate for use with smaller sample sizes.[92] Because each coder created quotations within the software separately, it is most appropriate to use the c-alpha binary statistic. Alpha coefficients range from zero to one, with higher levels indicating better agreement. An alpha statistic of 0.5 indicates that 50% of data is coded to a degree better than chance.

5.2.6 Role of the Funding Source

This study was supported by Promotion of Doctoral Studies I and II awards from the Foundation for Physical Therapy Research and by a Pilot Award from the University of Pittsburgh Rehabilitation Institute. Neither funding source was involved in study design, study procedures, data analysis, or developing the manuscript.

5.3 Results

5.3.1 Participants

Thirty-six patients who had undergone TKA surgery participated in focus groups (**Table 7**). Five groups were conducted: three groups (n = 7, 9, and 8) with white participants and two groups (n = 4 and 8) with black participants. White participants received TKA surgery at ten different hospitals with twelve surgeons, and black participants received TKA surgery at six different hospitals with seven surgeons. Overall, black participants were more poorly functioning both pre-operatively and post-operatively, as indicated by Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores.

Table 7: Characteristics of Focus Group Participants

	Groups 1, 2, 3 (White/Caucasian Participants) n = 24	Groups 4, 5 (Black/African-American Participants) n = 12
Sex	Male: 8 (33.3%) Female: 16 (66.7%)	Male: 3 (25.0%) Female: 9 (75.0%)
Health Insurance	Medicare: 13 (54.2%) Private: 10 (41.7%) Medicaid: 0 (0.0%) Medicare and Medicaid: 1 (4.2%)	Medicare: 8 (66.7%) Private: 1 (8.3%) Medicaid: 1 (8.3%) Medicare and Medicaid: 2 (16.7%)
Age	64.1 years, SD 9.4 years	66.6 years, SD 4.5 years
Pre-Operative WOMAC Total Score	44.8, SD 17.7	54.3, SD 11.4
Post-Operative WOMAC Total Score	18.0, SD 17.8	25.1, SD 13.5

Continuous variables are reported as mean, SD. Categorical variables are reported as n (percent). WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index, reported on a 0-96 scale where lower numbers indicate better pain, stiffness, and function.

5.3.2 Interrater Agreement

An alpha statistic of 0.742 was calculated, indicating moderate interrater agreement.

5.3.3 Theme 1: Positive Views of Overall Rehabilitation Experience

Within all five focus groups, there was consensus amongst participants that their overall rehabilitation experiences were positive. Across all groups, positive references to physical therapy care were mentioned nearly three times as often as negative references (127 mentions vs. 45 mentions).

We identified several subthemes describing factors that contributed to a positive rehabilitation experience, beginning in the pre-operative phase. Participants frequently discussed the importance of pre-operative education or brief rehabilitation interventions ("prehab") in their recovery post-surgically; this topic was mentioned 46 times across all five groups. Many participants touted the benefits of pre-operative educational classes offered by the surgeons and their staff, home assessments performed by home health therapists before surgery, and pre-operative exercise programs prescribed by outpatient physical therapists. **Table 8** contains specific quotes illustrating each major subtheme for Theme 1.

Table 8: Quotes for Theme 1 – Positive Views of Overall Rehabilitation Experience

Subtheme	Participant	Quote
Prehab, Pre-operative Education	G2P2 (white man)	"And [the surgeon] said okay, first thing we're going to do is put you through some intense physical therapy and see if that will help… It helped me so much I started to question whether I was going to have the replacement or not."
	G3P3 (white woman)	"Doing the exercises before I had the surgery, I thought was very important."
	G5P4 (black woman)	"I think my doctor's office did a nice job of telling me what to expect, so I knew what was coming. That made it easier… it helped me plan."
Individualized Care	G5P3 (black woman)	"I felt like my therapists understood that my goal was to get back to work, and they took it seriously and helped me get there."
	G1P5 (white woman)	"Same [physical therapist] did both knees… and that's why I went back. It was more one-on-one… you got a lot more individual attention, not in a big group."
Benefits of Specific Interventions	G1P3 (white man)	"When I did the bike at the outpatient… that's the best thing ever… Get people on the bike! Forget about the walking, get them on the bike."
	G2P7 (white man)	"At rehab… they had the little wooden stairs in the therapy room, but as soon as they saw you could go up and down those, they took you out in… the real stairwell in the building. That was very helpful because it was for real."

The identification markers for quotations cited from participants denote both the participant's group number and participant number within the group (e.g. G2P2 indicates Group 2, Participant 2).

Several participants reported perceiving value in physical therapy when individualized, one-on-one care with a physical therapist is provided that is specific to the individual's goals and functional activities. The vast majority of participants reported feeling that the total amount of physical therapy they received across all settings (hospital, skilled nursing facility, home health, and outpatient) was appropriate – there were more than twice as many mentions of receiving the "right" amount of physical therapy care than mentions of receiving "too much" or "not enough". However, at least one participant in each of the five focus groups reported needing to advocate for additional care when their surgeon or their health insurer felt that they did not require additional physical therapy.

Participants often pointed to particular aspects of physical therapy care as being beneficial to their recovery. Frequently, participants mentioned specific interventions as being helpful in aiding their functional recovery. These interventions included the use of stationary bicycles to improve knee range of motion (28 mentions across four groups), practicing stair negotiation (30 mentions across five groups), and learning how to kneel on their surgical knee (23 mentions across three groups).

5.3.4 Theme 2: Barriers to Optimal Rehabilitation

Although views of post-operative rehabilitation following TKA were largely positive, each of the five focus groups also identified barriers to their experience. These ranged from logistic barriers to insurance-related barriers to difficulty participating in rehabilitation. **Table 9** contains specific quotes illustrating each major subtheme for Theme 2.

Table 9: Quotes for Theme 2 – Barriers to Optimal Rehabilitation

Subtheme	Participant	Quote
Pain Management	G4P4 (black woman)	"I was in so much pain, I was shaking, I was freezing, I was crying. And finally they got the pain under control, so they came the next day and started physical therapy."
	G1P7 (white man)	"One of the things I really struggled with – how you should use [pain medications], and to what extent you should start weaning yourself off of them. I did have a lot of problems with withdrawal, because nobody explained anything to me. But I really feel it's the doctors duty… but it might be something the physical therapist could help with."
	G5P1 (black woman)	"I think the pain was sometimes a barrier. It was hard to figure out how much to push myself, or what kind of pain or how much pain is okay to have... so I'd be in a lot of pain and didn't feel like I could perform [in physical therapy] to the best of my ability."
Out-of-Pocket Costs	G4P1 (black woman)	"[The physical therapist] wanted me three days a week to start with. I said I can't afford that. So we did two days a week."
	G5P6 (black man)	"My copay was $35, so I tried to keep the home therapist as long as they would let me."
	G3P5 (white man)	"I went to physical therapy. I had a good experience, but I didn't go very much because it was $40 a visit."
Transportation	G5P3 (black woman)	"And my sister had to drive me, so that made it a bit more difficult to go to my appointments. I wasn't allowed to drive yet, and my husband isn't in good health and he couldn't take me."
	G1P3 (white man)	"The only catch with not doing [outpatient therapy] is, how do you get there if you don't have someone to take you?"

The identification markers for quotations cited from participants denote both the participant's group number and participant number within the group (e.g. G4P4 indicates Group 4, Participant 4).

By far, pain management was the most frequently-identified barrier to an optimal rehabilitation experience. Pain management was mentioned 92 times across all five focus groups. Participants reported having some difficulty completing exercise programs or fully participating in physical therapy visits because of unresolved pain in the surgical limb. Many participants mentioned attempting to time the administration of oral pain medicines to coincide with physical therapy visits, but that this was not always possible in the skilled nursing facility and home health settings, where exact appointment times are often not provided. Participants also identified communication regarding pain management as an area of improvement – when discussing suggestions for improved rehabilitation experiences or overall surgical experiences, communication regarding expectations for pain management was mentioned often (40 mentions across four groups). However, many participants did report that their physical therapists responded appropriately to increased pain by decreasing the intensity of exercise programs or manual therapy interventions for that particular visit.

Although the focus group moderator never mentioned health insurance or out-of-pocket costs, copayments were discussed at length by all five focus groups. Some participants reported altering their expected rehabilitation trajectory to avoid out-of-pocket costs, either by prolonging home health physical therapy (which is often covered at 100% by the insurer) to avoid transitioning to outpatient therapy where copayments would be due at each visit, or by stopping outpatient therapy before all functional goals were achieved.

Transportation was mentioned as a barrier to attending outpatient physical therapy by four of the five focus groups. Similar to the issue of health insurance expenses, the topic of

transportation was never mentioned by the moderator but became a frequent point of discussion. Some participants reported difficulty arranging transportation to outpatient physical therapy visits (30 mentions across four groups), often because they were not permitted to drive themselves for several weeks after surgery due to leg weakness and/or use of narcotic pain medications. Many participants reported that, without their family and friends as a support system, they would not have been able to attend outpatient physical therapy.

5.3.5 Theme 3: Differing Experiences

Although the first two themes were consistent across all five focus groups, there were some differing experiences between groups of white participants and groups of black participants. These included a longer path toward surgery and occasional difficulty interacting with rehabilitation providers. **Table 10** contains specific quotes illustrating each major subtheme for Theme 3.

Table 10: Quotes for Theme 3 – Differing Experiences

Subtheme	Participant	Quote
Delaying Surgery	G4P3 (black woman)	"[In 1996] the surgeon said, you're going to need a knee replacement in ten years." *(Authors note: the participant underwent TKA in 2018.)*
	G4P4 (black woman)	"[The surgeon] had told me in 2000 that I needed a knee replacement in my right knee. [But] I waited 15 years."
Poor Interactions with Providers	G4P2 (black woman)	"There was [another patient], and she said, 'I can't do it. I've done enough. I can't do it'… You could just look at her and tell she was in pain. And [the physical therapists] were like, 'well, we need you to get done, you can't leave until you finish [your exercises]'… [The therapist] wasn't listening."
	G4P4 (black woman)	"They had me doing physical therapy, putting pressure on my right knee, hurt so bad. And they kept telling me 'no, that's your hip'. I said 'no, it's my knee, it's my knee'. I got so angry, I said 'Listen, I've been in this body 60 years. I know what I'm talking about. It's my knee.' She said 'well I've been a therapist 20 years… I really had a big run-in with her about that."
	G5P7 (black man)	"I thought the… therapist left me on my own too much… they forgot to order me a walker, so I was hobbling around for two days."

The identification markers for quotations cited from participants denote both the participant's group number and participant number within the group (e.g. G4P3 indicates Group 4, Participant 3).

Black participants were substantially more likely to discuss trying a multitude of other therapies prior to finally deciding to undergo TKA – this topic came up in both focus groups with black participants but not in any of the groups with white participants. These included common non-surgical interventions such as oral pain medications, corticosteroid or hyaluronic acid injections, and physical therapy, as well as less invasive surgical options such as meniscectomy.

Unfortunately, most negative references to physical therapy were also made within the focus groups with black participants. Although a majority of black participants did report an overall positive view of physical therapists as a profession, several reported negative experiences at some point in their post-operative care. These ranged from a lack of individualized attention to not listening to the patient or challenging the patient's opinions in a disrespectful manner.

5.4 Discussion

In this qualitative study exploring the rehabilitation experiences of individuals status post TKA, we largely found that patients view physical therapy positively. However, participants also identified barriers and negative aspects of physical therapy, some of which were common across patients of different races and some of which varied between black and white participants.

Overall, participants expressed positive views of physical therapy. "Prehab", or pre-operative exercise programs and education, was often reported as being beneficial to participants' experiences because they were already familiar with the exercises, the physical

therapists, and/or understood the expected trajectory of post-operative recovery. This supports prior research showing small to moderate positive impacts of "prehab" programs on post-operative recovery in this population[93-98]. Receiving one-on-one attention and individualized care was strongly associated with a positive physical therapy experience in the outpatient setting. Although there is a paucity of research in this topic in the knee replacement population, this is consistent with prior literature in the spinal stenosis population, which showed that individuals desire rehabilitation programs designed specifically for them.[99] Participants also reported gaining benefit from time spent on specific functional activities such as stair negotiation and kneeling. This is consistent with prior literature in individuals with knee osteoarthritis (who had not undergone TKA), showing that impairment-focused rehabilitation programs are beneficial but do not necessarily lead to functional improvements.[100] Training in specific functional tasks that are patient-specific is needed to maximize outcomes, and patients appear to perceive value in such training.

Barriers to participating in rehabilitation, especially outpatient physical therapy, were identified by many participants in the present study. Pain management is a common barrier in recovery from TKA, so this was unsurprising. However, the issue of pain management is often left to the surgeon and/or nursing staff, but many participants in this study expressed a desire for physical therapists to take a larger role in managing post-operative pain. This is consistent with prior work by Kennedy and colleagues, in which participants undergoing hip and knee replacement surgery reported wanting greater patient education, particularly with respect to pain management.[101] Physical therapists, especially those working in the outpatient

environment, should consider broadening their knowledge of post-operative pain management and communicating more frequently with surgeons to enhance pain management and improve patients' ability to fully participate in physical therapy following TKA.

Studies have shown that out-of-pocket expenses and lack of transportation are frequently-cited barriers to accessing outpatient care for osteoarthritis and/or outpatient physical therapy services, and this was true for the participants in our focus groups.[102-105] Patients who have undergone TKA often are not permitted to drive for several weeks after surgery because of the use of narcotic pain medications and/or weakness in the surgical limb. In addition, public transportation is often inaccessible for those recovering from TKA because many subway entrances or buses require the patient to walk far distances to access them or negotiate difficult stairs to enter or exit. Although the large majority of participants in our study reside in urban or close suburban areas, transportation difficulties may exacerbate disparities in rural areas where public transportation infrastructure is poor.

A few aspects of participants' rehabilitation experience appeared to differ between white and black participants. Generally, black participants reported waiting as long as possible before undergoing TKA and trying a vast array of less invasive interventions before deciding to schedule TKA surgery. This is consistent with prior research that has shown that black participants may be less willing to undergo TKA surgery and that black participants tend to be more poorly functioning at the time of surgery, perhaps due to waiting longer than their white peers to undergo TKA.[37,43,106] In addition, several black participants in our focus groups reported personally experiencing or witnessing negative interactions with physical therapists, including two

participants who reported feeling that their physical therapist did not listen to them. Physical therapists should ensure that each patient receives their undivided attention and feels that their concerns are being heard and taken seriously.

5.4.1 Limitations

A primary limitation of this study is that it was conducted at a single site in an urban area. Although the focus group participants underwent surgery at a variety of hospitals with a variety of surgeons, they did all receive surgery and post-operative care within a fairly small geographic area. Therefore, the results of this study may not be generalizable to the United States as a whole. Additionally, we had a relatively small sample size which may have affected results. Finally, selection and recall bias could limit the results of this study. Although all participants within the larger study were invited to participate in a focus group, not all were able to attend due to scheduling limitations or lack of interest. It is possible that those who did not attend a focus group may have had different rehabilitation experiences following their TKA. However, we attempted to combat selection bias by hosting focus groups at varying times of day – one morning, two afternoon, and two evening sessions. However, we did note that white participants who attended focus groups generally had improved function compared to the overall cohort of white participants, but black participants who attended focus groups generally had lower function compared to the overall cohort of black participants. Finally, recall bias may have played a role in participants' reported experiences

due to a chronological gap between completing post-operative physical therapy and participating in a focus group. We minimized recall bias by pre-operatively providing participants with a form where they could take notes about their physical therapy experience across all post-acute care settings (skilled nursing facility, home health, and outpatient) in preparation for participating in a focus group after they completed their course of rehabilitation.

5.5 Conclusion

Individuals undergoing TKA can largely expect a positive rehabilitation experience post-operatively. However, some barriers to post-operative physical therapy exist and may differ between patients of different races. Physical therapists should increase their awareness of these barriers and work to minimize them whenever possible.

6.0 Conclusions and Future Directions

6.1 Brief Summary of Study Conclusions

In this three-aim dissertation study, we found that race was not predictive of functional outcome after TKA. We also found no significant differences in overall physical therapy utilization between white and black participants following TKA, although these results are preliminary because we have not yet achieved a sufficient sample size for 80% power. Focus groups with participants revealed overall very positive views of post-TKA rehabilitation, with minor differences in the rehabilitation experience between races.

6.2 Study Implications and Comparison to Prior Literature

To our knowledge, this is the first study to examine *both* physical therapy utilization and functional outcomes in the TKA population. It is also the first mixed-methods study of rehabilitation-related disparities in this population. Our study would be considered a Phase I disparities study using the theoretical model of Kilbourne et al; we sought to detect potential post-operative disparities in function and physical therapy use. Our results build upon prior research studies by Lavernia and colleagues and by Freburger and colleagues. A graphical summary comparing our work to others' is below in **Table 11**.

Table 11. Comparison of Present Work to Prior Literature

Study	Large Sample Size?	Reported Results on TKA Group Only?	Studied Differences in Functional Outcome?	Studied Differences in PT Utilization?
Bove, 2020	✗	✓	✓	✓
Lavernia, 2011	✓	✓	✓	✗
Freburger, 2011	✓	✗	✗	✓

We found that functional outcomes were similar between black and white participants after TKA. This conflicts with prior research by Carlos Lavernia and colleagues, which found that race and ethnicity were significantly related to decreased function following TKA and total hip arthroplasty. Both studies utilized the WOMAC as the primary measure of patient-reported physical function. While the Lavernia study did find statistically significant differences in post-operative function based on race and ethnicity, the absolute between-group differences were not large enough to meet the threshold for clinical significance. There are several other differences between the present study and Lavernia's study. Their study was a single-surgeon study that utilized a much larger sample size than ours. The periods under study were very different – our study included data collected from 2015-2019, while theirs included data collected from 1992-2007. It is possible that the relationship between race and post-operative functional recovery is simply different now than it was 12-27 years ago. Both our study

(Pittsburgh) and the Lavernia study (Miami) collected data from patients primarily from a single urban region, but the racial and ethnic demographics of the two regions are quite different. Finally, the Lavernia study did not explore rehabilitation utilization following TKA.

A 2011 study by Janet Freburger and colleagues found that patients of minority race received less intensive rehabilitation care following total hip and total knee arthroplasty, and that the effect of race was modified by insurance status and geographic region. In their study, they examined post-acute rehabilitation care as a continuum from more to less intensive, where inpatient acute rehabilitation → skilled nursing facility → home with home health → home without home health. Generally, they found that racial and ethnic minority patients received less intensive care upon discharge from the hospital. This somewhat conflicts with our study, where we found that no participants were discharged to inpatient acute rehabilitation and a non-statistically significantly greater proportion of black participants (27.6%) than white participants (17.3%) were discharged to a skilled nursing facility. One potential reason for this difference is that Freburger and colleagues studied patients who received both total hip and total knee arthroplasties and did not report the results separately by surgery, and we only included participants with TKA. TKA is almost always performed as an elective surgery for those with knee osteoarthritis. THA is often performed as an elective surgery for hip osteoarthritis, but is also sometimes performed emergently for hip fracture. This difference may result in differing patterns of post-acute rehabilitation when comparing our study to Freburger's. Despite any differences in post-operative physical therapy utilization, our qualitative focus group data

indicate that both black and white participants were satisfied with the total amount of post-operative physical therapy they received.

A strength of our study is that we examined all post-acute physical therapy use, whereas the Freburger study only looked at the immediate post-hospital discharge destination. However, the Freburger study included data from four different states within the United States and thus provides a broader picture of post-acute rehabilitation use following THA and TKA. Freburger and colleagues did not have data on patients' functional outcomes, so it is unknown whether the differences they observed in post-acute rehabilitation use is ultimately associated with disparities in functional outcomes.

Overall, our work suggests that there *may* be differences in where physical therapy is received – black participants tended to receive more care in skilled nursing and home health settings, and white participants tended to receive more care in outpatient physical therapy settings. We did not collect data to indicate the reasons for this, although the issues of high copayments for physical therapy and difficulty with transportation to attend outpatient visits were frequently mentioned during focus groups. However, our results also indicate that the total provision of post-acute rehabilitation was similar between white and black participants and that most participants were satisfied with the amount of physical therapy they received. Perhaps this shows that when access to physical therapy is similar between demographic groups, functional outcomes may be similar too. If that is true, disparities in post-operative function may be reasonably addressed by ensuring equitable provision of rehabilitation to all patients who undergo TKA.

6.3 Continuing Gaps in Literature

Our work adds to the literature regarding the role of race in functional outcomes and rehabilitation utilization after TKA, but continued gaps in the literature exist. First, we need more Phase I disparities studies to gain a better understanding of the relationship between post-acute physical therapy and patient-reported functional outcomes, and how those relate to any differences that exist between demographic groups. As stated above, the following question remains: is similar access to post-operative physical therapy associated with similar functional outcomes? Also, are there differences in where physical therapy is received between patients of different races? If so, do those differences create disparities in ultimate functional outcome? Or does the *total* amount of physical therapy play more of a role in generating functional gains, and the particular setting where that physical therapy is received does not matter? Related to all of these questions, how does the method of data collection (patient-reported functional outcome measures vs. performance-based measures of physical function) affect any of these relationships?

While our study lays the groundwork for future research, we did have a relatively small sample size to explore. Future work should focus on analyzing larger data sets for several reasons. First, larger data sets should yield a more diverse sample and allow for analysis of disparities according to race (including more races than only black and white), ethnicity, sex, and geographic setting (rural vs. suburban vs. urban). This would also allow us to explore any other demographic or clinical predictors of positive functional outcomes after TKA, and/or predictors of greater rehabilitation utilization after TKA. Secondly, large data sets including

claims data will allow exploration of physical therapy utilization across the continuum of post-acute care settings to allow exploration of potential differences in rehabilitation trajectory after TKA. Finally, ideally a large data set would also include functional data on those same patients across all settings where they received physical therapy, so the relationship between functional recovery and physical therapy utilization can be more fully understood.

6.4 Plans for Future Research

When the present dissertation study was designed, we were unaware of any publicly available large databases that contained patient-reported functional outcomes data and medical insurance claims data on the same patients following TKA. Therefore, we designed a study relying upon prospective primary data collection. In the following several years, many changes have occurred that will facilitate research of large data sets. The Center for Medicare and Medicaid Services Comprehensive Care for Joint Replacement program, which is the formal name for the pilot project investigating "bundled" payments for individuals undergoing knee and hip arthroplasty, has prompted many organizations to formalize processes to routinely collect patient-reported outcomes in this population. Many health care systems and professional organizations, including the American Physical Therapy Association, have begun large-scale projects to create data registries that researchers can use. Overall, this increased focus on the importance of "Big Data" in health care research provides great opportunities for researchers to uncover disparities where they exist, explore their potential causes, and generate ideas for solving them.

In the near future, I plan to build upon the present study by performing an analysis of a large data set that contains *both* functional outcomes and rehabilitation utilization on a diverse group of patients who have undergone TKA and/or THA. There are several research questions that I intend to explore:

First, additional Phase I disparities work exploring whether there are disparities in functional outcomes according to participants' race, ethnicity, sex, and/or geographic residence. Our work in the present study somewhat conflicts with the findings of Lavernia and colleagues, so this question warrants further exploration. In addition, there is very minimal existing literature regarding the potential existence of ethnicity, sex, and rural/urban disparities in function after joint arthroplasty.

Another relevant Phase I question would be to investigate potential differences in the trajectory of post-acute physical therapy following joint arthroplasty. If so, Phase II research should study whether any differences can be explained by differences in insurance status, employment status, family support, or other variables? And do these differences correlate to differences in functional outcomes? If differences in post-acute rehabilitation trajectory are not found, does the total amount of post-acute PT received correlate to functional outcomes? If more physical therapy corresponds with a better functional outcome, then we should focus on Phase III research, designing and deploying interventions that ensure equal access to physical therapy (across any and all practice settings) for all patients who undergo TKA.

Finally, the results of our study should be used to develop research questions regarding disparities in the TKA population within the broader context of health disparities and the social

determinants of health. Research regarding disparities in the *utilization* of TKA has studied the impact of insurance status, family dynamics, neighborhood characteristics, health literacy, and many other variables on the known race disparities in TKA surgery rates. Research regarding disparities among those actually *receiving* TKA has not yet studied these characteristics in sufficient detail. Social determinants of health play an important role in the success of a person's rehabilitation experience. High copayments often serve as a barrier to accessing physical therapy services. Poor health literacy and unsafe neighborhoods may make compliance with therapist-prescribed home exercise programs difficult or impossible. While quantitative studies can estimate health literacy rates in populations and discuss crime rates and other measures of neighborhood safety, qualitative data are also necessary to fully understand potential barriers to health care access. Future research should identify the impact of the social determinants of health on physical function and disparities in populations of patients seeking physical therapy.

6.5 Final Conclusion

In this mixed-methods dissertation study, we used quantitative and qualitative methods to explore race differences in patient-reported physical function and use of physical therapy after total knee arthroplasty. Our quantitative data indicated that race was not a substantial independent predictor of post-operative physical function and that total physical therapy utilization was similar between white and black participants. However, both quantitative and qualitative data hint at potential race differences in rehabilitation

following surgery, and further investigated is warranted regarding whether there are differences in the overall rehabilitation experience and in the specific settings where post-operative rehabilitation is received. Future work should use large data sets to further illuminate the relationship between race and post-operative rehabilitation following total knee arthroplasty.

Appendix A: Participant Phone Screening Script

DOB:___/___/___Date of Recruitment:___/___/___Eligibility: _____(Yes/No)

Functional Outcomes and Delivery of Physical Therapy Services

after Total Knee Arthroplasty

Thank you for calling to find out more about our research study. My name is Ally Bove, and I am the principal investigator of this study. The Department of Physical Therapy is currently conducting a research study to explore physical function and use of physical therapy services after total knee replacement surgery, and whether there may be differences between different groups of people. Participants who complete the study will receive up to $45.00 for their time.

Miss/Mr……..…. Are you interested in participating? _____ (Yes/No)

If you are eligible, we will discuss the study in greater detail, and I will provide you with a document that will fully explain the risks and benefits of the study, as well as the specific procedures involved with participation in the study. Remember, your participation is voluntary; you do not have to complete these questions. If it is determined that you are ineligible for the study, all information obtained during this phone conversation will be immediately destroyed.

Miss/Mr…… …… Is it ok if I ask you some questions? _____ (Yes/No)

Thank you.

Are you planning to have a knee replacement surgery soon? _____ (Yes/No)

If YES, when is your surgery scheduled? _____

Is your surgery going to be on one knee or both knees? _____

(Must answer "one" to be eligible)

Have you had a prior knee replacement surgery on that same side? _____

(Yes/No; must answer No to be eligible)

What is your race? _____

(Must answer white/Caucasian or black/African-American to be eligible)

Are you of Hispanic ethnicity? _____ (Yes/No; must answer No to be eligible)

(In case subject seems to be eligible provide him/her with the following information)

It seems that you're eligible to participate in this study. So would you like to know more about our study Miss/Mr.…….? (If Yes, continue below)

Participation would involve completing questionnaires by mail or by telephone before you have your surgery, then completing those same questionnaires after your surgery once you finish rehabilitation on your knee. In addition, we would ask your permission to access your outpatient physical therapy records so we can see how much physical therapy you got after your surgery, and what specifically was done during your time in therapy. Finally, some participants will be asked to come to the University of Pittsburgh to participate in a group discussion about your experiences in physical therapy after knee replacement surgery.

So Miss/Mr..…… do you have any other questions for me at this time?

Are you still interested in participating in our study? _____ (Yes/No)

If yes: Thank you. I would like to collect some contact information from you so I know how to reach you. I'm also going to send you an Informed Consent document. This document fully explains the study procedures, risks and benefits of the study. If you decide to participate, you and I will both sign this document before you begin participating in the study. After I send it to you, we'll talk again over the telephone to review it together and discuss any questions or concerns you may have. Would you prefer that I send this to you via postal mail or electronic mail?

Mailing address:

Email address:

Phone:

(In case subject is NOT eligible provide him/her with the following information)

Ok, thank you for answering these questions Miss/Mr..……..…….!

Unfortunately, based you on answers it seems that you're not eligible to participate in this study. All information obtained during this phone conversation will be immediately destroyed. Thank you for your interest and time.

Appendix B: Participant Demographics Form

Participant Demographics ID: _____

Functional Outcomes and Delivery of Physical Therapy Services After Total Knee Arthroplasty

1. Date of birth: _ _ / _ _ / _ _ _ _ *(dob)*
   mm dd yyyy
2. Age:_____ *(age)*

3. Sex: 1 ☐ Male 2 ☐ Female *(sex)*

4. Racial origin: (check all that apply) *(race)*

   1 ☐ White
   2 ☐ Black or African-American
   3 ☐ Asian
   4 ☐ Native American or Alaska Native
   5 ☐ Hawaii Native or other Pacific Islander
   6 ☐ Other (please specify _____)

5. Ethnicity (check one) *(ethn)*

   1 ☐ Hispanic
   2 ☐ Non-Hispanic

6. Marital status: (check one) *(mst)*

   1 ☐ Married
   2 ☐ Living with significant other
   3 ☐ Divorced/separated
   4 ☐ Widowed
   5 ☐ Single (never married)

Participant Demographics ID: _____

Functional Outcomes and Delivery of Physical Therapy Services After Total Knee Arthroplasty

7. Level of education: (check one) *(edu)*

1 ☐ Less than high school
2 ☐ Graduated from high school
3 ☐ Some college
4 ☐ Graduated from college
5 ☐ Some post-graduate course work
6 ☐ Completed post-graduate degree

8. Annual household income: (check one) *(income)*

1 ☐ <$25,000
2 ☐ $25,000-$49,999
3 ☐ $50,000-$99,999
4 ☐ $100,000 or greater

9. Health Insurance: (check all that apply) *(ins)*

1 ☐ Medicare
2 ☐ Medicaid
3 ☐ Private (UPMC, Highmark, Aetna, etc.)
4 ☐ Veterans Affairs
5 ☐ No health insurance

Participant Demographics ID: _____

Functional Outcomes and Delivery of Physical Therapy Services After Total Knee Arthroplasty

10. The following are a list of health problems. Do you currently have, or have you previously had the problem?

a. Myocardial Infarction (Heart attack)	1 ☐ Yes	0 ☐ No	*(mi)*
b. Congestive Heart Failure	1 ☐ Yes	0 ☐ No	*(chf)*
c. Peripheral Vascular Disease	1 ☐ Yes	0 ☐ No	*(pvd)*
d. Cerebrovascular Disease (Stroke)	1 ☐ Yes	0 ☐ No	*(cva)*
e. Dementia	1 ☐ Yes	0 ☐ No	*(dement)*
f. COPD	1 ☐ Yes	0 ☐ No	*(copd)*
g. Connective Tissue Disease	1 ☐ Yes	0 ☐ No	*(conntis)*
h. Peptic Ulcer Disease	1 ☐ Yes	0 ☐ No	*(peptic)*
i.Diabetes Mellitus	1 ☐ Yes	0 ☐ No	*(diabetes)*
If yes, with end organ damage? (Circle YES/NO)			
j. Moderate to Severe Chronic Kidney Disease	1 ☐ Yes	0 ☐ No	*(ckd)*
k. Hemiplegia	1 ☐ Yes	0 ☐ No	*(hemipl)*
l. Leukemia	1 ☐ Yes	0 ☐ No	*(leukem)*
m. Malignant Lymphoma	1 ☐ Yes	0 ☐ No	*(lympho)*
n. Solid Tumor	1 ☐ Yes	0 ☐ No	*(tumor)*
If yes, was it metastatic? (Circle YES / NO)			
o. Liver Disease	1 ☐ Yes	0 ☐ No	*(liver)*
If yes, circle MILD or MOD/SEVERE)			
p. AIDS	1 ☐ Yes	0 ☐ No	*(aids)*

11. At which hospital will you be receiving your total knee replacement? *(hospital)*

_____

12. What is the name of the surgeon who will be performing your total knee replacement?*(surgeon)*

_____

Data Log	Completed	Entered	Verified	Edited
Initials				
Date	/ /	/ /	/ /	/ /

Appendix C: Physical Therapy Utilization Form

Physical Therapy Utilization ID: _____

Functional Outcomes and Delivery of Physical Therapy Services After Total Knee Arthroplasty

Following discharge from the hospital following your total knee replacement, did you go to a rehabilitation or skilled nursing facility before going home or to a friend/family member's house?

1 ☐ Yes 0 ☐ No *(inpt)*

If yes, where did you go? Name of facility _____ *(inptname)*

Location of facility _____ *(inptloc)*

How many nights did you stay?_____ *(inptlos)*

Why were you discharged or sent home from this facility? *(dcwhy)*

0 ☐ Reached full potential; ready to go home

1 ☐ Insurance declined to cover additional days

2 ☐ Other (please specify) _____ *(dcwhy2)*

Did you receive home physical therapy?

1 ☐ Yes 0 ☐ No *(home)*

If yes, how many times did the physical therapist come to your house? _____ *(homenum)*

Did you go to outpatient physical therapy?

1 ☐ Yes 0 ☐ No *(outpt)*

If yes, where did you go? Name of facility _____ *(outptname)*

Location of facility _____ *(outptloc)*

(Researchers' note: Consent signed for outpatient record review? Y / N)

Data Log	Completed	Entered	Verified	Edited
Initials				
Date	/ /	/ /	/ /	/ /

Appendix D: Consent to Review of Records Form

Consent to Review of Physical Therapy Records

Functional Outcomes and Delivery of Physical Therapy Services After Total Knee Arthroplasty

I consent to any outpatient physical therapy records to be released to Allyn Susko, PT, DPT, for use in the study, "Racial Differences in Functional Outcomes and Delivery of Physical Therapy Services After Total Knee Arthroplasty". I agree to provide the research staff with the name(s) and location(s) of any and all physical therapy offices where I receive physical therapy for my knee following my total knee replacement surgery. I understand that any fees for accessing or printing these records will be paid by the research study. I acknowledge that my records may be retained for a period of not fewer than seven years in accordance with local Institutional Review Board policies for retention of data. I understand that my information will not be used for any purpose other than for this research study, and any information used in the research study will not be attached to my name or other identifying information.

*Print name:*_____

*Signature:*_____

*Date:*_____

*Witness:*_____

*Date:*_____

Appendix E: Outpatient Physical Therapy Utilization Form

Outpatient Physical Therapy Utilization ID: _____

Functional Outcomes and Delivery of Physical Therapy Services After Total Knee Arthroplasty

Outpatient PT start date: ___ / ___ / ___ *(outptstart)*

Outpatient PT end date: ___ / ___ / ___ *(outptend)*

Duration of care: _____ days *(outptEOC)*

Number of visits: _____ visits *(outptvis)*

Visit #	Date	Minutes PT billed	CPT codes	Visit #	Date	Minutes PT billed	CPT codes	Visit #	Date	Minutes PT billed	CPT codes
1				16				31			
2				17				32			
3				18				33			
4				19				34			
5				20				35			
6				21				36			
7				22				37			
8				23				38			
9				24				39			
10				25				40			
11				26				41			
12				27				42			
13				28				43			
14				29				44			
15				30				45			

Sum of Minutes PT billed: _____ *(outptmins)*

Total Hours of Outpatient PT: _____ *(outpttotal)*

Data Log	Completed	Entered	Verified	Edited
Initials				
Date	/ /	/ /	/ /	/ /

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