The Effectiveness of the Physical Therapist Assistant in the Acute Rehabilitation Setting

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By

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Abstract

Background and Purpose: Physical therapy care is delivered by physical therapists (PTs) as well as physical therapist assistants (PTAs) and other support personnel. There is very little published evidence describing patient outcomes when physical therapy care is directed to the PTA. This study investigates if higher utilization of PTAs affects patient outcomes in the acute rehabilitation setting for patients following a cerebrovascular accident (CVA) or following bilateral total knee replacements (TKR).

Methods: Retrospective data was gathered on subjects admitted to five inpatient acute rehabilitation facilities following CVA and bilateral TKR from 2008-2010. High PTA use was defined as greater than or equal to 20% of the physical therapy visits being provided by the PTA for an episode of care. Analysis of baseline characteristics was used to determine case mix similarities and differences between high and low PTA use groups. Multivariate regression techniques were used to examine differences in functional outcome (Motor FIM score change), discharge location, and length of stay between high and low PTA use groups. Propensity scoring methods were used to supplement findings of the regression analyses. All data analysis was performed with IBM®SPSS® Statistics Version 22.

Outcomes: Of the 1561 subjects following CVA, 496 (32%) had high PTA involvement. Of the 242 subjects following bilateral TKR, 91 (38%) had high PTA involvement. Baseline subject characteristics such as age, gender, baseline motor function and clinical co-morbidities were generally evenly distributed between high and low PTA use groups for both diagnostic groups. After controlling for patient characteristics, rehabilitation facility and year, there were no significant differences in functional outcome, discharge location or length of stay between groups with high and low PTA utilization for either diagnosis. The sample size was adequate to detect a small effect size of 0.2.

Conclusion: In the acute rehabilitation setting following CVA or bilateral TKR, subjects who had higher PTA involvement were similar in clinical severity as well as demographic characteristics to subjects who had lower PTA involvement. Higher PTA involvement in the rehabilitation of

patients following CVA or bilateral TKR did not adversely affect functional outcome, increase length of stay or reduce the likelihood of discharge to home.

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Statement of purpose and specific aims

This study investigates if the use of physical therapist assistants in place of physical therapists for some physical therapy care after cerebrovascular accident (CVA) or bilateral knee replacements affects patient outcomes.

Using a quasi-experimental design to assess patient outcomes data from electronic health records and physical therapy documentation from five inpatient acute rehabilitation facilities in the Twin Cities, this study:

1) Analyzes the factors that influence the proportion of physical therapy visits being delivered by the physical therapist assistant (PTA) in the inpatient rehabilitation setting for patients with cerebrovascular accident or following bilateral total knee replacements.
2) Examines if the proportion of physical therapy visits delivered by the physical therapist assistant (PTA) changes patients' physical function outcomes, discharge location, or length of stay in an inpatient rehabilitation facility for patients who have been diagnosed with a *cerebrovascular accident*;
3) Examines if the proportion of physical therapy visits delivered by the physical therapist assistant (PTA) changes patients' physical function outcomes, discharge location, or length of stay in an inpatient rehabilitation facility for patients who received *bilateral total knee replacements*

Chapter 1: Background, significance, and contribution.

Physical therapy provides a wide range of rehabilitative, preventative and wellness services to a diverse clientele in order to help them achieve the highest level of physical function. Physical therapy services are widely used in a variety of settings, such as: hospitals, skilled nursing facilities (nursing homes), hospice, schools, clinics, athletic clubs and homes.

The profession of physical therapy was organized in 1921, with the development of its first professional organization. In response to a growing demand for physical therapy services and not enough PTs or educational programs to fill the gap, the profession created the role of the physical therapist assistant in the late 1960's. This position required a two year technical educational program that gave students the skills to understand physical therapy principles and theories and to apply certain interventions (Wojciechowski 2004). Since that time, physical therapist assistants (PTAs) have provided many of the interventions essential to the field of physical therapy, including: therapeutic exercise, soft tissue mobilization, patient education and modalities. A PTA is a physical therapy provider who has received at least an associate degree in the field from a program accredited by the Commission for the Accreditation of Physical Therapy Education (CAPTE). PTAs are licensed or regulated by state following graduation and passing of a national board exam. While PTAs are educated to deliver many physical therapy interventions, they are not trained to complete patient evaluations, create a plan of care or initiate new or different interventions. Professional guidelines currently state that physical therapy should only be provided by physical therapists (PTs) or under the direction and supervision of PTs (APTA 2015). The incentive to delegate physical therapy care to the PTA allows a health care facility to deliver care at a lower cost due to salary differential, estimated to be $25,000 per year in the Minneapolis/St Paul area (www.bls.gov 2015).

The model for division of labor used in physical therapy allows a PT to direct portions of a patient's plan of care to a PTA after completing the evaluation, assessment and creating the plan of care (APTA 2009; Crosier 2010). This model is designed to allow the PT to determine what aspects of the physical therapy interventions are appropriate to direct to a PTA based upon both patient and provider factors. Patient factors could include medical acuity or frequency of status changes. Provider factors may include clinical experience of individual PTs or PTAs (APTA 2009). Professional guidelines encourage a team approach where interventions are provided by team members determined by the needs of the patient. The responsibility for the physical therapy care of the patient remains with the physical therapist (Crosier 2010).

The clinical reality is not always in concert with these established guidelines of PT and PTA interaction. From a clinical perspective, staffing decisions and scheduling processes seem to play a large role in determining which type of physical therapy provider will be treating an individual patient. Often, in acute rehabilitation settings, patients are seen by a combination of PTs and PTAs. Scheduling of patients with providers is driven by demand, such as if a patient requires an intervention only the PT is trained to provide, and availability, such as which provider has an opening on his or her schedule. Semi-structured interviews with physical therapy managers, supervisors, staff and schedulers at 3 different inpatient rehabilitation facilities (IRFs) in the Twin Cities area reinforce the notion of scheduling processes driving decision making regarding provider type with many decisions being left primarily to schedulers. Consistent across all facilities were the following parameters: patients are always scheduled with a PT for evaluations; after evaluation, patients are scheduled with team members (the PT or PTA) depending on staffing levels and census; and schedulers typically work to fill the PTA schedule first, such that open schedule times could be available with the PT for new patient evaluations if necessary. Patients who are not progressing as expected are not necessarily referred back to the physical therapist, but are generally the focus of team communication so that the physical therapist can determine if the plan of care requires adjustment. The ratio of provider type may remain the same after this type of adjustment, although if particular interventions are needed, it is possible the ratio may change (Personal interviews 2013).

At the state level providers must abide by additional requirements such as supervisory limitations. Minnesota statutes dictate that one PT can supervise only two PTA's at any given time and whenever a PTA will see a patient for a sixth time, a PT must be present to observe the interventions provided by the PTA (Minnesota Statutes 2012). Other states may have different requirements and these regulations have implications for this study. First, the PTA cannot be perfectly substituted for the PT in the delivery of physical therapy care. While the PTA involvement may be 0%, it will never reach 100%. Additionally, such state regulations could impact the generalizability of the results of this study. Health care facilities will be differently limited in the number of PTAs they could realistically employ and still be in compliance with these statutes, depending on the particular state. However, a recent study by the APTA Health Policy and Administration Section noted that a national sample of a variety of physical therapy practices demonstrated that none were close to any PTA supervisory statute limitations (Dwyer 2012).

Members of the professional association continue to advocate for alternate models of care delivery that include the PTA but there is very little published evidence to guide this work. This study examines if patient outcomes change when a greater proportion of physical therapy visits are provided by the PTA. This work can help inform the current discussion on determining new professional guidelines on the use of the PTA and possibly provide evidence for management decisions such as staffing in IRFs.

Chapter 2: Conceptual Models with Literature Review

The PT and the PTA have different roles in providing physical therapy care to patients. PTs are responsible for the physical therapy examination and evaluation of patients, setting the physical therapy plan of care, determining the patient prognosis, as well as implementing the interventions outlined in the plan of care. PTAs are educated to implement portions of the plan of care as determined by the PT (APTA 2015). Therefore, PTs and PTAs have some overlap in the care they provide. This project investigates outcomes given these overlapping roles.

While the roles of the PT and the PTA were designed to overlap, the current educational discrepancy leads to concern about the appropriate use of differently educated practitioners in the provision of physical therapy interventions. Physical therapists are currently educated at the clinical doctorate level and physical therapist assistants receive a two year associate degree. This is not an issue unique to the field of physical therapy. The concern about differently educated providers in the nursing profession has long been debated and investigated and the literature on patient outcomes in the field of nursing can be used as a guide for this project. While the literature about processes of care and patient outcomes with nurse practitioner substitution for physicians is generally positive (Laurant et al 2004; Mark 2001; Mundinger et al 2000; Rudy et al 1998), this is not the case when licensed practical nurses are substituted for registered nurses (Kane et al 2007; Ridley 2008; Glance et al 2012; Twigg et al 2012).

This information about nursing substitution provides additional incentive to examine the patient outcomes when health care workers who are differently educated are expected to provide similar care. While PTs continue to acquire more knowledge and skills with the increase in length of training, PTAs have not had this advantage. Therefore, some concern exists regarding what the optimal utilization of the PTA may be. The benefits of maximizing the use of the PTA are cost savings and the ability to reach more consumers who need and want physical therapy services. This may be particularly true rurally, where fewer PTs practice (King, et al 2010). The trade-off is the concern about maintaining optimal outcomes for these consumers.

There is a paucity of literature on patient outcomes with differently trained providers within physical therapy. One study, investigating the relationship between state regulations of PTs on 3 outcomes (PTA utilization, number of total physical therapy visits and patient reported health status at discharge), found that state regulations regarding the use of PTAs were sometimes associated with number of total physical therapy visits. However, they also conclude that high utilization of the PTA predicts increased number of visits and lower health status outcomes. High utilization was determined by the discharging physical therapist's estimates and was defined as greater than 50% of visits despite only 8% of patients studied falling into the high utilization category. The basis for this 50% cut off level was not stated. The authors concluded that high utilization of the PTA in an outpatient setting is "likely to result in less efficient and lower quality care" (Resnik, Feng, & Hart 2006).

Using the same database and timeframe, two of the authors completed a follow up study of physical therapy clinic characteristics and outcomes in the treatment of patients with low back pain syndromes. After collecting information at the patient, therapist and clinic levels, hierarchical linear models were constructed for patient outcomes and number of visits in an episode. This study primarily examined clinic level characteristics and determined if the clinic was a high utilizer of PTAs by evaluating the percentage of patients at each clinic with greater than 50% involvement of the PTA. The authors describe problems with a skewed variable distribution as 36% of the clinics had no patients with high PTA utilization. Clinics were identified as high utilizers of the PTA if the percentage of patients with greater than 50% PTA involvement fell above the mean of the remaining clinics in the sample. The mean was not disclosed. Of the 109 clinics included (291 were excluded), only 26 were classified as high utilizers. The authors determined the clinics classified as best performers were less likely to be high utilizers of the PTA than the middle or worst performing clinics. The authors conclude that their "findings suggest that, in the treatment of patients with low back pain syndromes, clinics that are low utilizers of physical therapist assistants are more likely to provide superior care (ie, better patient outcomes and lower service use)" (Resnik et al. 2008).

Both of these related studies used the same large subject populations, but have a number of limitations. Both studies define high PTA utilization as greater than 50% involvement of the PTA. As evidenced by the low number of subjects and clinics that reach this point, this might not be the most clinically relevant cut off point. No other cut off values were tested. Additionally, neither of these studies expressly addressed the potential for selection bias into the high versus low PTA utilization groups, which is clearly a methodological concern. Finally, the two previous studies analyzed community dwelling subjects (and the clinics treating those subjects) with shoulder impairments and low back pain from a variety of etiologies. This patient heterogeneity may introduce difficulty controlling for all relevant clinical factors in these studies.

In contrast to the two Resnik, et al publications, this study chose a more reasonable cut off score to define high or low PTA use to reflect clinical practice and avoid skewed data. It also tested different cut off values. The present study defined high PTA utilization as ≥ 20% involvement of the PTA, which was determined through a pilot study. This study also addressed selection bias by analyzing baseline characteristics in the high and low PTA utilization groups, careful inclusion of covariates in the regression model based on theoretical influence on outcomes, as well as using propensity scoring techniques to support the multivariate regression techniques. Finally, this study included only patients following CVA and bilateral total knee replacements. These patient diagnoses may make it easier to determine the appropriate severity and comorbidity measures to collect and control in the statistical model.

A more recent study examined patient outcomes and costs given the total number of physical therapy clinicians (PTs and PTAs) involved in a patient's care for musculoskeletal shoulder impairment. They found that failing to meet the practice standard, defined as 90% of visits provided by no more than two clinicians, was related to more overall visits per episode of care but was not related to PTA involvement (Toney, Winterhalter & Borgman 2011).

Of course, physical therapy is only one factor that may influence patient outcomes. There are many elements to consider in predicting patient outcomes after a neurological event such as a stroke, or after an elective orthopedic medical procedure such as a bilateral total knee replacement. Patient clinical profile and demographic factors (Jongloed 1986; Alexander 1994), facility type (Kramer, et al. 1997; Ronning & Guldvog 1998) and types of interventions (Bode, et al. 2004; DeJong, et al. 2011) all appear to play some role in patient outcomes.

The inpatient rehabilitation facility (IRF) is a good setting to investigate the question of whether patient outcomes differ when physical therapy is delivered by differently educated physical therapy providers. Patients who are admitted to acute rehabilitation facilities are considered medically stable and must be able to tolerate 3 hours of therapy daily. These patients will therefore be more consistently appropriate to delegate to the physical therapist assistant. Additionally, these facilities gather similar outcomes data as part of their accreditation status.

A population of patients following stroke is well suited for this investigation because they typically require physical therapy services, have a high likelihood of measured function changing from admission to discharge (van der Putten, et al. 1999; McKenna, et al. 2002) and the diagnosis often has a great impact on the patients' perceived disability and quality of life. Physical therapy interventions, along with other rehabilitative therapies such as occupational, speech and recreation therapy can potentially decrease the disability and improve quality of life.

The roles of several patient factors have been evaluated in outcomes following stroke. Stroke severity at admission, prior stroke and age appear to be strong predictors of functional outcomes (Alexander 1994; Jongbloed 1986). Additional factors found to impact functional outcomes include patient motivation and family support. Specific outcomes of stroke, such as cognitive changes and sensory neglect, can influence functional outcomes following rehabilitation (Henley 1985). Other predictors that are commonly controlled for in studies of outcomes following stroke include a variety of comorbidities, such as: obesity, diabetes, cardiopulmonary diseases, kidney failure, liver failure, depression, arthritis and the presence of pressure sores (McKenna, et al 2002; Bagg 2002; Strasser 2008;).

Patients following bilateral knee replacement are also appropriate for this investigation because following surgery they typically require physical therapy services and may have a high likelihood of measured function changing from admission to discharge (DeJong, et al. 2009). Patients electing a surgical procedure such as bilateral knee replacements may be likely to have fewer chronic conditions and require fewer hospital services than patients following stroke. These patients also require physical and occupational therapies to optimize function, but are much less likely to require speech therapy, except in unusual circumstances.

Patient factors that impact outcomes following knee replacement include age, gender, family support, and comorbidities such as peripheral vascular disease, heart disease, lung disease, diabetes, cancer, neurological disease, skin ulcers and kidney disease (Nilsdotter 2009; March, et al. 2004). While obesity is associated with lower pre-operative function, the same association has not been made for post-operative outcomes (Ayyar 2012).

Physical therapy (along with other rehabilitation therapies) is widely considered to be an effective intervention to improve outcomes following stroke and knee replacements. While quantity, content and setting of therapy are considered to be important (Bode, et al. 2004; Kramer, et al. 1997), different theoretical approaches delivered in IRFs have not been proven superior in improving health outcomes following a stroke or orthopedic surgery such as bilateral TKA. A systematic review concluded that no evidence indicates any particular approach to stroke rehabilitation as being more effective than another (Kollen, et al. 2009). Similarly, according to the 2003 NIH Consensus Statement on Knee Replacement, there is no evidence which supports the use of any particular rehabilitation intervention before or after knee replacement (NIH 2003). A study of functional outcomes in patients with stroke, knee arthroplasty and traumatic brain injury after an inpatient rehabilitation stay found that only gait training and community mobility interventions were positively associated with functional outcome (DeJong, et al. 2011). These are common intervention approaches used by both PTs and PTAs.

Given that physical therapy interventions are associated with improved functional outcomes for patients after stroke and total knee replacement, it is important to know if the type of physical therapy provider delivering these interventions has an impact on patient outcomes. The benefit of this study is to add to the evidence base concerning patient outcomes with the use of the PTA in an inpatient rehabilitation facility.

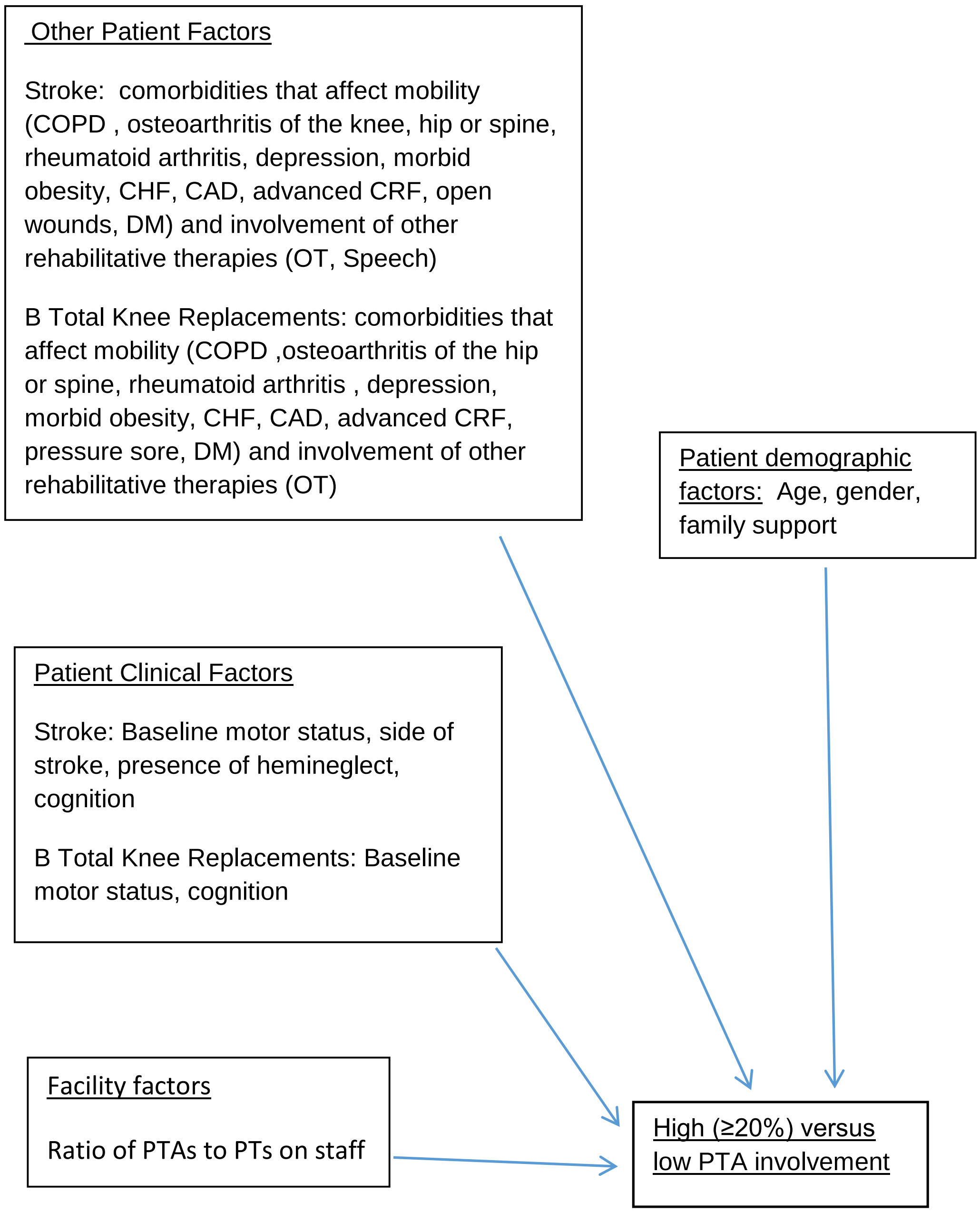
The conceptual models are described below.

Specific Aim #1: Analyze the factors which influence the proportion of physical therapy visits being delivered by the physical therapist assistant (PTA) in the inpatient rehabilitation setting for patients with acute cerebrovascular accident or following bilateral total knee replacements.

Physical therapy professional guidelines (APTA 2009; Crosier 2010) encourage PTs to direct patient care to a PTA based on patient and provider factors. Interviews with physical therapy staff at local IRFs indicate that while appropriateness of the patient is considered, most decisions about the type of physical therapy provider are determined by staffing and scheduling processes (Personal interviews 2013).

The data included in the outcomes component of this study was analyzed to determine those factors that predict a subject having a higher percentage of their physical therapy visits delivered by a PTA. The cut off point for a high proportion of visits being delivered by a PTA was determined a priori to be ≥ 20%. Prior studies have used a 50% cutoff but had problems with skewed data and small numbers in the higher category (Resnik 2006; Resnik, et al. 2008). Clinical, patient and demographic factors were considered. Facility factors would also be important to this model. All IRFs included in this study were determined to have similar numbers of PTAs to PTs on staff. Further investigation of staffing policies was beyond the scope of this project.

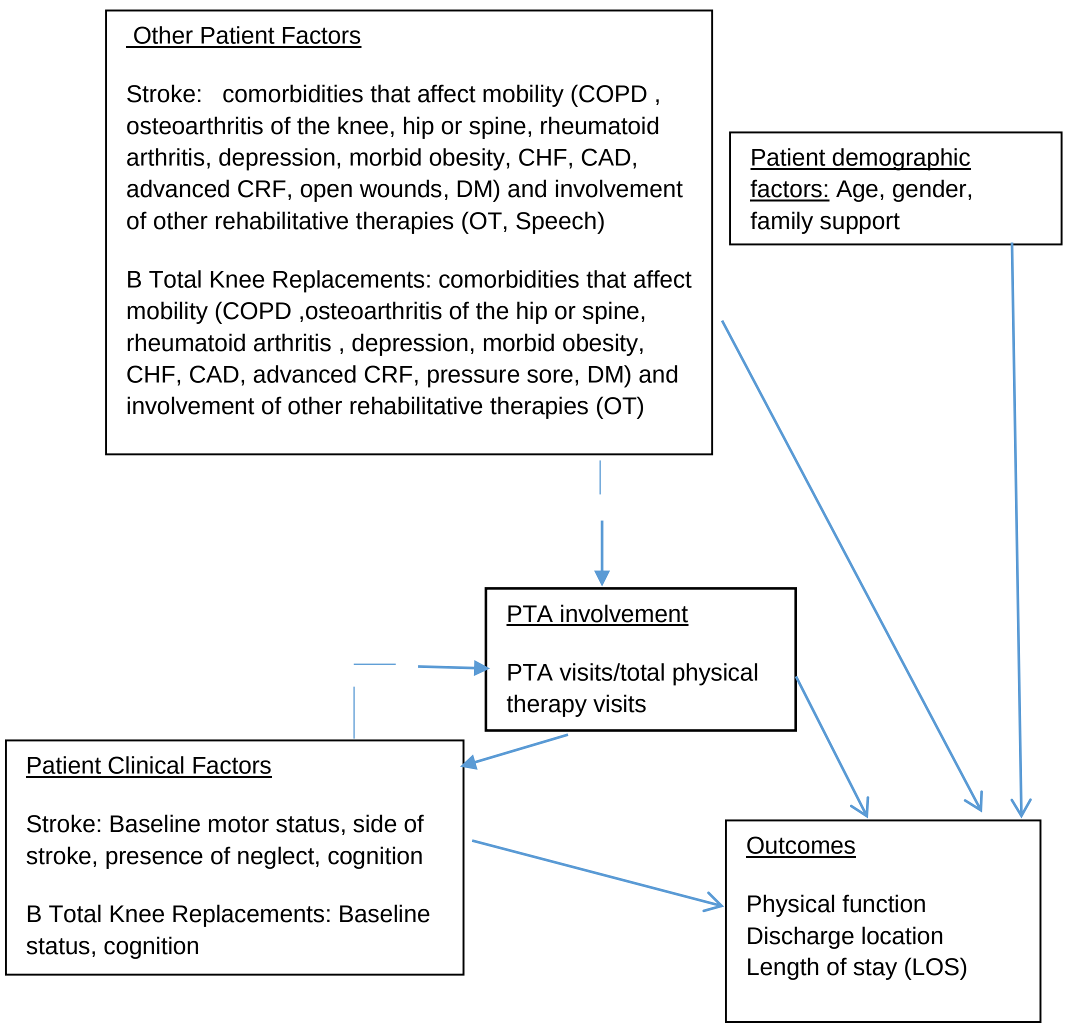
Figure 1. Diagram of conceptual model for specific aim #1



Specific Aim #2: Examine if the increased use of the physical therapist assistant changes patients' physical function outcomes, discharge location, or length of stay in an inpatient rehabilitation facility for patients who have been diagnosed with a cerebrovascular accident.

Specific Aim #3: Examine if the increased use of the physical therapist assistant changes patients' physical function outcomes, discharge location, or length of stay in an inpatient rehabilitation facility for patients who received bilateral total knee replacements.

Figure 2. Diagram of conceptual model for specific aims #2 and #3.



As reflected in the conceptual model diagram, many patient clinical factors affect functional outcomes as well as potentially influencing the level of participation in the treatment group.

Although scheduling procedures may be more directive than these clinical factors in determining the involvement of the different physical therapy providers, this model presents with selection bias as a significant issue to be dealt with analytically. The model also implies that the intervention (the level of involvement of PTAs as the physical therapy provider) interacts with some of the clinical factors to impact outcomes. These clinical factors become effect modifiers of the intervention, rather than simply confounders. Interaction is included in the model to analyze this effect.

The following table presents the variables that are included in the analysis:

Table 1. Variable table

Independent Variable	**Definition/calculation**	**Nature**	**Source**
PTA involvement in patient care	Visits by the PTA/total physical therapy visits Note: a visit will be defined as up to a 30 minute session	Ratio. Binary cut off at ≥20%	Medical record abstraction, or created by billing record
Other variables			
Age	Chronological age in years at admission	Categorical. Stroke:18-44, 45-64, 65-79, 80+ Knees: ≤50, 51-64,65-79, 80+	Facility rehabilitation database
Gender	Male or Female	Dichotomous	Facility rehabilitation database
Side of stroke	R CVA with Left hemiparesis; L CVA with R hemiparesis; Bilateral CVA; no hemiparesis	Categorical	Facility rehabilitation database
Knee Osteoarthritis (stroke only)	ICD-9 code 715.96 present on IRF-PAI	Dichotomous (present or not present)	Facility rehabilitation database
Hip osteoarthritis	ICD-9 code 715.95 present on IRF-PAI	Dichotomous (present or not present)	Facility rehabilitation database
Spine osteoarthritis (or disc disease)	ICD-9 codes 721.90, 721.91, 722.4, 722.5x, 722.6, 722.7, or 724.8 present on IRF-PAI	Dichotomous (present or not present)	Facility rehabilitation database
Rheumatoid Arthritis	ICD-9 code 714.0 present on IRF-PAI	Dichotomous (present or not present)	Facility rehabilitation database
Hemineglect (stroke only)	ICD-9 code 781.8 present on IRF-PAI	Dichotomous (present or not present)	Facility rehabilitation database

Other variables	Definition/calculation	Nature	Source
Chronic Obstructive Pulmonary Disease (COPD)	ICD-9 code 496 present on IRF-PAI	Dichotomous (present or not present)	Facility rehabilitation database
Morbid obesity	ICD-9 code 278.01 present on IRF-PAI	Dichotomous (present or not present)	Facility rehabilitation database
Congestive Heart Failure	ICD-9 code 428 present on IRF-PAI	Dichotomous (present or not present)	Facility rehabilitation database
Coronary Artery Disease	ICD-9 414 code present on IRF-PAI	Dichotomous (present or not present)	Facility rehabilitation database
Diabetes Mellitus	ICD-9 code 250 present on IRF-PAI	Dichotomous (present or not present)	Facility rehabilitation database
Chronic Renal Failure	ICD-9 code 586.3-.7 present on IRF-PAI	Dichotomous (present or not present)	Facility rehabilitation database
Pressure ulcer or chronic open wound	ICD-9 code 707 present on IRF-PAI	Dichotomous (present or not present)	Facility rehabilitation database
Depression	ICD-9 code 296.3 present on IRF-PAI	Dichotomous (present or not present)	Facility rehabilitation database
Baseline motor function	Motor component of FIM at IRF admission	Continuous	Facility rehabilitation database
Cognition	Cognitive component of FIM at IRF admission	Continuous	Facility rehabilitation database
Family support	Living situation: alone or with others immediately prior to hospitalization	Dichotomous	Facility rehabilitation database
Occupational Therapy involvement	Number of occupational therapy visits	Continuous	Medical record abstraction, created by billing record
Speech Language Pathology involvement (more than evaluation)	Pt receives >2 SLP services during IRF stay	Dichotomous	Medical record abstraction, or created by billing record

Outcome variables	Definition/calculation	Nature	Source
Functional outcome	Change in motor FIM score	Continuous	Facility rehabilitation database
Discharge location	First patient location following discharge: Home Nursing Home Acute hospitalization Death	Categorical	Facility rehabilitation database
Length of Stay (LOS)	Days admitted to IRF (date admitted to date discharged)	Continuous	Facility rehabilitation database

One important variable missing in this study was patient motivation. Patient motivation is known to be predictive of functional outcome following stroke (Henley 1985). Even if extensive medical record abstraction was completed, this information would be inconsistently reported in medical records. A diagnosis of clinical depression was included as a possible confounding variable and may control part, but certainly not all of the issue of patient motivation.

Outcome measures of this study included functional outcome, discharge location following the inpatient rehabilitation stay, and length of stay in the inpatient rehabilitation facility. Functional outcome was measured by change in the motor subscale of the Functional Independence Measure, or FIM (Keith, et al. 1987). The FIM is a valid and reliable tool used frequently in measuring outcomes of rehabilitation (Kidd et al, 1995). The FIM was developed in 1987, and in its entirety contains both a cognitive and motor component and is designed to determine levels of care patients require with the onset of a medical condition. It has 18 items, 13 which are considered to be a measure of motor function and 5 considered to be a measure of cognitive abilities. Possible scores range from 18-126 on the entire instrument. The FIM is a tool with four different domains on the physical function (motor) scale: self-care, sphincter control, transfers, and locomotion. Scores on each item range from 1 to 7, with 1 indicating that the patient requires total assistance and can provide 0-24% of the physical work to perform the task, and 7 indicating complete independence with the patient able to perform 100% of the physical work and to do so in a safe and timely manner. The response categories are ordinal and run in the same direction, with higher responses indicating less dependency. One of the benefits of the FIM is that it is maintained by the Uniform Data System (UDS) which has substantial resources and influence. When standard payments for diagnosis became the norm, it was necessary to have additional information that could indicate an appropriate level of care any given patient might require. The FIM was developed to do just this and is used to provide a severity level in addition to diagnosis and for reimbursement purposes. (MacDowell & Newell 1996). This measure has therefore been adopted widely across the United States and even internationally. Its widespread use means that it is easily understood and familiar to clinicians who often administer and score the FIM with patients. This project used the motor sub score of the FIM (Motor FIM) to describe functional outcome as it is the only consistently used measure of functional outcome in acute rehabilitation facilities. While specific components of the Motor FIM, such as sphincter control, are not necessarily salient to physical therapy outcomes, it has been determined to be predictive of location of discharge and how many minutes of care people require (MacDowell & Newell 1996).

Discharge location following an inpatient rehabilitation stay is primarily measured by return to living in the community or transfer to a nursing home environment such as skilled nursing or transitional care. Living in the community can include a return to prior housing arrangement or a new housing arrangement that may involve family members, care givers or services through home care agencies or assisted living facilities. Being able to function in a community environment is partly a reflection of functional mobility, but also depends on other dimensions of independence such as cognition (Chung 2012) and availability of resources. This study examines if the proportion of the physical therapy visits provided by the PTA has any bearing on discharge back to the community versus requiring a nursing home at discharge.

Fewer than 10% of discharges from inpatient rehabilitation involve a return to the acute hospital environment. This is typically necessitated by an unexpected medical event. In rare circumstances, patients die prior to discharge from inpatient rehabilitation. Conceptually, the physical gains achieved with the use of rehabilitative services are not related to an unexpected medical event or sudden death. If these outcomes differ by PTA involvement in physical therapy care, there would be concern regarding the management of selection bias and that the groups were different at baseline by an unmeasured variable.

Length of stay was measured by the dates the subject stayed in the inpatient rehabilitation facility. IRFs are reimbursed for patients' stays by diagnosis and severity measures not by individual services rendered to the patient. Because of this bundled payment system, length of stay can be an important efficiency or cost measure for IRFs. Length of stay (LOS) costs are likely to dominate the facility costs. By analyzing costs in the Decision Support System (DSS) National Data Extracts and cost-adjusted charges in the Uniform Data System for Medical Rehabilitation (UDSMR), a study of inpatient rehabilitation facility costs at Veteran Affairs (VA) and non-VA facilities demonstrated that LOS explained 80% of the variance of facility cost for all diagnoses (Wagner 2006). While other patient factors were statistically significant as predictors of cost, they added very little explanatory value. Because many services provided in inpatient rehabilitation occur daily, this strong relationship between LOS and cost is not necessarily surprising (Wagner 2006).

Chapter 3: Data Collection

This study utilized observational data from existing medical records and the rehabilitation management information systems of five local IRFs. As noted in the variables table, many of the variables were collected from the inpatient rehabilitation facility patient assessment instrument (IRF-PAI). This instrument is designed by the Centers for Medicare and Medicaid Services (CMS) to classify patients into distinct groups based on clinical characteristics and resource needs. All participating facilities were accredited by the Commission on the Accreditation of Rehabilitation Facilities (CARF) for the dates included in the study. Sites included five IRFs in the Twin Cities area of Minnesota. The sites chosen represented both urban and suburban communities. IRB approval was obtained with expedited review through four respective IRBs as two facilities were under the auspices of the same health care organization.

Data were used from the years 2008-2010 for three sites. Two sites did not begin warehousing their data in way conducive to this study until the end of 2008, therefore, only December of 2008-2010 is included for these facilities. While three facilities described an ideal staffing ratio of 1-2 PTAs to 5-6 PTs, two of the IRFs included in this analysis experienced decreases in the staffing level of PTAs in 2008 and 2009 attributable to outside influences. It is helpful to include the years 2008-2009 when such changes occurred because it provides data with different levels of PTA involvement that are completely separate from patient clinical factors and thus less likely to be subject to selection bias. However, including the two most recent years of 2009-2010 may have resulted in more patients with 0% PTA involvement. Given these issues with staffing at the different facilities, a variable for year of discharge was included in the model, as well as for the specific inpatient rehabilitation facility.

For subjects following a CVA, information was gathered on adult patients admitted to the IRF directly from an acute hospital stay following their stroke. Ideally, only subjects experiencing their first CVA would be included. However, inconsistencies in documenting and coding prevented the guarantee that only patients following their first CVA were included. Inclusion criteria further required that the patient received physical therapy interventions during their IRF stay. Exclusion criteria included age under 18 years. Information for each patient included in the analysis was gathered in part through electronic health record reports and in part via manual chart abstraction of the electronic health record. These records were linked by facility medical record number. All sites were combined for the analysis. After controlling for patients' age, gender, comorbidities, baseline function, the involvement of other rehabilitation disciplines, site of IRF and year, patient outcomes were linearly or logistically regressed on the percentage of physical therapy visits being with a physical therapist assistant. As the physical therapy evaluation visit was not included in the therapy visit count, this proportion ranged from 0% to 100% of their physical therapy services provided during their inpatient acute rehabilitation stay. Although this appears to inflate the level of involvement of the PTA, it removes the visits that the PTA may not legally provide.

Methods of data collection for specific aim #3 mirrored those for specific aim #2. Inclusion criteria required that patients received bilateral total knee replacements and discharged directly the IRF from their acute hospitalization. Exclusion criteria again included age under 18 years. There were slight differences in the included comorbidities (see conceptual model).

LOS data were collected directly from medical records. Day of admission through day of discharge was used to determine length of stay. LOS outcomes were determined separately for patients with stroke and patients following bilateral total knee replacement.

Power

The primary outcome measure in this study is the motor subsection of the Functional Independence Measure, or the FIM Motor score, which has a score range of 13-91. The minimal clinically important difference (MCID) change in Motor FIM score after stroke is 17 points. (Beninato, et al. 2006). Two studies have evaluated mean FIM Motor change scores in populations of acute stroke after inpatient rehabilitation and both found average change scores of approximately 20 points with a standard deviation of 16 (van der Putten, et al 1999; McKenna, et al 2002). Because this study is examining if the patient group with high PTA utilization is similar (not inferior) in outcomes to the patient group with lower PTA utilization, a smaller difference than the MCID is desired for between group differences. The study was designed to detect a standard small effect size of 0.2 (Cohen 1988) with 80% power. This allows for a 3 point difference on the Motor FIM to be detected between groups. Post hoc power analysis reveals the study, with 1562 participants, provided 99% power to detect this small effect size (Cohen 1988).

For patients completing inpatient rehabilitation for knee replacements, the average change is the FIM Motor score is 26 points with a standard deviation of 7.8 (DeJong, et al. 2009). This portion of the study was again designed to detect a small effect size of 0.2. For patients following knee replacements, this would detect a 1 point difference on the Motor FIM between groups. With 242 participants, post hoc analysis demonstrated 99% power to detect this small effect size (Cohen 1988).

Description of the data

This project analyzed existing medical record data. Much of the data were extracted from individual inpatient rehabilitation facility databases, although some information required individual medical record abstraction from an electronic health record. Data were then linked to data from the databases via unique patient identifiers. Following expedited IRB approval at the each of the health care systems, data was accessed on-site or via remote connection to the electronic health record.

Most of the variables collected for this study are items that are required by Medicare for payment. As missing data was not a major concern in this study, subjects with missing data were excluded from the analysis.

One exception to this is the variable of race. Because race is typically included as a covariate or confounding variable, the original plan for this project included race as a patient demographic factor to be included in the regression model. All facilities had some missing data for this variable and one site had only about a 20% completion rate for this variable Ultimately, race was eliminated as an explanatory variable due to inconsistent reporting.

Analysis Plan

Of particular concern in observational research is the possibility of selection bias. In this study, the patient characteristics that can impact outcomes, such as severity of the medical condition and the presence of many co-morbidities, are the same factors that could theoretically place them into groups with a different level of involvement of the physical therapist assistant.

While patient and provider factors could affect the role and level of involvement of the PTA in patient care, the clinical reality of decision-making coming from scheduling and staffing protocols suggests this study may be less prone to selection bias than the theoretical model indicates. Nonetheless, the concern regarding selection bias must still be addressed in the analysis of the results.

In this study, selection bias was addressed by including covariates in the analysis as well as by using propensity scoring analysis. Propensity scores address the selection bias introduced by the differential distribution of identifiable confounders by estimating their role in patient selection (Rubin 1997). According to Shadish, Cook and Campbell, propensity scores should include any variables that might influence selection and are related to outcome (Shadish, Cook & Campbell 2002). Although not used in this study, another way to deal with selection bias is via instrumental variables. Instrumental variable analysis relies on finding a variable which can help predict the selection into the treatment group but doesn't have an impact on outcomes. This is thought to address unobserved or unmeasured covariates which could influence outcomes (Joffe & Rosenbaum 1999). This would have been an ideal way to deal with selection bias in this study; however, a measurable variable that fulfills the requirements could not be determined. This is the major drawback of instrumental variables. (Hebert 2006).

To utilize propensity scoring, the independent variable of PTA involvement was dichotomized into high and low PTA utilization groups. A logistic regression was run with PTA involvement as the dependent variable and all other covariates as independent variables. Each subject then received a propensity score, or a likelihood of being in the treatment versus control group. Then the overlap in propensity scores between the two exposure groups was evaluated. With overlap, the propensity scores can be used in one of three ways: as a stratification measure, as a regression covariate, or to match subjects (Oakes & Johnson 2006). This study used both propensity matching and stratification techniques. When being used for stratification, the sample was divided into subgroups based on the propensity scores. Within each group the effect of being in the treatment group can be compared by a t test. Those results can then be pooled across the subgroups (Rosenbaum & Rubin 1984). Matching may provide a more exact covariate balance, but it is possible to lose the data from unmatched subjects (Oakes & Johnson 2006).

Confident use of the propensity score relies on the belief that those unobserved covariates do not significantly impact the level of involvement of the PTA. Given that staffing models seem to drive much of the decision making process for patient assignment to provider type, this could be a reasonable assumption.

The use of propensity scoring to control selection bias has been questioned. Propensity scores may even exacerbate selection bias in observational research (Brooks & Ohsfelt 2013). Therefore, this study used both multivariate analysis as well as propensity scoring techniques via stratification and matching to provide a level of robustness to the outcomes.

Also addressed was the possibility of interaction noted in the conceptual model. Expected interaction between the covariates and the independent variable was managed by inclusion of interaction terms in the model. The clinical factors of baseline function and cognition were included as covariates and in interaction terms with the level of PTA involvement.

Specific Aim #1: Analyze the factors which influence the proportion of physical therapy visits being delivered by the physical therapist assistant (PTA) in the inpatient rehabilitation setting for patients with acute cerebrovascular accident or following bilateral total knee replacements.

This aim will examine if any of the patient characteristics (or case mix) are different by differing levels of PTA involvement or by diagnosis type. Presence or levels of baseline characteristics (depending on the nature of the variable) will be listed according to the independent variable of proportion of PTA visits. While statistical significance will be set at $p<.05$, more than just statistical significant difference between groups needs to be examined. Clinical significance and relevance also need to be addressed.

Specific Aim #2: Examine if the increased use of the physical therapist assistant changes patients' physical function outcomes, discharge location, or length of stay in an inpatient rehabilitation facility for patients who have been diagnosed with an acute cerebrovascular accident.

Specific Aim #3: Examine if the increased use of the physical therapist assistant changes patients' physical function outcomes, discharge location or length of stay in an inpatient rehabilitation facility for patients who received bilateral total knee replacements.

The regression model for these two specific aims is as follows:

$$Y=\beta_0+\beta PTA + \beta_2X_1 + \beta_3X_2 + \beta_4PTA*X_2 + \beta_5DEM + \beta_6 IRF + \beta_7Year + \varepsilon$$

Where Y is the outcome of location of discharge or change in motor FIM scores, PTA is the independent variable of ratio of PTA to total PT visits, X_1 are the included clinical factors of severity (stroke only) osteoarthritis (stroke only), hemineglect (stroke only), diabetes, chronic obstructive pulmonary disease, morbid obesity, chronic renal failure, pressure sore, congestive heart failure, coronary artery disease, depression, baseline motor function, cognition, OT visits and Speech Therapy visits (stroke only), X_2 are the clinical factors thought to interact with PTA involvement (baseline cognition and baseline motor function), DEM are the demographic factors of age, gender and family support, Year is the year of the IRF stay, IRF is the specific facility and ε is the error term. The PTA*X indicates an interaction between the independent variable and the above mentioned covariates. The function is linear for the change in functional outcomes and multinomial logit for discharge location.

For functional outcomes, a coefficient and standard error were calculated for each variable. This determined the t statistic with the significant p value set at .05. The size and the sign of the coefficient explained the size of the effect and the direction of each variable on functional outcome.

For location of discharge, a multinomial logistical model was used. A likelihood ratio chi squared tested for any coefficient to be different than zero when examining all discharge locations against the referent location (home). Coefficients and standard errors were calculated for each variable in the model. In the multinomial logit model, the coefficient divided by the standard error determined the z statistic, which was also set at a significance level of .05. The coefficient in a multinomial regression indicates the log odds of a particular discharge location for a one unit change in the variable, holding all other included covariates constant.

Length of stay was examined with generalized linear models because LOS data typically are skewed with a long tail to the right. Distributional models and transformation were guided by the literature (Manning & Mullahy 2001; Deb, Manning & Norton 2011) and a gamma distribution with log-link was determined for the CVA population and a negative binomial distribution was used for the subjects recovering from bilateral total knee replacements. For the generalized linear models, parameters are determined through the iterative maximum likelihood estimation process. The significance of the effects in the model were tested by the Wald statistic.

In order to use propensity scoring, the independent variable was logistically regressed on the potential confounders that could impact selection into the treatment group. Then the outcomes of location of discharge and change in motor FIM scores were examined within propensity score quintiles. The model for the propensity score is as follows:

$$\text{Logit (PTA)}=\alpha+\beta Z$$

$$\text{Prob}(\text{PTA}=\text{high} \mid Z)=\frac{\exp(\alpha+\beta Z+\beta_2 \text{IRF}+\beta_3 \text{Year})}{1+\exp(\alpha+\beta Z+\beta_2 \text{IRF}+\beta_3 \text{Year})}$$

Where Z are all the covariates that could predict placement into the high PTA group. These covariates include: patient clinical factors of baseline status, severity, and cognition; other patient factors of type and side of stroke, presence of hemineglect, chronic obstructive pulmonary disease, osteo and rheumatoid arthritis, depression, morbid obesity, congestive heart failure, coronary artery disease, chronic renal failure, pressure sore or chronic wound, diabetes mellitus, and the involvement of other rehabilitative therapies; and patient demographic factors of age, gender and living situation. IRF location and year of discharge are also included.

Sensitivity analyses were also included. The independent variable of PTA involvement was examined as a continuous variable as well as a dichotomous one. In addition to the 20% cutoff determined a priori, other cutoff points, such as 0%, 10% and 30%, were analyzed for dichotomizing this variable. Also, different forms of the independent variable were considered. Polynomial terms of PTA^2 and PTA^3 were plotted to determine best fit of the variable.

Finally, the ratio of PTA visits/total PT visits for each subject was tracked and the ratio during the first half of the LOS was compared to the second half of the LOS, in order to address any concern regarding poorly progressing patients being referred back to the full care of the physical therapist. This could cause the paradoxical situation of patients with very poor outcomes appearing to have a low proportion of PTA visits (and subsequent high proportion of PT visits). There is no clinical evidence that this occurs, but the theoretical concept should be considered. All data analysis was performed with IBM© SPSS© Statistics Version 22.

Chapter 4: Results

Specific Aim #1: Analyze the factors which influence the proportion of physical therapy visits being delivered by the physical therapist assistant (PTA) in the inpatient rehabilitation setting for patients with acute cerebrovascular accident or following bilateral total knee replacements.

In this study, the independent variable of interest is the level of involvement of the PTA. This variable has been dichotomized in several ways in order to examine how patient characteristics are distributed when different cutoff points are used.

For patients in this study who had an inpatient rehabilitation stay following stroke, the following table contrasts the baseline characteristics for patients with a cutoff point at 20% of PTA involvement compared with less than 20% PTA involvement and between those with any PTA care and none. Differences in patient characteristics between groups is referred to as case mix. Most characteristics are quite evenly distributed between the two groups, regardless of how PTA involvement is defined. Using the 20% cutoff, cognition is slightly higher in the groups getting more PTA involvement, but motor function at baseline is not meaningfully different. As can be seen in Table 2, the differences in case mix at the 20% cutoff are slight, although CHF is more likely in the high PTA group.

Using the 0% cutoff point increases the differences between groups; however, not in the way predicted by professional guidelines (Watts 1979; APTA 2009; Crosier 2010). Here the group with some PTA involvement in their care have lower motor function at baseline, higher cognitive function, and more speech needs; they are more likely to have neglect, are slightly less likely to have COPD, morbid obesity, CAD, and slightly more likely to have OA of the spine, CHF, DM and depression. With the exception of neglect and OT visits among those with and without PTA involvement, none of the differences are substantial.

Table 2. Baseline characteristics of patients following stroke at two cutoff points for PTA involvement

	PTA <20% N=1065	PTA ≥20% N=496	PTA 0% N=519	PTA >0% N=1043
Gender=female	47.98%	52.62%	47.21%	50.62%
Age in years-mean (SD)	68.21 (14.90)	68.32 (14.22)	69.28 (14.4)	67.76 (14.81)
Living alone	24.98%	26.61%	23.89%	26.37%
Baseline Motor FIM-mean (SD)	42.25 (15.08)	42.62 (14.6)	47.81 (14.66)	39.88 (14.35)
Baseline Cog FIM-mean (SD)	22.47 (7.19)	23.31 (7.05)	22.7 (6.9)	27.77 (7.28)
OT visits-mean (SD)	26.66 (21.67)	27.65 (19.55)	18.42 (13.23)	31.20 (22.77)
Side of stroke	R=36.34% L=38.59%	R=33.87% L=39.11%	R=29.48% L=40.27%	R=38.54% L=37.97%
Speech involved	87.61%	86.49%	85.16%	88.21%
Neglect	9.2%	9.68%	5.78%	11.12%
Knee OA	0.09%	0.4%	0.19 %	0.19%
Hip OA	0.09%	0	0.19%	0
Spine OA	0.75%	1.4%	0.39%	1.25 %
RA	1.4%	1.4%	1.54%	1.34%
COPD	5.35%	5.04%	6.36%	4.7%
Morbid Obesity	2.54%	1.61%	3.08%	1.82%
CHF	8.45%	11.29%	8.86%	9.59%
CAD	11.74%	10.89%	13.68%	10.35%
DM	25.82%	26.41%	25.63%	26.17%
CRF	5.73%	3.83%	5.59%	4.99 %
Open wound	1.31%	1.81%	0.58%	1.92%
Depression	0.75%	1.0%	0.58 %	0.96%
comorbidities (SD)	.73 (.81)	.75 (.83)	0.73 (0.84)	0.74 (.8)

When the same comparisons are made for patients who had bilateral total knee replacements the baseline characteristics are quite also evenly distributed. High PTA involvement is associated with a slightly more severe case mix and more morbid obesity, but the other differences are modest. These comparisons can be seen in Table 3.

Table 3. Baseline characteristics of patients following B TKA using two cutpoints of PTA involvement

	PTA <20% N=151	PTA ≥20% N=91		PTA None N=95	PTA some N=147
Gender (female)	71.52%	71.42%		68.42%	74.15%
Age in years-mean (SD)	63.54 (10.02)	62.74 (10.03)		63.42 (9.00)	63.13 (10.64)
Living alone	26.49%	23.08%		25.27%	25.17%
Baseline Motor FIM-mean (SD)	49.19 (8.55)	48.74 (9.03)		51.59 (7.12)	47.37 (9.26)
Baseline Cog FIM-mean (SD)	33.38 (2.60)	33.30 (2.80)		33.67 (2.09)	33.14 (2.97)
OT visits-mean (SD)	12.96 (7.79)	13.24 (6.78)		10.08 (4.6)	14.99 (8.22)
Hip OA	0%	1.1%		0	0.68%
Spine OA	0.66%	1.1%		0	1.36%
RA	2.65%	1.1%		2.11%	2.04%
COPD	1.99%	1.1 %		2.11%	1.36%
Morbid Obesity	1.32%	10.99%		2.11%	6.8%
CHF	3.31%	1.1%		1.05%	3.4%
CAD	6.62%	4.4%		6.32%	5.44%
DM	18.54%	14.29%		17.89%	17.01%
CRF	0.66%	2.2%		0	2.04%
Open wound	0.66%	2.2%		0	2.04%
Depression	0%	1.1%		0	0.68%
Number of comorbidities	0.36 (.63)	0.41 (.60)		0.32 (.57)	0.42 (0.64)

Further analysis in this study will focus on the more clinically relevant 20% cutoff point for PTA involvement as well as using PTA as a continuous variable. Use of the cutoff point of 0% (versus any) PTA involvement will be presented for sensitivity analysis only.

Specific Aim #2: Examine if the increased use of the physical therapist assistant changes patients' physical function outcomes, discharge location or length of stay in an inpatient rehabilitation facility for patients who have been diagnosed with a cerebrovascular accident.

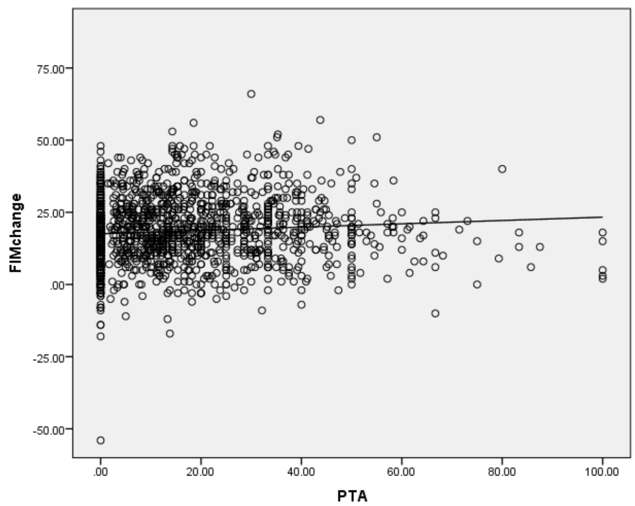
<u>Stroke and functional outcome:</u>

Impact of PTA involvement on the functional outcome of patients following a CVA was examined in this study. PTA involvement ranged from 0% to 100% of the physical therapy visits (as the examination/evaluation visits were not included). Of 1562 patients included in the study, 519

(33%) had 0% PTA involvement and 1043 had some PTA involvement in their physical therapy care. The mean and median of PTA involvement were 15% and 11%, respectively.

Figure 1 shows a scatterplot of the raw association of PTA involvement and change in functional outcome. Here PTA involvement is defined as a continuous variable, so the full spectrum of PTA utilization for this population can be seen.

Figure 3. Scatterplot of level of PTA involvement on Motor FIM change



The relationship does not appear to strongly depend on PTA involvement. But there is a slightly positive slope, which is significant at p=0.001 when no other covariates are included. In the full model, however, with 1,560 subjects, PTA involvement as a continuous variable is no longer significant at the p≤.05 level. The model summary and coefficients can be seen in Tables 4a and 4b. The significant F test in table 4a indicates that the model is a better predictor of FIM change than a model with just an intercept term. Table 4a also reports an adjusted R squared of 0.18; only a modest 18% of explained variance in FIM change is being predicted by this model. Table 4b shows each variable and its coefficient. The coefficients can be used to interpret the outcome. For each one unit change in the independent or predictor variables, the change in Motor FIM score will be equivalent to the coefficient. Therefore, for each one unit increase in PTA involvement (one percentage point), there is a small (.116) but insignificant increase in Motor FIM change when all the covariates are included. However, the interaction term between PTA involvement and baseline motor function on functional outcome is significant. Further analysis of the interaction, with only PTA involvement and baseline motor function included in the model, demonstrates that baseline motor function levels moderate the relationship between PTA involvement and functional outcome at low baseline motor FIM scores (one SD below the mean) and mean motor FIM scores. When baseline function is low, there is a significant positive relationship between PTA involvement and functional outcome as measured by motor FIM score change, b=0.112, 95% CI [0.042, 0.181], t=3.15,p=.002. This significant positive relationship is also present at the mean value of motor FIM score change, b=0.068, 95% CI [0.030, 0.106], t=3.52, p=.001. At high baseline motor function (motor FIM scores at one SD above the mean), the relationship is still positive, but no longer significant, b=0.025, 95% CI [-0.006, 0.056], t=1.58, p=.114.

Table 4a. Model summary of linear regression on motor FIM change with PTA involvement as a continuous variable (N=1560)

Model	**R**	**R square**	**Adj. R square**	**Standard error**	**F change**	**df1**	**Sign. F change**	**Durbin Watson**
1	.443	.198	.181	10.299	11.45	33	.000	2.06

Table 4b. Covariate results of linear regression on motor FIM change with PTA involvement as a continuous variable

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	22.002	2.452		8.975	.000
	PTA	.116	.062	.173	1.860	.063
	MotorFIM	-.124	.028	-.162	-4.396	.000
	CogFIM	.213	.059	.134	3.633	.000
	OTvisits	.106	.015	.195	7.040	.000
	KneeOA present	1.224	6.020	.005	.203	.839
	HipOA present	-.180	10.355	.000	-.017	.986
	SpineOA present	3.122	2.697	.027	1.157	.247
	RA present	-2.554	2.244	-.026	-1.138	.255
	Neglect present	-.950	.964	-.024	-.985	.325
	COPD present	-.360	1.181	-.007	-.305	.760
	Obesity present	-2.239	1.804	-.029	-1.241	.215
	CHF present	-.507	.912	-.013	-.556	.579
	CAD present	.749	.845	.021	.887	.375
	DM present	-1.573	.610	-.061	-2.582	.010
	CRF present	.050	1.210	.001	.042	.967
	Wound present	-4.510	2.190	-.048	-2.059	.040
	Depression present	.205	2.889	.002	.071	.943
	Family support (Living with others)	.260	.529	.012	.492	.623
	Age categories	-2.548	.318	-.197	-8.021	.000
	Gender=male	-.356	.540	-.016	-.660	.509
	Strokeside=Right	-.747	.912	-.031	-.819	.413
	Strokeside=Left	.037	.875	.002	.042	.966
	Strokeside=Bilateral	-.089	1.281	-.002	-.069	.945
	Strokeside=No paresis	1.631	1.746	.024	.934	.350
	Speech=yes	1.436	.856	.042	1.678	.094
	Year=2008	.701	.782	.025	.896	.370
	Year=2009	-.372	.595	-.016	-.625	.532
	Location=1	.082	.893	.003	.092	.927
	Location=3	2.755	.944	.087	2.919	.004
	Location=4	-1.224	.883	-.044	-1.386	.166
	Location=5	-.228	1.074	-.007	-.212	.832
	PTA * MFIM	-.003	.001	-.219	-2.505	.012
	PTA * CFIM	.002	.002	.065	.694	.488

Linear regression on functional outcome (motor FIM score change) was also analyzed with PTA involvement dichotomized as low (<20%) and high (≥20%). 1,560 cases were included in the model as 2 cases were excluded for missing data. This study, with 32 covariates controlling for patient factors, as well as facility and year, is 99% powered to detect a 0.2 difference in effect size in the regression analysis (Cohen 1988).

The regression model outcomes are listed in Tables 4a and 4b**.** Table 4a presents the overall outcomes from the regression model and 4b provides the details for each covariate. Neither the main effect of PTA involvement nor any of the interaction terms are significant in the model. The full model, with 33 variables, explained 17.9% of the variance in functional outcome (change in Motor FIM). This explained variance is the same as the previous model, where PTA involvement was modeled as a continuous variable. Baseline severity measure of both motor function and cognitive function, number of occupational therapy visits, and age were the greatest predictors of functional outcome. Being a patient at one of the inpatient rehabilitation facilities also had a significant impact on outcome. Neither the main effect of high PTA involvement, nor the interaction terms of PTA involvement with baseline function made a significant contribution to functional outcome.

Table 5a. Model summary for linear regression on Motor FIM change with PTA involvement dichotomized at 20% cutoff

Model	**R**	**R square**	**Adj. R square**	**Standard error**	**F change**	**df1**	**Sign. F change**	**Durbin Watson**
1	.444	.197	.179	10.31	11.33	33	.000	2.06

Table 5b. Covariate results for linear regression on Motor FIM change with PTA involvement dichotomized at 20% cutoff (N=1560)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	22.709	2.361		9.617	.000
	PTA≥20%	3.000	2.177	.123	1.378	.168
	MotorFIM	-.145	.026	-.190	-5.544	.000
	CogFIM	.229	.053	.144	4.314	.000
	OTvisits	.107	.015	.197	7.111	.000
	KneeOA present	.922	6.035	.004	.153	.879
	HipOA present	-.330	10.364	-.001	-.032	.975
	SpineOA present	3.306	2.696	.028	1.226	.220
	RA present	-2.572	2.247	-.027	-1.145	.252
	Neglect present	-.922	.966	-.024	-.954	.340
	COPD present	-.434	1.182	-.009	-.367	.714
	Obesity present	-2.203	1.807	-.029	-1.220	.223
	CHF present	-.529	.914	-.014	-.579	.563
	CAD present	.730	.845	.020	.864	.388
	DM present	-1.564	.610	-.060	-2.563	.010
	CRF present	.054	1.211	.001	.044	.965
	Wound present	-4.512	2.195	-.048	-2.056	.040
	Depression present	.244	2.892	.002	.084	.933
	Family support (Living with others)	.268	.530	.012	.505	.614
	Age categories	-2.539	.318	-.197	-7.990	.000
	Gender=male	-.350	.541	-.015	-.647	.518
	Strokeside=right	-.679	.913	-.029	-.744	.457
	Strokeside=left	.051	.875	.002	.058	.954
	Strokeside=bilateral	.033	1.280	.001	.026	.980
	Strokeside=no paresis	1.749	1.746	.026	1.002	.317
	Speech=yes	1.433	.857	.042	1.672	.095
	Year=2008	.727	.783	.025	.929	.353
	Year=2009	-.343	.595	-.015	-.576	.565
	Location=1	.025	.892	.001	.028	.978
	Location=3	2.757	.946	.087	2.915	.004
	Location=4	-1.327	.874	-.047	-1.519	.129
	Location=5	-.385	1.053	-.011	-.366	.715
	PTA20 * CFIM	.030	.086	.030	.345	.730
	PTA20 * MFIM	-.067	.042	-.126	-1.604	.109

Post hoc regression analysis included examination of residuals via observed and expected probability as well as by scatterplot of standardized residuals. This analysis supports the use of the linear model. These figures can be seen in Appendix A.

Propensity score techniques were also completed for functional outcome following stroke. Once propensity scores for each subject were determined, subjects were split into quintiles by propensity score such that outcomes could be analyzed within each quintile. Covariate balance within quintiles was examined by analysis of the baseline covariates. As in the original baseline covariate comparison, most covariates are balanced. The baseline cognitive function, which was different between groups of low and high PTA involvement, is no longer significantly different. However, the involvement of OT is different for those in the lowest propensity quintile. Two case mix variables had poorer balance in quintiles: presence of rheumatoid arthritis and diabetes in the lowest and highest quintiles, respectively. All of these variables increase the severity of the case mix for the high PTA group which again does not appear to follow available practice guidelines for direction of care to the PTA (Watts 1979; APTA 2009; Crosier 2010). This table is presented in Appendix A.

To further explore the outcomes within each quintile, a regression was run to determine the impact of low or high PTA involvement on functional outcome among groups with similar probabilities of being included in the high PTA involvement group. With all the covariates collapsed to the one predictor variable of high or low PTA (defined as ≥20% or <20%), each quintile was 98% powered to detect an effect size of 0.05. However, the adjusted R squared of the model is very low, indicating a very small amount of explained variance in functional outcome by these models. With this examination, higher use of the PTA demonstrated lower Motor FIM outcomes in the 1st and 3rd quintiles and higher Motor FIM outcomes in the 2nd, 4th and 5th quintiles. As shown in Table 6, none of these differences was statistically significant.

Table 6. Impact of high PTA involvement on Motor FIM change by propensity quintile (N=1560)

	N	variable	β	Std error	t	significance	Adjusted R squared
Quintile 1	312	Constant	16.473	.559	29.445	.000	.008
		PTA≥20%	-4.598	2.470	-1.861	.064	
Quintile 2	311	Constant	17.720	.728	24.351	.000	.002
		PTA≥20%	1.3	1.815	.716	.474	
Quintile 3	312	Constant	18.756	.809	23.186	.000	.001
		PTA≥20%	-1.272	1.466	-.867	.386	
Quintile 4	312	Constant	18.708	.852	21.947	.000	.004
		PTA≥20%	1.909	1.268	1.506	.133	
Quintile 5	313	Constant	18.420	1.089	16.922	.000	.008
		PTA≥20%	2.621	1.383	1.896	.059	

Finally, subjects with high PTA involvement were matched with those with low PTA involvement by their propensity score. Nearest neighbor matching with replacement was employed with a caliper of 0.01 (Oakes & Johnson 2006). 482 paired matches were created. A paired sample t-test was used to analyze differences in functional outcome, first by all case matches and then by case matches within each quintile.

When all 482 paired samples (N=964) are included, the difference in functional outcome between cases (high PTA involvement) and controls (low PTA involvement) was not significant at a $p \leq .05$ level. The mean difference of Motor FIM change between the high PTA involvement group and the low PTA involvement group was -1.23 with a standard deviation of 15.73. The paired sample t-test result was -1.723 with a significance of .085.

Within quintiles, case matched pairs were used again to analyze the difference in functional outcomes between the high PTA involvement and low PTA involvement groups. The direction of effect changes across the quintiles. In quintiles 1 and 3 the difference in Motor FIM outcomes favored the high PTA group, while the outcomes in quintiles 2, 4 and 5 favored the low PTA group. Only in quintile 4, the group with the second to highest probability of being placed in the high PTA group, was the difference significant at the $p \leq .05$ level. Table 7 shows the results of this analysis. Power was reduced in this analysis due to smaller populations within each quintile. Power to detect a moderate effect size of 0.5 ranged from 25% (quintile 1) to 70% (quintile 2) to greater than 90% in quintiles 3-5. This effect size would detect a difference in Motor FIM score of approximately 8 points between groups.

Table 7. Impact of level of PTA involvement on Motor FIM change by quintile of case matched pairs, N=964

	N pairs	Mean differences (case-control)	Standard deviation	t statistic	significance
Quintile 1	18	4.56	12.12	1.59	.13
Quintile 2	52	-.52	18.33	-.20	.84
Quintile 3	91	.88	16.57	.51	.61
Quintile 4	142	-2.93	15.1	-2.31	.02
Quintile 5	179	-1.75	15.17	-1.55	.12

Several sensitivity analyses were carried out on the linear model regressions investigating the impact of PTA involvement on change in functional outcome. First, different polynomial terms of the PTA involvement variable were considered. Exploration of the polynomial terms of PTA^2 and PTA^3 revealed no improvement in fit of the data. Further discussion of these results can be found in Appendix A.

Different cutoff points for creating a binary PTA involvement variable were also considered. Although analysis of baseline characteristics with a 0% cutoff point revealed a more severe case mix for the higher PTA group (see table 1 and 2), none of the additional cut off points evaluated (0%, 10% and 30%) were significant in the full regression model. When PTA involvement was defined by a 0% cutoff, the model had the greatest amount of explained variance, although this was still very low, at R^2=.038. Ultimately, the 20% cutoff for PTA involvement was used given its presumed clinical significance relative to the 0% cutoff.

Finally, a comparison of the proportion of PTA visits from the first half of the LOS to the second half of the LOS was made. Those patients with a decrease in PTA involvement from the first to the second half of their rehabilitation stay did show a slight increase in outcomes, although this result was not statistically significant. These results can be found in Appendix A.

Stroke and discharge location

Discharge to home is considered to be one successful outcome following rehabilitation for stroke. In this analysis, most people (70%) were discharged home following their inpatient rehabilitation stay. However, 22% of subjects were discharged to a nursing home setting as they required ongoing rehabilitation prior to return home or required longer term care. Only 6% of subjects were transferred back to acute care due to a medical need and one subject died prior to discharge from the inpatient rehabilitation facility. Multinomial logistical regression was performed to assess the impact of a number of factors on the likelihood of subjects being discharged to a nursing home setting and to an acute hospital setting instead of being discharged home from the inpatient rehabilitation unit. The model contained 31 variables, which included: gender, age, living situation prior to admission, baseline motor function, baseline cognitive function, side of stroke, OT involvement, Speech Therapy involvement, presence of comorbidities, inpatient rehabilitation facility and year of discharge.

The model explained between 42.0% (Cox and Snell) and 51.5% (Nagelkerke) of the variance in discharge location. PTA involvement in patient care was not a significant predictor in the model. Goodness of fit measures based on the Pearson and the deviance statistic are both non-significant, at p=.98 and p=1.0 respectively, indicating a good fit of the model. Table 8 presents the coefficients and odds ratios for each covariate in the model, with negative coefficients indicating lower odds for discharge to nursing home versus home and positive coefficients indicating greater likelihood of discharge to nursing home versus home. Some of the odds ratios are large and therefore seem unlikely to be insignificant. However, many of the covariates demonstrated very wide ranges for the confidence intervals. This, coupled with small numbers of some of the covariates included, led to large but insignificant odds ratios. This was particularly true for some of the comorbidities. In the multinomial logistical model, SPSS sets the reference category for predictors to 1, therefore the covariates in the table all represent the null value.

Table 8. Multinomial Logistic Regression predicting likelihood of discharge to skilled nursing facility setting (vs home); N=1560

Discharge to NH versus home				95% CI for odds ratio		
	β	**SE**	**p**	**Lower**	**OR**	**Upper**
Intercept	18.48	395.99	.96			
PTA<20%	.27	.61	.664	.393	1.3	4.33
PTA<20%*CogFIM	.003	.02	.89	.96	1.0	1.1
PTA<20%*MotorFIM	-.02	.01	.24	.96	.99	1.01
Age 18-44	-1.5	.40	.000	.102	.22	.49
Age 45-64	-.80	.21	.000	.30	.45	.68
Age 65-80	-.70	.20	.000	.34	.50	.73
Gender (F)	-.23	.159	.144	.58	.80	1.08
Motor function	-.078	.011	.000	.90	.93	.95
Cognitive function	-.06	.02	.002	.91	.94	.98
Family support (lives alone)	-.37	.388	.34	.32	.69	1.48
Side of CVA (not right)	.08	.58	.89	.35	1.09	3.41
OT	0.0	.004	.99	.99	1.0	1.01
Speech (NO)	-.034	.31	.91	.53	.97	1.76
Facility other than #5	-.25	.30	.420	.43	.78	1.42
Facility other than #4	-1.9	.32	.000	.08	.15	.28
Facility other than #3	-1.21	.34	.000	.15	.30	.59
Facility other than #2	-1.11	.33	.001	.17	.33	.63
Year (2009 or 2010)	.58	.22	.009	1.15	1.78	2.76
Depression (not present)	.46	.91	.61	.27	1.59	9.51
CRF (not present)	.18	.36	.612	.60	1.2	2.44
CAD (not present)	.27	.26	.284	.80	1.32	2.2
Morbid obesity (not present)	-.48	.59	.42	.197	.62	1.96
Neglect (not present)	-.14	.26	.58	.52	.87	1.44
Spine OA (not present)	.58	.84	.49	.35	1.79	9.27
Hip OA (not present)	-12.26	395.98	.98	.00	4.75E-6	Set to system missing
Knee OA (not present)	1.16	1.48	.43	.18	3.19	57.7
RA(not present)	-.40	.67	.55	.18	.67	2.50
COPD(not present)	-.24	.36	.49	.39	.78	1.57
CHF(not present)	-.08	.25	.77	.57	.93	1.53
DM(not present)	-.22	.17	.204	.57	.80	1.13
Wound(not present)	-.5	.56	.37	.20	.61	1.82

Similar to discharge to a nursing home, low PTA involvement was not a significant predictor of hospital re-admission. The interaction of low PTA involvement with baseline motor function on the odds ratio of re-admission was significant but very close to 1 at 0.95 (0.91, 0.99). This was almost identical to the contribution of baseline motor function to the model at 0.94 (0.91, 0.97). Baseline cognitive function did not play a large role. Lack of family support showed an increased likelihood of discharge to an acute setting. The comorbidities of CAD, presence of neglect and presence of an open wound were all contributors to the model, demonstrating less risk of discharge to an acute hospital if these conditions are not present. One IRF was a contributor to the model, but some IRFs did not have calculable effects due to low numbers of patients being discharged to an acute setting.

Table 9. Multinomial Regression on discharge to acute hospital setting (versus home); N=1560

Discharge to acute setting versus home				95% Confidence Interval		
	β	**SE**	**p**	**Lower**	**OR**	**Upper**
PTA<20%	1.19	.93	.20	.54	3.30	20.21
PTA<20%*Cog FIM	.04	.04	.32	.96	1.0	1.12
PTA<20%*MotorFIM	-.05	.02	.01	.91	.95	.99
Age 18-44	1.23	.51	.01	1.34	3.65	9.97
Age 45-64	.63	.39	.10	.88	1.88	4.04
Age 65-80	.78	.36	.03	1.1	2.17	4.41
Gender (F)	.04	.25	.88	.63	1.04	1.7
Motor function	-.06	.02	.001	.91	.94	.97
Cognitive function	-.02	.02	.30	.94	.98	1.02
Family support (lives alone)	.65	.28	.02	1.1	1.91	3.32
Side of CVA (not right)	.06	.42	.89	.47	1.06	2.38
OT	-.1	.01	.000	.88	.91	.93
Speech (NO)	-.01	.42	.98	.44	.99	2.23
Facility other than #5						
Facility other than #4	-2.20	.55	.00	.04	.11	.33
Facility other than #3	-1.9	.59	.001	.05	.15	.47
Facility other than #2	-1.36	.56	.01	.09	.26	.76
Year (2009 or 2010)	.45	.38	.23	.75	1.57	3.27
Depression (not present)	.26	1.21	.83	.12	1.30	13.96
CRF (not present)	-.61	.50	.23	.21	.55	1.45
CAD (not present)	-.72	.35	.04	.24	.49	.97
Morbid obesity (not present)	-.94	.64	.14	.11	.39	1.36
Neglect (not present)	-1.13	.38	.003	.15	.32	.68
Spine OA (not present)	11.59	221.02	.96	8.02E-184	107811.26	1.45E+193
Hip OA (not present)	-.68	.00		.51	.51	.51
Knee OA (not present)	13.41	639.78	.98	.00	666445.1	
RA(not present)	-.41	.92	.66	.11	.67	4.03
COPD(not present)	-.08	.51	.87	.34	.92	2.49
CHF(not present)	.41	.44	.35	.64	1.51	3.53
DM(not present)	-.03	.28	.92	.56	.97	1.68
Wound(not present)	-2.07	.76	.01	.03	.13	.56

A propensity score analysis was also performed on discharge location to nursing home settings and acute care settings as compared to discharge home. When each quintile is examined, low involvement of the PTA is sometimes associated with increased likelihood of discharge home and sometimes associated with the poorer discharge outcomes. All but one of these associations do not rise to the level of statistical significance. In quintile 4, lower PTA involvement is associated with an improved outcome. As indicated by the Nagelkerke pseudo R squared, the model fit is much poorer in the analysis by propensity quintiles than the multivariate regression on the full sample. Multinomial logistic regression coefficients of PTA involvement by propensity quintiles comparing discharge to nursing homes or re-admission to the acute hospital setting as compared to discharge home are presented in Table 10.

Table 10. Impact of level of PTA on discharge location within propensity quintiles

Quintile and model fit	N	Discharge setting (vs. home)	variable	β	SE	Wald	Sig.	OR	95% CI
Quintile 1 **Nagelkerke pseudo R^2=.012**	312	Nursing home	Constant	-.92	.59	2.4	.12		
			PTA<20%	-.38	.61	.40	.53	.68	.21-2.25
		Acute hospital	Constant	-1.61	.78	4.32	.04		
			PTA<20%	-1.39	.83	2.76	.10	.25	.049-1.28
Quintile 2 **Nagelkerke pseudo R^2=.006**	311	Nursing home	Constant	-1.39	.37	13.84	.000		
			PTA<20%	.42	.40	1.08	.30	1.52	.69-3.32
		Acute hospital	Constant	-2.20	.53	17.38	.000		
			PTA<20%	.012	.58	0.0	.98	1.01	.33-3.15
Quintile 3 **Nagelkerke pseudo R^2=.016**	312	Nursing home	Constant	-1.13	.25	20.26	.000		
			PTA<20%	-.28	.31	.83	.36	.75	.41-1.38
		Acute hospital	Constant	-2.38	.43	31.18	.000		
			PTA<20%	.33	.49	.45	.50	1.39	.53-3.62
Quintile 4 **Nagelkerke pseudo R^2=.022**	312	Nursing home	Constant	-.63	.18	11.73	.001		
			PTA<20%	-.57	.26	4.69	.03	.57	.34-.95
		Acute hospital	Constant	-2.85	.46	38.24	.000		
			PTA<20%	.24	.58	.17	.68	1.27	.41-3.92
Quintile 5 **Nagelkerke pseudo R^2=.001**	313	Nursing home	Constant	-1.31	.18	51.46	.000		
			PTA<20%	.15	.29	.27	.60	1.16	.66-2.05
		Acute hospital	Constant	-2.65	.33	65.39	.000		
			PTA<20%	.17	.51	.12	.74	1.19	.44-3.24

Stroke and length of stay (LOS)

LOS data is often positively skewed, making linear regression inappropriate. When analyzed, the LOS data in this study did demonstrate this phenomenon. Log transformation and square root transformation of LOS data improved the skewness but it continued to be greater than twice the standard error. The family link test was used to determine the best distributional model to use. Following the procedure described in *Modeling Health Care Costs and Counts* (Deb, Manning and Norton 2011) the appropriate regression model to use was identified as the generalized linear model with a gamma distribution and log link.

The independent variable of interest is again high versus low PTA involvement. The covariates included were: age, gender, baseline function (both cognitive and motor), side of the stroke, living situation prior to admission, the presence of certain comorbidities, facility and year. Table 11 presents the coefficients and significance of the variables included in this model. Coefficients represent the change in LOS (days) given a one unit change in the explanatory variable. The level of involvement of the PTA is not a significant predictor of LOS in this model. Significant predictors of length of stay following stroke are: age, side of the stroke, involvement of speech therapy, discharge year, baseline Motor FIM scores, and family support. Most of the inpatient rehabilitation facilities were significant predictors of length of stay as well. The Pearson and deviance statistics are not significant at .07 and .08 and indicate a reasonable fit of the model. The gamma with log link GLM sets the reference category to 1 (or the highest category). Therefore the coefficients are reported on the null (or least) value.

Table 11. GLM (Gamma with log link) regression on length of stay for patients following stroke, N=1560

Parameter	B	Std. Error	Wald Chi-Square	Sig.
(Intercept)	2.64	.38	48.21	.000
PTA<20%	.02	.06	.11	.74
KneeOA not present	.03	.17	.04	.85
HipOA not present	.09	.28	.10	.76
SpineOA not present	-.09	.07	1.49	.22
RA not present	-.04	.06	.38	.54
Neglect not present	.08	.03	10.07	.002
COPD not present	-.05	.03	2.19	.14
Obesity not present	.01	.05	.07	.80
CHF not present	-.03	.03	1.09	.30
CAD not present	.03	.02	1.76	.19
DM not present	-.02	.02	1.53	.22
CRF not present	-.04	.03	1.2	.27
Wound not present	.02	.06	.12	.73
Depression not present	.003	.08	.002	.97
Age 1: 18-44	.01	.033	.15	.70
Age 2: 45-64	.03	.02	2.19	.14
Age 3: 65-80	.04	.02	3.33	.07
Female	.002	.015	.01	.91
Not right CVA	-.07	.02	12.25	.000
Not left CVA	-.02	.019	1.14	.29
No speech	-.11	.024	23.01	.000
dcyear 2009 or 2010	-.07	.021	10.41	.001
[dcyear 2008 or 2010	-.02	.016	1.74	.19
Not facility 1	-.04	.026	2.54	.11
Not facility 2	-.06	.03	5.49	.02
Not facility 3	-.16	.03	28.27	.000
Not facility 4	-.18	.03	45.03	.000
MotorFIM	-.01	.001	30.55	.000
CogFIM	-.004	.0021	4.56	.03
PTA<20%*CogFIM	.001	.002	.08	.78
PTA<20%*MotorFIM	-.001	.001	.21	.64
Living with others	.03	.02	3.36	.07

A propensity score analysis by quintile was also completed regarding length of stay for patients admitted to an inpatient rehabilitation facility following stroke. To explore the outcomes within each quintile, a regression was run to determine the impact of low or high PTA involvement on length of stay among groups with similar probabilities of being included in the high PTA involvement group. Among those with the least likelihood to be included in the high PTA group (quintile 1), low involvement of the PTA (<20%) was associated with a longer length of stay. PTA involvement was not significantly associated with length of stay for any other quintile. These results can be seen in Table 12.

Table 12. Impact of PTA involvement on LOS within propensity quintile (stroke population); N=1560

	N	variable	β	Std error	Wald Chi square	significance	Pearson Chi squared/df
Quintile 1	313	Constant	2.18	.13	265.85	.000	.29
		PTA<20%	.30	.14	4.79	.03	
Quintile 2	311	Constant	2.68	.08	1214.97	.000	.29
		PTA<20%	-.02	.08	.06	.81	
Quintile 3	312	Constant	2.58	.06	1918.01	.000	.36
		PTA<20%	.001	.07	.00	.99	
Quintile 4	312	Constant	2.61	.05	2933.92	.000	.34
		PTA<20%	-.08	.07	1.33	.25	
Quintile 5	313	Constant	2.69	.04	4069.07	.000	.38
		PTA<20%	-.04	.07	.41	.52	

Again, matching by propensity score was used to examine the impact of PTA involvement on length of stay. A paired sample t-test was used to analyze differences in LOS, first by all case matches and then by case matches within each quintile.

When all paired samples are included, N=964, the difference in LOS between cases (high PTA involvement) and controls (low PTA involvement) is not significant at a $p \leq .05$ level. The mean difference of LOS between the high PTA involvement group and the low PTA involvement group was – 0.16 with a standard deviation of 11.97. The paired sample t test result was -0.29 with a significance of .78.

The results of the propensity matched quintile analysis are presented in Table 13. The negative differences in quintile 1 and 2 indicate that the high PTA group had a shorter length of stay than did the low PTA group. Note that the difference in length of stay costs between the high PTA group (cases) and the low PTA group (controls) is not significant in any quintile and the significant outcome found in quintile 1 of the quintile analysis without paired matches and seen in Table 12 does not persist here.

Table 13. Paired sample t-tests on LOS by propensity quintile (stroke population); N=964

	N pairs	Mean differences (case-control)	Standard deviation	t statistic	significance
Quintile 1	16	-2.31	7.33	-1.26	.23
Quintile 2	50	-.96	12.88	-.53	.60
Quintile 3	95	.88	10.92	.79	.43
Quintile 4	141	.77	10.45	.87	.39
Quintile 5	180	1.01	13.60	-1.0	.32

Specific Aim #3: Examine if the increased use of the physical therapist assistant changes patients' physical function outcomes, discharge location or length of stay in an inpatient rehabilitation facility for patients who received bilateral total knee replacements.

Impact of the involvement of the PTA on the rehabilitation outcomes following bilateral total knee replacement was also examined in this study. PTA involvement again ranged from 0% to 100% with examination/evaluation visits being removed. Of the 242 subjects included in the analysis, 147 (60.7%) had some PTA involvement in their rehabilitation and 95 subjects had no PTA involvement. Mean and median involvement were 17.4% and 11.1%, respectively.

A scatterplot of the relationship between PTA involvement level and Motor FIM change can be seen in Appendix B. There does not appear to be a strong relationship between PTA involvement and functional outcome change. A linear regression confirms PTA involvement level, when modeled as a continuous variable, is not an independent predictor of motor FIM change. The adjusted R squared is .001 with an insignificant F test at 0.28. .

As expected, in the full linear regression model with PTA as a continuous variable, the level of PTA involvement is not significant. The interaction terms of PTA involvement with baseline cognitive and motor function were also not significant. Linear regression on functional outcome (motor FIM score change) was then run with PTA involvement dichotomized as low (<20%) and high (≥20%). A graph demonstrating the distribution of the dependent variable in both groups can be seen in Appendix B. 242 cases were included in the model with no cases excluded for missing data. This study, with 25 covariates controlling for patient factors, as well as facility and year, is conservatively powered at 84% to detect an effect size of 0.10 in the regression analysis (Cohen 1988).

Table 14a summarizes the overall findings from the regression model and Table 14b provides the coefficients for each variable. The full model, with 24 variables, explained 61% of the variance in change in Motor FIM. Neither the main effect of high PTA involvement nor any of the interaction terms are significant in the model. Similar to the analysis of patients following stroke, baseline motor function and number of occupational therapy visits were the greatest predictors of functional outcome. Presence of an open wound also significantly impacted functional gain.

Table 14a. Model summary for linear regression on Motor FIM change, N=242

Model	R	R square	Adj. R square	Standard error	R square change	F change	df1	Sign. F change	Durbin Watson
1	.81	.65	.61	6.0	.65	16.33	25	.000	1.86

Table 14b. Covariate results from linear regression on Motor FIM change, N=242

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	48.975	8.321		5.885	.000
	PTA≥20%	-2.584	10.944	-.130	-.236	.814
	MotorFIM	-.804	.074	-.727	-10.932	.000
	CogFIM	.409	.210	.113	1.942	.053
	OT	.209	.076	.161	2.764	.006
	HipOA present	-1.376	6.218	-.009	-.221	.825
	SpineOA present	3.245	4.402	.031	.737	.462
	RA present	.921	2.911	.014	.316	.752
	COPD present	-5.565	3.108	-.074	-1.791	.075
	CHF present	-1.894	2.757	-.031	-.687	.493
	CAD present	1.071	1.777	.026	.603	.547
	DM present	-1.453	1.099	-.057	-1.322	.188
	CRF present	.664	3.745	.008	.177	.859
	Obesity present	-.436	2.105	-.010	-.207	.836
	Depression present	-.047	6.194	.000	-.008	.994
	Wound present	-7.794	3.892	-.090	-2.003	.046
	Living alone	1.410	.976	.064	1.445	.150
	gender=male	-.027	.918	-.001	-.030	.976
	Location=ABBOTT N	-2.944	1.672	-.080	-1.761	.080
	Location=Fairview	-1.004	.908	-.052	-1.106	.270
	Location=UNITED H	-2.635	3.693	-.030	-.714	.476
	Year=2009	-.921	.970	-.046	-.949	.344
	Year=2010	-3.013	1.043	-.141	-2.887	.004
	PTA≥20%*CogFIM	.127	.320	.214	.396	.692
	PTA≥20%*MotorFIM	-.016	.100	-.041	-.165	.869
	Age categories	-1.042	.638	-.077	-1.633	.104

Sensitivity analyses included examining the impact of the proportion of PTA visits during the first half of the LOS compared to the second half. This change in PTA involvement was an independent predictor of Motor FIM change but was not significant in the full regression model. Further discussion of this is included in Appendix B.

A propensity score analysis was also completed for functional outcome following bilateral total knee replacement. Once propensity scores for each subject were determined, subjects were split into quintiles by propensity score such that outcomes could be analyzed within each quintile. Covariate balance within quintiles was examined by analysis of the baseline covariates. As in the original baseline covariate comparison, most covariates were balanced. The only unbalanced covariates were in the 5th quintile (most likely to have greater PTA involvement) and all indicate higher "severity" in the high PTA involvement group. Despite statistical insignificance, some case mix differences are still noticeable, particularly in the number of comorbidities. Once again, the group with the higher number of comorbidities (and assumed greater complexity) was inconsistent across quintiles. The table is shown in Appendix B.

To further explore the outcomes within each quintile, a linear regression was run to determine the impact of high PTA involvement, defined as ≥ 20% visits provided by the PTA, on Motor FIM change among groups with similar probabilities of being included in the high PTA involvement group. With all the covariates collapsed to one predictor variable (high or low PTA), each quintile was 78% powered to detect an effect size of 0.15. While each quintile was still adequately powered to detect changes, the adjusted R squared indicates only a very small amount of the variation being explained by this model. The propensity quintile examination, shown in Table 15, revealed the direction of effect changed across the quintiles. Motor FIM outcomes were lower with high use of the PTA in quintiles 2 and 4 and these outcomes were higher with high use of the PTA in quintiles 1, 3 and 5. Higher use of the PTA was a statistically significant predictor of better outcome in the 5th quintile.

Table 15. Linear regression of PTA involvement on functional outcome by propensity quintile, N=242

	N	variable	β	Std error	t	significance	Adjusted R^2
Quintile 1	48	Constant	21.69	1.39	15.61	.000	
		PTA≥20%	2.20	2.31	0.68	.50	-.011
Quintile 2	49	Constant	22.11	1.58	13.98	.000	
		PTA≥20%	-2.76	2.96	-0.93	.36	-.003
Quintile 3	49	Constant	20.81	1.87	11.13	.000	
		PTA≥20%	3.96	3.63	1.09	0.28	.004
Quintile 4	48	Constant	24.04	1.95	12.31	.000	
		PTA≥20%	-2.04	2.71	-0.76	0.45	-.009
Quintile 5	48	Constant	17.11	2.22	7.71	.000	
		PTA≥20%	5.86	2.81	2.09	0.04	.07

Finally, subjects with high PTA involvement were matched with those with low PTA involvement by their propensity score. Nearest neighbor matching with replacement was employed with a caliper of 0.01 (Oakes & Johnson 2006). 76 paired matches were created. A paired sample t-test was used to analyze differences in functional outcome, first by all case matches and then by case matches within each quintile.

When all paired samples are included (N=152), the difference in functional outcome between cases (high PTA involvement) and controls (low PTA involvement) favors high PTA involvement but is not significant. The mean difference of Motor FIM change between the high PTA involvement group and the low PTA involvement group was 2.07 with a standard deviation of 13.00. The paired sample t-test result was 1.39 with a significance of 0.17.

Within quintiles, case matched pairs were used to analyze the difference in functional outcomes between the high PTA involvement and low PTA involvement groups. Again, the direction of effect changes across the quintiles. Only in quintile 3 was the difference significant at the p<.05 level. The difference was strongly in favor of the case (higher PTA involvement) group. The power is very low for these results, with only 25% power to detect a moderate effect size of 0.5. This would detect a difference of 4 points on the change in Motor FIM scores between groups. All of the results are presented in Table 16.

Table 16. Paired sample t-test results of functional outcome by propensity score quintile; N=152

	N pairs	Mean differences (case-control)	Standard deviation	t statistic	significance
Quintile 1	9	5.67	9.98	1.7	.13
Quintile 2	14	-.14	12.75	-.04	.97
Quintile 3	13	8.62	13.59	2.29	.04 *
Quintile 4	25	-2.32	13.00	-.89	.38
Quintile 5	15	3.60	12.64	1.1	.29

<u>TKA and discharge location</u>

As all but 8 of 242 patients were discharged to home following B TKA, discharge location was not analyzed via multinomial logistical regression. Of these 8 patients, 2 returned to an acute care setting and 6 discharged to a nursing home setting. Anecdotally, 2 of these patients had 10% or greater PTA involvement, but none had 20% or greater involvement.

TKA and Length of Stay (LOS)

The process to evaluate the effect of high or low use of the PTA on length of stay following bilateral total knee replacements was similar to that of the stroke population. Given the shorter lengths of stay, a count model was appropriate for analyzing the data. Therefore, a generalized linear model was used with a negative binomial distribution. Results are shown in Table 17. Coefficients indicate change in LOS given a one unit change in the explanatory variable, with negative values demonstrating shorter LOS. Once again, the amount of involvement of the PTA is not significant in this model. In fact, the only variable included in this model that is a significant predictor of LOS is number of OT visits.

Table 17. Model output of GLM regression with negative binomial distribution on length of stay following bilateral TKA

Parameter	B	Std. Error	Wald Chi-Square	Sig.
(Intercept)	1.651	3.0966	.284	.594
PTA<20%	-.224	1.9590	.013	.909
Gender=male	-.010	.1668	.004	.951
Age 1: ≤50	.019	.4976	.001	.969
Age 2: 51-64	.026	.4351	.004	.952
Age 3: 65-79	.050	.4227	.014	.905
living with others	-.013	.1816	.005	.943
Hip OA not present	-.185	1.1397	.026	.871
spine OA not present	.047	.7821	.004	.952
RA not present	-.041	.5358	.006	.938
COPD not present	.096	.5566	.030	.863
CHF not present	-.135	.5027	.072	.789
CAD not present	-.023	.3218	.005	.944
DM not present	-.021	.1997	.011	.915
CRF not present	.092	.6856	.018	.893
Obesity not present	.014	.3869	.001	.971
Depression not present	.001	1.0926	.000	.999
Wound not present	.142	.6870	.043	.836
Not IRF 1	-.135	.7134	.036	.850
Not IRF2	-.118	.6735	.031	.861
Not IRF 3	-.121	.6729	.032	.857
2009 or 2010	-.039	.1901	.042	.839
2008 or 2010	-.012	.1838	.004	.948
MotorFIM	-.002	.0161	.024	.878
CogFIM	-.003	.0448	.005	.941
OT	.048	.0141	11.811	.001
PTA<20% * MotorFIM	.001	.0183	.001	.971
PTA<20% * CogFIM	.004	.0568	.006	.938

A propensity score analysis by quintile was also completed on LOS for patients admitted to an inpatient rehabilitation facility following bilateral total knee replacement. The results are shown in Table 18. Consistent with the multivariate analysis, the involvement of the PTA is not a significant predictor in any of the propensity quintiles. The negative value on the coefficients indicates a shorter length of stay.

Table 18. Model output of GLM with negative binomial distribution on length of stay within propensity quintiles (TKA population)

	N	variable	β	Std error	Wald	significance
Quintile 1	48	Constant	-.14	.05	8.99	.000
		PTA<20%	.00	.05	.00	.997
Quintile 2	49	Constant	-.16	.04	13.97	.000
		PTA<20%	.002	.05	.002	.97
Quintile 3	49	Constant	-.16	.04	12.97	.000
		PTA<20%	-.01	.05	.01	.91
Quintile 4	48	Constant	-.15	.03	24.96	.000
		PTA<20%	-.004	.04	.01	.92
Quintile 5	48	Constant	-.14	.03	29.95	.000
		PTA<20%	-.02	.05	.17	.68

Finally, case and control matches paired by propensity scores were again used to examine the impact of PTA involvement on length of stay. A paired sample t-test was used to analyze differences in length of stay, first by all case matches and then by case matches within each quintile.

When all paired samples are included (N=152), the difference in LOS between cases (high PTA involvement) and controls (low PTA involvement) is not significant at a $p \leq .05$ level. The mean difference of LOS between the high PTA involvement group and the low PTA involvement group was 0.26 with a standard deviation of 3.30. The paired sample t test result was 0.69 with a significance of 0.49.

The results of this analysis within quintiles are presented in Table 19. Paired sample analysis within quintiles also demonstrates that the level of involvement of the PTA does not significantly impact length of stay.

Table 19. Paired sample t-test on length of stay by quintile (bilateral TKR population)

	N pairs	Mean differences (case-control)	Standard deviation	t statistic	significance
Quintile 1	9	1.56	3.84	1.21	0.26
Quintile 2	14	-.21	2.72	-0.3	.77
Quintile 3	13	-.23	5.09	-.16	.87
Quintile 4	25	.68	2.39	1.42	.17
Quintile 5	15	-.33	2.99	-.43	.67

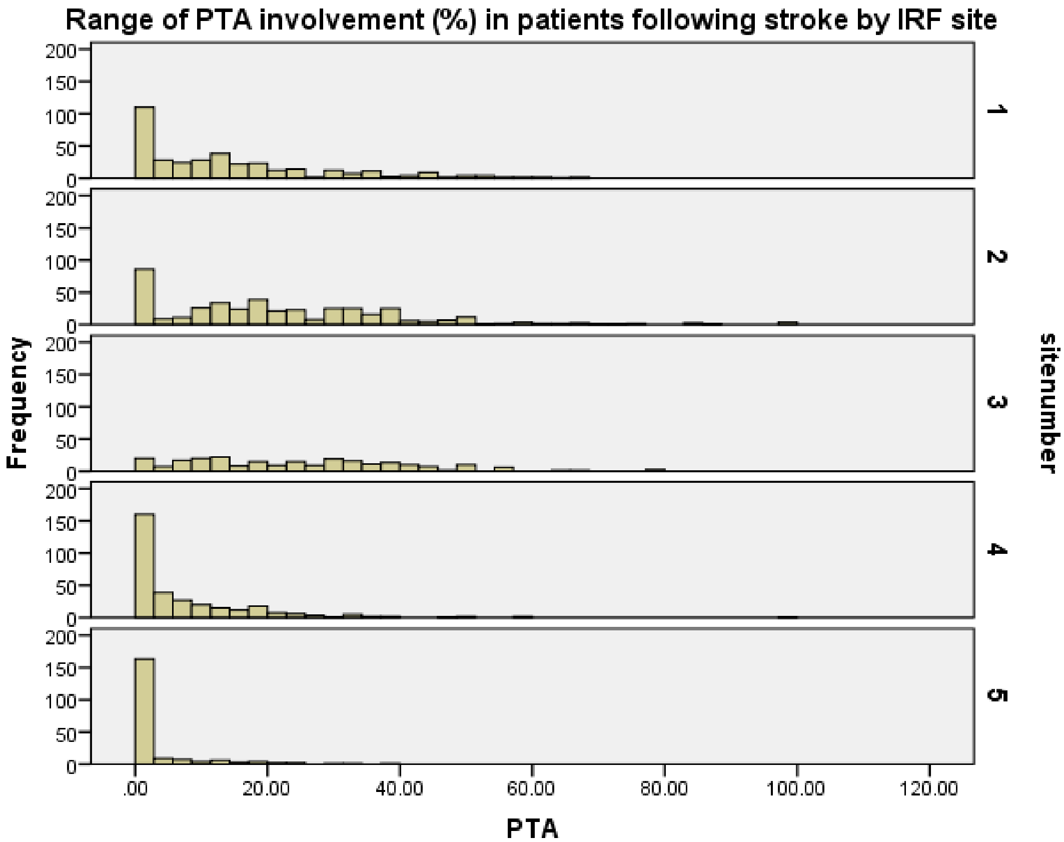
Chapter 5: Discussion and Conclusions

Specific Aim #1: Analyze the factors which influence the increased proportion of physical therapy visits being delivered by the physical therapist assistant (PTA) in the inpatient rehabilitation setting for patients with cerebrovascular accident or following bilateral total knee replacements.

In the population studied here, there do not appear to be certain patient characteristics that are consistently more likely to be present in an episode of physical therapy care that has an increased proportion of visits with the physical therapist assistant. While the seminal documents guiding the direction of care (Watts 1971; APTA 2009) would promote higher PTA involvement in cases that are less acute and less complex, this is not substantiated in this study. While we see occasional case mix differences by comorbidities, they are not consistent across various cutpoints of PTA involvement or across different diagnoses such as stroke and bilateral total knee replacement. These findings cannot be compared with previous literature because one study did not report baseline characteristics (Resnik, Feng & Hart 2006) and the other examined clinic level characteristics (Resnik, et al. 2008).

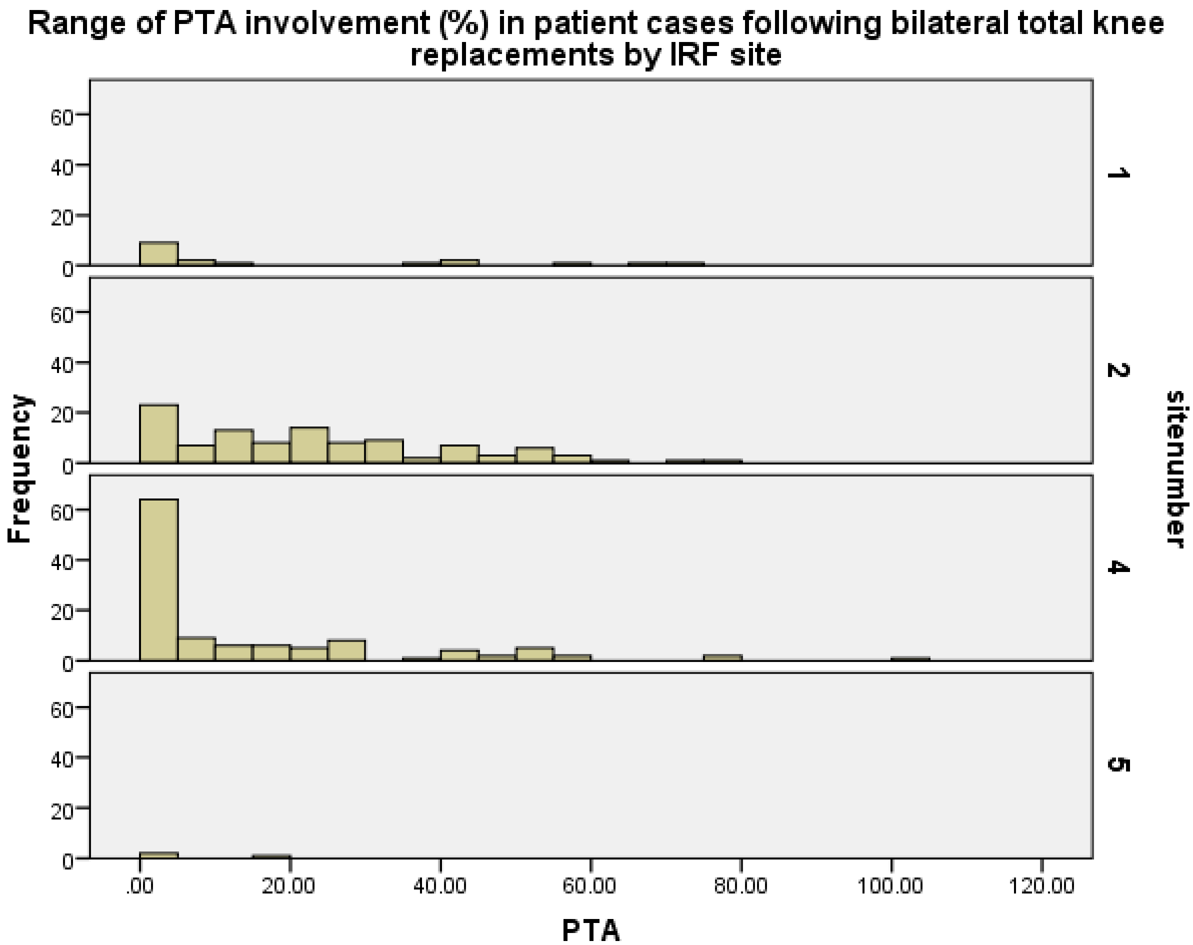
There are clear differences in the proportion of PTA visits by year and facility site. Among patients with stroke, higher PTA involvement (at the 20% cutoff) gradually decreased from 46% of all patients in 2008 to 26% in 2010. This is consistent with reports from two facilities that had outside influences leading to a reduction in their PTA staffing in the inpatient rehabilitation unit. While all facilities reported using PTAs in the role of patient care, the two smallest facilities did not have dedicated PTA staff for the inpatient rehabilitation unit. Accordingly, these two facilities have the two lowest levels of higher PTA involvement, at 4% and 12%. The other three facilities range from 28%-57% of patients receiving 20% or more of their physical therapy visits after stroke from the physical therapist assistant. Figure 4 demonstrates the range and frequency of PTA involvement at each rehabilitation facility among the subjects following stroke.

Figure 4. Range of PTA involvement in patient care (in %) following stroke at each IRF site



The pattern is similar for patients who received bilateral total knee replacements, although not as marked. Higher PTA involvement slightly decreased from 40% of all patients in 2008 to 34% in 2010. The two smallest sites again had the lowest levels of PTA involvement at 0% (only 3 patients total) and 26%. The other two facilities (one facility did not see patients in their rehabilitation facility for bilateral total knee replacements) had 33% and 52% of their patients with 20% or more of their physical therapy visits with a PTA. Figure 5 demonstrates the range and frequency of PTA involvement at each rehabilitation facility among the subjects following bilateral total knee replacement.

Figure 5. Range of PTA involvement in patient care (in %) following bilateral TKR by each IRF site



While this study did not find consistent patient characteristics or factors that influence the involvement of the physical therapist assistant, unmeasured variables could be influencing this selection. This study included many possible comorbidities and baseline severity measures, but prediction of rehabilitation pace or outcome may be more complex than just the chosen patient covariates. Perhaps it is something less measurable that plays a role in the physical therapist's decision-making whether or not to direct care to the PTA.

The guidelines on direction of care by the PT to the PTA also include taking into account the "personal scope" of the PTA, that is, the knowledge, skills and abilities of an individual (Crosier 2010). This type of information about individual PTs and PTAs was not available in this analysis which is a limitation of this study. Although this study did not assess if higher or lower PTA involvement is related to “personal scope”, the reliance on staffing and scheduling procedures would seem to limit this. It may be a useful exercise to corroborate guideline suggestions about individual skills and abilities with clinical data. As the profession of physical therapy moves forward with making decisions about how best to use support personnel such as the PTA, they will want to know if they are satisfied with how PTs in different settings currently make such decisions and if use of the guidelines is uniform across settings and diagnoses.

Specific Aim #2: Examine if the increased use of the physical therapist assistant changes patients’ physical function outcomes, discharge location or length of stay in an inpatient rehabilitation facility for patients who have been diagnosed with a cerebrovascular accident.

The linear regression models with careful inclusion of covariates do not demonstrate a change in functional outcome with the increased use of physical therapist assistants in an inpatient rehabilitation facility following a CVA. Interestingly, when PTA involvement is modeled as a continuous variable, baseline motor function mediates this relationship, demonstrating that at lower baseline motor function, the impact of PTA involvement is positive and significant. For patients with poorer initial function, greater PTA involvement appears to hold some benefit. The coefficients on the interaction terms are very small, so this benefit is not clinically significant. However, it certainly supports the non-inferiority of higher PTA involvement. In the linear regression model with PTA as a dichotomous variable, the interaction term is no longer significant. The models had ample power to support these null findings. The results were consistent across several analytic approaches to address selection bias as the propensity score models also support these findings when each quintile is examined individually for the impact of higher PTA usage on functional outcome.

Propensity score matching techniques also support the null findings. Nearest neighbor matching provided 482 matches, which did result in a loss of 596 subjects in this study. Power for detecting these null findings is reduced in the case matched quintiles given the fewer subjects included. The power for these findings to detect a moderate effect size of 0.5 ranged from 25% in quintile 1 to greater than 90% in quintiles 3-5. This effect size would be a difference in Motor FIM score of approximately 8 points between groups. When all the matches were included in the analysis, higher versus lower PTA involvement in care did not play a role in functional outcome as measured by the change in Motor FIM. When these matches were analyzed by quintile, quintile 4 did show a significantly poorer outcome for patients in the high PTA group. However, the direction of the effect changed across quintiles, and therefore no pattern of PTA impact on functional outcome could be discerned. Quintile 4 was also examined for outliers and only one was noted. This outlier did have a large impact on functional outcome. When it was removed, the paired sample t-test on functional outcome in quintile 4 changed from a negative number (favoring low PTA involvement) to a positive number that was close to statistical significance favoring high PTA involvement.

Overall, the finding of non-inferiority appears to be supported by both methods of analysis, indicating that the increased use of the PTA in an IRF for patients after stroke does not change physical function outcomes as measured by the Motor FIM. This is in contradiction to a 2006 study which analyzed observational data on patients getting outpatient care for musculoskeletal dysfunction. The 2006 study reports poorer outcomes for patients on a self-reported functional health status if their physical therapy care was provided by a PTA more than 50% of the time. While patient characteristics were controlled, selection bias was not addressed and baseline characteristics of the two groups were not disclosed. Although their results were statistically significant, the clinical significance of the effect on the outcome measure used was not described (Resnik 2006). Some of this difference may be attributable to the different settings studied. Case mix differences between groups in the outpatient clinic setting may be greater than those found in this study, given that only patients following stroke and bilateral total knee replacement were studied. Additionally, the skill set required by a PT or PTA within an inpatient rehabilitation setting is different than the skills or techniques used in an outpatient clinic setting where patients are being treated for musculoskeletal conditions.

In addition to physical function, the level of PTA involvement did not appear to play a role in discharge location following rehabilitation for stroke in an inpatient rehabilitation facility. In this case, the discharge location of interest was to subacute settings such as nursing homes or transitional care centers (versus discharge home). Re-admission to an acute hospital site was also analyzed. Overall, the most important predictors of discharge location for this sample appear to be baseline function and age. These findings are consistent with the previous literature (Alexander 1994; Jongbloed 1986; Henley 1985).

When the level of PTA involvement on discharge locations was analyzed by propensity score quintile, the direction of the results were mixed. Most of these results were not statistically significant. The only significant finding was again in quintile 4, where low PTA use was associated with a decreased likelihood of discharge to a subacute setting with an odds ratio of .57. In other words, those patients with fewer than 20% of their visits provided by a PTA had better outcomes as they were less likely to discharge to a nursing home setting as compared to discharge home. Despite statistical significance of this finding, further analysis revealed no pattern of increase or decrease in outcomes as the quintiles increase or decrease. It is likely that the poorer outcomes for the higher PTA involvement group in quintile 4 are due to multiple analyses.

Analysis of length of stay for patients following stroke in this study indicates that higher use of the PTA does not increase or decrease the length of stay when patient characteristics are controlled. This was true for the generalized linear model regression using the gamma and log-link distribution as well as the propensity score analyses in quintiles with and without case matched pairs. This is different from the outcomes determined by Resnik and her colleagues in 2006, when they looked at the length of episodes of care for patients with high (≥50%) versus low PTA involvement who were being seen for a musculoskeletal impairment as outpatients. Their findings indicated that those with higher PTA involvement had episodes of care that were about 2 visits longer than patients who had lower PTA involvement in their care (Resnik, et al. 2006). While LOS and episodes of care are not interchangeable measures, they both indicate the intensity of rehabilitation required by patients. Given that costs of an inpatient rehabilitation stay are dominated by costs associated with the length of stay (Wagner 2006), higher use of the PTA in the IRF setting following stroke does not appear to contribute to increased LOS costs.

Overall, the analysis supports the null finding that the higher level of PTA involvement in the inpatient rehabilitation physical therapy care following a stroke does not have an impact on patient outcomes, discharge location or length of stay.

Specific Aim #3: Examine if the increased use of the physical therapist assistant changes patients' physical function outcomes, discharge location or length of stay in an inpatient rehabilitation facility for patients who received bilateral total knee replacements.

Higher use of the PTA in the rehabilitation of patients following bilateral total knee replacement did not change patients' physical function outcomes in this model. This was supported by both the multivariate regression and the propensity models. There was a significant benefit, in terms of change in motor FIM score, to patients who received a higher proportion of care by the PTA in quintile 5 of the propensity analysis and quintile 3 of the case matched propensity analysis. This result presents concern for the possibility of selection bias. However, a look at baseline characteristics again demonstrates that all the characteristics measured were essentially well balanced, even across quintiles. Additionally, no pattern of increasing or decreasing outcomes was seen across the quintiles. This isolated significant finding is likely due to multiple analyses.

Analysis of length of stay for patients following bilateral total knee replacements in this study indicates that higher use of the PTA does not increase or decrease the length of stay when patient characteristics are controlled. Consistent with outcomes following stroke, this was true for the generalized linear model regression using the negative binomial count model as well as the propensity score analyses in quintiles with and without case matched pairs. Given that higher use of the PTA did not impact LOS, inpatient rehabilitation facilities could potentially realize some cost savings due to salary differentials. The average salary for PTs in the Minneapolis/St Paul area is approximately $76,000 annually, while average salary for a PTA is reported to be approximately $50,000 (Bureau of Labor Statistics 2015). To realize a cost savings would require an adjustment in staffing patterns such that there were more PTAs employed and fewer PTs employed, as well as relatively equal productivity by PTs and PTAs. This would change the staffing structure of these inpatient rehabilitation facilities and further analysis, beyond the scope of this project, would need to be completed to determine the best ratio of staff that would still meet all of the patients' needs.

Limitations:

This study has several limitations. As the few other studies that exist on this topic (Resnik 2006; Resnik 2008; Toney, Winterhalter & Borgman 2011), this study is observational. A randomized control trial may be ideal for establishing a causal relationship but would not be feasible for this study given the costs and the inability to perfectly substitute PTAs for PTs.

Observational research has a risk for selection bias. There was considerable concern regarding selection bias at the initiation of this study because the expectation is for the high PTA and low PTA caseload to be different by design. However, following structured interviews with inpatient rehabilitation managers and clinicians, as well as analysis of baseline characteristics included in this study, caseload does not appear to differ consistently by level of PTA involvement in patient care. Ultimately, the concern regarding selection bias is much reduced.

Of course, case mix between the PT and PTA, as well as outcomes, can be analyzed only by measured or known covariates. Several variables that are often included in analyses of functional outcome were not able to be collected for this study. The first such variable is that of patient race or ethnicity. Although race is not well established as predictive to outcome following stroke or bilateral knee replacement, it would have been included as a matter of course if the data were collected consistently. Additionally, in studies of subjects following stroke, prior stroke is often an exclusion criteria. This study intended to exclude subjects with prior stroke to ensure that all stroke subjects were rehabilitating from acute stroke versus the late effects from prior stroke. Unfortunately, coding irregularities both within and between facilities prevented this from being used as an exclusion criteria or even as a way to measure case mix at baseline.

There are likely other forces at play that impact patient outcomes other than baseline severity, patient socio-demographic data, comorbidities, and when and where the patient was treated. As mentioned previously, factors such as intrinsic motivation may play a significant role in how someone recovers from a surgery or an acute medical event, such as a stroke. Although clinical depression was used as a way to capture part of motivation, affective function such as this is not easily measured, particularly from medical records. Such unknown or unmeasured covariates are particularly problematic in the use of propensity scores. When possible confounding factors are overlooked, it is thought that propensity score methods can increase the problems associated with bias (Brooks & Ohsfeldt 2013). Instrumental variable techniques can address this issue, but there was not an identified instrumental variable that would work well for this analysis. This study has used both multivariate analysis with careful control of covariates, as well as propensity score methods to help manage the concern of selection bias. That both methods result in quite consistent outcomes that support the null hypothesis of no difference between the high and low PTA groups is reassuring. In the end, the multivariate regression analysis appears to be the more useful tool in this study, consistently demonstrating greater power and explaining more of the variance in each outcome measure than the propensity quintile analyses.

Inclusion of subjects from IRFs only located in Minnesota could have implications for the generalizability of these outcomes. Although a recent study determined that a national sample of a variety of physical therapy practices demonstrated that none were close to any PTA supervisory statute limitations (Dwyer 2012), Minnesota does have supervisory limitations that could influence the use of PTAs in clinical practice. Currently the statute reads that one PT can only supervise two PTAs at any one time (Minnesota Statutes 2012), thus limiting PTA involvement in patient care and impacting staffing decisions. It would be ideal to investigate if similar outcomes were determined from IRFs in states with more liberal supervisory limitations.

Deliberate use of IRFs as the setting for this study, with specific populations of patients following stroke and bilateral total knee replacements limited the heterogeneity between subjects. This was a benefit in limiting selection bias and case mix concerns for this study. However, it also likely limited the types of physical therapy interventions delivered. In the IRF setting, interventions focus on functional mobility and activities of daily living (ADLs) to allow return to the home setting. This has the potential to limit the generalizability of the outcomes to other settings. In outpatient clinic sites, physical therapy interventions may be more likely to rely on a wide range of specific manual tests and techniques, which may or may not be appropriate to direct to the PTA.

Obviously missing from this analysis is a look at the organizational structure of these different inpatient rehabilitation facilities. While facilities were screened for having a generally similar approach to the direction of care to the PTA, it was outside the scope of this research to take a deeper look at the different organizations to determine if this might play a role in the direction of care to the PTA. This might be an interesting next step, particularly considering the very different percentages of patients who had 20% or more of their care with the PTA at the different facilities. Again, this may help the profession in making decisions regarding the use of the PTA in the future. Knowing how and why substitution occurs may help promote the development of new practice guidelines around the use of the PTA and possibly additional providers as well.

Finally, a comprehensive analysis of PT and PTA staffing costs was not completed for this study. While higher use of the PTA is less costly to a rehabilitation facility in terms of salary, in order to adequately determine the potential for cost savings with higher use of the PTA a more detailed look at staffing costs, productivity, and staff ratios would be required.

Conclusion

Overall, this study supports the null findings of no difference in outcomes when the PTA is involved in the physical therapy care at a higher rate (20% or greater) for patients following a stroke or following bilateral total knee replacements, who are rehabilitating in an inpatient rehabilitation facility. These results are in contradiction to those of two studies from 2006 and 2008, which demonstrated poorer outcomes for patients with higher proportions of PTA involvement (Resnik 2006; Resnik, et al. 2008). These differences may be attributed to different methodologies and/or different care settings. This study further supports the findings of a 2011 study which found no association between the involvement of the PTA and meeting a practice standard of less than 3 clinicians involved in any given patient case (Toney, Winterhalter & Borgman 2011).

Although studies such as this require gathering a large amount of data, often not easily acquired, clearly more research on this topic is needed. Different patient diagnoses across the continuum of care should be analyzed, as well as different settings where higher PTA involvement may be more likely. Maximum proportions of PTA involvement would be useful to help guide staffing decisions and create updated guidelines for direction of care to the PTA. In this way costs can be minimized without compromising patient outcomes.

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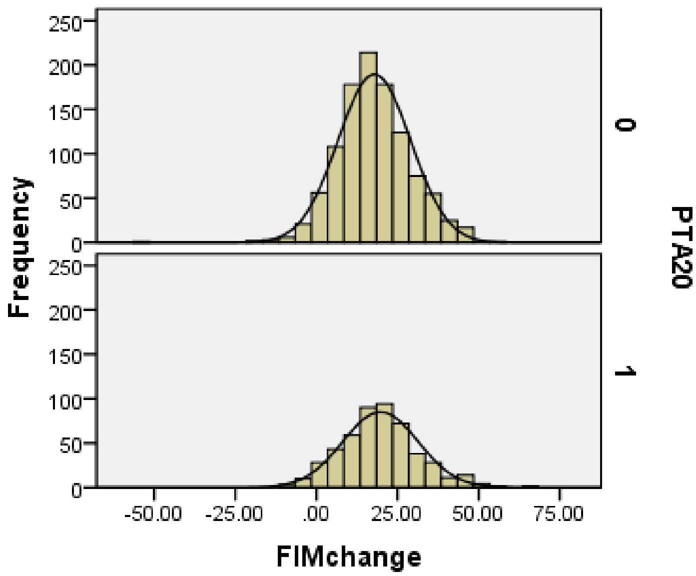
Appendix A

Stroke and functional outcome

Figure A1 demonstrates the distribution of the dependent variable, change in Motor FIM scores, in both groups, where the cutoff point is 20% involvement of the PTA.

Figure A1. Frequency histogram of Motor FIM change for PTA involvement <20% (denoted 0) and ≥20% (denoted 1)



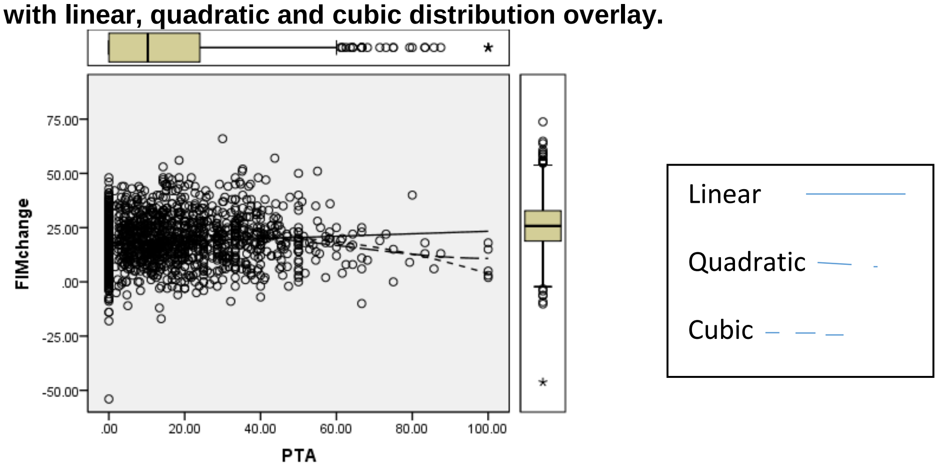
Sensitivity Analyses

Polynomials of the independent variable (level of PTA involvement) in the model were explored via a stepwise regression with analysis of the F test as these covariates were added. Both the squared and cubed versions of the independent variable were tested and the F test was significant at 0.00 and 0.014 respectively. However, their contribution to the model was small (with an R square change of 0.026 and 0.004) and their coefficients were negligible. The scatterplot of the association between functional outcome and PTA involvement was then overlaid with linear, quadratic and cubic distribution fit lines as seen in Figure A2. Neither the quadratic nor cubic distribution appeared provide a better fit to the data than the linear model. No polynomial terms were included in the model.

Given the large proportion of cases that had no PTA involvement, sensitivity analysis was performed on different cut points of PTA involvement. This can help tease out if those with any PTA involvement are different from those with no PT involvement. All cut off points assessed (some versus no PTA involvement, 10% cutoff, 20% cutoff and 30% cutoff) were independent predictors of functional outcome change. Some PTA involvement versus no PTA involvement contributed most to R squared change with a value of R squared= .038. None were significant in the full model.

A sensitivity analysis was also performed to determine the impact of the possible change in proportion of PTA visits over the course of a subject's inpatient rehabilitation stay. Proportion of visits with a PTA during the first half of their rehabilitation stay was compared with the proportion during the second half of their stay. Subjects were identified as having a difference in PTA involvement if the proportion of PTA visits was less in the second half than in the first half of the length of stay. This is to account for the potential issue of increasing the PT involvement in the case due to complications or lack of progress. While a change in PTA involvement was an independent predictor of functional outcome, when placed in the full regression model, a decrease in PTA involvement showed a slight increase in outcomes, thus negating concern about the potential for poor outcomes of these subjects. This increase in Motor FIM change was not significant (p=.278).

Figure A2. Scatterplot of independent variable (PTA involvement) on Motor FIM change with linear, quadratic and cubic distribution overlay.



Post hoc analysis of the linear regression of PTA involvement on Motor FIM change support the use of the linear model. Figures A3 and A4 demonstrate graphic representation of the residuals.

Figure A3. Observed and expected residuals of linear regression on Motor FIM change

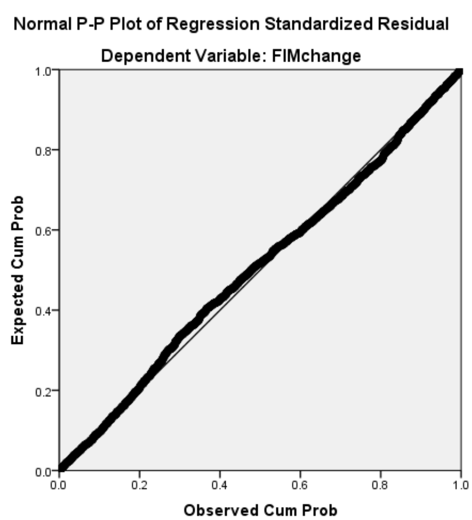
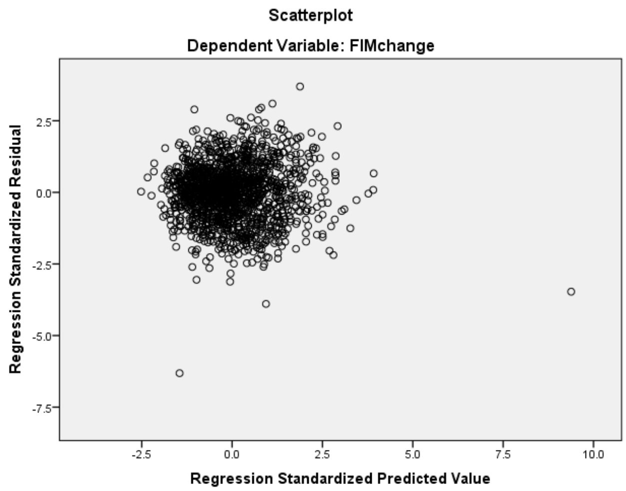


Figure A4. Scatterplot of residuals in linear regression on Motor FIM change



Covariate balance within quintiles was examined by analysis of the baseline covariates. As in the original baseline covariate comparison, most covariates are balanced. Table A1 shows distribution of the baseline measures for low and high PTA use groups for each quintile.

Table A1. Baseline Characteristics by Propensity Quintile

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
	Low PTA N=296	**High PTA** N=16	**Low PTA** N=261	**High PTA** N=50	**Low PTA** N=217	**High PTA** N=95	**Low PTA** N=171	**High PTA** N=141	**Low PTA** N=119	**High PTA** N=194
Baseline Motor FIM	43.91 (14.38)	49.75 (11.91)	43.20 (14.26)	43.52 (13.56)	38.12 (15.07)	38.67 (14.1)	42.9 (15.56)	40.99 (14.17)	44.57 (16.53)	44.92 (15.07)
Baseline Cognition FIM	21.71 (6.36)	19.5 (4.05)	22.21 (6.58)	21.48 (5.65)	21.54 (8.29)	22.16 (6.89)	25.07 (7.15)	24.57 (7.15)	22.95 (7.49)	23.76 (7.34)
Number of OT visits	24.03 (14.79)	15.81 (8.76)	29.59 (31.25)	30.04 (23.10)	27.22 (19.01)	27.24 (14.55)	24.58 (16.50)	27.14 (18.75)	28.40 (20.56)	28.58 (21.36)
Number of comorbidities	0.75 (0.8)	0.75 (0.78)	0.81 (0.83)	0.70 (0.79)	0.73 (0.82)	0.67 (0.86)	0.59 (0.72)	0.59 (0.72)	0.75 (0.86)	0.91 (0.87)
Age in years	67.93 (13.37)	66.81 (12.62)	69.94 (16.02)	66.58 (18.1)	66.87 (15.74)	67.8 (14.18)	67.22 (14.16)	68.04 (13.65)	69.45 (14.59)	69.38 (13.69)
Knee OA	0%	0%	0%	0%	0%	0%	1; 0.58%	0%	0%	2; 1.03%
Hip OA	1; 0.34%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Spine OA	0%	0%	3; 1.15%	0%	1; .46%	2; 2.1%	1; 0.58%	2; 1.4%	3; 2.52%	3; 1.55%
RA	2; 0.68%	1; 6.25%	4; 1.53%	1; 2.0%	5; 2.3%	2; 2.1%	3; 1.75%	1; 0.7%	1; 0.84%	2; 1.03%
Neglect	14; 4.73%	1; 6.25%	41; 15.71%	4; 8.0%	18; 8.29%	12; 12.63%	10; 5.85%	8; 5.67%	14; 11.76%	23; 11.86%
COPD	20; 6.76%	1; 6.25	7; 2.68%	4; 8.0%	13; 5.99%	4; 4.21%	11; 6.43%	9; 6.38%	6; 5.04%	7; 3.61%
Obesity	14; 4.73%	1; 6.25%	5; 1.92%	1; 2.0%	4; 1.84%	2; 2.1%	3; 1.75%	1; 0.7%	1; 0.84%	3; 1.55%
CHF	21; 7.1%	2; 12.5%	22; 8.43%	3; 6.0%	16; 7.37%	9; 9.47%	15; 8.77%	10; 7.09%	16; 13.45%	32; 16.5%
CAD	40; 13.51%	2; 12.5%	33; 12.64%	6; 12.0%	28; 12.90%	8; 8.42%	12; 7.02%	10; 7.09%	12; 10.08%	28; 14.43%
DM	78; 26.35%	4; 25.0%	76; 29.12%	10; 20.0%	55; 25.35%	20; 21.05%	39; 22.81%	30; 21.28%	27; 22.69%	67; 34.54%
CRF	24; 8.11%	0%	14; 5.36%	4; 8.0%	17; 7.83%	5; 5.23%	3; 1.75%	7; 4.97%	3; 2.52%	3; 1.55%
Wound	1; 0.34%	0%	6; 2.30%	1; 2.0%	2; 0.92%	1; 1.05%	1; 0.58%	4; 2.84%	4; 3.36%	3; 1.55%
Depression	1; 0.34%	0%	3; 1.15%	1; 2.0%	1; 0.46%	0%	1; 0.58%	1; 0.7%	2; 1.68%	3; 1.55%
R CVA	113; 38.18%	3; 18.75%	107; 41.0%	23; 46.0%	72; 33.18%	31; 32.63%	57; 33.33%	50; 35.46%	38; 31.93%	61; 31.44%
L CVA	105; 35.47%	9; 56.25%	104; 39.85%	18; 36.0%	92; 42.4%	36; 37.9%	61; 35.67%	50; 35.46%	48; 40.34%	81; 41.75%
Living alone	68; 22.97%	7; 43.75%	74; 28.35%	12; 24.0%	52; 23.96%	23; 24.21%	35; 20.47%	35; 24.82%	37; 31.09%	55; 28.35%
Male	167; 56.42%	9; 56.25%	143; 54.79%	22; 44.0%	111; 51.15%	47; 49.47%	83; 48.54%	71; 50.36%	50; 42.02%	86; 44.33%
Speech	263; 88.85%	16; 100%	238; 91.19%	46; 92.0%	178; 82.03%	78; 82.11%	146; 85.38%	120; 85.11%	107; 89.92%	169; 87.11%

Appendix B

<u>Knee replacements and functional outcome</u>

As with stroke, there does not appear to be a strong relationship between PTA involvement and functional outcome change for the subjects following bilateral total knee replacements. A scatterplot of the relationship between PTA involvement level and Motor FIM change can be seen in Figure B1.

Figure B1. Scatterplot of PTA involvement level (continuous) and functional outcome (Motor FIM change)

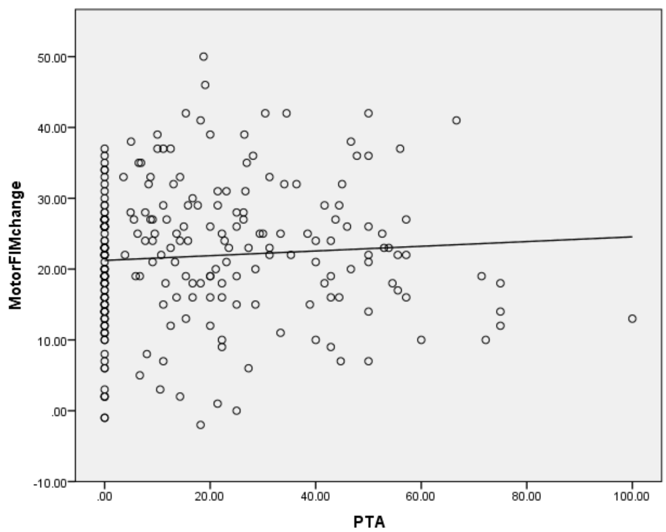
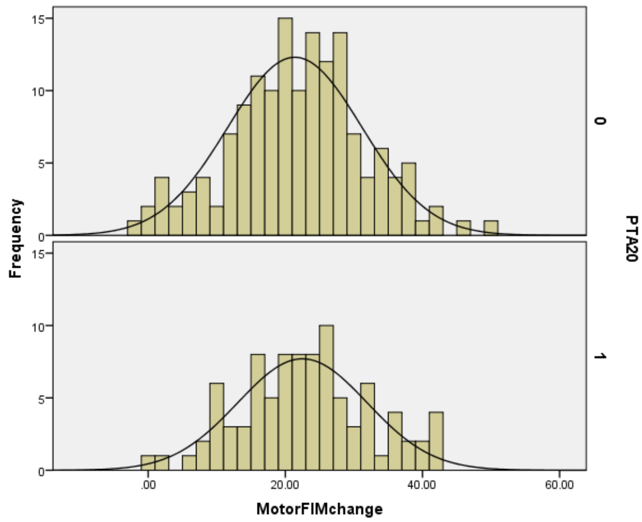


Figure B2. Distribution of functional outcome on levels of PTA involvement (0=PTA<20%; 1=PTA≥20% involvement)



A sensitivity analysis performed to determine the impact of the possible change in proportion of PTA visits over the course of a subject's inpatient rehabilitation stay. Proportion of visits with PTA during the first half of their rehabilitation stay was compared with the proportion during the second half of their stay. Subjects were identified as having a difference in PTA involvement if the proportion of PTA visits was less in the second half than in the first half of the length of stay. This is to account for the potential issue of increasing the PT involvement in the case due to complications or lack of progress. While a change in PTA involvement was an independent predictor of functional outcome, in the full regression model the slight decrease in outcomes (-.303) related to the change in PTA involvement was not statistically significant (p=.797).

Covariate balance within quintiles was examined by analysis of the baseline covariates for all subjects following bilateral total knee replacements. As in the original baseline covariate comparison, most covariates are balanced. Table B1 shows distribution of the baseline measures for low and high PTA use groups for each quintile.

Table B1. Baseline covariates by quintile of propensity score

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
	Low PTA N=39	**High PTA** N=9	**Low PTA** N=35	**High PTA** N=14	**Low PTA** N=36	**High PTA** N=13	**Low PTA** N=23	**High PTA** N=25	**Low PTA** N=18	**High PTA** N=30
Baseline Motor FIM	48.18 (8.14)	50.00 (7.19)	49.94 (7.88)	50.64 (10.96)	48.0 (8.95)	49.0 (8.90)	48.61 (10.04)	48.60 (6.99)	53.06 (7.4)	47.50 (10.23)
Baseline Cognition FIM	33.08 (3.07)	34.0 (1.0)	33.37 (2.33)	33.86 (1.88)	33.50 (1.94)	32.69 (2.5)	32.83 (3.66)	34.0 (2.02)	34.56 (0.62)	32.50 (3.87)
Number of OT visits	15.08 (6.82)	14.33 (9.7)	11.89 (6.68)	11.71 (6.68)	11.61 (7.42)	11.15 (5.34)	13.91 (6.25)	13.28 (5.62)	11.94 (12.63)	14.5 (7.31)
Number of comorbidities	0.72 (0.83)	0.44 (0.53)	0.25 (0.44)	0.07 (0.27)	0.17 (0.38)	0.31 (0.63)	0.22 (0.52)	0.28 (0.46)	0.39 (.70)	0.70 (.70)
Age in years	63.39 (9.34)	60.44 (7.35)	64.63 (9.27)	60.57 (9.03)	65.11 (9.35)	67.46 (9.66)	60.96 (10.96)	61.44 (9.36)	61.94 (12.84)	63.5 (11.55)
Hip OA	0%	0%	0%	0%	0%	0%	0%	0%	0%	1; 3.33%
Spine OA	0%	0%	0%	0%	0%	1; 7.7%	0%	0%	1; 5.56%	0 %
RA	3; 7.69%	1; 11.11%	0%	0%	0%	0%	1; 4.35%	0%	0%	0%
COPD	1; 2.56%	1; 11.11%	1; 2.86%	0%	1; 2.78%	0%	0%	0%	0%	0%
Obesity	0%	0%	0%	0%	0%	0%	0%	0%	2; 11.11%	10; 33.33%
CHF	5; 12.82%	0%	0%	0%	0%	0%	0%	0%	0%	1; 3.33%
CAD	4; 10.26%	0%	4; 11.43%	0%	1; 2.78%	1; 7.7%	1; 4.35%	2; 8.0%	0%	1; 3.33%
DM	15; 38.46%	2; 22.22%	4; 11.43%	1; 7.14%	4; 11.11%	2; 14.14%	2; 8.7%	5; 20%	3; 16.67%	3; 10%
CRF	0%	0%	0%	0%	0%	0%	1; 4.35%	0%	0%	2; 6.67%
Wound	0%	0%	0%	0%	0%	0%	0%	0%	1; 5.56%	2; 6.67%
Depression	0%	0%	0%	0%	0%	0%	0%	0%	0%	1; 3.33%
Living alone	15; 38.46%	3; 33.33%	13; 37.14%	4; 28.57%	7; 19.44%	2; 15.39%	5; 21.74%	4; 16.0%	0%	8; 26.67%
Male	12; 30.77%	1; 11.11%	10; 28.57%	5; 35.71%	11; 30.56%	2; 15.39%	3; 13.04%	9; 36.0%	7; 38.89%	9; 30%